23. B. Tech in Electronics and Communication Engineering

23. (a) Mission of the Department

Mission Stmt - 1	Build an educational process that is well suited to local needs as well as satisfies the international accreditation requirements.
Mission Stmt - 2	Attract the right people and retain them by building an environment that foster work freedom and empowerment.
Mission Stmt - 3	With the right talent pool, create knowledge and disseminate, get involved in collaborative research with reputed universities and produce competent graduates.

23. (b) Program Educational Objectives (PEO)

The Program Educational Objectives for the Electronics and Communication Engineering program describe accomplishments that graduates are expected to attain within five years after graduation. Graduates within 5 years of graduation will / should demonstrate:

PEO – 1	**Expertise** using their mathematical and scientific knowledge to solve emerging real-world problems, design and **create** novel products and solutions related to Electronics and Communication System Design that are technically sound, economically feasible and socially acceptable.
PEO – 2	Broad knowledge to **establish** themselves as **creative** practicing professionals, locally and globally, in fields such as design, research, testing and manufacturing of Electronics and Communication Systems.
PEO – 3	Communication skills (in both written and oral forms) and critical reasoning skills in **bridging** the divide between advanced technology and end users in the practice of Electronics and Communication Engineering.
PEO – 4	Sustained **learning** and adapting to a constantly changing field through graduate work, professional development, self-study and collaborative activities.
PEO – 5	**Leadership** and initiative to ethically advance professional and organizational goals, facilitate the achievements of others, and obtain substantive results.
PEO – 6	Ability to work productively as individuals and in groups (**teamwork**) of diverse cultural and multidisciplinary backgrounds.

23. (c) Mission of the Department to Program Educational Objectives (PEO) Mapping

	Mission Stmt. - 1	Mission Stmt. - 2	Mission Stmt. – 3
PEO - 1	L	M	H
PEO - 2	H	L	H
PEO - 3	L	L	M
PEO - 4	M	L	M
PEO - 5	L	H	H
PEO - 6	H	H	H

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

23. (d) Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)

	Program Learning Outcomes (PLO)														
	Graduate Attributes (GA)												Program Specific Outcomes (PSO)		
	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	Design, Prototype and Test Modern ECE Systems	Project Management Techniques	Implement ECE Systems
PEO - 1	H		H			H	M	H			H		H		H
PEO - 2		H	M	H	M								M		M
PEO - 3					L			M		H				M	
PEO - 4												H	L		
PEO - 5						L			M					M	
PEO - 6						M			H					H	L

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

Program Specific Outcomes (PSO)

Graduates of baccalaureate degree program in ECE must demonstrate knowledge and hands-on competence in the ability to:

PSO – 1	Design, prototype and test modern electronics and telecommunication engineering systems as per the specifications for the professional achievement in an industry and organization
PSO – 2	Apply project management techniques to electrical/ electronic/ telecommunications systems
PSO – 3	Analyze and research appropriate technologies for implementation of the electronics and telecommunication engineering systems

23. (e) Program Structure (B.Tech in Electronics and Communication Engineering)

1. Humanities & Social Sciences including Management Courses (H)

Course Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18LEH102J	Chinese	2	0	2	3
18LEH103J	French				
18LEH104J	German				
18LEH105J	Japanese				
18LEH106J	Korean				
18PDH101L	General Aptitude	0	0	2	1
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDH103J	Social Engineering	1	0	2	2
18PDH201L	Employability Skills & Practices	0	0	2	1
Total Learning Credits					**12**

2. Basic Science Courses (B)

Course Code	Course Title	Hours/ Week L	T	P	C
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18CYB101J	Chemistry	3	1	2	5
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18MAB201T	Transforms and Boundary Value Problems	3	1	0	4
18MAB203T	Probability and Stochastic Process	3	1	0	4
18MAB302T	Discrete Mathematics for Engineers	3	1	0	4
18BTB101T	Biology	2	0	0	2
Total Learning Credits					**32**

3. Engineering Science Courses (S)

Course Code	Course Title	Hours/ Week L	T	P	C
18MES101L	Engineering Graphics and Design	1	0	4	3
18EES101J	Basic Electrical and Electronics Engineering	3	1	2	5
18MES103L	Civil and Mechanical Engineering Workshop	1	0	4	3
18CSS101J	Programming for Problem Solving	3	0	4	5
18ECS201T	Control Systems	3	0	0	3
	Total Learning Credits				**19**

4. Professional Core Courses (C)

Course Code	Course Title	Hours/ Week L	T	P	C
18ECC102J	Electronic Devices	3	0	2	4
18ECC103J	Digital Electronic Principles	3	0	2	4
18ECC104T	Signals and Systems	3	1	0	4
18ECC105T	Electromagnetics and Transmission Lines	3	0	0	3
18ECC201J	Analog Electronic Circuits	3	0	2	4
18ECC202J	Linear Integrated Circuits	3	0	2	4
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques	3	0	2	4
18ECC204J	Digital Signal Processing	3	0	2	4
18ECC205J	Analog and Digital Communication	3	0	2	4
18ECC206J	VLSI Design	3	0	2	4
18ECC301T	Wireless Communications	3	1	0	4
18ECC302J	Microwave & Optical Communications	3	0	2	4
18ECC303J	Computer Communication Networks	3	0	2	4
18ECC350T	Comprehension	0	1	0	1
	Total Learning Credits				**52**

5. Professional Elective Courses (E)

Course Code	Course Title	Hours/ Week L	T	P	C
	Professional Elective – 1	3	0	0	3
	Professional Elective – 2	3	0	0	3
	Professional Elective – 3	3	0	0	3
	Professional Elective – 4	3	0	0	3
	Professional Elective – 5	3	0	0	3
	Professional Elective – 6	3	0	0	3
	Total Learning Credits				**18**

6. Open Elective Courses (O)

Course Code	Course Title	Hours/ Week L	T	P	C
	Open Elective – 1	3	0	0	3
	Open Elective – 2	3	0	0	3
	Open Elective – 3	3	0	0	3
	Open Elective – 4	3	0	0	3
Total Learning Credits					**12**

7. Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)						
Course Code	Course Title	Hours/ Week L	T	P	C	
18ECP101L	MOOC- 1	0	0	2	1	
18ECP102L	Industrial Training-1					
18ECP103L	Seminar - 1					
18ECP104L	MOOC- 2	0	0	2	1	
18ECP105L	Industrial Training-2					
18ECP106L	Seminar - 2					
18ECP107L	Minor Project	0	0	6	3	
18ECP108L	Internship (4-6 weeks)					
18ECP109L	Project	0	0	20	10	
18ECP110L	Semester Internship					
Total Learning Credits					**15**	

8. Mandatory Courses (M)					
Course Code	Course Title	Hours/ Week L	T	P	C
18PDM101L	Professional Skills and Practices	0	0	2	0
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM203L	Entrepreneurial Skill Development				
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
18PDM204L	Business Basics for Entrepreneurs				
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
19PDM302L	Entrepreneurship Management				
18LEM101T	Constitution of India	1	0	0	0
18LEM102J	Value Education	1	0	1	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
18GNM102L	NSS	0	0	2	0
18GNM103L	NCC				
18GNM104L	NSO				
18LEM109T	Indian Traditional Knowledge	1	0	0	0
18LEM110L	Indian Art Form	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
Total Learning Credits					**-**

List of Professional Elective Courses (E) *Any 6 Courses*					
Course Code	Course Title	Hours/ Week L	T	P	C
	Sub-Stream: Electronic System Engineering				
18ECE201J	Python and Scien236tific Python	2	0	2	3
18ECE202T	Micro- and Nano-Fabrication Technologies	3	0	0	3
18ECE203T	Semiconductor Device Modeling	3	0	0	3
18ECE204J	*ARM based Embedded System Design*	2	0	2	3
18ECE205J	FPGA based Embedded System Design	2	0	2	3
18ECE206J	Advanced Digital System Design	2	0	2	3
18ECE207J	Real Time Operating Systems	2	0	2	3
18ECE301J	CMOS Analog IC Design	2	0	2	3
18ECE302T	MEMS Technologies	3	0	0	3
18ECE303T	Nanoelectronic Devices and Circuits	3	0	0	3
18ECE304T	Microwave Integrated Circuits	3	0	0	3
18ECE305J	ARM-SoC	2	0	2	3
18ECE306J	ARM based Digital Signal Processing	2	0	2	3
18ECE307J	Applied Machine Learning	2	0	2	3
	Sub-Stream: Communication System Engg.				
18ECE220T	Advanced Mobile Communication Systems	3	0	0	3
18ECE221T	Radar And Navigational Aids	3	0	0	3
18ECE222T	Adhoc and Sensor Networks	3	0	0	3
18ECE223T	Satellite Communication and Broadcasting	3	0	0	3
18ECE224T	Cryptography and Network Security	3	0	0	3
18ECE225T	Information Theory and Coding	3	0	0	3
18ECE226T	Optical Components, Systems and Networks	3	0	0	3
18ECE320T	Software Defined Networks	3	0	0	3
18ECE321T	RF and Microwave Semiconductor Devices	3	0	0	3
18ECE322T	Opto Electronics	3	0	0	3
18ECE323T	Advanced Optical Communication	3	0	0	3
	Sub-Stream: Signal Processing				
18ECE240T	Wavelets and Signal Processing	3	0	0	3
18ECE241J	Signal Processing for Auditory System	2	0	2	3
18ECE242J	Pattern Recognition and Neural Networks	2	0	2	3
18ECE243J	Digital Image and Video Processing	2	0	2	3
18ECE244J	DSP System Design	2	0	2	3
18ECE245T	Adaptive Signal Processing	3	0	0	3
18ECE340T	Machine Perception with Cognition	3	0	0	3
18ECE341T	Multimedia Compression Techniques	3	0	0	3
18ECE342T	Acoustical Signal Processing	3	0	0	3
18ECE343T	Automatic Speech Recognition	3	0	0	3

List of Open Elective Courses (O) *Any 4 Courses*					
Course Code	Course Title	Hours/ Week L	T	P	C
18ECO101T	Short-Range Wireless Communication	3	0	0	3
18ECO102J	Electronic Circuits & Systems	2	0	2	3
18ECO103T	Modern Wireless Communication Systems	3	0	0	3
18ECO104J	Audio and Speech Processing	2	0	2	3
18ECO105T	Underwater Acoustics	3	0	0	3
18ECO106J	PCB Design and Manufacturing	2	0	2	3
18ECO107T	Fiber Optics and Optoelectronics	3	0	0	3
18ECO108J	Embedded System Design using Arduino	2	0	2	3
18ECO109J	Embedded System Design using Raspberry Pi	2	0	2	3
18ECO110J	3D Printing Hardware and Software	2	0	2	3
18ECO131J	Virtual Instrumentation	2	0	2	3
18ECO132T	Analytical Instrumentation	3	0	0	3
18ECO133T	LOGIC and Distributed Control System	3	0	0	3
18ECO134T	Sensors and Transducers	3	0	0	3
18ECO135T	Fundamentals of MEMS	3	0	0	3
18ECO121T	**Basics of Biomedical Engineering**	3	0	0	3
18ECO122T	Hospital Information Systems	3	0	0	3
18ECO123T	**Biomedical Imaging**	3	0	0	3
18ECO124T	Human Assist Devices	3	0	0	3
18ECO125T	Quality Control for Biomedical Devices	3	0	0	3
18ECO126T	Sports Biomechanics	3	0	0	3

23. (f) Program Articulation (B.Tech in Electronics and Communication Engineering)

Course Code	Course Name	Program Learning Outcomes (PLO)														
		Graduate Attributes												PSO		
		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	System Design & Analysis	Project Management	Natural Sciences and Mathematics
18EES101J	Basic Electrical and Electronics Engineering	H	M	H	M	L										H
18MES103L	Civil and Mechanical Engineering Workshop	M			H	H					H		L	M	L	
18ECS201T	Control Systems	L		H	M									H		M
18ECC102J	Electronic Devices	L	M	H					M	H				L	L	M
18ECC103J	Digital Electronic Principles	L	M	H					M	H				H	L	
18ECC104T	Signals and Systems	L	H	M												H
18ECC105T	Electromagnetics and Transmission Lines	L		M	H									M		M
18ECC201J	Analog Electronic Circuits	M	L	H	H									H	L	
18ECC202J	Linear Integrated Circuits	M	L	H	H									H	L	
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques		M	H		H							L	H	L	
18ECC204J	Digital Signal Processing	M	L	H	H	H	M	L							L	H
18ECC205J	Analog and Digital Communication	L	L	H	H	H			H	M			M	H	L	
18ECC206J	VLSI Design															
18ECC301T	Wireless Communication	M					L	H	M					L		M
18ECC302J	Microwave & Optical Communications	L	L	H		M			L	L				L	L	
18ECC303J	Computer Communication Networks			M			H	H	L	L			M	L	L	
18ECC350T	Comprehension															
18ECP101L	MOOC / Industrial Training / Seminar – 1						M	L			H		H		M	
18ECP102L	MOOC / Industrial Training / Seminar – 2						M	L			H		H		M	
18ECP103L	Project (Phase-I) / Internship (3-4 weeks)	M	M	H	H	M	H	H	L	H	H	H	H	H	H	M
18ECP103L	Project (Phase-II) / Semester Internship	M	M	H	H	M	H	H	L	H	H	H	H	H	H	M

H – High Correlation, M – Medium Correlation, L – Low Correlation, PSO – Program Specific Outcomes (PSO)

23. (g) Implementation Plan (B. Tech in Electronics and Communication Engineering)

Semester - I

Code	Course Title	Hours/ Week L	T	P	C
18LEH102J-18LEH106J	Foreign Language (Chinese/ French/ German/ Japanese / Korean)	2	0	2	3
18MAB101T	Calculus and Linear Algebra	3	1	0	4
18CYB101J	Chemistry	3	1	2	5
18CSS101J	Programming for Problem Solving	3	0	4	5
18MES103L	Civil and Mechanical Engineering Workshop	1	0	4	3
18PDM101L	Professional Skills and Practices	0	0	2	0
18LEM102J	Value Education	1	0	1	0
18GNM102L	NCC / NSS / NSO	0	0	2	0
Total Learning Credits					20

Semester – II

Code	Course Title	Hours/ Week L	T	P	C
18LEH101J	English	2	0	2	3
18MAB102T	Advanced Calculus and Complex Analysis	3	1	0	4
18PYB101J	Physics: Electromagnetic Theory, Quantum Mechanics, Waves and Optics	3	1	2	5
18MES101L	Engineering Graphics and Design	1	0	4	3
18EES101J	Basic Electrical and Electronics Engineering	3	1	2	5
18PDH101L	General Aptitude	0	0	2	1
18LEM101T	Constitution of India	1	0	0	0
18GNM101L	Physical and Mental Health using Yoga	0	0	2	0
Total Learning Credits					21

Semester - III

Code	Course Title	Hours/ Week L	T	P	C
18MAB201T	Transforms and Boundary Value Problems	3	1	0	4
18ECS201T	Control Systems	3	0	0	3
18ECC102J	Electronic Devices	3	0	2	4
18ECC103J	Digital Electronic Principles	3	0	2	4
18ECC104T	Signals and Systems	3	1	0	4
18ECC105T	Electromagnetics and Transmission Lines	3	0	0	3
18PDH103J	Social Engineering	1	0	2	2
18PDM201L	Competencies in Social Skills	0	0	2	0
18CYM101T	Environmental Science	1	0	0	0
Total Learning Credits					24

Semester - IV

Code	Course Title	Hours/ Week L	T	P	C
18MAB203T	Probability and Stochastic Process	3	1	0	4
18BTB101T	Biology	2	0	0	2
18ECC201J	Analog Electronic Circuits	3	0	2	4
18ECC202J	Linear Integrated Circuits	3	0	2	4
	Professional Elective-1	3	0	0	3
	Open Elective-1	3	0	0	3
18PDH102T	Management Principles for Engineers	2	0	0	2
18PDM202L	Critical and Creative Thinking Skills	0	0	2	0
Total Learning Credits					22

Semester - V

Code	Course Title	Hours/ Week L	T	P	C
18MAB302T	Discrete Mathematics for Engineers	3	1	0	4
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques	3	0	2	4
18ECC204J	Digital Signal Processing	3	0	2	4
18ECC205J	Analog and Digital Communication	3	0	2	4
	Professional Elective – 2	3	0	0	3
	Open Elective – 2	3	0	0	3
18ECP101L	MOOC / Industrial Training / Seminar – 1	0	0	2	1
18PDM301L	Analytical and Logical Thinking Skills	0	0	2	0
18LEM110L	Indian Art Form	0	0	2	0
Total Learning Credits					23

Semester - VI

Code	Course Title	Hours/ Week L	T	P	C
18ECC206J	VLSI Design	3	0	2	4
18ECC302J	Microwave and Optical Communications	3	0	2	4
18ECC303J	Computer Communication Networks	3	0	2	4
18ECC350T	Comprehension	0	1	0	1
	Professional Elective-3	3	0	0	3
	Professional Elective-4	3	0	0	3
	Open Elective-3	3	0	0	3
18ECP102L	MOOC / Industrial Training / Seminar – 2	0	0	2	1
18PDH201L	Employability Skills and Practices	0	0	2	1
18LEM109T	Indian Traditional Knowledge	1	0	0	0
Total Learning Credits					24

Semester - VII

Code	Course Title	Hours/ Week L	T	P	C
18ECC301T	Wireless Communications	3	1	0	4
	Professional Elective-5	3	0	0	3
	Professional Elective-6	3	0	0	3
	Open Elective-4	3	0	0	3
18ECP103L	Project (Phase-I) / Internship (4-6 weeks)	0	0	6	3
Total Learning Credits					16

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
18ECP104L	Project (Phase-II) / Semester Internship	0	0	20	10
Total Learning Credits					10

B. Tech in Electronics and Communication Engineering

2018 Regulations

Engineering Science Courses (S)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECS201T	Course Name	CONTROL SYSTEMS	Course Category		Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB102T	Co-requisite Courses	18ECC104T	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Learn about mathematical modeling techniques of mechanical and electrical systems
CLR-2 :	Impart knowledge about the transient and steady state error and analysis
CLR-3 :	Identify and analyze stability of a system in time domain using root locus technique
CLR-4 :	Know about different frequency domain analytical techniques
CLR-5 :	Acquire the knowledge of a controller for specific applications
CLR-6 :	Impart knowledge on controller tuning methods

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO–1: Professional Achievement	PLO 14 PSO – 2: Project Management Techniques	PLO 15 PSO – 3: Analyze & Research
CLO-1 :	Determine Transfer function of a system by mathematical modeling, block diagram reduction and signal flow graphs	1,2	80	80	H	H	H	H	-	-	-	-	-	-	-	H	H	-	H
CLO-2 :	Identify the standard test inputs, time domain specifications and calculate steady state error	1,2	85	80	H	H	H	H	H	-	-	-	-	-	-	H	H	-	H
CLO-3 :	Plot a root locus curve and analyze the system stability using Routh array	2,3	90	85	H	H	H	H	H	-	-	-	-	-	-	H	H	-	H
CLO-4 :	Analyze the frequency domain specifications from bode and polar plots	2,3	90	85	H	H	H	H	H	-	-	-	-	-	-	H	H	-	H
CLO-5 :	Design a closed loop control system for specific application	1,2,3	80	80	H	H	H	H	H	-	-	-	-	-	-	H	H	H	H
CLO-6 :	Identification of controller parameters and tuning	1,2,3	85	85															

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Open and closed loop control system	Standard test signals and their expression	Poles and zeros of a system	Frequency domain analysis	Controllers-Significance and Need
	SLO-2	Feedback and Feed forward control systems	Type number and order of a system	Pole zero plot and concept of s plane	Frequency domain specifications	Stability of closed loop systems
S-2	SLO-1	Transfer function of a system and basis of Laplace transforms	Transfer function of First order system for Step and ramp signal	Proper, Strictly Proper and Improper systems	Frequency domain plots, minimum and non minimum phase systems	SISO and MIMO control systems
	SLO-2	Need for mathematical modeling	Transfer function of First order system Impulse and parabolic signal	Characteristic equation	Correlation between time and frequency domain	Types of controllers-ON-OFF,P,I,D
S-3	SLO-1	Representation of mechanical translational systems using differential equation and determination of transfer function	General transfer function of second order system	Concept of stability from pole zero location	Bode plot approach and stability analysis	Composite Controller-PI,PD and PID
	SLO-2		Identification of damping factor and classification based on it	Need for Stability analysis and available techniques	Rules for sketching bode plot	Controller parameters and tuning methods
S-4	SLO-1	Representation of mechanical rotational systems and determination of transfer function	Step response of critically damped second order system	Necessary and sufficient Condition for stability	Bode plot of typical systems	Design Specification, controller configurations- ON-OFF controller
	SLO-2		Step response of under damped second order system	Significance of Routh Hurwitz Technique		
S-5	SLO-1	Conversions of Mechanical system to Electrical system	Step response of over damped second order system	Computation of Routh array	Bode plot of typical systems	Design Specification, controller configurations-PID controller

	SLO-2	*f-V and f-I electrical analogies*	*Step response of undamped second order system*	*Routh array of stable systems*		
S-6	**SLO-1**	*Block diagram reduction rules and methodology*	*Time domain specifications and their significance*	*Routh array of Unstable systems*	*Polar plot and significance*	*Design of speed control system for DC motor*
	SLO-2		*Numerical solution*	*Routh array of Unstable systems*	*Nyquist stability criterion*	
S-7	**SLO-1**	*Evaluation of transfer function using block diagram reduction*	*Transient and steady state error analysis*	*Root locus technique*	*Sketching of polar plot on polar graphs*	*Design of control system for Twin Rotor Multi input Multi output System(TRMS) with one degree of freedom*
	SLO-2		*Static and dynamic Error coefficients*	*Rules for sketching root locus*		
S-8	SLO-1	*Signal flow graphs and evaluation of transfer function*	*Static error constants and evaluation of steady state error*	*Root locus plot of typical systems*	*Polar plot of typical systems*	*Case study 1*
	SLO-2					
S-9	SLO-1	*Block diagram to signal flow conversion*	*Dynamic error constants and evaluation of steady state error*	*Root locus plot of typical systems*	*Polar plot of typical systems*	*Case study 2*
	SLO-2					

Learning Resources	*1.*Nagrath.J and Gopal.M,, "Control System Engineering", 5th Edition, New Age, 2007 2. Benjamin C Kuo, "Automatic Control System", 9th edition, John Wiley & Sons, 2010	3. Gopal.M, "Control System Principles and Design", 2nd Edition, TMH, 2002 4. Sivanandam and Deepa, "Control system Engineering using MATLAB", 2nd edition, Vikas publishers, 2007

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

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

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

B. Tech in Electronics and Communication Engineering

2018 Regulations

ProfessionalCore Courses (C)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology

SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECC102J	Course Name	ELECTRONIC DEVICES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	18ECC201J, 18ECC202J, 18ECE203T, 18ECE303T, 18ECE321T, 18ECE322T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Provide a basis for understanding semiconductor material, how a pn junction is formed and its principle of operation			
CLR-2 :	Explain the importance of diode in electronic circuits by presenting appropriate diode applications			
CLR-3 :	Discuss the basic characteristics of several other types of diodes that are designed for specific applications			
CLR-4 :	Describe the basic structure, operation and characteristics of BJT, and discuss its use as a switch and an amplifier.			
CLR-5 :	Describe the basic structure, operation and characteristics of MOSFET, and discuss its use as a switch and an amplifier.			
CLR-6 :	Use modern engineering tools such as PSPICE to carry out design experiments and gain experience with instruments and methods used by technicians and electronic engineers			

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 :	Understand the operation, characteristics, parameters and specifications of semiconductor diodes and special diodes	1	90	80
CLO-2 :	Demonstrate important applications of semiconductor diodes and special diodes.	2	80	75
CLO-3 :	Review bipolar transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	90	80
CLO-4 :	Review field-effect transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	80	75
CLO-5 :	Build a circuit, then make functional measurements to understand the operating characteristics of the device / circuit.	3	80	75
CLO-6 :	Solve specific design problem, which after completion will be verified using modern engineering tools such as PSPICE.	3	90	75

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

Duration (hour)		Semiconductor Diodes	Diode Circuits	Special Diodes	Bipolar Junction Transistors	MOS Field-Effect Transistors
		15	15	15	15	15
S-1	SLO-1	Basic semiconductor theory: Intrinsic & extrinsic semiconductors	HWR operation, Efficiency and ripple factor	Backward diode	Physical structure	Physical structure
	SLO-2	Current flow in semiconductors	Problem solving	Varactor diode	Device operation of BJT	Device operation of E-MOSFET & D-MOSFET
S-2	SLO-1	PN junction theory: Equilibrium PN junction	Center-Tapped Transformer FWR operation, Efficiency and ripple factor	Step recovery diode	Current-Voltage characteristics of CE BJT configuration	I-V characteristics of E-MOSFET
	SLO-2	Forward biased PN junction	Problem solving	Point-contact diode	Current-Voltage characteristics of CE BJT configuration	Problem solving
S-3	SLO-1	Reverse biased PN junction	Bridge FWR operation, Efficiency and ripple factor	Metal-semiconductor junction: Structure, Energy band diagram	Current-Voltage characteristics of CB BJT configuration	Derive drain current
	SLO-2	Relation between Current and Voltage	Problem solving	Forward & Reverse Characteristics of Schottky Diode	Current-Voltage characteristics of CB BJT configuration	Problem solving
S 4-5	SLO-1	Lab 1: PN Junction Diode Characteristics	Lab 4: Diode clipping and clamping circuits	Lab 7: Series and Shunt Regulators	Lab 10: BJT and MOSFET Switching Circuits	Lab 13: Repeat Experiments
	SLO-2					
S-6	SLO-1	Calculate depletion width	Filters: Inductor & Capacitor Filters	Tunnel Diode	Current-Voltage characteristics of CC BJT configuration	Derive transconductance
	SLO-2	Calculate barrier potential	Problem solving	Tunnel Diode	Current-Voltage characteristics of CC BJT configuration	Problem solving

S-7	SLO-1	*Derive diode current equation*	*Filters: LC & CLC Filters*	*Gunn Diode*	*BJT as an amplifier*	*CMOS FET*
	SLO-2	*Derive diode current equation*	*Problem solving*	*Gunn Diode*	*BJT as a switch*	*MOSFET as an amplifier*
S-8	SLO-1	*Effect of Capacitance in PN junction: Transition Capacitance*	*Diode Clippers*	*IMPATT Diode*	*BJT circuit models – h-parameter*	*MOSFET as a switch*
	SLO-2	*Diffusion Capacitance*	*Problem solving*	*IMPATT Diode*	*BJT circuit models – hybrid-π parameter*	*Problem solving*
S 9-10	SLO-1 SLO-2	*Lab 2: Zener diode characteristics*	*Lab 5: BJT Characteristics*	*Lab 8: MOSFET Characteristics*	*Lab 11: Photoconductive Cell, LED, and Solar Cell Characteristics*	*Lab-14: Model Examination*
S-11	SLO-1	*Energy band structure of PN Junction Diode*	*Diode Clampers*	*PIN Diode*	*BJT biasing circuits and stability analysis: Base bias and emitter bias*	*Biasing Circuits for MOSFET: Gate Bias*
	SLO-2	*Ideal diode and its current-voltage characteristics*	*Problem solving*	*PIN Photodiode*	*Problem solving*	*Problem Solving*
S-12	SLO-1	*Terminal characteristics & parameters*	*Voltage Multipliers*	*Avalanche photodiode*	*Voltage-divider bias*	*Self-bias*
	SLO-2	*Diode modeling*	*Zener diode: Characteristics, breakdown mechanisms*	*Laser diode*	*Problem solving*	*Problem Solving*
S-13	SLO-1	*DC load line and analysis*	*Zener resistances and temperature effects Zener diode as voltage regulator*	*Problem solving*	*Collector-feedback bias*	*Voltage-divider bias*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem Solving*
S 14-15	SLO-1 SLO-2	*Lab 3: Diode rectifier circuits*	*Lab 6: BJT Biasing Circuits*	*Lab 9: MOSFET Biasing Circuits*	*Lab 12: Simulation experiments using PSPICE*	*Lab 15: End-Semester Practical Examination*

Learning Resources	1. *David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015* 2. *Donald Neamen, Electronic Circuits: Analysis and Design, 3rd ed., McGraw-Hill Education, 2011* 3. *Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits: Theory and Applications, OUP, 2014* 4. *Thomas L. Floyd, Electronic Devices", 9th ed., Pearson Education, 2013*	5. *Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013* 6. *Muhammad Rashid, Microelectronic Circuits: Analysis & Design, 2nd ed., Cengage Learning, 2010* 7. *Muhammed H Rashid, Introduction to Pspice using OrCAD for circuits and electronics, 3rd ed., Pearson, 2004* 8. *Laboratory Manual, Department of ECE, SRM University*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECC103J	Course Name	DIGITAL ELECTRONIC PRINCIPLES	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18EES101J	Co-requisite Courses	Nil	Progressive Courses	18ECC203J, 18ECC206J, 18ECE206J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand binary codes, digital arithmetic operations and able to simplify Boolean logic expressions			
CLR-2 :	Describe how basic TTL and CMOS gates operate at the component level			
CLR-3 :	Able to design simple combinational logics using basic gates and MSI circuits			
CLR-4 :	Familiarize with basic sequential logic components: flip-flops, registers, counters and their usage, and able to design and analyze sequential logic circuits and Finite State Machines.			
CLR-5 :	Know how to implement logic circuits using PLDs.			
CLR-6 :	Use modern engineering tools such as PSPICE / Logisim to carry out design experiments and gain experience with instruments and methods used by technicians and electronic engineers			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Have a thorough understanding of the fundamental concepts and techniques used in digital electronics.	1	90	75
CLO-2 :	Understand the basic electronics of various logic families and able to use Integrated Circuits.	1	80	70
CLO-3 :	Understand, analyze, design and troubleshoot various combinational logic circuits.	2,3	90	75
CLO-4 :	Understand, analyze, design and troubleshoot various clocked sequential logic circuits.	2,3	90	75
CLO-5 :	Analyze, design and implement various digital logic circuits using PLDs	2,3	80	75
CLO-6 :	Solve specific design problem, which after completion will be verified using modern engineering tools such as PSPICE / Logisim	3	90	75

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

Duration (hour)		Binary Codes, Digital Arithmetic and Simplification of Boolean Functions	Logic Families	Combinational Systems	Sequential Systems	Memory and Programmable Logic
		15	15	15	15	15
S-1	SLO-1	Binary Codes, Digital Arithmetic and Simplification of Boolean Functions	Introduction	Binary arithmetic units	Flip-flop and Latch: SR latch,	RAM Memory decoding
	SLO-2	Error detecting codes	TTL Logic Family	Adder	JK flip-flop, T flip-flop,D flip-flop	ROM
S-2	SLO-1	Error correcting code	Totem-pole TTL	Design of Half adder	Master-slave RS flip-flop	Programmable Logic Devices (PLDs): Basic concepts
	SLO-2	Hamming Code	open-collector and tristate TTL	Design of Full adder	Master-slave JK flip-flop	PROM
S-3	SLO-1	Arithmetic number representation	Schottkey TTL, standard TTL characteristics	Subtractor	Registers & Counters	PROM as PLD
	SLO-2	Binary arithmetic	Metal Oxide Semiconductor logic families	Design subtractor using logic gates	Shift registers (SISO, SIPO, PISO, PIPO)	Programmable Array Logic (PAL)
S 4-5	SLO-1	LAB 1: Study of logic gates	LAB 4: Design and implement encoder and decoder using logic gates	LAB 7: Implement combinational logic functions using standard ICs	LAB 10: Design and implement Synchronous Counters	LAB 13: Construct combinational circuit using Logisim
	SLO-2					
S-6	SLO-1	Hexadecimal arithmetic	N-MOS	n-bit parallel adder & subtractor	Universal shift register	Programmable Array Logic (PAL)

	SLO-2	*Hexadecimal arithmetic*	*P-MOS*	*look ahead carry generator*	*Counters: Asynchronous/Ripple counters*	*Programmable Logic Array (PLA)*
S-7	SLO-1	*BCD arithmetic simplification*	*CMOS logic circuits*	*Decoder*	*Synchronous counters, Modulus-n Counter*	*Programmable Logic Array (PLA)*
	SLO-2	*Minimization of Boolean Functions: Algebraic simplification*	*Characteristics of MOS logic*	*Encoder*	*Ring counter, Johnson counter*	*Design combinational circuits using PLD's*
S-8	SLO-1	*Problems on Algebraic simplification*	*Compare MOS logic circuits(CMOS) with TTL digital circuit*	*Multiplexer*	*Up-Down counter*	*Design combinational circuits using PLD's*
	SLO-2	*Karnaugh map simplification*	*Electrical characteristics*	*Demultiplexer*	*Mealy and Moore model*	*Design combinational circuits using PLD's*
S 9-10	SLO-1 SLO-2	*LAB 2: Design and implement Adder and Subtractor using logic gates*	*LAB 5: Design and implement Multiplexer and Demultiplexer using logic gates*	*LAB 8: Verify characteristic table of flip-flops*	*LAB 11: Construct and verify shift registers*	*LAB 14: Model Practical Examination*
S-11	SLO-1	*Problems on Karnaugh map simplification*	*Fan-out*	*Code converters*	*Synchronous (Clocked) sequential circuits*	*Design of combinational circuits using PLD's*
	SLO-2	*Problems on Karnaugh map simplification*	*Propagation Delay*	*Magnitude comparators*	*Synchronous (Clocked) sequential circuits*	*Design sequential circuits using PLD's*
S-12	SLO-1	*Quine McCluskey*	*Power dissipation*	*Magnitude comparators*	*Synchronous (Clocked) sequential circuits*	*Design sequential circuits using PLD's*
	SLO-2	*Tabulation method*	*Noise margin*	*Parity generators (Odd parity)*	*Analyze and design synchronous sequential circuits*	*Design sequential circuits using PLD's*
S-13	SLO-1	*Problems on Quine McCluskey or Tabulation method.*	*Supply voltage levels*	*Parity generators (Even parity)*	*State reduction*	*Design sequential circuits using PLD's*
	SLO-2	*Exercise problems using Tabulation method*	*Operational voltage levels*	*Implementation of combinational logic by standard IC's.*	*State assignment*	*Design sequential circuits using PLD's*
S 14-15	SLO-1 SLO-2	*Lab 3: Design and Implement 2-bit Magnitude Comparator using logic gates*	*LAB-6: Design and implement code converters using logic gates*	*LAB 9: Construct and verify 4-bit ripple counter, Mod-10/Mod-12 ripple counters*	*Lab 12: Construct mini project work*	*LAB 15: University Practical Exam*

Learning Resources	1. *Morris Mano M, Michael D. Ciletti, Digital Design with an Introduction to the Verilog HDL, 5th ed., Pearson Education, 2014* 2. *Charles H Roth (Jr), Larry L. Kinney, Fundamentals of Logic Design, 5th ed., Cengage Learning India Edition, 2010* 3. *Thomas L. Floyd, Digital Fundamentals, 10th ed., Pearson Education, 2013*	4. *Ronald J. Tocci, Digital System Principles and Applications, 10th ed., Pearson Education, 2009* 5. *Donald P Leach, Albert Paul Malvino, Goutam Saha, Digital Principles and Applications, 6th ed., Tata-Mcgraw Hill, 2008* 6. *LAB MANUAL, Department of ECE, SRM University*

Learning Assessment

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

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

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

Course Code	18ECC104T	Course Name	SIGNALS AND SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	Nil	Co-requisite Courses	18MAB201T	Progressive Courses	18ECC204J, 18ECS201T, 18ECE240T, 18ECE241J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Know about requirements of signal and system analysis in communication.			
CLR-2 :	Understand the analysis of Periodic and Aperiodic Continuous time Signals using Fourier series and transforms			
CLR-3 :	Educate about Continuous time system through Laplace transform and Convolution integral			
CLR-4 :	Understand the characterization of the Discrete time signals and system through DTFT, Convolution sum			
CLR-5 :	Understand the concept of Z-Transform for the analysis of DT system			
CLR-6 :	Develop expertise in time-domain and frequency domain approaches to the analysis of continuous and discrete systems and also the ability to apply modern computation software tool for the analysis of electrical engineering problems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research	
CLO-1 :	Acquire knowledge of various classifications of Signals and Systems	1	85	70	H	-	-	-		-	-	-	-	-	-	-	-	-	-	
CLO-2 :	Analyze Periodic and Aperiodic Continuous time Signals using Fourier series and Fourier Transform	2	85	70	H	M	-	-	M	-	-	-	-	-	-	-	-	-	-	
CLO-3 :	Analyze and characterize the Continuous time system through Laplace transform and Convolution integral.	2	85	70	H	M	-	-	M	-	-	-	-	-	-	-	-	-	-	
CLO-4 :	Analyze and characterize the Discrete time signals and system through DTFT, Convolution sum	2	85	70	H	M	-	-	M	-	-	-	-	-	-	-	-	-	-	
CLO-5 :	Analyze and characterize the Discrete time system using Z transform	2	85	70	H	M	-	-	M	-	-	-	-	-	-	-	-	-	-	
CLO-6 :	Present the mathematical techniques used for continuous-time signal and discrete-time signal and system analysis	3	85	70	H	M	-	-	-	-	-	-	-	-	-	L	L	-	-	

Duration (hour)		*Classification of Signals and Systems*	*Analysis of Continuous Time Signals*	*Analysis of LTI CT System*	*Analysis of DT Signals and Systems*	*Analysis of LTI DT System using Z-Transform*
		12	12	12	12	12
S-1	SLO-1	Introduction to signals and systems	Introduction to Fourier series	System modeling	Representation of sequences	Z transform – introduction
	SLO-2	Requirements of signal and system analysis in communication	Representation of Continuous time Periodic signals	Description of differential equations	Discrete frequency spectrum and range	Region of convergence of finite duration sequences
S-2	SLO-1	Continuous time signals (CT signals)	Fourier series: Trigonometric representation	Solution of Differential equation	Discrete Time Fourier Transform (DTFT) – Existence	Properties of ROC
	SLO-2	Discrete time signals (DT signals)	Fourier series: Trigonometric representation	Differential equation: Zero initial conditions	DTFT of standard signals	Properties of ROC
S-3	SLO-1	Representation of signals: Step, Ramp, Pulse, Impulse	Fourier series: Cosine representation	Differential equation: Zero state response	Properties of DTFT	Properties of Z transform
	SLO-2	Representation of signals: Sinusoidal, Exponential	Fourier series: Cosine representation	Differential equation: Zero Input response	Properties of DTFT	Properties of Z transform
S-4	SLO-1	Basic operation on the signals	Symmetry conditions	Total Response	Inverse DTFT	Unilateral z transforms
	SLO-2	Problems on signal operations	Properties of Continuous time Fourier series	Step response	Practice on IDTFT	Properties of z transform
S-5	SLO-1	Classification of CT and DT signals: Periodic & Aperiodic signals.	Practice problems on Fourier series	Impulse response	Impulse response of a system with DTFT	Bilateral Z transforms

	SLO-2	*Classification of CT and DT signals: Deterministic & Random signals.*	*Practice problems on Fourier series*	*Frequency response*	*Frequency response of a system with DTFT*	*Properties of z transform*
S-6	SLO-1	*Energy signal*	*Gibb's Phenomenon*	*Convolution integral*	*Practice problems*	*Relation between DTFT and Z transform*
	SLO-2	*Power signal*	*Parseval's relation for power signals*	*Properties of convolution*	*Practice problems*	*Practice problems*
S-7	SLO-1	*Even & Odd signals*	*Power density spectrum,*	*Practice Problems*	*Solution of linear constant coefficient difference equations*	*condition for causality in Z domain*
	SLO-2	*Even & Odd signals*	*Frequency spectrum.*	*Practice Problems*	*Initial conditions*	*condition for stability in Z domain*
S-8	SLO-1	*CT systems and DT systems*	*Fourier transform: Introduction*	*Signal and system analysis with Laplace transform*	*Solution of difference equations*	*Inverse Z transform*
	SLO-2	*Classification of systems: Static & Dynamic*	*Representation of Continuous time signals*	*Convergence of Laplace Transform*	*Zero input response*	*Power series expansion*
S-9	SLO-1	*Superposition theorem*	*Properties of Continuous time Fourier transform*	*Properties of Laplace transform*	*Solution of difference equations with Zero state response*	*Inverse Z transform with Partial fraction*
	SLO-2	*Linear & Nonlinear system*	*Properties of Continuous time Fourier transform*	*Properties of Laplace transform*	*Total response*	*Inverse Z transform with Partial fraction*
S-10	SLO-1	*Time-variant & Time-invariant system*	*Parseval's relation for energy signals*	*Inverse Laplace transform*	*Evaluation of Impulse response*	*Residue method*
	SLO-2	*Time-invariant system*	*Energy density spectrum*	*Problems*	*Evaluation of Step response*	*Convolution method*
S-11	SLO-1	*Causal system*	*Analysis of LTI system using Fourier Transform*	*Analysis and characterization of LTI system using Laplace transform*	*Convolution Properties*	*Analysis and characterization of DT system using Z-transform*
	SLO-2	*Noncausal system*	*Analysis of LTI system using Fourier Transform*	*Analysis and characterization of LTI system using Laplace transform*	*Convolution Sum*	*Analysis and characterization of DT system using Z-transform*
S-12	SLO-1	*Stable & Unstable,LTI System*	*Practice problems on Fourier Transform*	*Practice problems on Laplace transform*	*Circular convolution*	*Practice problems on LTI-DT systems in Z transform*
	SLO-2	*Unstable, LTI System*	*Practice problems on Fourier Transform*	*Practice problems on Laplace transform*	*Frequency response*	*Practice problems on LTI-DT systems in Z transform*

Learning Resources	1. *Alan V Oppenheim, Ronald W. Schafer Signals & Systems, 2nd ed., Pearson Education, 2015* 2. *P.Ramakrishna Rao, Shankar Prakriya, Signals & Systems, 2nd ed., McGraw Hill Education, 2015* 3. *Simon Haykin, Barry Van Veen, Signals and Systems, 2nd ed., John Wiley & Sons Inc., 2007* 4. *Lathi B.P, Linear Systems & Signals, 2nd ed., Oxford Press, 2009*	5. *John G. Proakis, Manolakis, Digital Signal Processing, Principles, Algorithms and Applications, 4th ed., Pearson Education, 2007.* 6. *Software: Matlab Student Version Release 2011a, Mathworks, Inc. The Matlab Student Version and toolboxes may be purchased through the Mathworks website at http://www.mathworks.com/*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. A. Ruhan Bevi, SRMIST*

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

Course Code	18ECC105T	Course Name	ELECTROMAGNETICS AND TRANSMISSION LINES	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18PYB101J	Co-requisite Courses	Nil	Progressive Courses	18ECC301T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Clark's Table, IS : 456-2000	

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 :	Gain knowledge on the basic concepts and insights of Electric field			
CLR-2 :	Gain knowledge on the basic concepts and insights of Magnetic field and Emphasize the significance of Maxwell's equations.			
CLR-3 :	Interpret the wave propagation in guided waveguide.			
CLR-4 :	Acquire the fundamental knowledge on Transmission Line Theory.			
CLR-5 :	Acquire the knowledge on transmission line parameter calculation and impedance matching concepts.			
CLR-6 :	Acquire knowledge on theoretical concepts and analysis techniques to find solutions for problems related to electromagnetic wave propagation and Transmission line Theory.			

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research	
CLO-1 :	Apply the concepts and knowledge to solve problems related to electric field.	2	80	70	M	H														
CLO-2 :	Interpret and apply the concepts of Magnetic field and Maxwell's equations in the real world application.	2	80	70	H	M														
CLO-3 :	Understand the phenomenon of guided wave propagation and its mode of propagation.	1	80	70	H	M														
CLO-4 :	Realize the importance of transmission line theory applicable to low frequency transmission lines.	1	80	70	M	H														
CLO-5 :	Solve transmission line parameter and impedance matching through analytical and graphical methods.	2	80	70	M	H														
CLO-6 :	Understand how electromagnetic waves are generated using Maxwell's equations and how Transmission lines are used to transfer electromagnetic energy from one point to another with minimum losses over a wideband of frequencies.	2	80	70	M	H										H				L

Duration (hour)		Electrostatics	Magnetostatics and Maxwells Equations	Electromagnetic Waves and Waveguides	Transmission Line Theory	Transmission Line Calculator and Impedance Matching
		9	9	9	9	9
S-1	SLO-1	Introduction	Energy density in electrostatic field	Introduction	Transmission line parameters	Introduction
	SLO-2	Rectangular co-ordinate	Problem discussion.	Waves in general	Transmission line parameters	Smith chart Introduction
S-2	SLO-1	Cylindrical & Spherical Co-ordinate	Biot savart law-Magnetic field intensity due to Infinite line charge	Plane wave in lossless dielectric	Transmission line equivalent circuit	Reflection coefficient, Standing wave ratio Input impedance calculation in smith chart
	SLO-2	Review of vector calculus	H- due finite and semi finite line charge	Plane wave in free space	Explanation	Practice problems.
S-3	SLO-1	Coulomb's Law and field intensity	Ampere's circuital law& application: Infinite line current	Plane wave in good conductor	Transmission line equation derivation	Single stub matching Introduction
	SLO-2	Problem based on coulomb's law	Infinite Sheet current	Problems based on plane waves in lossless, free space and good conductor	Problem discussion.	Procedure for single stub matching
S-4	SLO-1	Electric field due to continuous charge distribution-.Concept	Infinitely long coaxial Transmission line	Rectangular waveguide	Transmission line characteristics: lossless line	Problems solving in smith chart
	SLO-2	Derivation of E due Infinite Line charge	Problem based on ACL.	Rectangular waveguide-Problems	Distortionless line.	Problems solving in smith chart

S-5	SLO-1	*Electric field due to sheet charge*	*Magnetic flux density*	*Transverse Electric (TE) mode*	*Input impedance derivation*	*Impedance matching using Quarter wave transformer*
	SLO-2	*Problem based on sheet charge*	*Problem based on magnetic field and flux.*	*Transverse Electric (TE) mode-problems*	*Problems for input impedance calculation.*	*Problems.*
S-6	SLO-1	*Electric field due to volume charge*	*Maxwell's equation for static field*	*Transverse Electric (TE) mode*	*Standing wave ratio*	*Single stub tuner*
	SLO-2	*Electric flux density*	*Faraday's law*	*Transverse Electric (TE) mode-Problems*	*Calculation of standing wave ratio.*	*Problem discussion*
S-7	SLO-1	*Gauss law application-point charge*	*Transformer EMF*	*Wave propagation in guide*	*Reflection coefficient*	*Slotted Line (Impedance Measurement)*
	SLO-2	*Electric flux due infinite line charge*	*Motional EMF*	*Problem discussion*	*Problem discussion.*	*Problem discussion*
S-8	SLO-1	*Electric flux due sheet charge*	*Displacement current.*	*Power Transmission*	*Shorted line, open circuited line*	*Transmission Lines as circuit Elements*
	SLO-2	*Electric flux due coaxial cable*	*Maxwell's equation in time varying field*	*Calculation of Pavg and Ptotal*	*Matched line*	*Problem discussion*
S-9	SLO-1	*Relation between E&V*	*Time varying potential concepts*	*Power attenuation*	*Power calculations*	*Additional smith chart problem solving.*
	SLO-2	*Electric dipole and flux lines*	*Time varying potential derivation.*	*Calculation of αTE and αTE*	*Problem discussion.*	*Additional smith chart problem solving.*

Learning Resources	1. *Matthew N. O. Sadiku., S. V. Kulkarni, Elements of Electromagnetics, 6th ed., Oxford University Press, 2015* 2. *G. S. N. Raju, Electromagnetic Field Theory and Transmission Lines, Pearson Education, 2006* 3. *Nannapaneni Narayana Rao, Principles of Engineering Electromagnetics,6th ed., Pearson Education, 2016*	4. *William H. Hayt,Jr., John A.Buck., Engineering Electromagnetics, 8th ed., Tata McGraw-Hill 2012* 5. *John D.Ryder, Networks, Lines and Fields, PHI, 2009*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECC201J	Course Name	ANALOG ELECTRONIC CIRCUITS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC102J	Co-requisite Courses	18ECC202J	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the operation and design of BJT amplifier circuits for a given specification
CLR-2 :	Understand the operation and design of MOSFET amplifier circuits for a given specification
CLR-3 :	Understand the effects of negative feedback on amplifier circuits, and analyze the different RC and LC oscillator circuits to determine the frequency of oscillation
CLR-4 :	Understand the operation and design of various types of power amplifier circuits.
CLR-5 :	Understand how matched transistor characteristics are used in the IC design and to be able to design BJT and MOSFET current sources.
CLR-6 :	Gain hands-on experience to put theoretical concepts learned in the course to practice.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO–1: Professional Achievement	14: PSO – 2: Project Management Techniques	15: PSO – 3: Analyze & Research
CLO-1 :	Analyze and design bipolar amplifier circuits to meet certain specifications, and to Analyze the frequency response of amplifier circuits, taking into account various circuit capacitors, to determine the bandwidth of the circuit.	2,3	80	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Analyze and design MOSFET amplifier circuits to meet certain specifications, and to Analyze the frequency response of amplifier circuits, taking into account various circuit capacitors, to determine the bandwidth of the circuit.	2,3	80	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Understand the characteristics and principles of feedback amplifier circuits and oscillator circuits to analyze and design circuits to meet certain specifications.	2,3	80	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze three principle classes of power amplifiers, and determine the maximum possible conversion efficiency of each type of power amplifier	2,3	80	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Present the basic circuit building blocks that are used in the design of IC amplifiers, namely current mirrors and sources	2,3	80	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Analyze and design analog electronic circuits using discrete components, and take measurement of various analog circuits to compare experimental results in the laboratory with theoretical analysis.	3	90	80	-	-	H	-	M	-	-	L	M	-	-	M	H	L	-

Duration (hour)		BJT Amplifiers	FET Amplifiers	Feedback amplifies & Oscillators	Oscillators & Power Amplifiers	IC Biasing & Amplifiers with Active Load
		15	15	15	15	15
S-1	SLO-1	Overview of DC analysis of BJT circuits	Overview of FET DC circuit analysis	Basic feedback concepts, general feedback structure	Crystal Oscillators	BJT current sources: Cascode current source, Widlar current source
	SLO-2	Overview of BJT models	Problem solving	Properties of negative feedback	Problem solving	Multi-transistor current source Problem solving
S-2	SLO-1	AC load line analysis	Graphical analysis, load lines, and small-signal models	Feedback Topologies: Voltage-Series & Current-Series feedback connections	Negative-resistance oscillator	FET current sources: 2-transistor MOSFET current source
	SLO-2	Problem solving	Problem solving	Problem solving	Problem solving	Problem solving
S-3	SLO-1	AC analysis of Common-Emitter BJT amplifier config. using hybrid-π model	AC analysis of Common-Source MOSFET amplifier configuration	Feedback Topologies: Voltage-Shunt & Current-Shunt feedback connections	Power Amplifiers: Definitions and amplifier types	FET current sources: Cascode current mirror and Wilson current mirror
	SLO-2	Problem solving	Problem solving	Problem solving	Q point placement	Problem solving
S 4-5	SLO-1 SLO-2	Lab 1: Learning to design amplifier and oscillator circuits	Lab 4: Design & analyze differential amplifier with resistive load	Lab 7: Design and analyze RC oscillators	Lab 10: BJT & FET Current Sources	Lab 13: Design and analyze differential amplifier with active load

S-6	SLO-1	*AC analysis of Common-Base BJT amplifier configuration using hybrid-π model*	*AC analysis of Common-Gate MOSFET amplifier configuration*	*Practical Feedback Amplifier Circuits*	*Maximum dissipation hyperbola*	*Analysis of CE BJT amplifier circuit with active load*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Heat sink*	*Problem solving*
S-7	SLO-1	*AC analysis of Common-Collector BJT amplifier config. using hybrid-π model*	*AC analysis of Common-Drain MOSFET amplifier configuration*	*Oscillators: Principles of Oscillation*	*Class A amplifier*	*Analysis of CS FET amplifier circuit with active load*
	SLO-2	*Problem solving*	*Problem solving*	*Types of Oscillators*	*Problem solving*	*Problem solving*
S-8	SLO-1	*Multi-stage amplifier configurations: CE - CE, CE - CC amplifiers*	*BiFET amplifier configuration*	*Audio Frequency Oscillators: RC Phase-Shift Oscillator*	*Class B and Class AB push-pull amplifiers*	*DC and small-signal analysis of basic BJT differential pairs*
	SLO-2	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*	*Problem solving*
S 9-10	SLO-1	*Lab 2: Design and analyze BJT amplifier configurations*	*Lab 5: Design and analyze negative feedback amplifier configurations*	*Lab 8: Design and analyze LC oscillators*	*Lab 11: Design and analyze BJT CE amplifier with active load*	*Lab 14: Model Practical Examination*
	SLO-2					
S-11	SLO-1	*Multi-stage amplifier configurations: CE - CB, and CC - CC amplifiers*	*Low Frequency response analysis of a basic FET CS amplifier*	*Audio Frequency Oscillators: Wein Bridge Oscillator*	*Class C amplifiers*	*DC and small-signal analysis of basic FET differential pairs*
	SLO-2	*Problem solving*	*Problem Solving*	*Problem Solving*	*Problem solving*	*Problem solving*
S-12	SLO-1	*Low Frequency response analysis of a basic BJT CE amplifier*	*High Frequency response analysis of a basic FET CS amplifier*	*Radio Frequency Oscillators: Hartley Oscillator*	*Class D and Class E amplifiers*	*Analysis of BJT differential amplifier with active load*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem solving*	*Amplifier distortions*	*Problem solving*
S-13	SLO-1	*High Frequency response analysis of a basic BJT CE amplifier*	*Design problems in MOSFET amplifier configurations*	*Radio Frequency Oscillators: Colpitts & Clapp Oscillators*	*IC Biasing & Amplifiers with Active Load: BJT current sources: 2- & 3-transistor current sources*	*Analysis of FET differential amplifier with active load*
	SLO-2	*Problem Solving*	*Operational voltage levels*	*Problem solving*	*Problem solving*	*Problem solving*
S 14-15	SLO-1	*Lab 3: Design and analyze multistage amplifier configurations*	*Lab 6: Design and analyze MOSFET amplifier configurations*	*Lab 9: Classes of power amplifier (efficiency calculation)*	*Lab 12: Design and analyze FET CS amplifier with active load*	*Lab 15: End Semester Practical Examination*
	SLO-2					

Learning Resources	1. *David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015* 2. *Donald Neamen, Electronic Circuits: Analysis and Design, 3rd ed., McGraw-Hill Education, 2011* 3. *Muhammad Rashid, Microelectronic Circuits: Analysis & Design, 2nd ed., Cengage Learning, 2010* 4. *Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits: Theory and Applications, OUP, 2014*	5. *Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013* 6. *Albert P. Malvino, David J. Bates, Electronic Principles, 8th ed., Tata McGraw Hill, 2015*

Learning Assessment

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

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

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

Course Code	18ECC202J	Course Name	LINEAR INTEGRATED CIRCUITS	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC102J	Co-requisite Courses	18ECC201J	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Study the basic principles, configurations and practical limitations of op-amp			
CLR-2 :	Understand the various linear and non-linear applications of op-amp			
CLR-3 :	Understand the operation and analysis of op-amp oscillators, single chip oscillators and frequency generators			
CLR-4 :	Identify the active filter types, filter response characteristics, filter parameters and IC voltage regulators.			
CLR-5 :	Gain knowledge on data converter terminology, its performance parameters, and various circuit arrangements for A/D and D/A conversions.			
CLR-6 :	Gain hands-on experience to put theoretical concepts learned in the course to practice.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques	3	80	70
CLO-2 :	Elucidate and design the linear and non-linear applications of an opamp and special application ICs	3	85	75
CLO-3 :	Explain and compare the working of multivibrators using special application IC 555 and general purpose opamp	3	75	70
CLO-4 :	Classify and comprehend the working principle of data converters and active filters	3	85	80
CLO-5 :	Illustrate the function of application specific ICs such as Voltage regulators, PLL and its application in communication	3	85	75
CLO-6 :	Analyze and design electronic circuits and systems using linear ICs, and take measurement of various analog circuits to compare experimental results in the laboratory with theoretical analysis	3	85	75

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

Duration (hour)		15	15	15	15	15
S-1	SLO-1	Op-amp symbol, terminals, packages	Basic op-amp circuits: Inverting & Non-inverting voltage amplifiers	Waveform Generators: Sine-wave Generators - Design	Filters: Comparison between Passive and Active Networks	Digital to Analog Conversion: DAC Specifications
	SLO-2	Op-amp-Specifications	Voltage follower	Implementation & Solving problems	Active Network Design	Solving problems
S-2	SLO-1	Block diagram Representation of op-amp	Summing, scaling & averaging amplifiers,	Square Wave generators- Design	Filter Approximations	Weighted Resistor DAC
	SLO-2	Ideal op-amp & practical op-amp - Open loop & closed loop configurations	AC amplifiers	Implementation & Solving problems	Design of LPF & Solving problems	Solving problems
S-3	SLO-1	DC performance characteristics of op-amp	Linear Applications: Instrumentation Amplifiers	Triangle wave generators	Design of HPF & Solving problems	R-2R Ladder DAC
	SLO-2	Solving Problems	Instrumentation Amplifiers, Solving Problems	Saw-tooth Wave generators.	Design of BPF& Solving problems	Solving problems
S 4-5	SLO-1 SLO-2	Lab-1:Basic op-amp circuits	Lab 4: Comparators	Lab 7: Waveform generators: using op-amp & 555 Timer	Lab 10: Design of LPF, HPF, BPF and Band Reject Filters	Lab 13: Flash Type ADC
S-6	SLO-1	AC performance characteristics of op-amp	V-to-I Converters	IC 555 Timer: Circuit schematic	Design of Band Reject Filters	Inverted R-2R Ladder DAC
	SLO-2	Solving Problems	I-to-V converters	Operation and its applications	Solving problems	Monolithic DAC
S-7	SLO-1	Frequency response	Differentiators	IC 555 Timer: Monostable operation	State Variable Filters – All Pass Filters,	Analog to Digital conversion: ADC specifications

	SLO-2	*Frequency response*	*Integrators*	*Applications & Solving problems*	*Solving problems*	*Solving problems*
S-8	SLO-1	*Frequency compensation*	*Non-linear Applications: Precision Rectifiers*	*IC 555 Timer: Astable operation*	*Switched Capacitor Filters.*	*Ramp Type ADC*
	SLO-2	*Frequency compensation*	*Wave Shaping Circuits (Clipper and Clampers)*	*Applications & Solving problems*	*Solving problems*	*Solving problems*
S 9-10	SLO-1 SLO-2	*Lab 2: Integrators and Differentiators*	*Lab 5: Wave shaping circuits*	*Lab 8: Waveform generators: using op-amp & 555 Timer*	*Lab 11: IC Voltage regulators*	*Lab 14: Simulation experiments using EDA tools*
S-11	SLO-1	*Basic op-amp internal schematic*	*Log and Antilog Amplifiers,*	*PLL: Operation of the Basic PLL*	*Voltage Regulators: Basics of Voltage Regulator*	*Successive Approximation ADC*
	SLO-2	*operations of blocks*	*Analog voltage multiplier circuit and its applications,*	*Closed loop analysis of PLL*	*Specifications and characteristic parameters*	*Solving problems*
S-12	SLO-1	*Basic op-amp internal schematic*	*Operational Trans-Conductance Amplifier (OTA)*	*Voltage Controlled Oscillator*	*Linear Voltage Regulators using Op-amp,*	*Dual Slope ADC*
	SLO-2	*operations of blocks*	*Comparators : operation*	*Solving problems*	*IC Regulators (78xx, 79xx, LM 317, LM 337, 723),*	*Flash Type ADC,*
S-13	SLO-1	*Review of data sheet of an op-amp.*	*Comparators applications*	*PLL applications*	*Switching Regulators -operation*	*Solving problems on Flash Type ADC,*
	SLO-2	*Solving Problems*	*Sample and Hold circuit.*	*Solving problems*	*Types*	*Monolithic ADC*
S 14-15	SLO-1 SLO-2	*Lab 3: Rectifiers*	*Lab 6: Waveform generators: using op-amp & 555 Timer*	*Lab 9: Design of LPF, HPF, BPF and Band Reject Filters*	*Lab 12: R-2R ladder DAC*	*Lab 15: Simulation experiments using EDA tools*

Learning Resources	1. *Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, 4th ed., Prentice Hall, 2000* 2. *David A. Bell, Operational Amplifiers and Linear ICs, 3rd ed., OUP, 2013* 3. *Roy Choudhury, Shail Jain, Linear Integrated Circuits, 4th ed., New Age International Publishers, 2014* 4. *Robert F. Coughlin, Frederick F. Driscoll, Operational-Amplifiers and Linear Integrated Circuits, 6th ed., Prentice Hall, 2001* 5. *Sergio Franco, Design with operational amplifier and analog integrated circuits, McGraw Hill, 1997*	6. *LABORATORY MANUAL, Department of ECE, SRM University* 7. *David A Bell, Laboratory Manual for Operational Amplifiers & Linear ICs, 2nd ed., D.A. Bell, 2001* 8. *David La Lond, Experiments in Principles of Electronic Devices and Circuits, Delmar Publishers, 1993* 9. *Muhammed H Rashid, Introduction to PSpice using OrCAD for circuits and electronics, 3rd ed., Pearson, 2004* 10. *L. K. Maheshwari, M. M. S. Anand, Laboratory Experiments and PSPICE Simulations in Analog Electronics, PHI, 2006*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECC203J	Course Name	Microprocessor, Microcontroller and Interfacing Techniques	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	18ECE204J, 18ECE205J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand basic architecture of Intel 8086 microprocessor and Intel 8051 Microcontroller
CLR-2 :	Familiarize the students with the programming and interfacing of microprocessors and microcontrollers with memory and peripheral chips
CLR-3 :	Interface a microprocessor / microcontroller to external input/output devices and perform input/output device programming in assembly
CLR-4 :	Use the computer to write and assemble assembly language programs and also run them by downloading them to the target microprocessor
CLR-5 :	Understand the hardware and software interrupts and their applications, and as well the properties and interfacing of the parallel and serial ports
CLR-6 :	Provide strong foundation for designing real world applications using microprocessors and microcontrollers.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Learning: Expected Proficiency (%)	Learning: 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: Professional Achievement	PLO 14: PSO – 2: Project Management Techniques	PLO 15: PSO – 3: Analyze & Research
CLO-1 :	Recall and apply a basic concept of digital fundamentals to Microprocessor based personal computer system	1	80	70		H			L										
CLO-2 :	Solve basic binary math operations using the microprocessor. / microcontroller	2	90	80	M											M			
CLO-3 :	Demonstrate programming proficiency using the various addressing modes and data transfer instructions of the target microprocessor / microcontroller	3	90	80		M	H		H										L
CLO-4 :	Distinguish and analyze the properties of Microprocessors & Microcontrollers.	1	80	70		M										H			
CLO-5 :	Train their practical knowledge through laboratory experiments.	3	90	80		M	M		H					H					H
CLO-6 :	Design,program and interface external devices, memory chips and various peripheral chips with microprocessor / microcontroller	3	90	80			M		H							H	L		M

		Learning Unit / Module 1: Intel 8086 – Architecture, Signals and Features	Learning Unit / Module 2: Programming with Intel 8086	Learning Unit / Module 3: 8086 Interfacing with Memory and Programmable Devices	Learning Unit / Module 4: Intel 8051 – Architecture and Programming	Learning Unit / Module 5: Interfacing of 8051
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Introduction: History of computers, Block diagram of a microcomputer	Addressing modes of 8086	Semiconductor memory interfacing	Introduction: Differences between microprocessor and microcontroller	8051 parallel ports, and
	SLO-2	Intel 80x86 evolutions		Dynamic RAM interfacing	Intel's family of 8-bit microcontrollers, and feature of 8051 microcontroller	its programming
S-2	SLO-1	Features of 8086 microprocessor	Instruction Set of 8086: Data Transfer Instructions	Programmable Peripheral Interface 8255	Architecture of 8051	8051 timers, and
	SLO-2	Register organization of 8086	Example programs	Interfacing 8255 with 8086 and programming		its programming
S-3	SLO-1	Architecture of 8086	Data Conversion Instructions, Arithmetic Instructions	Interfacing ADC with 8086 and programming	Signal descriptions of 8051	8051 interrupts, and
	SLO-2		Example programs	Interfacing DAC with 8086 and programming		its programming
S-4,5	SLO-1	**Lab-1: (a) Learning to Program with**	**Lab-4: General Purpose Programming**	**Lab-7: Interfacing DAC / ADC with 8086**	**Lab-10: Programming timer / counter in**	**Lab-13: Simulation of 8051 using Keil**

	SLO-2	***8086 processor kit; Learning the hardware features of the 8086 processor kit***	***in 8086***	***/ 8051***	***8086 / 8051***	***Software***
S-6	***SLO-1***	*Instruction queue and pipelining*	*Logical instructions and Processor control instructions*	*Stepper Motor interfacing*	*Register set of 8051*	*8051 serial port, and*
	SLO-2	*Segmentation of memory used with 8086*	*Example programs*		*Operational features of 8051*	*its programming*
S-7	***SLO-1***	*Methods of generating physical address in 8086*	*String instructions*	*Programmable Interval Timer 8254*	*Memory and I/O addressing by 8051*	*Interfacing program memory with 8086*
	SLO-2	*Pin signals of 8086: Common signals*	*Example programs*	*Interfacing 8254 with 8086 and programming*	*Interrupts and Stack of 8051*	*Interfacing data memory with 8086*
S-8	***SLO-1***	*Minimum mode signals*	*Branch Instructions*	*Programmable Interrupt Controller 8259*	*Addressing modes of 8051*	*Interfacing input devices: push-button / matrix keypad*
	SLO-2	*Maximum mode signals*	*Example programs*	*Interfacing 8259 with 8086 and programming*		*Example programs*
S-9,10	***SLO-1***	*Lab-2: General Purpose Programing in 8086*	*Lab-5:* ***Simulation of 8086 using MASM Software / 8086 Emulator***	***Lab-8: Interfacing DC motor / stepper motor / servo motor with 8086 / 8051***	***Lab-11: Programming interrupts in 8086 / 8051***	***Lab-14: Model Practical Exam***
	SLO-2					
S-11	*SLO-1*	*Minimum mode 8086 system, and*	*Assembly Language Programming of 8086*	*Programmable Keyboard / Display Controller 8279*	*8051 Instruction Set: Arithmetic and Logical Instructions*	*Interfacing display devices: LED / 7-segment / LCD displays*
	SLO-2	*Timings*	*Assembly Language Programming of 8086*	*Interfacing 8279 with 8086 and programming*	*Example Programs*	*Example programs*
S-12	*SLO-1*	*Maximum mode 8086 system, and*	*Stack structure, and*	*Programmable Communication Interface 8251 USART*	*Data Transfer Instructions*	*Interfacing DAC*
	SLO-2	*Timings*	*related programming*	*Interfacing 8251 with 8086 and programming*	*Example Programs*	*Interfacing ADC*
S-13	*SLO-1*	*Intel 8088 Microprocessor: Pins signals and Architecture*	*Interrupt structure, and*	*DMA Controller 8257*	*Boolean Variable Instructions and Branch Instructions*	*Interfacing DC motor / stepper motor / servo motor*
	SLO-2	*Differences between 8086 & 8088 microprocessors*	*related programming*	*Interfacing 8257 with 8086 and programming*	*Example Programs*	*Example programs*
S-14,15	*SLO-1*	***Lab-3:*** *General Purpose Programing in 8086*	***Lab-6: Interfacing 8255 with 8086 / 8051***	***Lab-9: General Purpose Programming in 8051***	***Lab-10: Programming serial communication in 8086 / 8051***	***Lab-15: End-Semester Exam***
	SLO-2					

Learning Resources	1. *K. M. Bhurchandi and A. K. Ray, "Advanced Microprocessors and Peripherals-with ARM and an Introduction to Microcontrollers and Interfacing ", Tata McGraw Hill, 3rd edition 2015* 2. *Muhammad Ali Mazidi and Janice GillispieMazidi, "The 8051 - Microcontroller and Embedded systems", 7th Edition, Pearson Education, 2011.* 3. *Doughlas.V.Hall, "Microprocessor and Interfacing : Programming and Hardware", 3rd edition, McGraw Hill, 2015*	4. *Kenneth.J.Ayala, "8051 Microcontroller Architecture, Programming and Applications", 3rd edition, Thomson, 2007* 5. *Subrataghoshal " 8051 Microcontroller Internals Instructions ,Programming And Interfacing",2nd edition Pearson 2010* 6. *Yu-cheng Liu, Glenn A.Gibson, "Microcomputer systems: The 8086/8088 family-Architecture,programming and design",2nd edition, Prentice Hall of India,2007*

Learning Assessment

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

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

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

Course Code	18ECC204J	Course Name	DIGITAL SIGNAL PROCESSING	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC104T	Co-requisite Courses	Nil	Progressive Courses	18ECE243J, 18ECE244J, 18ECE245T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the operations involved in digital conversion of analog signals.			
CLR-2 :	Realize a digital filter in direct, cascade and parallel forms. Perform efficient computation of DFT using radix 2 FFT			
CLR-3 :	Design digital FIR filter using windowing technique and frequency sampling methods.			
CLR-4 :	Design IIR filters using both direct method and method involving conversion of analog filter to digital filter			
CLR-5 :	Understand sampling rate conversion and apply it for applications like QMF, sub band coding.			
CLR-6 :	Utilize the techniques for digital conversions, filter designs and multi rate signal processing to solve real time problems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Acquire knowledge of sampling and quantization and understand the errors that arise due to quantization.	2	90	70	H	M	-	L	-	-	-	-	-	-	-	-	L	L	M
CLO-2 :	Understand the concept of DFT and its efficient computation by using FFT algorithm.	2	95	75	H	M	-	L	-	-	-	-	-	-	-	-	L	L	M
CLO-3 :	Design FIR filters using several methods	2	85	70	-	M	H	H	-	-	-	-	-	-	-	-	L	L	H
CLO-4 :	Design IIR filters using several methods	2	85	80	-	M	H	H	-	-	-	-	-	-	-	-	L	L	H
CLO-5 :	Understand the basics of multirate DSP and its applications.	2	90	75	H	M	-	M	-	-	-	-	-	-	-	-	L	L	M
CLO-6 :	Apply the concepts of digital filter designs and multi rate signal processing for real time signals	2	80	70	H	M	-	H	-	-	-	-	-	-	-	-	M	M	H

		Learning Unit / Module 1: Signals and Waveforms	Learning Unit / Module 2: Frequency Transformations	Learning Unit / Module 3: FIR Filters	Learning Unit / Module 4: IIR Filters	Learning Unit / Module 5: Multirate signal Processing
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Basic Elements of DSP	Realization of digital filters Direct form of realization	Design of Linear Phase FIR filters General consideration	Design of digital IIR filters Comparison of FIR and IIR filters	Introduction to Multirate signal processing
	SLO-2	Advantages and applications of DSP	Cascade form of realization	Causality and its implication Characteristics of practical frequency selective filters	Analog IIR filter design	Decimation
S-2	SLO-1	Continuous Time vs Discrete time signals	Parallel form of realization	Frequency response of symmetric FIR filter	Properties of Butterworth filters	Interpolation
	SLO-2	Continuous valued vs discrete valued signals	Introduction to DFT	N is odd	Properties of chebyshev filters Comparison of Butterworth and chebyshev filters	Spectrum of interpolated signal
S-3	SLO-1	Concepts of frequency in analog signals	Computation of DFT	Frequency response of symmetric FIR filter	Analog IIR filter design	Sampling rate conversion by a rational factor I/D
	SLO-2	Continuous and discrete time sinusoidal signals	Properties of DFT Periodicity, linearity and symmetry properties	N is even	Design of low pass Butterworth filter	Anti-aliasing and anti-imaging filters
S-4	SLO-1	**Lab 1 :Generation of basic signals**	**Lab 7: Linear convolution**	**Lab 13: Design of digital FIR Low Pass and High Pass filter using rectangular window**	**Lab 19: Design of analog Butterworth filter**	**Lab 25: Interpolation**
	SLO-2					
S-5	SLO-1	**Lab 2: Unit step, ramp and impulse**	**Lab 8: Circular convolution**	**Lab14: Design of digital FIR Band Pass and Band Stop filter using rectangular window**	**Lab 20: Design of analog Chebyshev filter**	**Lab 26: Effect of interpolation in frequency domain**
	SLO-2					

S-6	SLO-1	Sampling of analog signals Sampling theorem	Circular convolution	Frequency response of antisymmetric FIR filter	Analog IIR filter design	Polyphase structure of decimator Polyphase decimation using z transform
	SLO-2	Aliasing Quantization of continuous amplitude signals	Matrix method and concentric circle method	N is odd and N is even	Design of low pass Chebyshev filter	Polyphase structure of interpolator Polyphase interpolation using z transform
S-7	SLO-1	Analog to digital conversion Sample and hold,	Efficient Computation of the DFT	Design of FIR filters Fourier series method	Design of digital filters Impulse invariance method	Advantages of multirate DSP
	SLO-2	Quantization and coding	Divide and Conquer Approach to Computation of the DFT Using FFT	Need for filter design using window Comparison of various windowing techniques	Design of digital filters Bilinear transformation	Applications of multirate DSP
S-8	SLO-1	Oversampling A/D converters	N Point DFT Decimation-in-Time FFT Radix-2 FFT Algorithm	Filter Design using windowing technique	Design of digital filters Impulse invariance method	Practical Applications of multirate DSP
	SLO-2	Digital to analog conversion Sample and hold	N Point DFT Decimation-in-Frequency FFT	Rectangular window	Design of digital filters Bilinear transformation	interfacing of digital systems with different sampling rates
S-9	SLO-1	Lab 3: Generation of waveforms	Lab9: Autocorrelation and cross correlation	Lab 15: Design of digital FIR Low Pass and High Pass filter using Hanning and Hamming window	Lab 21: Design of digital Butterworth filter using impulse invariance method	Lab 27: Decimation
	SLO-2					
S-10	SLO-1	**Lab 4: Continuous and discrete time**	**Lab10: Spectrum analysis using DFT**	**Lab 16: Design of digital FIR Band Pass and Band Stop filter using Hanning and Hamming window**	**Lab 22: Design of digital Butterworth filter using bilinear transformation**	**Lab 28: Effect of decimation in frequency domain**
	SLO-2					
S-11	SLO-1	Oversampling D/A converters	Radix-2 FFT Algorithm Implementation of FFT Using DIT	Filter Design using windowing technique Hanning window	Design of digital Chebyshev filters	Practical Applications of multirate DSP Sub band coding of speech signals
	SLO-2	Quantization noise	Implementation of FFT Using DIF	Filter Design using windowing technique Hamming window	Impulse invariance method	Filter banks Analysis filter bank
S-12	SLO-1	Errors due to truncation	IDFT	Filter Design using windowing technique	Design of digital Chebyshev filters	Synthesis filter bank
	SLO-2	Probability of error	Using DIT FFT	Blackmann window	Bilinear transformation	Subband coding filterbank
S-13	SLO-1	Errors due to rounding	IDFT	Design of FIR filters	Frequency transformation in analog domain	Quadrature Mirror Filter
	SLO-2	Probability of error	Using DIF FFT	Frequency sampling method	Frequency transformation in digital domain	Alias free filter bank
S-14	SLO-1	**Lab 5: Study of sampling theorem**	**Lab 11: Efficient computation of DFT using FFT**	**Lab 17: Design of digital FIR Low Pass, High Pass, Band pass and band stop filter using Blackmann window**	**Lab 23: Design of digital Chebyshev filter using impulse invariance method**	**Lab 29: Design of anti-aliasing filter**
	SLO-2					
S-15	SLO-1	**Lab 6: Aliasing effects**	**Lab12: Computation of IDFT**	**Lab 18: Design of digital FIR filter using frequency sampling method**	**Lab 24: Design of digital Chebyshev filter using bilinear transformation**	**Lab 30: Design of anti-imaging filter**
	SLO-2					

Learning Resources	1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", Pearson Education, 4th edition, 2014 2. Alan V. Oppenheim, Ronald W. Schafer, "Discrete-Time Signal Processing", Pearson Education, 1st edition, 2015	3. Sanjit Mitra, "Digital Signal Processing –A Computer Based Approach", McGraw Hill, India, 4th Edition, 2013. 4. Fredric J. Harris, "Multirate Signal Processing for Communication Systems",1st edition, Pearson Education, 2007

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

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

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Course Code	18ECC205J	Course Name	ANALOG AND DIGITAL COMMUNICATION	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18MAB203T	Co-requisite Courses	Nil	Progressive Courses	18ECC301T, 18ECC302J, 18ECE221T & 18ECE223T
Course Offering Department	ECE	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Introduce and Understand the need for modulation, various Amplitude modulators/demodulators, frequency modulators and demodulators
CLR-2 :	Comprehend the radio transmitters and receivers using the modulators and demodulators and to analyze the noise performance
CLR-3 :	To introduce basics of Digital modulation and detection techniques
CLR-4 :	To analyze the pass band data transmission techniques in terms of probability of error
CLR-5 :	To introduce basics of spread spectrum techniques and information theory concepts
CLR-6 :	Gain hands-on experience to put theoretical concepts learned in the course to practice.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the concepts of analog modulation and demodulation techniques	2	80	70
CLO-2 :	Learn the function of radio transmitters and receivers and familiarize with noise performance of various receivers	2	85	75
CLO-3 :	Understand various digital modulation schemes and matched filter receiver	2	75	70
CLO-4 :	Understand and analyze various digital pass band data transmission schemes	2	85	80
CLO-5 :	Understanding data transmission using spread spectrum and error coding techniques	2	85	75
CLO-6 :	Analyze the operation of analog and digital communication systems and take measurement of various communication systems to compare experimental results in the laboratory with theoretical analysis	2	85	75

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
M	-	-	-	-	-	-	-	-	H	-	-	H	-	-
-	M	H	-	-	-	-	-	-	-	-	-	H	-	-
M	-	-	-	-	-	-	-	-	-	-	-	-	M	H
-	-	-	M	-	-	-	-	-	-	-	-	-	M	-
-	H	-	-	-	-	-	-	-	-	-	-	M	-	H
-	-	H	-	H	-	-	-	H	-	-	M	-	M	H

		Analog Modulation	Radio Transmitters and Receivers	Digital Modulation System and Baseband Detection	Passband Data Transmission	Spread Spectrum Techniques and Information theory Concepts
Duration (hour)		15	15	15	15	15
S-1	SLO-1	Modulation, Need for Modulation,	AM transmitter : Low Level,	Pulse modulation systems, Overview of PAM,PWM,PPM	Overview of ASK, FSK, PSK	Spread spectrum Communications, Frequency Hopping Spread Spectrum (FHSS)
	SLO-2	Amplitude Modulation, Types of Amplitude Modulation	AM transmitter : High Level Transmitter	Pulse modulation systems, Overview of PAM,PWM,PPM	Overview of ASK, FSK, PSK	Spread spectrum Communications, Frequency Hopping Spread Spectrum (FHSS)
S-2	SLO-1	Double sideband Full carrier	FM transmitter: Direct Method	Pulse modulation systems, Sampling and quantization	Generation, Signal Space Diagram and detection of FSK	Direct Sequence Spread Spectrum (DSSS)
	SLO-2	Double sideband Full carrier	FM transmitter: Direct Method	Pulse modulation systems, Sampling and quantization	Generation, Signal Space Diagram and detection of FSK	Direct Sequence Spread Spectrum (DSSS)
S-3	SLO-1	Double sideband Suppressed carrier	FM transmitter: Indirect Method	PCM systems	Probability of Error for FSK	Direct Sequence Spread Spectrum (DSSS)
	SLO-2	Single sideband Suppressed carrier, VSB	FM transmitter: Indirect Method	Bandwidth of PCM, PCM TDM signal multiplexing, Limitations of PCM system	Probability of Error for FSK	Code Division Multiple Access of DSSS
S	SLO-1	**Lab-1: AM modulator and Demodulator**	**Lab-4: Pre emphasis and De-emphasis**	**Lab-7: DPCM and its Demodulation**	**Lab-10: QPSK Modulation and**	**Lab-13: *Mini Project***

4-5	**SLO-2**				**Demodulation**	
S-6	**SLO-1**	Generation of AM waves: Linear method-Collector modulator	Classification of radio receiver, Functions and Characteristics of radio receiver	Data formatting	Generation, Detection, Signal Space Diagram of PSK	Code Division Multiple Access of DSSS
	SLO-2	Generation of AM waves: Linear method-Collector modulator	Tuned Radio Frequency receiver	Data formatting	Generation, Detection, Signal Space Diagram of PSK	OFDM Communication
S-7	**SLO-1**	Non-linear Modulation-Balanced Modulator	*Super-heterodyne receiver- AM*	Differential PCM (DPCM)	Probability of Error for PSK	OFDM Communication
	SLO-2	Non-linear Modulation-Balanced Modulator	*Super-heterodyne receiver- AM*	Differential PCM (DPCM)	Probability of Error for PSK	OFDM Communication
S-8	SLO-1	Demodulation of AM waves : Linear diode detector	*Super-heterodyne receiver- FM*	Delta modulation (DM)	Generation, signal space diagram and detection of QPSK	Measures of Information
	SLO-2	Demodulation of AM waves : Linear diode detector	*Super-heterodyne receiver- FM*	Delta modulation (DM), Noise in DM	Generation, signal space diagram and detection of QPSK	Measures of Information
S 9-10	SLO-1	**Lab-2: DSB-SC modulator and demodulator**	**Lab-5: PAM,PPM,PWM modulation and demodulation**	**Lab-8: DM and its Demodulation**	**Lab-11: DPSK Modulation and Demodulation**	**Lab-14: *Model Practical Exam***
	SLO-2					
S-11	SLO-1	Frequency modulation, Types of FM	*Sources of Noise*	Demodulation and detection process	Probability of Error for QPSK	Source encoding, Shannon's Channel capacity theorem
	SLO-2	Narrow Band FM, Wide Band FM, Phase modulation	*Sources of Noise*	Demodulation and detection process	Probability of Error for QPSK	Shannon's Channel capacity theorem
S-12	SLO-1	Generation of Narrowband FM	*Noise in AM (Envelope Detection),*	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4QPSK	Linear block codes
	SLO-2	Generation of Narrowband FM	*Noise in AM (Envelope Detection),*	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4QPSK	Linear block codes
S-13	SLO-1	Demodulation of FM : Foster seely discriminator	*Noise in FM*	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
	SLO-2	Demodulation of FM : Foster seely discriminator	*Threshold effect, Pre-emphasis and De-emphasis*	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
S 14-15	SLO-1	**Lab-3: FM Modulator and Demodulator**	**Lab-6: Pulse Code Modulation and Demodulation**	**Lab-9: PSK Modulation and Demodulation**	**Lab-12: BER performance analysis of various Modulation Schemes**	**Lab-15: University Practical Exam**
	SLO-2					

Learning Resources	1. *Simon Haykin and Michael Moher, "Communication Systems," 5th edition, John Wiley & Sons, 2013* 2. Singh. R. P & Sapre. S. D, "Communication Systems: *Analog & Digital," 3rd edition, McGrawHill Education, Seventh Reprint, 2016.* 3. Simon Haykin, "Communication Systems", John Wiley & Sons, 4th Edition, 20008. 4. Bernard Sklar, "Digital Communication, Fundamentals and Application", Pearson Education Asia, 2nd Edition, 2001	5. Taub & Schilling, "Principle of Communication Systems", McGraw Hill Inc, 2nd Edition, 2003. 6. John G. Proakis, "Digital Communication", McGraw Hill Inc, 5th Edition, 2008. 7. B.P. Lathi, "Modern Digital and Analog Communication System", Oxford University Press, 3rd Edition, 2005. 8. Shu Lin, Daniel Costello, "Error control coding – Fundamentals and Applications", Prentice Hall, Upper Saddle River, NJ, 2nd Edition, 2004. 9. *Lab Manual*

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

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

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

Course Code	18ECC206J	Course Name	VLSI Design	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	18ECE301J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Use Verilog HDL as a design-entry language for FPGA in electronic design automation of digital circuits
CLR-2 :	Design, construct and simulate VLSI adders and multipliers.
CLR-3 :	Understand MOSFET operation
CLR-4 :	Implement a given logic function using appropriate logic styles for improved performance
CLR-5 :	Understand the basic processes in IC fabrication, steps in the fabrication of MOS ICs, and as well the layout design rules.
CLR-6 :	Use modern engineering tools such as HSPICE / Modelsim / Xilinx to carry out design experiments and gain experience with the design and analysis of MOS circuits and systems.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Design and implement digital circuits using Verilog HDL to simulate and verify the designs.	3	85	75	-	H	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Design general VLSI system components, adder cells and multipliers to address the design of datapath subsystem.	3	85	75	-	H	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Examine the characteristics of MOS transistors	2	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Examine CMOS inverter and other complex logic gates designed using different logic styles	2	80	70	-	L	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Explain how the transistors are built, and understand the physical implementation of circuits.	2	80	70	-	L	L	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Use HSPICE computer analysis program and Verilog HDL for simulation and analysis of MOS circuits and building blocks	3	85	75	-	-	-	-	-	-	-	-	H	M	L	M	-	L	M

Duration (hour)		Learning Unit / Module 1: Introduction to Verilog HDL & Coding	Learning Unit / Module 2: Subsystem Design	Learning Unit / Module 3: MOS Transistor	Learning Unit / Module 4: CMOS Inverter and Circuit Design Styles	Learning Unit / Module 5:
		15	15	15	15	15
S-1	SLO-1	Introduction to HDL & Verilog HDL	**General VLSI System Components:** Multiplexers	**Generic overview of the MOS device:** MOS transistor symbols	**CMOS Inverter Characteristics:** Operation and properties of static CMOS inverter	**Properties of basic materials used in microelectronics:** Silicon, Silicon dioxide
	SLO-2	Introduction to Verilog HDL, modules and ports	Decoders	MOS structure demonstrating (a) accumulation, (b) depletion, and (c) inversion; nMOS transistor demonstrating cutoff, linear, and saturation regions of operation	VTC of static CMOS inverter	Polysilicon and Silicon Nitride
S-2	SLO-1	**Lexical Conventions:** White Space and Comments, Operators	Comparators	**MOS Transistor under Static Conditions:** The threshold voltage	DC Inverter Calculations	**Basic Processes in Integrated-Circuit Fabrication:** Wafer Formation, Photolithography, Well and Channel Formation
	SLO-2	Numbers, Strings, Identifiers, System Names, and Keywords	priority encoder	Resistive operation	Symmetrical Inverter	Silicon Dioxide (SiO_2), Isolation, Gate Oxide
S-3	SLO-1	**Verilog Data Types:** Nets, Register Variables, Constants	shift and rotate operations	Saturation region	Inverter switching characteristics	Gate and Source/Drain Formations, Contacts and Metallization, Passivation, Metrology
	SLO-2	Referencing Arrays of Nets or Regs	**Adders:** Standard adder cells	Current-voltage characteristics	Output capacitance	**Some Recurring Process Steps:** Diffusion and Ion Implantation, Deposition, Etching, Planarization

S-4, 5	**SLO-1** **SLO-2**	**Lab-0: Verilog Operators:** Arithmetic Operators, Bitwise Operators, Reduction Operators, Logical Operators, Relational Operators, Shift Operators, Conditional Operator, Concatenation Operator, Expressions and Operands, Operator Precedence	**Lab-3:**Design using FSM and ASM charts	**Lab-6:** Realization of VLSI multipliers - I	**Lab-9:**Design and Analysis of CMOS Inverter using HSPICE	Lab-12: Design and Analysis of 4-input Dynamic NAND gate using HSPICE
S-6	**SLO-1**	**Verilog modelling:** Gate-level modelling	Ripple Carry Adder (RCA)	**Dynamic behavior:** MOSFET Capacitances, viz., MOS structure capacitances	**Secondary Parasitic Effects:**Leakage Currents, Parasitic Resistances	Simplified CMOS Process flow
	SLO-2	Realization of Combinational and sequential circuits	Carry Look-Ahead Adder (CLA)	Channel capacitance and Junction (or, depletion) capacitances	Inverter layout	
S-7	**SLO-1**	Compilation and simulation of Verilog code	Carry Select Adder (CSL)	Parasitic Resistances, viz., Drain and Source Resistance, Contact Resistance	**Power-Delay Product:** Static Power Consumption	**Layout design rules:** Well rules, transistor rules
	SLO-2	Test bench	Carry Save Adder (CSA)	**Non-ideal I-V effects:** Mobility Degradation, Velocity Saturation	Dynamic Power Consumption, Total Power Consumption, PDP	Contact rules, metal rules, via rules and other rules
S-8	**SLO-1**	Dataflow modelling	Carry Skip Adder (CSK)	Channel Length Modulation, Threshold Voltage Effects	**CMOS Circuit Design Styles:**Static CMOS logic styles	Gate Layouts
	SLO-2	Realization of Combinational and sequential circuits	Carry Bypass Adder (CBA)	Leakage, Temperature Dependence, Geometry Dependence, Subthreshold Current	CMOS circuits, pseudo-nMOS, tristate circuits, clocked CMOS circuits	Stick diagrams
S-9, 10	**SLO-1** **SLO-2**	**Lab-1:**Realization of combinational and sequential circuits using gate-level and dataflow modeling	**Lab-4:**Realization of VLSI adders - I	**Lab-7:** Realization of VLSI multipliers - II	**Lab-10:** (a) Design and Analysis of complex CMOS gate using HSPICE (b) Design and Analysis of Pseudo-NMOS gates using HSPICE	Lab-13: Model Practical Examination
S-11	SLO-1	Behavioral modelling	**Multipliers:** Overview of multiplication (unsigned multiplication, shift/add multiplication algorithms, multiplication of signed numbers, types of multiplier architectures)	**Short-channel MOSFETS:** Hot carriers, Lightly-Doped Drain (LDD)	Differential Cascade Voltage Switch Logic (DCVSL), Pass Transistor Logic (PTL)	**CMOS Process Enhancements:** Transistors (Multiple Threshold Voltages and Oxide Thicknesses, Silicon-on-Insulator, High-k Gate Dielectrics, Higher Mobility, Plastic Transistors,)
	SLO-2	Realization of Combinational and sequential circuits	Braun multiplier	MOSFET scaling	**Dynamic CMOS logic styles:** Basic dynamic logic	
S-12	SLO-1	Switch-level modelling	Baugh-Wooley multiplier	**Short-channel effects:** Negative Bias Temperature Instability (NBTI), oxide breakdown	Signal integrity issues in dynamic design	Interconnects
	SLO-2	Realization of MoS circuits	Wallace Tree multiplier	Drain-Induced Barrier Lowering (DIBL), Gate-Induced Drain Leakage (GIDL), Gate Tunnel Current	Signal integrity issues in dynamic design	Circuit elements
S-13	SLO-1	Design using FSM	Booth multiplier	Tutorials	**Domino Logic Circuits:** Differential Domino logic, multiple-output domino	Beyond conventional CMOS
	SLO-2	Realization of sequential circuits	Booth multiplier	Tutorials	Compound domino, NORA, TSPC	Tutorials
S-14, 15	SLO-1 SLO-2	Lab-2: (a) Realization of digital circuits using behavioral modeling (b) Realization of MOS circuits using switch-level mdeling	**Lab-5:**Realization of VLSI adders - II	Lab-8: Realization of RAM & ROM	**Lab-11:** (a) Design and Analysis of AND/NAND gate in DCVSL using SPICE (b) Design and Analysis of Pass-Transistor gates and CPL gates using HSPICE	Lab-14: End-Semester Practical Examination

Learning Resources	9. Jan Rabaey, Anantha Chandrakasan, B Nikolic, "Digital Integrated Circuits: A Design Perspective". Second Edition, Feb 2003, Prentice Hall of India. 10. Weste, Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", 4th edition, Addision-Wesley, 2011. 11. Wayne Wolf, "Modern VLSI Design: IP-based Design", 4th edition, PHI, 2009.	12. R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", Wiley, (3/e), 2010. 13. John P. Uyemura, "CMOS Logic Circuit Design", Kluwer, 2001. 14. S. Palnitkar , Verilog HDL – A Guide to Digital Design and Synthesis, Pearson , 2003 15. Paul. R.Gray, Robert G. Meyer, "Analysis and Design of Analog Integrated Circuits", Wiley, (4/e), 2001. 16. M.D.Ciletti , Modeling, Synthesis and Rapid Prototyping with the Verilog HDL, Prentice Hall, 1999

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

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

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

Course Code	18ECC301T	Course Name	Wireless Communication	Course Category	C	Professional Core	L	T	P	C
							3	1	0	4

Pre-requisite Courses	18ECC205J, 18ECC105T	Co-requisite Courses	Nil	Progressive Courses	18ECE220T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the elements of Wireless Communication and mobile communications
CLR-2 :	Understand the Mobile Radio Wave Propagation - Large Scale Fading
CLR-3 :	Analyze how to apply Mobile Radio Wave Propagation - Small Scale Fading
CLR-4 :	Study the Capacity and Diversity concepts in wireless communications
CLR-5 :	Acquire the knowledge of Wireless System and Standards
CLR-6 :	Understand and design various wireless systems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Acquire the knowledge of Wireless communication and basic cellular concepts	2	75	60
CLO-2 :	Understand` the essential Radio wave propagation and mobile channel models	2	75	60
CLO-3 :	Familiarize about Various performance analysis of mobile communication system.	2	75	60
CLO-4 :	Attain the knowledge of Diversity and capacity concepts	2	75	60
CLO-5 :	Be familiar with the various standards of Mobile Communication Systems	2	75	60
CLO-6 :	Explore the various concepts of wireless communication, its design with respect to fading and link performance	2	75	60

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

Duration (hour)		Wireless communication: Mobile communications	Large Scale Fading	Small Scale Fading	Improvement on Link performance	Wireless systems and standards
		12	12	12	12	12
S-1	SLO-1	Introduction to wireless communication and mobile radio communication	Introduction to Radio wave Propagation	Introduction Small scale multipath propagation	Introduction to diversity, equalization and capacity	AMPS Voice modulation Process
	SLO-2	Classification of wireless communications - simplex, half duplex, dull duplex	Large scale and small scale fading	Impulse response model of multipath channel		
S-2	SLO-1	Paging and Cordless systems	Friis transmission equation- Free space propagation model - pathloss model	Impulse response model of multipath channel	Space diversity	GSM system architecture and its interfaces
	SLO-2	Cellular telephone systems		Small scale multipath measurements - Direct Pulse measurement	Scanning diversity	
S-3	SLO-1	Timing diagram - landline to mobile	Two Ray model	Small scale multipath measurements - Sliding correlator measurement	Maximal ratio combiner	GSM frame structure
	SLO-2	Timing diagram - mobile to mobile		Small scale multipath measurements - Swept frequency measurement	Equal gain diversity	
S-4	SLO-1	Basic antenna parameters, Far field and near field	Simplified pathloss model	Parameters of mobile multipath channels - Time dispersion and Coherent bandwidth	Rake Receiver	GSM speech operations input - output
	SLO-2	Frequency reuse, sectored and omni-directional antennas	Emperical model - Okumara			
S-5	SLO-1	Channel assignment strategies	Emperical model - Hata model	Parameters of mobile multipath channels - Doppler spread and Coherent time	Capacity in AWGN	Forward CDMA process
	SLO-2	Handoff and its types	Emperical model - Walfish and bertoni model			
S-6	SLO-1	Interference and system capacity	Piecewise linear model - log normal model	Types of fading: Flat and Frequency	Capacity of flat fading channels	Reverse CDMA Process

	SLO-2			selective fading		
S-7	**SLO-1**	Trunking and Grade of Service	Shadowing	Types of fading: Flat and Frequency selective fading	Equalizer and its mode	Multicarrier modulation
	SLO-2		Combined pathloss and shadowing			
S-8	**SLO-1**	Cell splitting	Outage Probabilty	Types of fading: Fast and Slow fading	Adaptive equalizer block diagram	OFDM Transmitter Block diagram
	SLO-2					
S-9	**SLO-1**	Sectoring	Cell Coverage Area	Types of fading: Fast and Slow fading	Types of Equalizers - elementary level only	OFDM Receiver Block diagram
	SLO-2					
S-10	**SLO-1**	Microcell zone concepts	*Solving problems – Brewster angle*	Ricean distribution	Introduction to MIMO antennas	Importance of Cyclic Prefix
	SLO-2					
S-11	**SLO-1**	*Umbrella cells*	*Solving problems –empirical model*	Rayleigh distribution	Introduction to MIMO antennas	Case study - Modern antennas
	SLO-2					
S-12	**SLO-1**	*Solving Problems*	*Solving problems – friis transmission formula*	*Solving problems – Doppler effect*	*Case study :Recent trends in Diversity and MIMO antennas*	Case study - Modern antennas
	SLO-2					

Learning Resources	1. *Rappaport.T.S., "Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2011.* 2. *John D Kraus , Ronald J Marhefka, Ahmed S Khan "Antenna and Wave Propagation", 4th Edition, Tata McGraw Hill, 2010* 3. *Constantine Balanis. A, "Antenna Theory: Analysis and Design", 3rd Edition, John Wiley, 2012.* 4. *Andreas.F.Molisch., "Wireless Communications", Wiley, 2nd Edition-2005, Reprint-2014*	5. *Andrea Goldsmith, " Wireless Communications", Cambridge University Press, Aug 2005* 6. *Schiller, "Mobile Communications", Pearson Education Asia Ltd., Reprint 2012* 7. *Lee W.C.Y., " Mobile Communications Engineering: Theory and Applications", McGraw Hill, New York, 2nd Edition, 1998*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECC302J	Course Name	Microwave & Optical Communications	Course Category	C	*Professional Core*	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*18ECC205J*	Co-requisite Courses	*Nil*	Progressive Courses	*18ECE226T & 18ECE323T*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify Microwave active devices and Microwave generators*
CLR-2 :	*Analyze Microwave passive devices*
CLR-3 :	*Explore Microwave Measurements*
CLR-4 :	*Analyze Optical Fibers Optical Sources, Amplifier and Transmitter Optical Detectors , Receiver and Performance Measurements*
CLR-5 :	*Explore Optical Communication System Design and Concepts*
CLR-6 :	*Analyze Microwave and optical components*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**		
		1	*2*	*3*
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Acquire knowledge on the theory of microwave transmission, microwave generators and associated components.	*2*	80	*70*
CLO-2 :	Analyse microwave passive devices and components.	*2*	80	*70*
CLO-3 :	Understand microwave measurements and associated techniques with equipment	*2*	80	*70*
CLO-4 :	Familiarize with the fundamentals of light transmission through fiber	*2*	80	*70*
CLO-5 :	Design a basic optical communication system.	*2*	80	*70*
CLO-6:	Understand the working principle of microwave components , Microwave measurements, optical sources, detector and fibers	*2*	80	*70*

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
H	-	-	*L*	-	-	-	-	-	-	-	-	-	-	*L*
H	*M*	*H*	*H*	-	-	-	-	-	-	-	-	*L*	-	*M*
H	*M*	*H*	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
H	*H*	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
H	*H*	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*M*
H	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*

Duration (hour)		**15**	**15**	**15**	**15**	**15**
S-1	**SLO-1**	Introduction to microwaves and optical communications	High frequency parameters: S parameters and S matrix analysis for N-port microwave device	Impedance matching.	Elements of Optical fiber communication	Point-to-Point link –Analog system design considerations and design steps
	SLO-2					
S-2	**SLO-1**	History of Microwave Engineering, Microwave transmission and Applications; Maxwell Equations	Directional coupler	VSWR and Impedance measurement	Functional block diagram of a Transmitter and receiver module	Point-to-Point link – Digital system design considerations and design steps
	SLO-2					
S-3	**SLO-1**	Microwave Tubes	E and H plane Tee	Measurement of Power	Optical fiber structure, Light Propagation in Optical fibers: Ray theory , Total Internal reflection, Skew rays	Digital Link Design: Link power budget
	SLO-2	Klystron amplifier				
S-4-5	**SLO-1**	**Lab- 1 Characteristics of Reflex Klystron**	**Lab- 4 Gain and radiation pattern of Horn antenna**	**Lab- 7 Practice session**	**Lab- 10 Measurement of Numerical Aperture, propagation and bending losses of optical fiber**	**Lab- 13 Design of basic Optical Communication system using computational tool**
	SLO-2					
S-6	**SLO-1**	Reflex Klystron oscillators	Magic Tee	Measurement of Frequency and Q factor	Optical Sources: Light source materials, LED Structures	Rise time budget
	SLO-2					
S-7	**SLO-1**	Magnetron oscillators	Microwave Circulators, Isolators	Insertion loss measurements	LED Characteristics	Overview of Analog links: Radio over Fiber;
	SLO-2					
S-8	**SLO-1**	Microwave Bipolar Transistors	Attenuators and Phase Shifters	Attenuation measurements	Semiconductor Laser Diode, Laser	Key link parameters

	SLO-2	**Field effect transistor**			Characteristics	
S-9-10	**SLO-1**	**Lab- 2 Study of power distribution in Directional coupler, E plane, H plane and Magic Tee**	**Lab- 5 Characteristics of filters, Microstrip patch antenna and parallel line coupler**	**Lab- 8 DC characteristics of LED and Laser diode**	**Lab- 11 Analysis of Analog optical link**	**Lab- 14 Practice Session**
	SLO-2					
S-11	**SLO-1**	IMPATT, TRAPATT and Tunnel diode	Rectangular Waveguides	Measurement of Scattering parameters	Optical Detectors: PIN and APD photo detector	Multichannel System: Need for multiplexing
	SLO-2					Operational principles of WDM, DWDM
S-12	**SLO-1**	Gunn diode	Rectangular Waveguides	Measurement of Scattering parameters	Responsivity and efficiency of APD	WDM Components: Coupler/Splitter, Fabry Perot Filter
	SLO-2					
S-13	**SLO-1**	Gunn Oscillation modes	Power Dividers	Functioning details of Vector Network Analyzer; Signal Analyzer; Spectrum analyzers	Fiber attenuation and dispersion	WDM Components: Optical MEMS switches
	SLO-2					
S-14-15	**SLO-1**	**Lab- 3 Impedance measurement by slotted line method**	**Lab- 6 Design of RF Filters and Amplifier using computational tool**	**Lab- 9 DC characteristics of PIN and APD photo-diode**	**Lab- 12 Analysis of Digital optical link**	**Lab- 15 Study experiment - Gunn Diode (Microwave) and Optical WDMA (Optical)**
	SLO-2					

Learning Resources	1. David M. Pozar, "Microwave Engineering", 4th Edition, John Wiley & Sons, 2012. 2. David M. Pozar, "Microwave & RF Design of Wireless Systems", John Wiley & Sons, 2001. 3. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson Education, 2013. 4. Robert. E. Collin, "Foundations for Microwave Engineering", 2nd edition, Wiley, Reprint 2014. 5. Annapurna Das, Sisir K. Das, "Microwave Engineering", 3rd Ed., McGraw Hill, 2015. 6. I. Hunter, "Theory and design of microwave filters", The Institution of Engineering &Technology, 2001. 7. Keiser G, "Optical Fiber Communication Systems", 5th Edition, 6th Reprint, McGraw Hill Education (India), 2015. 8. Vivekanand Mishra, Sunita P. Ugale, "Fiber Optic Communication: Systems and Components", Wiley-India, 1st edition, 2013 9. Djafar.K. Mynbaev and Lowell and Scheiner, "Fiber Optic Communication Technology", Pearson Education Asia, 9th impression, 2013 10. John M. Senior, " Optical fiber Communications: Principles and Practice", Pearson Education, 3rd Edition, 2009 11. R.P. Khare, "Fiber Optics and Optoelectronics", Oxford University Press, 2007. 12. 12. Rajiv Ramaswami, Kumar N. Sivaranjan, Galen H.Sasaki "Optical Networks A practical perspective", 3nd edition, 2013

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

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

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

Course Code	18ECC303J	Course Name	Computer Communication Networks	Course Category	C	Professional Core	L	T	P	C
							3	0	2	4

Pre-requisite Courses	18CSS101J	Co-requisite Courses	Nil	Progressive Courses	18ECE320T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Introduce the basic concepts in the field of computer networks.
CLR-2 :	Understand the functional aspects of OSI model architecture.
CLR-3 :	Acquire knowledge of the Network Layer protocols
CLR-4 :	Analyze the various issues and challenges of Transport Layer.
CLR-5 :	Familiarize the various Application Layer Protocols.
CLR-6:	Utilize the networking concepts to analyze the performance of Routing protocols.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Understand the basic services and concepts related to internetworking.	2	80	70	H	-	-	-	-	M	M	-	-	-	-	M	H	M	-
CLO-2 :	Explain the basic OSI model architecture and its lower layer functions.	2	85	75	H	-	-	-	-	M	M	-	-	-	-	M	H	M	-
CLO-3 :	Give an insight of the various Network Layer concepts, mechanisms and protocols.	2	75	70	H	-	-	-	-	M	M	-	-	-	-	M		M	H
CLO-4 :	Appreciate the services and techniques of Transport Layer.	2	85	80	H	-	-	-	-	M	M	-	-	-	-	M	-	H	M
CLO-5 :	Discuss the various services and protocols in Application Layer.	2	85	75	H	-	-	-	-	M	M	M	-	-	-	M	H		M
CLO-6 :	Implement and analyze the various Networking concepts and Routing protocols.	2	80	70	-	-	-	-	H	-	-	-	-	-	-		M		H

Duration (hour)		DATA COMMUNICATION & NETWORKING BASICS	OSI LOWER LAYERS	NETWORK LAYER	TRANSPORT LAYER	APPLICATION LAYER
		15	15	15	15	15
S-1	SLO-1	Introduction to Data Communication and Networking	Network models	*Introduction to Network Layer*	*Introduction to Transport Layer*	*Introduction to Application Layer*
	SLO-2	Data transfer modes-Serial and Parallel transmission	OSI layer architecture	Need for Internetworking	*TCP/IP Model*	*Application Layer Paradigms*
S-2	SLO-1	Protocols & Standards	Data Link Layer-Introduction	*Addressing-Classful*	*User Datagram Protocol(UDP)*	*Client Server Interaction*
	SLO-2	Layered Architecture	Link Layer Addressing	*Addressing-Classful*	*User Datagram Protocol(UDP)*	*Client Server Interaction*
S-3	SLO-1	Principles of Layering & Description	Error Detection	*Addressing-Classless*	*Transmission Control Protocol(TCP)*	*SIP*
	SLO-2	Brief description of concepts in OSI & TCP/IP model	Error Detection	*Addressing-Classless*	*Transmission Control Protocol(TCP)*	*SIP*
S 4-5	SLO-1	**Lab 1:To build and configure a simple network of four nodes connected with point-to-point links**.	**Lab 4: To simulate token ring protocol and to study its performance.**	***Lab 7:To simulate CSMA/CA protocol and to study its performance***	***Lab 10: Implementation and study of Selective Repeat protocol.***	***Lab 13: Create a Socket (TCP&UDP) between two computers and enable file transfer between them.***
	SLO-2					
S-6	SLO-1	Switching Types- Circuit- & Packet switching	Error Correction	*Network Layer Protocol-IPV4*	*TCP Services & Features*	*Compression Techniques*
	SLO-2	Switching Types- Message switching, Comparison of switching types	Error Correction	*Internet Protocol(IP)-IPV4*	*TCP Services & Features*	*Compression Techniques*

S-7	**SLO-1**	LAN, MAN & WAN	Data link control-LLC	*Internet Protocol(IP)-IPV6*	*Congestion Control*	*Introduction to Cryptography*
	SLO-2	LAN, MAN & WAN	Data link control-LLC	*Internet Protocol(IP)-IPV6*	*Congestion Control*	*Types, Attacks and Services*
S-8	**SLO-1**	Network topologies-Types	Data link control-MAC	*Routing Protocols- Distance Vector& Link State*	*Congestion Control*	*DES*
	SLO-2	Comparison of topologies	Data link control-MAC	*Routing Issues-Delivery, Forwarding and Routing*	*Congestion Control*	*DES*
S 9-10	**SLO-1**	**Lab 2: *To simulate star and bus network topologies.***	**Lab 5:Implementation of Error detection and Correction scheme.**	***Lab 8: Implementation and study of stop and wait protocols***	***Lab 11: To configure a network using Link State Routing protocol .***	***Lab 14: Implementation of Data Encryption and Decryption.***
	SLO-2					
S-11	**SLO-1**	*IEEE standards for LAN-Ethernet*	*Flow & Error Control Protocol*	Routing Information Protocol-RIP	*QOS-Quality of Service*	*RSA*
	SLO-2	*Types of Ethernet*	*Flow & Error Control Protocol*	Routing Information Protocol-RIP	*QOS-Quality of Service*	*RSA*
S-12	**SLO-1**	*Token Bus*	*ARQ Schemes*	*Open Shortest Path First-OSPF*	*Techniques to improve QOS*	*Email*
	SLO-2	*Token Ring*	*ARQ Schemes*	*Open Shortest Path First-OSPF*	*Techniques to improve QOS*	FTP
S-13	**SLO-1**	*FDDI*	*HDLC*	*Border Gateway Protocol-BGP*	*Techniques to improve QOS*	*HTTP*
	SLO-2	*FDDI*	*HDLC*	*Border Gateway Protocol-BGP*	*Techniques to improve QOS*	*SNMP*
S 14-15	**SLO-1**	***Lab 3:To simulate token bus protocol and to study its performance.***	**Lab 6:To simulate CSMA/CD protocol and to study its performance**	***Lab 9: Implementation and study of Go back N protocol.***	***Lab 12: To configure a network using Distance Vector Routing protocol.***	***Lab 15: Mini Project***
	SLO-2					

Learning Resources	1. Behrouz A.Fehrouzan, "Data communication & Networking", Mc-Graw Hill, 5th Edition Reprint, 2014. 2. Andrew S.Tanenbaum, "Computer Networks", Pearson Education India, 5th Edition, 2013.	3. William Stallings, "Data & Computer Communication", Pearson Education India, 10th Edition, 2014. 4. James F. Kurose, Keith W. Ross, "Computer Networking: A Top–Down Approach Featuring the Internet", Pearson Education,6th Edition, 2013. 5. "Lab Manual" , Department of ECE, SRM Institute of Science and Technology

Learning Assessment

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

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

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

B. Tech in Electronics and Communication Engineering

2018 Regulations

ProfessionalElective Courses (E)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology

SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECE201J	Course Name	PYTHON AND SCIENTIFIC PYTHON	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understanding the python language construct and apply them for scientific computation
CLR-2 :	Apply python vector ,list and plot concept to solve curve fitting
CLR-3 :	Applying Dictionary concept to model Polynomials
CLR-4 :	Create insights to difference equation based system model and solving them with python
CLR-5 :	Analyze Monte Carlo Simulation for computing Probabilities
CLR-6 :	Create insights to the concepts and programming of SciPy, numpy, matplotlib to solve scientific problem

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Apply python language construct to compute formula and scientific problem	2	80	70
CLO-2 :	Analyze Mathematical Models system using f Difference Equations and solving	2	85	75
CLO-3 :	Apply time sequence concept for generation and processing of audio signal by python	2	75	70
CLO-4 :	Apply python language construct to solvePolynomials	2	85	80
CLO-5 :	Apply python language construct to compute probability byMonte Carlo Simulation ,game design and dynamic random motion creation	2	85	75
CLO-6 :	ApplySciPy, numpy, matplotlib to statistical analysis , correlation coefficient analysis , Solving equations-Linear least squares solutions and signal processing	2	80	70

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 PSO – 3: Analyze & Research
CLO-1 :	H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-2 :	H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-3 :	H	-	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	H	-	H	-	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	-	-	-	-	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Solving Simple Formula And Scientific Problem	Plots, Array and Difference Equation Modelling	File I/O, Polynomials and Web Programming	Random Process and Game Programming	SciPy ,Numpy and Signal Processing
		12	12	12	12	12
S-1	SLO-1	Computing with Formulas- Using a Program as a Calculator	Vectors, Mathematical Operations on Vectors,Vector Arithmetics and Vector Function	Reading Data from File-Line by Line,Reading a Mixture of Text and Numbers	Drawing Random Numbers-Uniformly Distributed Random Numbers	SciPy, numpy,matplotlib
	SLO-2	Using Variables,Formatting Text and Numbers	Arrays in Python Programs-Using Lists for Collecting Function Data	Making Dictionaries	Computing the Mean and Standard Deviation	Basic array methods in numpy,Changing the shape of an array
S-2	SLO-1	Celsius-Fahrenheit Conversion,	Curve Plotting-The SciTools and Easyviz Packages	Dictionary Operations	The Gaussian or Normal Distribution-Drawing a Random Element from a List	Maximum and minimum values
	SLO-2	Evaluating Standard Mathematical Functions,Type Conversion	Plotting a Single Curve,Decorating the Plot,Plotting Multiple Curves,Controlling Line Styles	Polynomials as Dictionaries,File Data in Dictionaries,File Data in Nested Dictionaries	Drawing random interger	Reading and writing an array to a fle
S-3-4	SLO-1	***Lab 1:programming on formula and Standard Mathematical Functions-Evaluate a Gaussian function,Compute the air resistance on a football***	***Lab 4:*** Curve Plotting	***Lab 7:reading student marks file into a dictionary data with the student name as key and computing the average grades***	***Lab 10: real card games***	***Lab 13: numpy file reading and data analysis***
	SLO-2					
S-5	SLO-1	Complex Numbers,Complex Arithmetic's in Python	Numerical Python Arrays manipulations	Strings-Common Operations on Strings	Computing Probabilities-Principles of Monte Carlo Simulation	Statistical methods in numpy
	SLO-2	Input Data-Reading Keyboard Input-Reading from the Command Line	Higher-Dimensional Arrays-Two-Dimensional Numerical Python Arrays	Reading Coordinates	Throwing Dice,Rolling Two Dice game	Statistical methods in numpy

S-6	**SLO-1**	*Making Modules,Collecting Functions in a Module File*	*Matrix Objects*	*Reading Data from Web Pages-About Web Pages*	*Drawing Balls from a Hat*	*Histograms*
	SLO-2	*Using Modules*	*Mathematical Models Based on Difference Equations-Interest Rates*	*Access Web Pages in Programs-Reading Pure Text Files,*	*Simple Games- Guessing a Number*	*Solving equations-Linear least squares solutions-Beer-Lambert Law*
S-7-8	**SLO-1**	***Lab 2: program on Making Modules and using them***	***Lab 5:Animating a Function-temperature on earth***	***Lab 8:reading web temperature text file into Dictionaries and computing average Temperature***	***Lab 11: Simple Games***	***Lab 14: the correlation coefficient between pressure and temperature***
	SLO-2					
S-9	**SLO-1**	*while loops and for loops*	*the Factorial as a Difference Equation*	*Extracting Data from an HTML Page*	*Random Walk in One Space Dimension*	*One-Dimensional Fast Fourier Transforms*
	SLO-2	*Lists and list manipulation*	*Growth of a Population, Payback of a Loan, Making a Living from a Fortune*	*Writing a Table to File,Reading and Writing Spreadsheet Files*	*Basic Implementation, visualization and Computing Statistics of the Particle Positions*	*Matplotlib basics-Plotting on a single axes object, scatter plot,Bar charts and pie charts*
S-10	**SLO-1**	*Loops with List Indices,Nested Lists*	*Logistic Growth,Programming with Sound Writing Sound to File,Reading Sound from File,*	*Representing a Function as a Class and manipulation*	*Random Walk in Two Space Dimensions*	*Choosing the Length of the DFT*
	SLO-2	*Tuples,Functions,Lambda Functions,If Tests*	*Playing Many Notes*	*Bank Accounts as class,A Class for Solving ODEs*	*Basic Implementation, visualization and Computing Statistics of the Particle Positions*	*Filters in Signal Processing*
S-11-12	**SLO-1**	***Lab 3: Programming on list and loops***	***Lab 6: Sound generated by formula and difference equation***	***Lab 9: Programming on class***	***Lab 12:Random Walk in One Space Dimension or Two Space Dimensions***	***Lab 15: Numpy signal processing***
	SLO-2					

Learning Resources	1. *Hans Petter Langtangen," A Primer on Scientific Programming with Python", Springer, 2000.* 2. *Christian Hill, "Learning Scientific Programming with Python",Cambridge University Press, 2015.*	3. *Juan Nunez-Iglesias, Stéfan van der Walt, and Harriet Dashnow Elegant SciPy Te Art of Scientific Python, O'Reilly Media, 2017.*

Learning Assessment

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

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

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

Course Code	18ECE202T	Course Name	Micro- and Nano-Fabrication Technologies	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	**Learning**		
		1	*2*	*3*
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Provide learners a systematic overview of micro and nano fabrication processes*			
CLR-2 :	*Gain understanding of lithography, etching and ion implantation methods to fabricate, structure and modify the layer*			
CLR-3 :	*Understand thin film fabrication techniques including PVD and CVD and to apply the knowledge to film formation*			
CLR-4 :	*Apply the knowledge of microfabrication technology to the fields of general microelectronics systems*			
CLR-5 :	*Learn the significant advances in molecular engineering*			
CLR-6 :	*Embark on building micro/ nano structures applicable to their needs.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	*Understand the various layering Technologies*	*2*	*80*	*70*	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	-	
CLO-2 :	*Realize how the pattern generation is done using Lithography Techniques*	*2*	*85*	*75*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	*M*	-	
CLO-3 :	*Gain knowledge on particle sources, Optics and Interaction*	*2*	*75*	*70*	*H*	-	*M*	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-4 :	*Learn the device and circuit fabrication Techniques*	*2*	*85*	*80*	*H*		*M*	-	-	-	-	-	-	-	-	-	-	-	*H*
CLO-5 :	*Learn about new and advances in fabrication Technologies*	*2*	*85*	*75*	*H*	-		*H*	-	-	-	*M*	-	-	-	*M*	-	-	*H*
CLO-6 :	*Know the limitations and tools of micro, nanofabrication.*	*2*	*80*	*70*	*H*	*M*	-	-	*M*	-	-	-	-	-	-	*L*	*M*	-	*H*

Duration (hour)		Crystal Growth, Epitaxy, Oxidation	Lithographic Processes	Deposition, Diffusion, Ion implantation	Device Circuit Fabrication	Molecular Nanotechnology
		9	9	9	9	9
S-1	**SLO-1**	Starting Materials	*Photoreactive Materials*	*Vaccum Evaporation*	*Isolation*	*Directed Self Assembly*
	SLO-2	Growth from Melt (Czochralski Technique)	*Image Reversal*	*Sputter Deposition*	*Self Alignment*	*Device Assembly*
S-2	**SLO-1**	Considerations for Paper Crystal Growth	*Pattern Generation*	*Chemical Vapour Deposition*	*Local Oxidation-Trench Technique*	*Electrostatic*
	SLO-2	Cystal Orientation, Crystal hardening Techniques	*Mask Making*	*Growth Habit*	Planarization	*Templated self assembly*
S-3	**SLO-1**	Doping, Dislocation	*Pattern Transfer*	*Fims for protection & Masks*	Metalization	*Colloids & Nanoparticles*
	SLO-2	*Molecular Beam Epitaxy*	*Optical Printing*	*Self-aligned Masks*	Gettering	*Block Copolymers*
S-4	**SLO-1**	*Gas Source MBE*	*Advanced Techniques*	*Films for Doping*	NIOS-based Micro Circuits	*DNA Nanostructures*
	SLO-2	*Vapour Phase Epitaxy*	*Short Wave lengths*	*Dopart Sources*	P,n Channel Transistors	*Scanning probe lithography Techniques*
S 5-6	**SLO-1**	VPE Process to Silicon	*Multilayer Resists*	*Films for Ohmic contacts*	Complementary Transistors	*Local Anodic Oxidation*

	SLO-2	*VPE Process for GaAs*	*Phase Shifting Masks*	*Wet Chemical etching*	Memory Devices	*Scribing*
S-7	**SLO-1**	*Liquid Phase Epitaxy*	*Electron Beam Techniques*	*Anisotropic Effects*	SOI Devices	*Atomic Manipulation*
	SLO-2	*LPE System*	*Lon-Beam Techniques*	*Dry Physical Etching*	BJT based Silicon Micro Circuits	*SPM Scanning Probe Microscopy*
S-8	**SLO-1**	*Thermal Oxidation of Silicon*	*X Ray Printing*	*Dry Chemical Etching*	The buried layer	*Erasable Electrostatic Lithography*
	SLO-2	*Kinetics of Oxide Growth*	*Problem areas- defects*	*Reactive Lon Etching*	p-n-p Transistor	*Limits to Nano Fabrication*
S-9	SLO-1	*Oxidation System*	*Feature size control & anisotropic Etch Mechanism*	*Penetration range &Transverse effects*	Field Effect Transistor	*Limits to MSO Devices*
	SLO-2	*Halogenic Oxidation*	*Lift off Techniques*	*Annealing*	*BICMOS Integrated Circuits*	*Limits for Pattern Generation*
	SLO-2	Anodix Oxidation Plasma Processes	Plasma reactor Relative Plasma etching Technique	Ion Implantation systems High energy, high current Inplants	Self Aligned Technology The Hetero junction Bipolar Transistor	Nanofabrication Tools

Learning Resources	1. *Sorab. K. Gandhi, "VLSI Fabrication and Principles", McGraw Hill, 2005* 2. *Sami Franssila, "Introduction to Microfabrication", Wiley Publications, 2010* 3. *Richard C.Jaeger, "Introduction to Microelectronic Fabrication", Prentice hall, 2002* 4. *Ivor Brodie & Julius J. Muray,"The Physics of Micro/ Nano- Fabrication" Springer, 1992*	5. *Bo Cui, "Recent advances in Nanofabrication Techniques and Applications", InTech Publisher, 2011* 6. *A G Davies and J M T Thompson, "Advances in Nanoengineering Electronics, Materials and Assembly",Imperial College Press, 2007* 7. *Michael Pycraft Hughes , "Nanoelectromechanics in Engineering and Biology", by CRC Press LLC, 2003*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE203T	Course Name	SEMICONDUCTOR DEVICE MODELING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC102J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the properties of semiconductor materials
CLR-2 :	Utilize the mechanisms that occur in a PN junction
CLR-3 :	Utilize the characteristics and modeling of BJT
CLR-4 :	Utilize the modeling aspects of MOSFET
CLR-5 :	Identify the effects of MOSFET scaling and special MOSFETs
CLR-6 :	Understand the fundamental physical processes of semiconductor devices to meet the challenge of these dynamic fields.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	Identify and Choose semiconductor materials for various applications	2	80	70
CLO-2 :	Interpret the characteristics of Junction devices	3	85	75
CLO-3 :	Modify and model the BJT parameters for better performance	3	75	70
CLO-4 :	Evaluate and optimize the performance of MOSFET	3	85	80
CLO-5 :	Build new devices with small channel	3	85	75
CLO-6 :	Explain the equations, approximations and techniques available for deriving a model with specified properties, for a general device characteristic with known qualitative theory	3	80	70

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 PSO – 3: Analyze & Research
CLO-1 :	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	H	H	-	H	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	H	H	-	H	-	-	-	-	-	-	-	-	-	-	H
CLO-4 :	H	H	-	H	-	-	-	-	-	-	-	-	-	-	H
CLO-5 :	H	-	-	H	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	H	H	-	H	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Electron, Hole Densities In Equilibrium: Distribution of quantum states in energy band	PN Junction under thermal equilibrium: Built in potential, concept of space charge layer	Current components, Basic BJT parameters,	MOS diode	Scaling of MOSFETS
	SLO-2	Fermi – Dirac Statistics	Problem Solving	Limitations on the junction voltage	Operation of Ideal MOS diode (at VGB >0)	Effect of Gate voltage on carrier mobility
S-2	SLO-1	Electron concentration conduction band	Distribution of electric filed and potential within the space charge layer for abrupt junctions at Zero bias	Capacitances in a BJT,	Operation of ideal MOS diode (at VGB <0)	Effect of Drain voltage on carrier mobility
	SLO-2	Hole concentration Valence band	Distribution of electric filed and potential within the space charge layer for abrupt junctions at Zero bias	Switching of BJT	Operation of ideal MOS diode with and without oxide charge	Effect of Drain voltage on carrier mobility
S-3	SLO-1	Carrier concentration in intrinsic semiconductors	Distribution of electric filed and potential within the space charge layer for linearly graded junctions at Zero bias	Ebers-Moll model	Effects of mobile Ionic charges	Channel length modulation
	SLO-2	Position of Fermi level in extrinsic semiconductors	Distribution of electric filed and potential within the space charge layer for linearly graded junctions at Zero bias	Problem Solving	Problem Solving	Breakdown and punch through
S-4	SLO-1	Ionization of impurities, Equilibrium electron and hole concentration	PN Junction under applied bias: Depletion layer capacitance in an abrupt PN junctions	Early effect (CB & CE)	Oxide charges and Interface states	Sub threshold current
	SLO-2	Problem Solving	Problem Solving	Operation of BJT at high frequencies: Charge control model	C-V Characteristics	Sub threshold current

S-5	SLO-1	*Fermi level at thermal equilibrium*	*Depletion layer capacitance with arbitrary doping profiles*	*Small signal equivalent circuit,*	*Problem Solving*	*Short channel effects*
	SLO-2	*Problem Solving*	*Static current voltage characteristics of PN junction,*	*Problem Solving*	*Threshold voltage of MOSFET*	*Short channel effects*
S-6	SLO-1	*Excess Carriers: Generation and recombination of carriers*	*Current-voltage relationship in an infinitely long diode,*	*Design of high frequency transistors*	*Bulk charge model*	*Meyer's model*
	SLO-2	*Mobility of carriers*	*Quasi Fermi level under bias condition*	*Problem Solving*	*Problem Solving*	*Small signal model*
S-7	SLO-1	*Charge transport in semiconductors: Drift current*	*Current –voltage relation in practical diodes having finite lengths*	*Second order effects in BJT: Non-uniform doping in the base*	*square law method (Level 1 in SPICE*	*MOSFET scaling*
	SLO-2	*Hall effect*	*Ideality factor*	*Non-uniform doping in the base*	*square law method (Level 1 in SPICE*	*Non-uniform doping in channel*
S-8	SLO-1	*Diffusion current*	*Transient analysis: Time variation of stored charge*	*Variation of β with collector current*	*Level 3 model in SPICE*	*SOI MOSFET*
	SLO-2	*Problem Solving*	*Problem Solving*	*High injection in collector*	*BSIM Models*	*SOI MOSFET*
S-9	SLO-1	*Current density equations*	*Reverse recovery of a diode, charge storage capacitance*	*Heavy doping effects in the emitter*	*Comparison of Models*	*Buried channel MOSFET*
	SLO-2	*Current density equations*	*Problem Solving*	*emitter crowding in bipolar transistors*	*Comparison of Models*	*Fin FET*

Learning Resources	1. *Nandita Das Gupta, Amitava Das Gupta, Semiconductor devices, modeling and Technology, Prentice Hall of India, 2004* 2. *Philip. E. Allen Douglas, R. Hoberg, CMOS Analog circuit Design, 2nd ed., Oxford Press, 2002*	3. *S.M. Sze, Semiconductor Devices-Physics and Technology, John Wiley and Sons, 1985.* 4. *Kiat Seng Yeo, Samir R.Rofail, Wang-Ling Gob, CMOS/BiCMOS VLSI-Low Voltage, Low Power, Pearson 2003*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE204J	Course Name	ARM-based Embedded System Design	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC203J	Co-requisite Courses	Nil	Progressive Courses	18ECE305J, 18ECE306J
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand fast software development tools of ARM processor			
CLR-2 :	Understand I/O programming for ARM chip; A/D, PWM etc.			
CLR-3 :	Understand the usage of timers and serial interfacing.			
CLR-4 :	Know effective use of memory; and network interfacing, Ethernet and wireless protocol supports			
CLR-5 :	Make application for audio signal processing.			
CLR-6 :	Develop ARM Cortex-M based embedded systems for networking and signal processing applications.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Learns about "mbed" software and C language application for ARM Cortex-M processors.	2	80	70	L												H		
CLO-2 :	Learns using mbed software to use A/D converter, PWM generation and digital input / output.	2	80	70	L	M	M		M								H		
CLO-3 :	Learns to program System timer and interval timers; use serial interface and use LCD display.	2	80	70													H		
CLO-4 :	Learns to use memory effectively and program network interface.	3	80	60		M	M										M		
CLO-5 :	Learns to do audio signal processing on embedded platform.	3	80	60		M	M	M	M								M		
CLO-6 :	Use of "mbed" software pack on ARM Cortex-M processor for networking and simple signal processing.	3	80	60	L	M	M	M	M								M		

Duration (hour)		Learning Unit / Module 1 Cortex-M processor	Learning Unit / Module 2 Peripheral Interfacing-I	Learning Unit / Module 3 Peripheral Interfacing-II	Learning Unit / Module 4 Network Interfacing	Learning Unit / Module 5 Audio Signal Processing
		15	15	15	15	15
S-1	SLO-1	***Introducing embedded systems and mbed***	*Starting to Program Digital Input and Output*	*Introducing Synchronous Serial Communication*	*Memory organization*	*An Introduction to Digital Audio*
	SLO-2	***Introducing embedded systems and mbed***	*Voltages as Logic Values*	*I2C bus*	*Memory organization*	*USB MIDI on the mbed*
S-2	SLO-1	***ARM Cortex assembly language basics.***	*Introducing Analog output Data Conversion*	*Communicating With I2C-Enabled Sensors*	*Using Data Files With the mbed*	*Digital Audio Processing*
	SLO-2	***ARM Cortex assembly language basics.***	*Digital Output on the mbed*	*Asynchronous Serial Data Communication*	*Example mbed Data File Access*	*Digital Audio Filtering Example*
S 3-4	**SLO-1**	***Lab-1:Assembly language program, simulation -1***	***Lab 4: A/D conversion program***	***Lab 8: Multinode I2C Bus***	***Lab 10: Data logging***	***Lab 13: Audio signal generation***
	SLO-2					
S-5	SLO-1	***Cortex-M processor architecture and Basics : Programming exercises***	*Digital Input and Output.*	*LCD interfacing*	*Using External SD Card Memory With the mbed*	*Delay/Echo Effect*
	SLO-2	***Cortex-M processor architecture and Basics : Programming exercises***	*Digital Input and Output.*	*Using the mbed TextLCD Library*	*Using External USB Flash Memory With the mbed*	*Working With Wave Audio Files*

S-6	SLO-1	*Development Environment using the mbed*	*Switching Larger DC Loads*	*Time and Tasks in Embedded Systems*	*Introduction to Internet Communication*	*High-Fidelity Digital Audio With the mbed*
	SLO-2	*Development Environment using the mbed*	*Switching Larger DC Loads*	*Responding to External Events*	*The Ethernet Communication Protocol*	*High-Fidelity Digital Audio With the mbed*
S 7-8	**SLO-1**	***Lab 2: Assembly language program, simulation-2***	***Lab 5: Mini Project: Letter Counter***	***Lab 8: A/D output on LCD***	***Lab 11: Ethernet communication***	***Lab 14: Model lab examination***
	SLO-2					
S-9	SLO-1	*Keil IDE and Debugging tools*	*Another Form of Analog Output: Pulse Width Modulation*	*An Introduction to Timers*	*Introducing Wireless Data Communication*	*Summary on Digital Audio and Digital Signal Processing*
	SLO-2	*Keil IDE and Debugging tools*	*Pulse Width Modulation on the mbed*	*Using the mbed Timer*	*Wireless Data Communication : Bluetooth and Zigbee*	*Summary on Digital Audio and Digital Signal Processing*
S-10	SLO-1	*C- language review*	*Design of PWM problem*	*Using the mbed Timeout* ***and Ticker***	*Local Area Network Communications With the mbed*	*Review and discussions*
	SLO-2	*Embedded C , introduction*	*Design of PWM problem*	*The Real-Time Clock*	*Using RPC*	*Review and discussions*
S 11-12	**SLO-1**	***Lab 3: Parallel port programming, simulation***	***Lab 6: PWM waveform generation***	***Lab 9: ExperimentingInterrupts, Timers***	***Lab 12: RPC communication through ethernet***	***Lab 15: Final lab examination***
	SLO-2					

Learning Resources	1. *Tim Wilmshurst, "Fast and effective embedded system design, Applying the ARM mbed", ARM Education Media, 2018.* 2. *Andrew Sloss, Dominic Symes, Chris Wright, "ARM System Designers Guide: Designing and optimizing System Software", The Morgan Kaufmann Series in Computer Architecture and Design, 2004.*	3. ***Theory/Lab teaching materials, "Efficient embedded system design kit", ARM Education media.***

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE205J	Course Name	FPGA-based Embedded System Design	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC203J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Know why many high volume embedded systems need to be function specific			
CLR-2 :	Design circuits using FPGA knowledge of using its resources like, clock, cells, device modules, etc.			
CLR-3 :	study Xilinx FPGA IDE and design practice			
CLR-4 :	Understand platform FPGAs			
CLR-5 :	Understand FPGA system design and practical issues			
CLR-6 :	Develop designs using FPGAs/PSoCs for specific embedded modules and low-power designs			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Explain Micro controller subsystems	2	80	70
CLO-2 :	Make system design with PSoCs	3	80	70
CLO-3 :	Understanding of Platform FPGAs	2	80	70
CLO-4 :	Understanding of FPGA architecture design	3	80	60
CLO-5 :	Designing with Platform FPGAs (examples)	3	80	60
CLO-6 :	Design simple FPGA based systems	3	80	60

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

Duration (hour)		Learning Unit / Module 1 Basics of Peripherals	Learning Unit / Module 2 PSoC Design	Learning Unit / Module 3 Xilinx Virtex 5 IDE	Learning Unit / Module 4 Platform FPGA Designs	Learning Unit / Module 5 Designing Simple FPGA based Systems
		15	15	15	15	15
S-1	SLO-1	Embedded systems performance criteria - Interrupts	PSoC3/5 architecture overview	Design challenges, life cycle	Design quality: correctness, reliability, resilience.	Communication: Coprocessor model
	SLO-2	Embedded systems performance criteria - Interrupts	PSoC3 architecture details and 8051 instructions	Metrics: measures of success	Modules and interfaces	Network on chip model
S-2	SLO-1	Embedded systems performance criteria - DMA	Interrupts and interrupt lines	Spectrometer example using Xilinx IDE	Abstraction and state,	Transfer of state
	SLO-2	Latency and its problems	Interrupt priority and nesting	Spectrometer example using Xilinx IDE	Cohesion and coupling and control flow graph	Practical issues: profiling issues
S 3-4	SLO-1 SLO-2	***Lab 1: Embedded sensors and sensing -1***	***Lab 4: PSoC Design -1***	***Lab 7: VHDL, Verilog Practice session -1***	***Lab 10: Sample design implementation***	***Lab 13: On-chip memory access, FIFOs***
S-5	SLO-1	Embedded system subsystems: A/D conversion	The concept of memory and its connectivity to CPU	Xilinx Virtex 5 IDE	Origin of Platform FPGA Designs	Spatial design: Principles of parallelism
	SLO-2	Digital ports & its current capacity	Different DMA modes	Xilinx Virtex 5 IDE	Platform FPGA components	Granularity, degree of parallelism

S-6	SLO-1	*Introduction to other digital interfaces*	*Clocking system: Internal master oscillator*	*PLD basics*	*Adding to platform FPGA systems*	*Spatial organizations*
	SLO-2	*Introduction to other digital interfaces*	*IMO, and sleep/wake up modes*	*FPGA configurations*	*Assembling custom compute cores*	*Spatial organizations*
S 7-8	SLO-1 SLO-2	***Lab 2: Embedded sensors and sensing - 2***	***Lab 5: PSoC Design -2***	***Lab 8: VHDL, Verilog Practice session -2***	***Lab 11: Building base systems***	***Lab 14: Model lab examination***
S-9	SLO-1	*Sensors and sensing principles. Optical, capacitive sensors*	*Clock distribution*	*Various slices in Virtex 5*	*Software design :root file system, cross-developmental tools*	*Managing bandwidth: Balancing*
	SLO-2	*Magnetic, RF sensors*	*Power management: Internal regulators*	*Various slices in Virtex 5*	*Monitors and boot loaders*	*Khan process network*
S-10	SLO-1	*Processing: Mathematical views.*	*Types of reset*	*Bit stream*	*Overview of partitioning platform*	*Platform FPGA bandwidth techniques*
	SLO-2	*Programmable logic and mixed signal design fundamentals*	*Intro to PSoC creator IDE*	*Programming FPGA*	*Analytical solution to partitioning*	*On-chip, off-chip memory*
S 11-12	SLO-1 SLO-2	***Lab 3: Programmable logic design***	***Lab 6: PSoC Design - 3***	***Lab 9: Sample design implementation***	***Lab 12: Creating IP core***	***Lab 15: Final lab examination***

Learning Resources	1. ***Robert Ashby, "Designers guide to the Cypress PSoC", Cypress Semiconductors, 2005.*** 2. ***Edward H. Currie and David Van Ess, " PSoC3/5 Reference Book", Cypress Semiconductor, 2010.***	3. ***Sass and Shmidt, "Embedded system design with Platform FPGAs", Morgan Kaufmann, 2010.*** 4. ***Theory/Lab Session Teaching Materials, ARM Educational Media.***

Learning Assessment

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

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

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

Course Code	18ECE206J	Course Name	ADVANCED DIGITAL SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC103J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand advanced Boolean theorems for logic simplification and implementation
CLR-2 :	Understand the formal procedures for the analysis and design of synchronous and asynchronous sequential circuits
CLR-3 :	Understand concept of Programmable Devices (PROM, PLA, PAL, CPLD and FPGA) and implement combinational and sequential logic circuits using them.
CLR-4 :	Adopt systematic approach with the use of ASM chart ASMD chart, RTL representation for the design of digital circuits and systems
CLR-5 :	Use VHDL as a design-entry language for FPGA in electronic design automation of digital circuits
CLR-6 :	Develop the ability to simulate circuits for more advanced design projects.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Learning: Expected Proficiency (%)	Learning: 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	PSO-1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Apply advanced theorems to simplify the design aspects of various practical circuits	3	80	75	M														
CLO-2 :	Analyze and design synchronous sequential circuits	3	80	70		M	M												
CLO-3 :	Identify methods to analyze and design Asynchronous sequential circuits	3	75	70		M	M												
CLO-4 :	Implement various digital circuits using Programmable Logic Devices	3	80	75		M	M												
CLO-5 :	Design and implement digital circuits using VHDL.	3	80	70		H	H	H	H			L	H	M					L
CLO-6 :	Perform experiments in the laboratory with hardware and as well with software (VHDL) to simulate and verify the design	3	80	70												H	H		L

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Shannon's Expansion theorem	state reduction	Analyze asynchronous sequential circuit	Dynamic hazards	Xilinx 3000 series FPGA
	SLO-2	Shannon's Expansion theorem application	state reduction	flow table reduction	Essential hazards	Xilinx 3000 series FPGA
S-2	SLO-1	Shannon's Expansion theorem and its application	state assignment	races-state assignment	Programming logic device families	Xilinx 4000 series FPGA
	SLO-2	Consensus theorem	state assignment	Variables Signals, Constants, Sequential statements VHDL processes	Designing synchronous sequential circuit using PROM	Xilinx 4000 series FPGA
S 3-4	SLO-1	Lab 1: Implement six-variable function using four-variable function generators	Lab 4: Implement hazard-free circuits	Lab 7: VHDL Programming Practice	Lab 10: Construct multiplexers, de-multiplexers in VHDL	Lab13: Implement BCD adder, comparator in VHDL
	SLO-2					
S-5	SLO-1	Reed-Muller Expansion technique	Design of synchronous sequential circuits	races-state assignment	Designing synchronous sequential circuit using PROM	Design of sequential circuits (using VHDL)
	SLO-2	Reed-Muller Expansion technique	Design of synchronous sequential circuits	Transition table and problems in transition table	Designing synchronous sequential circuit using PROM	Design of sequential circuits (using VHDL)
S-6	SLO-1	Multiplexer logic as function generators	Introduction to VHDL, Entity and Architecture description	Transition table and problems in transition table	Programmable Array Logic (PAL)	Design of sequential circuits (using VHDL)
	SLO-2	Implementation of Multiple output logic functions	VHDL Data types and Operators	Design of asynchronous sequential circuit	Programmable Array Logic (PAL)	Design of sequential circuits (using VHDL)
S 7-8	SLO-1	Lab 2: Implement Reed-Muller expressions using logic gates.	Lab 5: Demo of VHDL programmes, Simple programmes	Lab 8: Combinational Circuit Design using Structural, behavioral, data flow modeling	Lab 11: Construct code converters, 4-bit binary adders in VHDL	Lab 14: Mini Project Work
	SLO-2					

S-9	SLO-1	*Mealy and Moore machines*	*ASM chart and realization using ASM*	*Design of asynchronous sequential circuit*	*Programmable Logic Array (PLA)*	*Additional circuit designs using VHDL*
	SLO-2	*Clocked synchronous sequential circuit design procedure*	*ASM chart and realization using ASM*	*Design of asynchronous sequential circuit*	*Programmable Logic Array (PLA)*	*Additional circuit designs using VHDL*
S-10	SLO-1	*State diagrams*	*Concurrent, Sequential Assignment Statements, Types of Modeling in VHDL*	*Static hazards*	*FPGA-Xilinx FPGA*	*Additional system designs using VHDL*
	SLO-2	*State table*	*Behavioral, dataflow and structural modeling*	*Static hazards*	*FPGA-Xilinx FPGA*	*Additional system designs using VHDL*
S 11-12	SLO-1	*Lab 3: Implementation of Sequence detector circuit.*	*Lab 6: VHDL Programming Practice*	*Lab 9: Implement Combinational Circuits using Structural, behavioral and data flow modeling- Arithmetic circuits, decoders, encoders.*	*Lab 12:* BCD adder, comparator, Design of Sequential circuits (using VHDL)	*Lab 15: End-Semester Practical Examinations*
	SLO-2					

Learning Resources	1. *Charles H. Roth, Jr. University of Texas at Austin. Larry L. Kinney, Fundamentals of Logic Design, 7th ed., Cengage Learning, 2012* 2. *Richard S. Sandige, Michal L. Sandige, Fundamentals of digital and computer design with VHDL, Mc Graw Hil, 2014*	3. *Jayaram Bhasker, A VHDL Primer, 3rd ed., Prentice Hall, 2011* 4. *Charles. H. Roth, Jr, Digital Systems Design using VHDL, CENGAGE Learning, 2010* 5. *Morris Mano M, Michael D. Ciletti, Digital Design with an Introduction to the Verilog HDL, 5th ed., Pearson, 2014*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE207J	Course Name	Real Time Operating Systems	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18CSS101J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Develop application program in ARM based hardware, we need to know, C and assembly programming and IDE.
CLR-2 :	Interface pheripherals, and hence gain the knowledge of programming, need to be known.
CLR-3 :	Study RTOS principles
CLR-4 :	Study RTOS principles of various types
CLR-5 :	Develop application programming of sample projects
CLR-6 :	Study and understand, how OS on ARM processor can be implemented and used.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	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	PSO 1 Professional Achievement	PSO 2 Project Management Techniques	PSO 3 Analyze & Research
CLO-1 :	Read and understand many microprocessor instruction sets and their use.	2	80	50	M												H		
CLO-2 :	Implement and write code in assembly and C for embedded applications.	3	99	70		H	H		M				M				H		
CLO-3 :	Understand the concepts and requirements of RTOS, in general basic OS principles.	2	80	70					M								H		
CLO-4 :	Implement and use RTOS for embedded programs	3	90	70			H	M	M				M				H		
CLO-5 :	Apply the knowledge in related sample use cases.	2	90	85	L	L			L										M
CLO-6 :	Design processor based embedded systems along with OS implementation. (Specifically RTOS)	2	90	70	L	M	H	M	M				M				H		L

Duration (hour)		Learning Unit / Module 1 Cortex-M processor & 'C'	Learning Unit / Module 2 Peripheral Programming in 'C'	Learning Unit / Module 3 Concepts of RTOS	Learning Unit / Module 4 RTOS Implementation	Learning Unit / Module 5 RTOS Applications
		15	15	15	15	15
S-1	SLO-1	Cortex-M processor architecture	Parallel I/O programming	Introduction to RTOS	Process management	Real time systems: Data acquisition system
	SLO-2	Cortex-M processor architecture	Sample programs	Introduction to RTOS	Dynamic linking and loading	Real time systems: Data acquisition system
S-2	SLO-1	ARM Cortex assembly language – part1	Interrupt processing basics	Concurrent programming	Spin-lock semaphore, cooperative scheduling	Performance metrics
	SLO-2	ARM Cortex assembly language – part2	System tick; periodic interrupts	Thread fundamentals	Thread rendezvous	Examples and discussions
S 3-4	SLO-1	**Lab 1: Arm Assembly language programming**	**Lab 4: Interrupts and timers in C and assembly**	**Lab 7: Simple thread programming in RTOS – Wave form simulation**	**Lab 10: Semaphore implementation experiment in RTOS**	**Lab 13: Any application program using RTOS.**
	SLO-2					
S-5	SLO-1	ARM Cortex microcontroller interface standards	UART programming	Shared resources and Critical sections	FIFO & Little's theorem	Solid state disk
	SLO-2	IDE software tools	UART programming	Consumer producer problem	Three semaphore implementation	Flash device driver
S-6	SLO-1	Pointers in C	Digital signal time measurement	Switching threads	Thread sleeping	SD card interface

	SLO-2	*Arrays, structures and unions, Linked lists*	*Use of timers and compare, capture registers.*	*Profiling the OS*	*Deadlocks, monitors*	*Communication systems with Ethernet*
S 7-8	SLO-1 SLO-2	***Lab 2: C & assembly programming using Keil IDE and kit***	***Lab 5: Debugging hardware with target board – UART interface programming***	***Lab 8: Multi threaded application in RTOS – LED blinking with multi threads***	***Lab 11: Multi threaded application with communication -1***	***Lab 14: Model lab examination***
S-9	SLO-1	*Embedded debugging tools in Keil IDE*	*SSI interface*	*Semaphores and implementation*	*Fixed scheduling*	*Application layer protocols for embedded systems*
	SLO-2	*Embedded debugging example with simulation*	*SSI programming with interrupt*	*Operations on semaphores*	*Fixed scheduling*	*CoAP, MQTT*
S-10	SLO-1	*Memory management -1*	*Analog I/O; A/D converter interfacing*	*Resource sharing*	*Kahn process networks*	*Discussions & Reviews*
	SLO-2	*Memory management -2*	*OS considerations of I/O devices*	*Thread communications*	*Review*	*Discussions & Reviews*
S 11-12	SLO-1 SLO-2	***Lab 3: Practice: C & assembly programming using Keil IDE and kit***	***Lab 6: Debugging hardware with target board – Analog I/O programming***	***Lab 9 : Multi threaded application in RTOS, with semaphores***	***Lab 12: Multi threaded application with communication -2***	***Lab 15: Final Lab Examination***

Learning Resources	1. ***Jonathan Valvano, "Real time operating systems for ARM Cortex-M Microcontrollers, Embedded systems - Volume 3", ARM Educational Media, 2017.*** 2. ***Andrew Slosset all, "ARM system developers guide", Elsevier, 2004.***	3. ***Quing Li, "Real time techniques for embedded systems", CMP Books, 2003.*** 4. ***K.C. Wang, "Embedded and Real time operating systems", Springer, 2017.*** 5. ***Theory/Lab Session teaching materials, " RTOS kit", ARM Educational media***

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE301J	Course Name	CMOS ANALOG IC DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC206J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Identify Analog IC Design process flow and IC biasing			
CLR-2 :	Analyze the operation and frequency response of CMOS single stage amplifiers			
CLR-3 :	Analyze operation and frequency response of the Differential amplifiers and Op-amp			
CLR-4 :	Create insights to the concepts of noises in amplifiers			
CLR-5 :	Utilize the concepts of oscillators and switched capacitor circuits			
CLR-6 :				

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Identify IC Biasing concepts	2	80	70
CLO-2 :	Analyze Single stage amplifiers	2	85	75
CLO-3 :	Analyze Differential Amplifiers and Op-amp	2	75	70
CLO-4 :	Identify the noises in Amplifiers	2	85	80
CLO-5 :	Identify oscillators and switched capacitors circuits	2	85	75
CLO-6 :				

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
H	H	-	-	H	-	-	-	-	-	-	-	-	-	-
H	H	-	-	H	-	-	-	-	-	-	-	-	-	-
H	-	-	H	H	-	-	-	-	-	-	-	-	-	-
H	H	-	-	H	-	-	-	-	-	-	-	-	-	-
H	-	H	-	H	-	-	-	-	-	-	-	-	-	-

Duration (hour)		12	12	12	12	12
S-1	SLO-1	IC Design Philosophy : Introduction to MOSFET scaling	CMOS Single stage Amplifiers: Analog Design Octagon	Differential Amplifier: MOS Differential Pair- Operation with Common mode input	Noise in Amplifiers: Statistical characteristics of noise	Oscillators: General Considerations
	SLO-2	Analog IC design process flow, Typical values of IC MOSFET parameters	Common Source stage with resistive load	Operation with differential input	Statistical characteristics of noise-contn	Ring oscillators
S-2	SLO-1	IC Biasing: MOSFET current source	CS stage with diode connected load	Small signal operation of MOS differential pair- Differential gain	Types of Noises- Thermal Noise, flicker noise	LC oscillators
	SLO-2	Effect of the output resistance of the current source load	CS stage with current source load	Common mode gain, CMRR	Noise Model- MOSFET, Resistor	Cross coupled oscillators
S 3-4	SLO-1	Lab 1: Basic MOS Circuits: MOSFET as a switch & Inverter using HSPICE	Lab 4: Common source amplifier with resistive load and diode connect load	Lab 7: Differential amplifier	Lab 10: Noise analysis and a measure of noise figure in CS, CG and CD amplifier	Lab 13: Switched capacitor circuits
	SLO-2					
S-5	SLO-1	Basic MOSFET current mirror-operation	CS stage with triode load	Differential amplifier with current source load	Representation of noise in circuits	One port oscillators
	SLO-2	Study on the effects which deviates performance of the current mirror	CS stage with source degeneration	Cascode Differential amplifier	Representation of noise in circuits-Contn	Colpitt oscillator
S-6	SLO-1	Cascode Current mirror	Source Follower	Frequency response of the differential amplifier	Noise Analysis of CS stage	Voltage Controlled oscillators
	SLO-2	Cascode Current mirror- contn. and problem solving	Common gate stage	Frequency response of the differential amplifier- contn..	Noise Analysis of CD stage	Voltage Controlled oscillators-contn

S 7-8	**SLO-1**	*Lab 2: Basic MOS current mirror, Current mirror circuit to overcome the channel length modulation effect*	*Lab 5: Common gate amplifier and Source follower*	*Lab 8: One stage op-amp*	*Lab 11: Ring oscillator*	*Lab 14: Pre and Post layout simulation of CMOS inverter using Cadence EDA (Virtuoso tool)*
	SLO-2					
S-9	**SLO-1**	*Wilson MOS current mirror*	*Cascode Amplifier*	*Multistage Amplifiers: Performance parameters of Op-Amp*	*Noise Analysis of CG stage*	*Switched Capacitors circuits: Basic principles*
	SLO-2	*MOS current steering circuits*	*Folded Cascode amplifier*	*One stage op-amp*	*Noise Analysis of Cascode stage*	*Sampling switches*
S-10	**SLO-1**	*Band gap reference circuits*	*Frequency response of CS amplifier*	*Two stage op-amp*	*Noise Analysis of Differential amplifier*	*Switched capacitor amplifier*
	SLO-2	*Band gap reference circuits-contn.*	*Frequency response of CS amplifier - Contn*	*Two stage op-amp with gain boosting*	*Noise Bandwidth, Noise Figure Concepts*	*Switched capacitor integrator*
S 11-12	**SLO-1**	*Lab 3: Cascode current mirror, Wilson current mirror*	*Lab 6: Cascode amplifier*	*Lab 9: Two stage op-amp*	*Lab 12: Voltage Controlled oscillators*	*Lab 15: Pre and Post layout simulation of CMOS Amplifier using Cadence EDA (Virtuoso tool)*
	SLO-2					

Learning Resources	1. *Adel S. Sedra, Kenneth C.Smith, "Microelectronic Circuits-Theory and Applications "– 6th Edition, Oxford University Press, 2011.* 2. *Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Mc Graw Hill, 2001*	3. *Allen Holberg, "CMOS Analog Circuit Design", Oxford University Press, 2004* 4. *Gray, Meyer, Lewis, Hurst, "Analysis and Design of Analog Integrated Circuits", 4th edition, Willey International, 2002.*

Learning Assessment

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

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

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Course Code	18ECE302T	Course Name	MEMS TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify the characteristics and various technology adopted in MEMS fabrication
CLR-2 :	Understand the electrical and mechanical phenomenon used in MEMS design
CLR-3 :	Analyze how to apply electrostatic and thermal principles in MEMS components design
CLR-4 :	Study the application of piezoresistive, piezoelectric principle and the design of microfluidic devices
CLR-5 :	Classify the application of polymer in MEMS application, also to explore the principle and application of optical, and RF MEMS devices
CLR-6 :	Study the mechanics of miniaturization, learning various micro fabrication technologies and the application of mechanisms used in MEMS sensor and Actuators design.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Acquire the knowledge of MEMS devices principles and microfabrication techniques	2	75	60
CLO-2 :	Understand` the essential electrical and mechanical concepts of MEMS.	2	75	60
CLO-3 :	Familiarize about electrostatic and thermal sensing principles and actuating technique.	2	75	60
CLO-4 :	Attain the knowledge of piezoresistive, piezoelectric and magnetic sensing and actuating technique and microfluidic devices	2	75	60
CLO-5 :	Be familiar with the polymers material used in MEMS, design and exposure on optical and RF MEMS.	2	75	60
CLO-6 :	Understand the mechanics of miniaturization, familiar with various micro fabrication technologies and able to design MEMS sensor and Actuators based on the required application.	2	75	60

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

Duration (hour)		INTRODUCTION TO MEMS AND MICRO FABRICATION	ELECTRICAL AND MECHANICAL CONCEPTS OF MEMS	ELECTROSTATIC AND THERMAL PRINCIPLE SENSING AND ACTUATION	PIEZORESISTIVE, PIEZOELECTRIC AND MAGNETIC PRINCIPLE SENSORS AND ACTUATOR	POLYMER, OPTICAL, RF MEMS AND ITS APPLICATION
		9	9	9	9	9
S-1	SLO-1	History of MEMS Development	Conductivity of semiconductors	Electrostatic sensing - Parallel plate capacitor	Piezoresistive sensors -piezoresistive sensor material	Polymers in MEMS- polymide,SU-8, Liquid crystal polymer (LCP)
	SLO-2		Problems on conductivity of semiconductors	Problems on electrostatic sensing		
S-2	SLO-1	Characteristics of MEMS – Miniaturization,	Crystal plane and orientation- Single crystal Si (FCC, Miller Indices and notation, crystal planes & characteristics, flats & wafer identification)	Electrostatic actuation Parallel plate capacitor	Stress in flexural cantilever and membrane	Polymers in MEMS- PDMS, PMMA , Parylene, Fluorocarbon
	SLO-2	Microelectronics integration - Mass fabrication with precision		Problems on electrostatic actuation		
S-3	SLO-1	Miniaturization and scaling	Stress and strain - definition , Relationship between tensile stress and strain	Electrostatic sensing and actuation- Application - Inertial, pressure and tactile sensor	Piezoelectric sensing and actuation- piezoelectric material properties	Optical MEMS-passive MEMS optical components-lenses-mirrors
	SLO-2	Sensors and Actuators- Energy domains and example devices for each				

S-4	**SLO-1**	Micro fabrication process - Bulk and Surface Micromachining	Stress and strain - definition , Relationship between tensile stress and strain	Electrostatic sensing and actuation- Application - parallel plate actuator comb drive	Quartz - PZT-	Actuation for active optical MEMS.
	SLO-2				PVDF -ZnO -Applications	
S-5	**SLO-1**	Silicon based MEMS processes- processing anisotropic wet etching	Flexural beam bending analysis under single loading condition	Problems on electrostatic sensing and actuation	Magnetic actuation- Principles- Deposition of magnetic materials	RF MEMS: Switches
	SLO-2	Isotropic wet etching				
S-6	**SLO-1**	Dry etching (plasma etching, ion milling, RIE, DRIE)	Types of beam, longitudinal strain under pure bending	Thermal sensing and Actuations- sensors and actuators based on thermal expansion	Design and fabrication of magnetic coil	RF MEMS - Filters, oscillators
	SLO-2	Photolithography,				
S-7		Thin film deposition -sputtering, evaporation,	Deflection of beam- Spring constant	Thermocouples	Microfluidics – Concepts of fluid mechanics	MEMS Packaging
		Thin film deposition - LPCVD, PECVD	Problems: Deflection of beam- Spring constant	Thermal resistors		
S-8	**SLO-1**	Thin film deposition - sputtering, evaporation, LPCVD, PECVD	Torsional deflection, intrinsic stress	Application of thermal sensors – Inertial, Flow, Infrared.	Microfluidics –Application: Channels, valves	MEMS Testing
	SLO-2	Thin film deposition - plating, spin-on				
S-9	SLO-1	New material and fabrication processing techniques	Resonance and quality factor	Problems on thermal sensing and actuation	Microfluidics – Application valves	Reliability issues in MEMS packaging
	SLO-2	Points of consideration for processing structural and sacrificial material.				

Learning Resources	1. Chang Liu, "Foundations of MEMS", Second Edition, Pearson , 2017 2. Tai-Ran Hsu, MEMS & Microsystem Design and Manufacturing, McGraw Hill Education (India) 1st Edition , 2015. 3. Gaberiel M. Rebiz, "RF MEMS Theory,Design and Technology", John Wiley & Sons, 2010. 4. Microsystem Design - by S. Senturia; Publisher: Springer., 5. Charles P. Poole and Frank J. Owens, "Introduction to Nanotechnology", John Wiley & Sons, 2009. 6. Julian W.Gardner and Vijay K Varadhan, "Microsensors, MEMS and Smart Devices", John Wiley & sons, 2013. 7. Fundamentals of Microfabrication - by M. Madou; Publisher: CRC Press; 2 edition.

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE303T	Course Name	*Nanoelectronic Devices and Circuits*	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ECC102J*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	**Learning**		
		1	*2*	*3*
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Identify the need and effects of device miniaturization*			
CLR-2 :	*Understand the principles of nano devices*			
CLR-3 :	*Learn about new devices at nano scale*			
CLR-4 :	*Create insights to the concepts of nano CMOS circuits*			
CLR-5 :	*Analyze the design considerations of the circuits*			
CLR-6 :	*Utilize the design procedure in circuits*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*				**Program Learning Outcomes (PLO)**														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	*Realize the importance of scaling of devices.*	*2*	*80*	*70*	*H*	*M*	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*
CLO-2 :	*Identify the difference of nano devices from conventional devices.*	*2*	*85*	*75*	*H*	-	-	*M*	-	-	-	-	-	-	-	-	*M*	-	
CLO-3 :	*Analyze the performance measures of various devices*	*2*	*75*	*70*	*H*	-	*M*	*H*	*H*	-	-	-	-	-	-	-	-	-	*H*
CLO-4 :	*Choose appropriate application of the device*	*2*	*85*	*80*	*H*	*H*	-	-	-	*H*	*L*	*H*	-	-	-	-	-	*L*	*H*
CLO-5 :	*Understand the design considerations of nano circuits*	*2*	*85*	*75*	*H*	-	*H*	*H*	*M*	-	-	-	-	-	-	-	-	-	*M*
CLO-6 :	*Apply the design concepts of nano circuits in real time applications*	*2*	*80*	*70*	*H*	*M*	-	-	-	*H*	*L*	*H*	-	-	-	-	*M*	-	*M*

Duration (hour)		**Introduction to Nano Devices**	**Silicon MOSFETs- Novel Materials and Alternative Concepts**	**Nano Devices – Principles and Techniques**	**Nano- CMOS scaling Problems and Implications**	**Mixed Signal Circuit Design**
		9	**9**	**9**	**9**	**9**
S-1	**SLO-1**	MOS transistor- A First Glance at the Device	SOI MOSFET, partially depleted	Classical transport: classical resistance and conductance	Design Methodology in the Nano-CMOS Era	Design Considerations – Device Modeling
	SLO-2	The MOS Transistor under Static Condition	fully depleted SOI	Quantum ballistic transport: quantum Resistance and conductance	Innovations needed to continue performance scaling -	Passive Components
S-2	**SLO-1**	MOS Transistor Capacitances- Channel Capacitance	Strained channel MOSFET,	Coulomb blockade effect	Sub-100-nm Scaling Challenges- Back-End-of-Line Challenges (Metallization)-	Design Using Thin Oxide Devices – Design Using Thick Oxide Devices
	SLO-2	Junction Capacitance	Hi-k gate dielectric, Metal gate electrode	Single Electron Transistor	Interconnect scaling-copper wire technology	Low-Voltage Techniques
S-3	**SLO-1**	The Actual MOS Transistor—Some Secondary Effect	Double gate MOSFET	Performance of the single-electron transistor	Low –k dielectric challenges-future global interconnect technologies	Design Procedures
	SLO-2	Challenges in Nanoscale MOSFETs	FinFET	SET technology and Field effect transistors	Front-End-of-Line Challenges (Transistors)-Quantum effects model	Electrostatic Discharge Protection
S-4	**SLO-1**	Scaling of transistor dimensions	Tunnel Effect	Carbon Nano Tube(CNT)	Polysilicon gate , Metal gate electrodes,	Multiple-Supply Concerns
	SLO-2	Moore's law	Tunneling through a potential barrier	Electronic properties of CNT	Direct tunneling gate leakage-Parasitic capacitance	Noise Isolation
S 5-6	**SLO-1**	Short Channel Effects (SCE) : Sub-threshold Conduction,	Potential energy profiles for material interfaces	Geometrical structure, Electronic structure of CNT Transport properties	Reliability concerns	Guard Ring Structures Isolated NMOS Devices
	SLO-2					

S-7	**SLO-1**	Drain Induced Barrier Lowering	Metal -insulator, metal -semiconductor	CNTFET, comparison of Si MOSFET with CNTFET	Process Control Reliability	Epitaxial Material versus Bulk Silicon –
	SLO-2	Velocity Saturation, Hot electrons	Metal –insulator -metal junctions	FeFET	Lithographic Issues	Decoupling
S-8	**SLO-1**	Emergence of new materials,	Tunneling Diode	Principle of Spintronics	Mask Data Explosion	Power Busing
	SLO-2	Hi-k materials and its issues	Resonant Tunneling diode	Spin valves, SpinFET	New Breed of Circuit	Integration Problems
S-9	SLO-1	metal gate, copper interconnect and	Three-terminal resonant tunneling devices	Magnetic Tunnel Junctions	– Physical Design – Modeling Challenges	Corner Regions
	SLO-2	low-k interlayer dielectric	inverter and logic OR gates based on RTD	MRAM	Need for Design Methodology Changes	Neighboring Circuitry

Learning Resources	1. *Rainer Waser (Ed.), "Nanoelectronics and Information Technology",Wiley-VCH, Third, Completely Revised and Enlarged Edition, 2012.* 2. *Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic," Digital Integrated Circuits 2nd edition", Pearson, 2000.* 3. *Ban P. Wong, Anurag Mittal, YuCao, Gren Starr, "Nano- CMOS Circuit and Physical Design", John Willey and sons Publication, 2005*	4. *George W. Hanson, "Fundamentals of Nanoelectronics", Prentice Hall, 20073.Karl Goser, Peter GlÖsekötter,Jan Dienstuhl, "Nanoelectronics and Nanosystems", Springer, 2004* 5. *Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press, 2012*

Learning Assessment

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

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

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Course Code	18ECE304T	Course Name	Microwave Integrated Circuits	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC105T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Create the insights of microwave circuits
CLR-2 :	Analyze matching networks and filter design
CLR-3 :	Identify and implement amplifiers and oscillators
CLR-4 :	Layout the types of mixers and control circuits
CLR-5 :	Utilize techniques to fabricate and measurement of MICs
CLR-6 :	Analyze and realize microwave circuits and its techniques

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the different types of MICs, different MIC devices and parameters to be used in MICs	2	75	60
CLO-2 :	Explore the concept of frequency parameters, ZY smith chart and its interpretation in the analysis and design of matching circuits	2	75	60
CLO-3 :	Understand the design of Amplifiers and Oscillators	2	75	60
CLO-4 :	Explore the different Mixer types and Microwave diodes	2	75	60
CLO-5 :	Understand Micro fabrication of MIC devices and measurement techniques of MICs	2	75	60
CLO-6 :	Comprehend the MICs, fabrication and measurement of MIC devices	2	75	60

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

Duration (hour)		Introduction to MIC	Matching Circuits	Microwave Amplifiers and Oscillators	Mixers and Microwave Diodes	MIC Measurement Techniques
		9	9	9	9	9
S-1	SLO-1	Introduction to MICs	Circuit Representation of two port RF/Microwave Networks	Introduction to amplifiers	Introduction to Mixers	Microwave Integrated Circuits : Introduction to SOC, SOP
	SLO-2			Stability considerations in active networks		
S-2	SLO-1	Frequency Bands	Low Frequency Parameters	Gain Consideration in Amplifiers	Mixer Types	MIC Materials.
	SLO-2	Lumped versus Distributed Circuits	High Frequency Parameters			
S-3	SLO-1	Behavior of finite length transmission lines	Transmission Matrix	Noise Consideration in active networks	Conversion Loss	Hybrid versus Monolithic MICs
	SLO-2					
S-4	SLO-1	General Characteristics of PC Boards	ZY Smith Chart	Broadband Amplifier design	SSB Mixers	Multichip Module Technology
	SLO-2			Low Noise Amplifier Design	DSB Mixers	
S-5	SLO-1	Transmission Lines on PC Boards	ZY Smith Chart	Introduction to oscillators	Design of Mixers: Single Ended Mixers	Fabrication Techniques
	SLO-2					
S-6	SLO-1	Passives made from Transmission Lines	Design of Matching Circuits using Lumped Elements	Oscillator versus Amplifier Design	Single Balanced Mixers	Miniaturization techniques
	SLO-2					
S-7	SLO-1	Resonators	Design of Matching Circuits using Lumped Elements	Oscillation conditions	Sub Harmonic Diode Mixers	Test fixture measurements
	SLO-2		Matching Network Design using Distributed			

			Elements			
S-8	**SLO-1**	Combiners and Splitters	Matching Network Design using Distributed Elements	Design and stability considerations of Microwave Transistor Oscillators.	Microwave Diodes	probe station measurements
	SLO-2					
S-9	**SLO-1**	Couplers	Filter design	Design and stability considerations of Microwave Transistor Oscillators.	Phase Shifters and PIN Diode Attenuators	thermal and cryogenic measurements
	SLO-2					

Learning Resources	1. Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004 2. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics", Pearson Education, II Edition 2002 3. Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy. 4. Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989. 5. Gupta K.C. and Amarjit Singh, "Microwave Integrated Circuits", John Wiley, New York, 1975.	6. Hoffman R.K. "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987. 7. Ulrich L. Rohde and David P.N., " RF / Microwave Circuit Design for Wireless Applications", John Wiley, 2000. 8. C. Gentili, "Microwave Amplifiers and Oscillators", North Oxford Academic, 1986. 9. Samuel. Y. Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice Hall. Inc., 1987.

Learning Assessment

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

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Course Code	18ECE305J	Course Name	ARM -SoC	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECE204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Study the hardware architecture of ARM Cortex-M core			
CLR-2 :	Study the AHB (high speed bus) and peripherals			
CLR-3 :	Study the AHB (high speed bus) and peripherals			
CLR-4 :	Program high speed peripherals			
CLR-5 :	Study APB bus and peripherals. Designing applications with CMSIS			
CLR-6 :	Understand and learn to use ARM Cortex-M processor architecture, and deice level programming.			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Explain hardware and register architecture of ARM Cortex-M based processors	2	80	70													H		
CLO-2 :	Explain AHB and its signals, and program high speed peripherals	3	80	70		M	H	L	H								H		M
CLO-3 :	Understand AHB and its signals and program high speed peripherals	3	80	70		H	H	L	H								H		M
CLO-4 :	Program high speed peripherals with case study.	3	80	60		M	H		H								M		
CLO-5 :	Program device driver and create libraries.	3	80	60		M	H		M								M		
CLO-6 :	Perform system programming of ARM Cortex-M based processor.	3	80	60		M	H	L	H								M		

Duration (hour)		12 ARM Cortex-M architecture	12 ARM Internal bus	12 ARM pheripherals	12 SOC programming	12 Case studies
S-1	SLO-1	*Introduction to Programmable SoC*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*Programming an SOC using C language*	*Graphics LCD interfacing*
	SLO-2	*Introduction to Programmable SoC*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*Programming an SOC using C language*	*Graphics LCD interfacing*
S-2	SLO-1	*ARM architecture*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*APB Bus*	*Board support package*
	SLO-2	*ARM architecture*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*APB Bus*	*Board support package*
S 3-4	SLO-1	***Lab-1:ARM Keil IDE usage – sample ARM program.***	***Lab 4: Study of AHB peripheral***	***Lab 7:*** *Multinode I2C Bus*	***Lab 10: Making a device driver***	***Lab 13: Case study – 2***
	SLO-2					
S-5	SLO-1	*ARM Register architecture*	*AHB SRAM controller*	*AHB timer*	*ARM CMSIS*	*Ethernet interfacing*
	SLO-2	*ARM Register architecture*	*AHB SRAM controller*	*AHB timer*	*ARM CMSIS*	*Ethernet interfacing*
S-6	SLO-1	*ARM assembly language*	*AHB SRAM controller*	*AHB-APB bridge*	*Device drivers*	*Ethernet interfacing*
	SLO-2	*ARM assembly language*	*Review and discussions*	*AHB-APB bridge*	*Device drivers*	*Ethernet interfacing*
S	SLO-1	***Lab 2: Assembly language***	***Lab 5: ARM memory management***	***Lab 8: Application of timers***	***Lab 11: Using CMSIS***	***Lab 14: Model lab examination***

7-8	SLO-2	***programming of ARM processor using Keil IDE***				
S-9	SLO-1	*ARM Cortex-M Architecture -1*	*AHB VGA peripheral*	*Fast GPIO programming*	*Application programming*	*Student Seminar / discussions*
	SLO-2	*ARM Cortex-M Architecture -1*	*AHB VGA peripheral*	*Fast GPIO programming*	*Application programming*	*Student Seminar / discussions*
S-10	SLO-1	*ARM Cortex-M Architecture -2 (pipelines)*	*AHB VGA peripheral*	*Interrupt mechanism of ARM*	*Case study - 1*	*Student Seminar / discussions*
	SLO-2	*ARM Cortex-M Architecture -2*	*AHB VGA peripheral*	*Interrupt mechanism of ARM*	*Case study - 2*	*Student Seminar / discussions*
S 11-12	SLO-1	***Lab 3: Parallel port programming***	***Lab 6: Graphics application***	***Lab 9: Experimenting*** *Interrupts, Timers*	***Lab 12: Study of USB interface***	***Lab 15: Final lab examination***
	SLO-2					

Learning Resources	1. *Steve Furber, "ARM System on a Chip Architecture – 2nd Edition", Pearson Education, 2000.* 2. *"AMBA -3 APB Protocol", ARM Limited, 2003.* 3. *"AMBA -3 AHB Lite Protocol", ARM Limited, 2003.*	4. *Theory/Lab teaching materials, "Introduction to SoC kit", ARM Education media, 2018.*

Learning Assessment

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

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

Course Code	18ECE306J	Course Name	ARM based Digital Signals Processing	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECE204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the concepts of DSP, discrete time signals and its properties.			
CLR-2 :	Understand applications of transforms in solving digital signal processing			
CLR-3 :	Study FIR filters			
CLR-4 :	Study IIT filters			
CLR-5 :	Understand the usage of adaptive filter techniques			
CLR-6 :	Understand the usage of DSP in embedded ARM Cortex-M processor platform			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Apply theory and application of discrete time signals	3	80	70		M	-	-	M	-	-	-	-	-	-	-	H	-	L
CLO-2 :	Apply theory and implementing methods of Z-transforms, DFT and FFT.	3	80	70		H	-	-	M	-	-	-	-	-	-	-	H	-	L
CLO-3 :	Apply FiR filter theory and processor implementation in C.	3	80	70		H	-	-	M	-	-	-	-	-	-	-	H	-	L
CLO-4 :	Apply IIR filter theory and processor implementation in C	3	80	60		H	-	-	M	-	-	-	-	-	-	-	H	-	L
CLO-5 :	Implement adaptive filter design theory, methods and its uses.	2	80	60		H	-	-	L	-	-	-	-	-	-	-	H	-	L
CLO-6 :	Apply the theory and implementation aspects of DSP in ARM Cortex-M based processor platform.	3	80	60		H	-	-	M	-	-	-	-	-	-	-	H	-	L

Duration (hour)		Learning Unit / Module 1 Basics of digital signals	Learning Unit / Module 2 Transforms for DSP	Learning Unit / Module 3 FIR filters	Learning Unit / Module 4 IIR filters	Learning Unit / Module 5 DSP applications
		12	12	12	12	12
S-1	SLO-1	DT Signals-basics properties &Operations on DT signals	Z-Transform Properties	Design of Finite Impulse Response Filters-Symmetric and Antisymmetric FIR filters	Frequency Response and Characteristics of Analog Filters	Introduction-Steepest Descent Method-Least Mean Squares Method
	SLO-2	DT Signals-basics properties &Operations on DT signals	Z-Transform Properties	Design of Finite Impulse Response Filters-Symmetric and Antisymmetric FIR filters	Frequency Response and Characteristics of Analog Filters	Introduction-Steepest Descent Method-Least Mean Squares Method
S-2	SLO-1	DT systems-Properties of DT Systems – LTI system	Inverse Z-Transform-solving Difference Equation	Design of Linear- Phase FIR filters Using window methods	IIR Filter Design by Impulse Invariance	Adaptive Filters: Prediction and System Identification
	SLO-2	DT systems-Properties of DT Systems – LTI system	Inverse Z-Transform-solving Difference Equation	Design of Linear- Phase FIR filters Using window methods	IIR Filter Design by Impulse Invariance	Adaptive Filters: Prediction and System Identification
S 3-4	SLO-1 SLO-2	***Lab 1: Introduction- Keil MDK-ARM application development Environment.***	***Lab 4: LTI System Implementation***	***Lab 7: Filter Structures in the CMSIS-DSP Library***	***Lab 10: IIR Filter Structures in the CMSIS-DSP Library***	***Lab 13: CMSIS Implementation of the LMS and Normalized LMS methods***
S-5	SLO-1	*Convolution and Correlation*	*DFT-review; problems*	*Design of Linear- Phase FIR filters Using window methods*	*Design of Butterworth filter using Bilinear Transformation*	*Adaptive Filters: Equalization and Noise Cancellation*
	SLO-2	*Convolution and Correlation*	*DFT-review; problems*	*Design of Linear- Phase FIR filters Using window methods*	*Design of Butterworth filter using Bilinear Transformation*	*Adaptive Filters: Equalization and Noise Cancellation*

S-6	**SLO-1**	*CT-to DT Conversion Sampling Theorem in the Time Domain*	*DIT-FFT Radix 2 butterfly derivation - problems*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Bilinear Transformation*	*Adaptive Filters: Adaptive FIR Filter*
	SLO-2	*CT-to DT Conversion Sampling Theorem in the Time Domain*	*DIT-FFT Radix 2 butterfly derivation - problems*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Bilinear Transformation*	*Adaptive Filters: Adaptive FIR Filter*
S 7-8	**SLO-1**	***Lab 2: Digital Signals-operations on Digital Signals***	***Lab 5: Calculating the DFT-FFT***	***Lab 8: FIR Filter Design***	***Lab 11: IIR Filter Design***	***Lab 14: Model Practicals***
	SLO-2					
S-9	**SLO-1**	Sampling Theorem in the Frequency Domain-Aliasing	Filtering in the FD-Circular & Convolution	Design of Optimum Equiripple Linear-Phase FIR filters	Chebyshev Filter Designs based on the Impulse Invariance	Review, Problems and Discussions
	SLO-2	Sampling Theorem in the Frequency Domain-Aliasing	Filtering in the FD-Circular & Convolution	Design of Optimum Equiripple Linear-Phase FIR filters	Chebyshev Filter Designs based on the Impulse Invariance	Review, Problems and Discussions
S-10	**SLO-1**	Reconstruction in the Frequency Domain & time Domain	Filtering in the FD-Linear Convolution	Filter Design using Software	Filter Design using Software	*Review, Problems and Discussions*
	SLO-2	Reconstruction in the Frequency Domain & time Domain	Filtering in the FD-Linear Convolution	Filter Design using Software	Filter Design using Software	*Review, Problems and Discussions*
S 11-12	**SLO-1**	***Lab 3: A-D & D-A conversion-Changing the Sampling Frequency***	***Lab 6: Filtering in the Frequency Domain***	***Lab 9: Implementing a FIR Filter using Different Structures***	***Lab 12: Implementing a Filter using Different Structures***	***Lab 15: University practicals***
	SLO-2					

Learning Resources	1. *Cem Unsalan, M. Yerkin Yuccel, H. Deniz Gurham, "Digital Signal Processing Using ARM Cortex-M based microcontrollers, Theory and Practice", ARM Education Media, 2018.*	2. *Theory/Lab teaching materials, ARM Educational Media.*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Anuj Kumar, Bombardier* Transportation, Ahmedabad, *kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor* of ECE, CEG, Anna University, *meena68@annauniv.edu*	*1. Prof. V. Natarajan, SRMIST*
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Course Code	18ECE307J	Course Name	Applied Machine Learning	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understanding the Machine Learning concept and types
CLR-2 :	Analyze the ML algorithm performance byLearning Curve and error
CLR-3 :	Applying ML algorithm for solving practical problems
CLR-4 :	Create insights to the concepts and programming of supervised and unsupervised ML methods
CLR-5 :	Analyze and understand the working principle and model development of Evolutionary Learning
CLR-6 :	Create insights to the concepts and programming of Reinforcement learning

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	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: Professional Achievement	PLO 14 PSO – 2: Project Management Techniques	PLO 15 PSO – 3: Analyze & Research
CLO-1 :	Apply Genetic Algorithm for evalualionary learning	2	80	70	H	H	H	-	-	-	-	-	-	-	-	-	-	-	H
CLO-2 :	Analyze Reinforcement learning	2	85	75	H	H	-	H	H	-	-	-	-	-	-	-	-	-	H
CLO-3 :	Apply linear model of linear regression and SVM for classification problem	2	75	70	H	H	H	H	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	Apply neural network and CNN for classification problem	2	85	80	H	H	H	H	H	-	-	-	-	-	-	-	H	-	H
CLO-5 :	Apply Decision Trees , clustering For classification problem	2	85	75	H	H	H	H	H	-	-	-	-	-	-	-	H	-	H
CLO-6 :	Apply probability model of Bayesian decision theory and HMM for classification problem	2	80	70	H	H	H	H	H	-	-	-	-	-	-	-	H	-	H

Duration (hour)		Introduction to Machine Learning and Linear Model	Multiplayer Perceptrons and Decision Tree	Clustering, SOM and HMM	Bayes Network, Reinforcement Learning and CNN	Genetic Algorithm and Application of ML
		12	12	12	12	12
S-1	SLO-1	Introduction to Machine learning: Types of Machine Learning - Supervised Learning – Unsupervised, Learning	Multiplayer, Perceptrons	Clustering	Bayesian decision theory	The Genetic Algorithm
	SLO-2	reinforcement learning , The Curse of dimensionality	Multiplayer, Perceptrons	K-Means clustering	Bayesian decision theory	The Genetic Algorithm
S-2	SLO-1	Bias and Variance, Learning Curve	Multiplayer, Perceptrons	Hierarchical clustering	Bayesian estimation	Facial Expression Recognition
	SLO-2	Classification, Error and noise,linear regression	Multiplayer, Perceptrons	Agglomerative clustering	Bayes network	Human Emotion Research
S-3,4	SLO-1	**Lab 1: Linear Regression**	**Lab 4: Multiplayer, Perceptrons**	**Lab 7: K-Means clustering**	**Lab 10: Bayes Network**	**Lab 13: Genetic Algorithm**
	SLO-2					
S-5	SLO-1	Support Vector Machines	example of using MLP	Vector Quantization	Reinforcement learning	Facial Expression Recognition System
	SLO-2	Support Vector Machines	example of using MLP	Vector Quantization	Reinforcement learning	Facial Expression Recognition System
S-6	SLO-1	Support Vector Machines	example of using MLP	The Self-Organizing Feature Map	Reinforcement learning	Speech Emotion Recognition
	SLO-2	Support Vector Machines	example of using MLP	The Self-Organizing Feature Map	Reinforcement learning	Speech Emotion Recognition
S-7,8	SLO-1	**Lab 2: Support Vector Machines**	**Lab 5: MLP application**	**Lab 8: SOFM**	**Lab 11: Reinforcement learning**	**Lab 14: Speech Emotion Recognition Basic classification**
	SLO-2					

S-9	**SLO-1**	*basics of neural network*	*Decision Trees- classification*	*HMM*	*Understanding Convolutions*	*Neural Network Multi-Layer Perceptron Modeling For Surface Quality Prediction in Laser Machining*
	SLO-2	*Perceptrons*	*regression tree,*	*HMM*	*Understanding Convolutions*	
S-10	**SLO-1**	*LINEAR SEPARABILITY*	*pruning, rule from tree and data*	*HMM*	*CNN Building Blocks*	*Machine Learning in Cybersecurity-Supervised Learning for Misuse/Signature Detection*
	SLO-2	*Perceptrons and introduction to Multiplayer, Perceptrons*	*multivariate tree*	*HMM*	*CNN Building Blocks*	*Machine Learning in Cybersecurity-Supervised Learning for Misuse/Signature Detection*
S-11,12	**SLO-1**	***Lab 3: Perceptrons***	***Lab 6: Decision Trees***	***Lab 9: HMM***	***Lab 12: CNN***	***Lab 15:Mini project***
	SLO-2					

Learning Resources	1. *Ethem Alpaydin, "Introduction to Machine Learning", 3rd edition,MIT Press,2014.* 2. *Stephen Marsland, "Machine Learning –An Algorithmic Perspective", 2nd edition, CRC Press,2015.* 3. *Sumeet Dua and Xian Du , "Data Mining and Machine Learning in Cybersecurity",CRC Press, 2011.* 4. *Aurélien Géron Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems. O'Reilly Media,2017.*	5. *Yagang Zhang, "Application of Machine Learning", Published by In-Tech, 2010.* 6. *Starter Bundle, "Deep Learning: A Practitioner's Approach",O'Reilly Media,2017.* 7. *Dr. Adrian Rosebrock, "Deep Learning for Computer Vision with Python", Packt Publisher,2018.* 8. *Ankur A Patel, "Hands-On Unsupervised Learning Using Python: How to Build Applied Machine Learning Solutions from Unlabeled Data", O'Reilly media,2019.*

Learning Assessment"

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

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

Course Designers

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1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. P. Vijayakumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE220T	Course Name	Advanced Mobile Communication Systems	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC301T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Gain knowledge about the latest Standards from 3G to 5G systems.
CLR-2 :	Introduce the concepts of OFDM systems and standards.
CLR-3 :	Study the basics of MIMO system and the impact of different channel models on it.
CLR-4 :	Understand the techniques of cognitive radio spectrum sensing and sharing
CLR-5 :	Study the techniques of Millimeter wave communication
CLR-6 :	Apply the knowledge gained to various Advanced Mobile Communication Systems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	Apply the architecture and functionalities of 3G and 4G systems	2,3	85	80
CLO-2 :	Understand the concepts of OFDM and it issues	2,3	80	85
CLO-3 :	Understand the MIMO communication systems	2,3	85	80
CLO-4 :	Understand the principle of Cognitive Radio Techniques	2,3	80	75
CLO-5 :	Acquire the concept of millimeter wave communication	2,3	85	80
CLO-6 :	Able to analyze the Advance Mobile communication systems			

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

Duration (hour)		Advanced cellular mobile communication systems	Multicarrier modulation technique-OFDM	MIMO systems	Cognitive Spectrum management	Millimeter wave communication
		9	9	9	9	9
S-1	SLO-1	Overview of the legacy 3GPP cellular systems	Introduction to OFDM	Introduction to MIMO	Cognitive transceiver Introduction	Millimeter Wave Characteristics
	SLO-2	Overview of the legacy 3GPP cellular systems	Multicarrier Modulation Introduction	Introduction to MIMO Channel Capacity	Cognitive transceiver architecture	Introduction to Channel Performance at Mm wave communication
S-2	SLO-1	WiMAX systems: Introduction	Multicarrier Modulation	MIMO Channel Estimation	Interweaving	Channel Performance at Mm wave communication
	SLO-2	WiMAX systems: Architecture	Cyclic Prefix	MIMO Channel Estimation	Principle of interweaving	Modulation for Millimeter Wave communication
S-3	SLO-1	WiMAX systems: Architecture	Channel model	MIMO Spatial Multiplexing	Principle of interweaving	Modulation for Millimeter Wave communication
	SLO-2	WiMAX systems : Frame structure	SNR	MIMO Spatial Multiplexing	Introduction to Spectrums	Millimeter wave transmitter
S-4	SLO-1	WiMAX systems : Frame structure	SNR Performance	V- BLAST 2	Types of Spectrum	Millimeter wave Receiver
	SLO-2	WiMAX systems : Applications	SNR Problems	V- BLAST 2	Spectrum sensing	Millimeter wave Antenna
S 5-6	SLO-1	LTE systems: Introduction	OFDM Introduction	MIMO Diversity	Advantages of Spectrum sensing	Introduction Mm wave Communications
	SLO-2					
S-7	SLO-1	LTE systems: Architecture	OFDM Issues	MIMO Diversity	Disadvantages of Spectrum sensing	Emerging applications of Mm wave Communications

	SLO-2	*LTE systems: Architecture*	*OFDM Issues*	*Alamouti*	*Disadvantages of Spectrum sensing*	*Emerging applications of Mm wave Communications*
S-8	**SLO-1**	*LTE systems: Frame structure*	*PAPR*	*Alamouti*	*Spectrum Management*	*Millimeter Wave Standards.*
	SLO-2	*LTE systems: Frame structure*	*Frequency and timing*	*OSTBC*	*Spectrum Management*	*Introduction to Millimeter Wave Standards.*
S-9	SLO-1	*LTE systems: applications*	*Frequency offset issues.*	*MIMO :OFDM system Introduction*	*Spectrum Management*	*Development of Millimeter Wave Standards.*
	SLO-2	*LTE systems: applications*	*Timing offset issues.*	*MIMO :OFDM system*	*Spectrum Management*	*Development of Millimeter Wave Standards.*

Learning Resources	1. Andrea Molisch, "Wireless Communication", Cambridge University Press, 2nd edition, 2013. 2. Theodre Rappaport, "Wireless Communication: Principle and Practice", Prentice Hall, 2nd edition, 2014. 3. Kao-Cheng Huang, Zhaocheng Wang, "Millimeter Wave Communication System", Wiley-IEEE Press, 2nd edition, 2011. 4. EzioBigleri, "MIMO Wireless Communications", Cambridge University Press, 1st edition, 2007.	5. Arslan, Hüseyin, ed. *Cognitive radio, software defined radio, and adaptive wireless systems*. Springer Science & Business Media, 2007.(263-284) 6. Thomas W.Rondeau, Charles W. Bostain, "Artificial Intelligence in Wireless communication", ARTECH HOUSE .2009 {pp1-51] 7. Andrew Goldsmith, Wireless Communications, Cambridge University Press, 2005. 8. Mischa Dohler, Jose F. Monserrat Afif Osseiran " 5G Mobile and Wireless Communication Technology", Cambridge University Press 2016.

Learning Assessment

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

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

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

Course Code	18ECE221T	Course Name	RADAR AND NAVIGATIONAL AIDS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Get introduced to basics of Radar System
CLR-2 :	Impart the knowledge of different types of Radar
CLR-3 :	Analyze the various detection schemes
CLR-4 :	Understand the Radar transmitters and Receivers
CLR-5 :	Understand the fundamentals of navigation system
CLR-6 :	Acquire knowledge on theoretical concepts and analysis techniques related to different types of Radar and various navigational aids

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Gain knowledge about Radar theory and Range equation	2	80	70
CLO-2 :	Apply Doppler principle to Radars and hence understand the working principle of different types of Radar	2	85	75
CLO-3 :	Gain knowledge on Radar signal detection methods and propagation as related to Radars	2	75	70
CLO-4 :	Acquire information about Radar transmitters and Radars	2	85	80
CLO-5 :	Understand principles of navigation , in addition to approach and landing aids as related to navigation	2	85	75
CLO-6 :	Understand the principle of operation of Radar in the detection of different types of targets and various navigational aids	2	85	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	H	-	-	M	-	-
-	H	-	-	-	-	-	-	-	-	-	-	M	-	-
H	H	-	-	-	-	-	-	-	-	-	-	-	-	H
H	M	-	-	-	-	-	-	-	M	-	-	M	-	-
H	H	-	-	-	-	-	-	-	H	-	-	-	-	H

Duration (hour)		Introduction To Radar Equation	MTI And Pulse Doppler Radar	Detection Of Signals In Noise	Radar Transmitter And Receiver	Radio Navigation
		9	9	9	9	9
S-1	SLO-1	Introduction-Basic Radar	Introduction to Doppler Radar	Detection of Signals in Noise -Detection Criteria	Radar Transmitters and Receivers.	Introduction - Four methods of Navigation .- Positioning- Errors in Direction Finding
	SLO-2	Radar Frequencies -Applications of Radar	Introduction to MTI Radar	Probabilities of Detection and False Alarm	Linear Beam Power Tubes-Reflex Klystron	Line of sight Distance measurement
S-2	SLO-1	The Simple form of Radar Equation	Delay –Line Cancellers	Matched Filter Receiver	Linear Beam Power Tubes-TWT	Terrestrial Radio Navigation systems
	SLO-2	Tutorials	Delay –Line Cancellers	Derivation of Matched filter frequency response	Solid State RF Power Sources	Radio transmission and Reception
S-3	SLO-1	Radar Block Diagram	Doppler Filter Banks	Automatic Detector	Magnetron - Crossed Field Amplifiers	System design considerations-System Performance Parameters
	SLO-2	Receiver Noise	Digital MTI Processing	Constant-False-Alarm Rate Receivers	Magnetron - Crossed Field Amplifiers	The Loop Antenna - Adcock Direction Finders
S-4	SLO-1	Signal-to-Noise Ratio	Block Diagram of Digital MTI Doppler Signal Processor	Signal Management	Other RF Power Sources	Direction Finding at Very High Frequencies - Automatic Direction Finders
	SLO-2	Integration of Radar Pulses	Moving Target Detector - Limitations to MTI Performance	Propagation Radar Waves- Atmospheric Refraction	Other aspects of Radar Transmitter	VHF Omni Directional Range(VOR) - VOR Receiving Equipment - Range and Accuracy of VOR
S-5	SLO-1	Radar Cross Section of Targets-Simple Targets	Pulse Doppler Radar	Standard propagation	The Radar Receiver	Hyperbolic Systems of Navigation-Loran
	SLO-2	Radar Cross Section of Targets-Complex Targets Transmitter Power	High, Medium and Low prf Doppler	Nonstandard Propagation	Receiver noise Figure	Loran-C

S-6	**SLO-1**	Radar cross Section Fluctuations	*Other Doppler Radar Topics*	Ambiguity Diagram	Receiver noise Figure	The Decca Navigation System -Decca Receivers
	SLO-2	*Swerling Target Model*	*Tracking with Radar*	Ambiguity Diagram	Super heterodyne Receiver	Range and Accuracy of Decca
S-7	SLO-1	*Transmitter Power*	*Mono pulse Tracking*	Pulse compression	LNA and Mixers	TACAN
	SLO-2	*Pulse Repetition Frequency*	*Two Coordinate amplitude comparison monopulse tracking*	Linear FM pulse compression	Duplexers	TACAN Equipment
S-8	SLO-1	*Antenna Parameters*	*Conical Scan and Sequential Lobing*	Binary Phase Coded pulse compression	Receiver Protectors	Case study on Airborne Tactial networks-Instrument Landing System
	SLO-2	*System losses-Microwave plumbing loss, Antenna loss, Signal Processing loss*	*Limitations to Tracking Accuracy*	***Questionnaire***	Receiver Protectors	Case study on Airborne Tactial networks-Instrument Landing System
S-9	SLO-1	*System losses-Doppler processing, Collapsing, Operator loss, propagation Effects*	*Case study on weather radars*	Introduction to clutter	Radar Displays	Introduction to satellite Radio Navigation-
	SLO-2	*Other Radar Equation Considerations*	*Case study on weather radars*	Surface Clutter Radar equation	*Surprise Test*	Navstar Global Positioning System (GPS)

Learning Resources

1. *Merrill I. Skolnik," Introduction to Radar Systems", 3rd Edition Tata Mc Graw-Hill 2008*
2. *R.B. Underdown and David Cockburn, "Ground Studies for Pilots: Radio Aids", sixth Edition, Blackwell Publishing, 2011.*
3. *Myron Kayton, Walter R.Fried, "Avionics Navigation Systems", second Edition, Wiley- India Edition, 2010*.
4. *N*.S.Nagaraja, "Elements of Electronic Navigation Systems", 2nd Edition, TMH, 2000.
5. Mark, Richards.A, "Fundamentals of radar signal processing", Mc-Graw Hill, Electronic Engineering, 1st Edition, 2005.
6. Jenny L. Reed, Aaron D. Lanterman, John M. Trostel," Tutorial: Weather Radar: Operation and Phenomenology", IEEE Aerospace and Electronic Systems Magazine, Vol: 32, 7, 2017.
7. Bow-Nan Cheng, Frederick J. Block, B. Russ Hamilton, David Ripplinger, Chayil Timmerman, Leonid Veytser, and Aradhana Narula-Tam," Design Considerations for Next-Generation Airborne Tactical Networks, IEEE Communications Magazine , May 2014.

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE222T	Course Name	ADHOC AND SENSOR NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Utilize the Ad hoc Networks and its various routing protocols
CLR-2 :	Learn the MAC Layer and the concept of Quality of Service
CLR-3 :	Analyze energy management in Ad hoc Networks
CLR-4 :	Identify insights of Sensor network
CLR-5 :	Analyze various aspects Hybrid networks and routing configuration
CLR-6 :	Expose to the different types of adhoc network routing protocols and sensor networks

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Acquire knowledge about Ad hoc Networks and various routing protocols used in Ad hoc networks	3	80	75	H	M	L	M	-	-	H	-	-	-	-	M	-	-	H
CLO-2 :	Analyze the various functional areas such as MAC Layer and QOS	3	80	70	H	M	-	M	-	-	H	-	-	-	-	M	M	-	H
CLO-3 :	Identify energy management in Ad hoc Networks	3	75	70	L	H	-	M	-	-	M	-	-	-	-	H	-	-	L
CLO-4 :	Analyze the Sensor network	3	80	75	H	L	-	M	-	-	-	-	-	-	-	-	-	M	H
CLO-5 :	Identify Hybrid networks and routing configuration	3	80	70	-	-	H	M	-	-	M	-	-	-	-	-	-	-	-
CLO-6 :	Understand the various types of adhoc networks and sensor networks	3	80	70	H	M	-	L	-	-	H	-	-	-	-	M	-	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Cellular and Ad hoc Wireless Networks	Quality of service in Ad hoc wireless networks, Real-Time Traffic support	Energy Management-Needs	Sensor Networks, Applications. Comparison with Ad hoc network,	Hybrid wireless network, Introduction, classification
	SLO-2	Applications of Ad hoc Wireless Networks	Issues and challenges in providing QoS	Classifications of Energy Management Schemes	Issues, challenges in designing sensor network Sensor Network Architecture	Multi-hop cellular network (MCN) Architecture
S-2	SLO-1	Issues in Ad hoc Wireless Networks	Classifications of QoS solutions	Battery Management Scheme-Overview,	Layered Architecture, Clustered Architecture	Mobile assisted data forwarding (MADF) Architecture
	SLO-2	MAC Protocol for Ad hoc Networks Issues in Designing and Design Goals	MAC Layer solution-cluster TDMA, IEEE 802.11e, DBASE	Data link layer solution-Lazy packet scheduling scheme,	Data Dissemination, Flooding, Gossiping, Rumor Routing, Sequential Assignment Routing	Hybrid wireless Network (HWN) Architecture
S-3	SLO-1	Classifications of MAC protocols-Floor Acquition Multiple Access protocols	Network Layer solution-QOS routing protocols,	Battery Aware MAC protocol	Cost field approach	Routing in Hybrid wireless network Base assisted ad hoc routing (BAAR)
	SLO-2	Collision Avoidance Time Allocated Protocol	Ticket Based QOS Routing protocols,	Network Layer solution	Data Gathering, Direct Transmission, Binary scheme	Operation of BAAR protocol
S-4	SLO-1	Routing Protocol for Ad hoc wireless network-Classification	Predictive location based QOS routing	Transmission Power Management Schemes-Data link layer solution	Chain Based Three level scheme	Base driven multi-hop bridging protocol(BMBP)-Message used
	SLO-2	Table driven Routing Protocols-Wireless Routing Protocol	QOS frame work	Dynamic power adjustments policies, Distribute topology control Algorithm	MAC protocols for sensor Networks-Self organizing MAC, CSMA Based MAC	BMBP procedure
S-5	SLO-1	On demand routing protocols-Dynamic Source Routing protocol	QOS models	Construct distributed power control loop, Centralized Topology control Algorithm	Location discovery-Indoor and sensor network localization	Issues in pricing Multi-Hop wireless networks
	SLO-2	Multicast Routing Architecture Reference model	QOS Resource Reservation Signaling	Network layer solution-common power protocol	Quality of Sensor Networks-coverage,	Pricing in Multi-Hop wireless WANs
S-6	SLO-1	Tree Based Routing	INSIGNIA-QOS framework	Minimum power consumption Technique	Exposure	Pricing in Ad hoc Wireless Networks

	SLO-2	*Mesh Based Routing*	*Operation of INSIGNIA framework, Advantages and disadvantages*	*Minimum battery cost Routing*	*Recent Trends in Sensor Networks-Energy Efficient Design, synchronization*	*Power control scheme in Hybrid Wireless Networks, Issues in using variable power in IEEE 802.11*
S-7	SLO-1	*Energy Efficient Multicasting-Routing protocols*	*INORA-Coarse feedback scheme,*	*Higher Layer solution*	*Transport Layer Issue*	*Power optimization scheme*
	SLO-2	*Cluster Adaptation of Multicast protocols*	*Class based fine feedback scheme*	*System power management scheme, Processor power management*	*Security-Localized Encryption and Authentication protocols (LEAP)*	*Load Balancing in Hybrid Wireless Networks*
S-8	SLO-1	*Multicast with QOS Guarantees-Real Time Multicasting Protocols*	*SWAN-Model*	*Power saving Mode Power Aware Multi-Access Signaling*	*Intrusion Tolerant Routing in Wireless Sensor Network (INSENS)*	*Preferred Ring Based Routing Scheme*
	SLO-2	*Priority Scheduling Protocols*	*Advantages and Disadvantages*	*Addition of separate signaling scheme*	*Real –Time communication*	*Preferred inner Routing Scheme(PIRS)*
S-9	SLO-1	*Application Dependent Multi Cast Routing-Role Based,*	*Proactive RTMAC framework*	*Device power Management Scheme-Low Power Design of Hardware*	*SPEED Protocol*	*Preferred outer Ring Routing Scheme (PORS)*
	SLO-2	*Content Based, Location Based*	*Advantages and Disadvantages*	*Hard Disk Drive (HDD) power consumption*	*RAP protocols*	*Preferred Destination/Source Ring Based Routing Scheme*

Learning Resources	1. *Siva Ram Murthy C., Manoj B.S, Ad hoc Wireless Networks – Architectures and Protocols, 2nd ed., Pearson, 2004* 2. *Feng Zhao, LeonidasGuibas,Wireless Sensor Networks, 1st ed., Morgan Kaufman Publishers, 2004*	3. *C.K.Toh, Ad hoc Mobile Wireless Networks, 7th ed., Pearson, 2002* 4. *Thomas Brag, Sebastin Buettrich, Wireless Mesh Networking, 3rd ed., O'Reilly Publishers, 2007*

Learning Assessment

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

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

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

Course Code	18ECE223T	Course Name	Satellite Communication and Broadcasting	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC205J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the orbital and functional principles of satellite communication systems			
CLR-2 :	Architect, interpret, and select appropriate technologies for implementation of specified satellite communication systems			
CLR-3 :	Analyze and evaluate a satellite link and suggest enhancements to improve the link performance			
CLR-4 :	Select an appropriate modulation, multiplexing, coding and multiple access schemes for a given satellite communication link			
CLR-5 :	Specify, design, prototype and test analog and digital satellite communication systems as per given specifications			
CLR-6 :	Utilize the concepts in optical communication for the understanding of engineering and technology			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the principles, concepts and operation of satellite communication systems	2	80	70
CLO-2 :	Gain the knowledge of Satellite orbits and launching, link design, link availability and perform interference calculations	2	85	75
CLO-3 :	Analyze the concepts of Satellite systems in relation to other terrestrial systems	2	75	70
CLO-4 :	Evaluate the performance of various channel access schemes	2	85	80
CLO-5 :	Familiarize with applications of satellites and compression standards	2	85	75
CLO-6 :	Apply their idea in Satellite communication module	2	80	70

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

Duration (hour)		Satellite Orbit	Link Design	Space and Earth Segment	Multiple Access Techniques for Satellite Communication	Broadcast and Services
		9	9	9	9	9
S-1	SLO-1	Satellite Orbit	Link Design	Space Segment	Concepts of Multiple Access techniques, types	Concept of Broadcasting satellites
	SLO-2	Kepler's law	EIRP	Basic concept of space segmen	Single Access	Direct Broadcasting Satellite
S-2	SLO-1	Earth - Orbiting satellites terms	Transmission Losses	Power Supply	Pre assigned FDMA	Orbital Spacing
	SLO-2	Types of satellites	Link Power Budget equation	Altitude control	Demand Assigned FDMA	Power ratings
S-3	SLO-1	Orbital elements	System Noise	Station keeping	SPADE system	Frequency and polarization
	SLO-2	Orbit Perturbations	Carrier to noise ratio	Thermal Control	TWT amplifier operation	Transponder Capacity
S-4	SLO-1	Inclined Orbits	Types of FEC	TT&C Subsystems	Downlink analysis	Bit rate
	SLO-2	Sun synchronous orbits	Computer-Aided Design	Antenna subsystem	TDMA	MPEG

S-5	**SLO-1**	*Constellation:Geo stationary satellites*	*Uplink*	*Transponders*	*Reference bursts*	*Forward Error Correction*
	SLO-2	*Non geostationary constellation*	*saturation flux density, input backoff*	*Wideband Receiver*	*Preamble, Postamble*	*Outdoor Unit*
S-6	**SLO-1**	*Launching of Geostationary satellites*	*Down Link*	*Earth Segment*	*Carrier recovery*	*Indoor Unit*
	SLO-2	*Launch vehicle Types*	*output backoff, TWTA output*	*Basic concept of Earth segment*	*Network synchronization*	*Downlink Analysis*
S-7	**SLO-1**	*Antenna Look angles*	*Effects of rain*	*Receive only home TV system*	*Pre assigned TDMA*	*Uplink Analysis*
	SLO-2	*Sun transit outage*	*Inter modulation Noise*	*Community antenna TV system*	*Demand assigned TDMA*	*Satellite Mobile services*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*CDMA*	*VSAT*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Direct Sequence Spread Spectrum , CDMA throughput*	*GPS*
S-9	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Learning Resources	6. *Dennis Roddy, "Satellite Communications", Tata Mc-Graw Hill Publications, 4th Edition, 13th Reprint, 2014* 7. *TIMOTHY PRATT, CHARLES BOSTIAN JERMEY ALLNUTT, Satellite Communications, John Wiley, Singapore, 2nd Edition, reprint 2013.*	8. *MadhavendraRichharia, Leslie David, "Satellite Systems for Personal Applications Concepts and Technology", Wiley-Blackwell, 1st Edition, 2010.* 9. *Louis J. IppolitoJr, "Satellite Communications Systems Engineering", John Wiley and Sons , Ltd, Publication, 1st Edition, 2008*

Learning Assessment

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

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

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

Course Code	18ECE224T	Course Name	CRYPTOGRAPHY AND NETWORK SECURITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication 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 :	Utilize classical and modern encryption methods			
CLR-2 :	Utilize the different key generation standards			
CLR-3 :	Utilize the various techniques in authentication of information			
CLR-4 :	Analyze the aspects in network security			
CLR-5 :	Identify the effect of various malwares and counter measures			
CLR-6 :	Understand various conventional and modern cryptography techniques with its added security features			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Identify the methods of classical and modern Encryption	3	80	75
CLO-2 :	Identify the concepts of Number theory, Key generation and distribution standards	3	80	70
CLO-3 :	Analyze Message authentication and Digital Signature algorithm.	3	75	70
CLO-4 :	Obtain information about various forms of network security	3	80	75
CLO-5 :	Analyze the effects of intrusion, viruses, firewalls and various levels of system security	3	80	70
CLO-6 :	Obtain the knowledge about various encryption techniques, standards and security aspects	3	80	70

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

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Security Services Mechanisms	Number Theory	Basics of Message authentication codes	IP Security	Intruders
	SLO-2	Attacks	Basics of Modulo operations, additive and multiplicative inverse	Basics of Message authentication codes	Overview of techniques	Intrusion
S-2	SLO-1	Network Security Model	Euclidean algorithm	Requirements of MAC	Architecture	Intrusion Detection
	SLO-2	Block cipher, stream cipher, symmetric and Assymetric	Extended Euclidean algorithm	MAC logic	Authentication Header	Techniques
S-3	SLO-1	Conventional Encryption techniques	Fermet's theorem	MD5 Logic, MD5 Compression Function,	Authentication Protocols	Password Management
	SLO-2	Substitution and transposition techniques	Euler's theorem	MD4, Strength of MD5	Mututal authentication, one way authentication	Techniques
S-4	SLO-1	Steganography	Key cryptography	Requirements for a Hash Function, simple Hash Function,	Encapsulating Security Payload	Viruses
	SLO-2	Basics of LSB, Histogram,DE techniques	Key cryptography	Birthday Attacks, Block Chaining Techniques	Encapsulating Security Payload	Worms
S-5	SLO-1	DES	RSA	Securities	Security Associations	Advanced Security
	SLO-2	Algorithm and examples	Algorithms and examples	HASH - MAC	Techniques overview	OS Security
S-6	SLO-1	SDES	Key distribution	Birthday Attack	Kerbros V4, V5 certificate	WLAN Security
	SLO-2	Block cipher modes operation	Algorithms	SHA	Authentication Procedure	Ad hoc Network Security

S-7	SLO-1	*Overview of IDEA*	*Key Management*	*Digital Signature standard*	*PGP*	*GSM Security*
	SLO-2	*Overview of Blowfish*	*Algorithms*	*Overview of blocks*	*Email Security*	*E-commerce Security*
S-8	SLO-1	*Overview of RC5*	*Diffie Hellman key exchange*	*Digital Signature Algorithms*	*Web security requirements*	*Cloud Computing Security*
	SLO-2	*Overview of CAST-128*	*Diffie Hellman key exchange*	*Examples*	*SSL -TLS - SET*	*Introduction to Firewall*
S-9	SLO-1	*Characteristics of advanced symmetric Block ciphers*	*Elliptic curve cryptography*	*Basics of proof*	*Port Scanning*	*Firewall-Types, configurations*
	SLO-2	*Characteristics of advanced symmetric Block ciphers*	*Elliptic curve cryptography*	*Proof of DSS Message Authentication Codes.*	*Port Knocking*	*Trusted System*

Learning Resources	1. *William Stallings, Cryptography & Network Security,6th ed., Pearson, 2014* 2. *Bruce Schneier, Applied Cryptography, 2nd ed., 2015* 3. *Eric Maiwald,Fundamentals of Network Security, Tata McGraw Hill, 2011*	4. *BehrouzA.Forouzan, Debdeep Mukhopadhyay, Cryptography and Network Security, 2nd ed., Tata McGraw Hill, 2010* 5. *Bernard Menezes, Network Security and Cryptography, Cengage Learning, 2010*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE225T	Course Name	Information Theory and Coding	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB203T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/ Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Introduce source coding in information theory
CLR-2 :	Impart the fundamentals of error control coding techniques and their applications
CLR-3 :	Address the noisy channel coding problem
CLR-4 :	Assess the performance of both block and convolutional coding schemes in different practical situations
CLR-5 :	Derive Shannon's fundamental channel capacity results
CLR-6 :	Know about channel and impairments channel and how to mitigate them

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Comprehend various source coding schemes	2	80	70
CLO-2 :	Apply variable length codes for source coding	2	85	75
CLO-3 :	Apply linear block codes for error detection and correction	2	75	70
CLO-4 :	Apply convolution codes for performance analysis & cyclic codes for error detection and correction.	2	85	80
CLO-5 :	Design the channel performance using Information theory	2	85	75
CLO-6 :	Analyse any type of channel and select coding techniques to improve channel performance			

Program Learning Outcomes (PLO)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-2 :	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-3 :	-	H	-	-	-	-	-	-	-	-	-	-	-	H	-
CLO-4 :	-	H	-	-	-	-	-	-	-	-	-	-	-	H	-
CLO-5 :	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	-	H	-	-	-	-	-	-	-	-	-	-	-	-	H

Duration (hour)		Source coding	Variable-Length Codes	Error Detecting and Error Correcting Codes	Convolutional Codes	Entropy and Channel Capacity
		9	9	9	9	9
S-1	SLO-1	**Introduction to Information theory**	Unique decoding	Hamming codes Generation	Convolutional codes introduction	Entropy
	SLO-2	Model of signaling system	**Rules and construction of** Unique decoding	**Hamming code checking**	Convolutional codes generation	Mathematical properties
S-2	SLO-1	**Block Diagram**	Instantaneous codes	Hamming weight	Convolutional encoder	Entropy and coding
	SLO-2	Mathematical models for information sources	Construction of Instantaneous codes	Hamming distance	**Encoder for different rates**	System entropies
S-3	SLO-1	Encoding a source alphabet	The Kraft's inequality	Minimum distance decoding	code tree formation	Mutual information
	SLO-2	**Source coding**	Shortened block codes	Linear block codes Generator polynomial	code tree formation	**Example Problem solving-** Mutual information
S-4	SLO-1	ASCII code	The McMillan's Inequality	Linear block codes Generation	state diagram generation	Shannon-Fano coding
	SLO-2	**Code Formation for an information**	Huffman codes	Linear block codes Decoding	state diagram generation for different rates	**Example Problem solving-** Shannon-Fano coding
S-5	SLO-1	Radix r code	Huffman codes -special cases	**Example Problem solving-** Linear block codes	trellis diagram for decoding convolutional codes	Classification of channels
	SLO-2	**Different examples for different 'r'**	Extensions of a code	Cyclic codes Generator polynomial	trellis diagram for decoding convolutional codes	Channel Capacity
S-6	SLO-1	Simple parity checks – Generator	Huffman codes Radix r	Cyclic codes Generation	Maximum likelihood decoding of convolutional codes	Calculation of channel capacity

	SLO-2	Simple parity **Checker**	**Example Problem solving in Huffman coding**	Cyclic codes Decoding	Maximum likelihood decoding of convolutional codes	**Types of channel**
S-7	**SLO-1**	CRC codes-Generation	**Example Problem solving in Huffman coding-special cases**	**Example Problem solving -**Cyclic codes	Sequential decoding of convolutional codes-	Conditional mutual information
	SLO-2	CRC codes-Checking	Noise in Huffman coding probabilities	**Example Problem solving-** Syndrome calculation	Sequential decoding of convolutional codes	Random encoding
S-8	**SLO-1**	Single parity checks	Use of Huffman codes	Block encoders	Applications of Viterbi decoding	Average random code
	SLO-2	Double parity checks	Hamming coding	Block Decoders	Viterbi decoding	Fano bound
S-9	**SLO-1**	Miscellaneous codes	**Example Problem solving in Hamming coding**	**Assignment Problems in Linear Block codes**	Turbo codes	Converse of Shannon's theorem
	SLO-2	**Problems in source coding with different radix and parity**	**Assignment Problems in Huffman and Hamming coding**	**Assignment Problems in Cyclic codes**	**Assignment Problems in Convolutional codes**	**Assignment Problems in Channel capacity and mutual information**

Learning Resources	1. Kennedy, "Electronic Communication systems", McGraw Hill, 4th Ed., 1999 2. Daniel Costello, and Shu Lin, "Error Control coding fundamentals and applications", Prentice Hall Inc, 1983 3. Hamming, Richard W, "Coding and Information Theory", Prentice Hall Inc., NJ, 1986.	4. Proakis J. G., "Digital Communications", McGraw Hill Inc., 4th Edition, NY, 2001. *5.* Simon Haykin, "Communication System", Wiley, 2008

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE226T	Course Name	Optical Components, Systems and Networks	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Understand the basics working principle of optical fibers, fiber modes configurations and structures.*			
CLR-2 :	*Learn the various optical source materials, LED structures, quantum efficiency, Laser diodes. To learn the fiber optical network components, switches, EDFA, SOA.*			
CLR-3 :	*Acquire the basic knowledge of fiber optical receivers such as PIN APD diodes, noise performance in photo detector, receiver operation and configuration.*			
CLR-4 :	*Get the knowledge on optical wave guides modulators and other signal degradation factors*			
CLR-5 :	*Understand the basic working principle of WDM, DWDM etc..*			
CLR-6 :	*Understand, the basic optical networks and their applications*			

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	*Familiarize with the fundamentals of light transmission through fiber*	*2*	*80*	*70*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-2 :	*Understand how signal degrades inside the fiber due to physical effects and externally due to various factors like alignment, splicing and connecterization*	*2*	*85*	*75*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-3 :	*Understand the operation of optical sources, amplifiers and detectors and thereby build transmitter and receiver circuits*	*2*	*75*	*70*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	*H*	-	*H*
CLO-4 :	*Familiarize with optical measurements for performance analysis*	*2*	*85*	*80*	*H*	*M*	-	-	-	*M*	*M*	-	-	-	-	-	*H*	-	-
CLO-5 :	*Design a basic optical communication system*	*2*	*85*	*75*	*H*	-	*H*	-	-	-	-	-	-	-	-	-	*H*	-	*M*
CLO-6 :	*Acquire fundamental concepts on multichannel system and related components*	*2*	*80*	*70*	-	-	-	-	*M*	-	-	-	-	-	-	-	-	-	-

Duration (Hour)		Optical Fibers and transmission characteristics	Optical Sources, Amplifier and Transmitter	Optical Detectors and receivers	Optical modulators, switches and OEICs	Optical communication systems
		9	9	9	9	9
S-1	SLO-1	*Elements of Optical fiber communication, Optical spectral bands*	*Introduction to Luminescence: Photo, electro, cathodo, injection luminiscence*	*Photo detection principle*	*Electro optic modulators*	*Point to point links*
	SLO-2	*Optical fiber structure, Light Propagation in Optical fibers: Ray theory , Total Internal reflection, Skew rays, Fiber types: SI, GI, MM, SM*	*Plasma display, LCD*	*Photoconductor,*	*Acousto optic modulators*	*Digital and analog systems design considerations*
S-2	SLO-1	*Overview of Modes, Cutoff wavelength and V number,*	*LED: Choice of material,*	*Noise in photoconductors, SNR*	*Interferometry modulators*	*Digital link design,*
	SLO-2	*Problems on v-number*	*LED Structures; Surface and Edge emitters,*	*Response time*	*Semiconductor optical amplifiers*	*Links power budget*
S-3	SLO-1	*Wave Equations for Step index fiber, Modal equation, Modes in SI fibers*	*Quantum efficiency and power, LED Characteristics*	*Problems on response time and SNR*	*Optical switching and logic devices*	*Rise time budget*
	SLO-2	*Problems on V-number, modes*	*Problems on LED quantum efficiency*	*Problems on Photoconductor*	*Problems on modulators*	*Overview of analog links*
S-4	SLO-1	*Special Fibers introduction, Polarization Maintaining fibers,*	*Semiconductor Laser Diode, Operating principles,*	*Photodiode: PIN Photodiode*	*Optical switching*	*Radio over fibers*

	SLO-2	*Photonic Crystal fibers, Dispersion compensated fiber*	*Emission absorption and radiation*	*Avalanche photodiode*	*Logic devices*	*Key link parameters*
S-5	**SLO-1**	*Attenuation Introduction*	*Population inversion*	*Detector performance parameters*	*Hybrid integration*	*Multichannel systems*
	SLO-2	*Material Adsorption, Scattering, bending and core cladding losses*	*Optical feed- back, Threshold condition*	*Detectors for long wavelength operation*	*Monolithic integration*	*Need for multiplexing*
S-6	**SLO-1**	*Problems*	*External Quantum efficiency, LASER Characteristics*	*wavelength selective detection*	*Comparison of hybrid and monolithic*	*Operating principle of WDM*
	SLO-2	*Overview of Signal dispersion in fibers*	*Problems on LASER quantum efficiency*	*Fundamental receiver operation*	*Slab waveguides*	*Operating principle of DWDM*
S-7	**SLO-1**	*Dispersion limitations, Intermodal dispersion*	*Single mode Laser: VCSEL*	*Front end amplifier and decision circuit*	*Strip waveguides*	*WDM components*
	SLO-2	*Intra-Modal dispersion: Material dispersion,*	*Introduction to Fiber Amplifiers*	*Functional block diagram of receiver circuit*	*Guided wave devices*	*Couplers/splitters*
S-8	**SLO-1**	*Waveguide dispersion and PMD*	*EDFA*	*Measurement standards, basic test equipment*	*Active filters*	*Isolators and circulators*
	SLO-2	*Problems on Dispersion*	*SOA*	*Optical spectrum analyzer*	*Problems*	*Machzender interferometer*
S-9	**SLO-1**	*Non linear effects : Non linear scattering, Kerr effects*	*Modulation characteristics and Driver circuits*	*Oprtical power meter*	*Integrated Transmitter*	*Fabry perot filters*
	SLO-2	*Fiber alignment and Joint Loss, Fiber Splices Optical fiber connectors, Expanded Beam Connectors*	*Functional block diagram of a Transmitter module*	*OTDR*	*Integrated Receivers*	*Optical MEMS*

Learning Resources	1. *Gerd Keiser, "Optical Fiber Communication" McGraw –Hill International, Singapore, 3rd edition, 2000* 2. *J. Wilson and JF B Hawkes "Optoelectronics – An Introduction"' 3rd Edition PearsonEducation Taiwan Ltd 2010* 3. *Pallab Bhattachara "Semiconductors Optoelectronics Devices", 2nd Edition, Prentice Hall of India Pvt Ltd, New Delhi, 2009.* 4. *Jasprit Singh " Optoelectronics- An Introduction to Materials and Devices",Mc Graw HillEducation India 2014.* 5. *S C Gupta " Optoelectronics Devices and systems", 2nd Edition, Prentice Hall of India, 2015.* 6. *S O Kasap "Optoelectronics and Photonics: Principles and practices", 2nd Edition Person Education International, 2012.* 7. *Rajiv Ramaswami, Kumar N. Sivaranjan, "Optical Networks A practical perspective", 2nd edition, Elsevier, 2004* 8. *Djafar K. Mynbaev, Lowell L. Scheiner, "Fiber-Optic Communications Technology", 1st edition, Pearson Education, 2001.* 9. *John Powers, "An Introduction to Fiber optic Systems", 2nd edition, Irwin-McGraw Hill,1999.* 10. *J.Gowar, "Optical Communication System", 2nd edition, Prentice Hall of India, 2001.*

Learning Assessment

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

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

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Course Code	18ECE320T	Course Name	SOFTWARE DEFINED NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC303J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understanding SDN- Evolution
CLR-2 :	Understanding The Control Plane, Data Plane of SDN
CLR-3 :	Analyze and understand various SDN controller
CLR-4 :	Create insights to the standard OpenFlow for SDN
CLR-5 :	understand the Network Programmability for SDN and SDN Open Source
CLR-6 :	understand the Application of SDN and role of SDN in 5G

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning: Level of Thinking (Bloom)	Expected Proficiency (%)	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: Professional Achievement	PLO 14 PSO – 2: Project Management Techniques	PLO 15 PSO – 3: Analyze & Research
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLO-1 :	understand the SDN architecture and benefit	2	80	70	H	-	-	-	H	-	-	-	-	-	-	-	-	H	-
CLO-2 :	Analyze and compare available SDN controller	2	85	75	H	-		H	H	-	-	-	-	-	-	-	-	-	H
CLO-3 :	Program the SDN elements	2	75	70	H		H	H	-	-	-	-	-	-	-	-	H	-	-
CLO-4 :	Apply NVF for next generation networks and 5G	2	85	80	H	H	H	H	H	-	-	-	-	-	-	-	-	-	H
CLO-5 :	Understand the possible application of SDN	2	85	75	H	-		H	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Understand standard OpenFlow	2	80	70	H	-	H	-	H	-	-	-	-	-	-	-	-	-	-

Duration (hour)		Basics of SDN	SDN Devices and Controller	OpenFlow, Programmability and the Management Interface	SDN Application and Use Case	SDN Implementation and Mobile Networks
		9	9	9	9	9
S-1	SLO-1	Introduction to SDN-Evolution of Switches and Control Planes ,Cost	How SDN Works-Fundamental Characteristics of SDN	OpenFlow Overview-The OpenFlow Switch,The OpenFlow Controller,	SDN in the Data Center - Data Center Definition,Data Center Demands	SDN Open Source-Chapter-Specific Terminology ,Open Source Licensing Issues
	SLO-2	Introductionto SDN -SDN Implications for Research and Innovation	SDN Operation, SDN Devices	The OpenFlow Protocol,The OpenFlow Protocol	Tunneling Technologies for the Data Center.	Profiles of SDN Open Source Users ,OpenFlow Source Code,
S-2	SLO-1	need of SDN-Data Center Innovation,	SDN Controller	OpenFlow 1.0 and OpenFlow Basics-Ports and Port Queues,Flow Table,Packet Matching,	Path Technologies in the Data Cente Ethernet Fabrics in the Data Center	Switch Implementations , Controller Implementations SDN Applications
	SLO-2	need of SDN- Data Center Needs	SDN Applications ,Alternate SDN Methods	Actions and Packet Forwarding,Messaging Between Controller and Switch	SDN Use Cases in the Data Center	Simulation, Testing, and Tools, OpenStack, Example: Applying SDN Open Source .
S-3	SLO-1	Genesis of SDN-The Evolution of Networking Technology	General Concepts of SDN Controller	Example: Controller Programming Flow Table ,Example: Basic Packet Forwarding, Example: Switch Forwarding Packet to Controller	Open SDN versus Overlays in the Data Center	SDN Futures-Current State of Affairs
	SLO-2	the Genesis of SDN- forerunners of SDN	VMware	OpenFlow 1.3 Additions and OpenFlow Limitations	Real-World Data Center Implementations	Potential Novel Applications of Open SDN
S-4	SLO-1	the Genesis of SDN- software Defined Networking is Born, Sustaining SDN Interoperability	Nicira	Introduction to Network Programmability and The Management Interface	SDN in Other Environments -Wide Area Networks. Service Provider and Carrier Networks	role of SDN in 5G- Drawback of hardware-based network functions.,Network Functions Virtualization (NFV) and Software Defined Networking (SDN) in

						5G
	SLO-2	*Open Source Contributions, Legacy Mechanisms Evolve Toward SDN , Network Virtualization*	*VMware/Nicira*	*The Application-Network Divide*	*Campus Networks, Hospitality Networks*	*optimization models that aim at finding the optimal design for a mobile core network based on SDN and NFV*
S-5	**SLO-1**	*The Control Plane, Data Plane*	*OpenFlow-Related ,*	*Modern Programmatic Interfaces-Publish and Subscribe Interfaces, XMPP*	*Mobile Networks. In-Line Network Functions,*	*SDN and NFV Mobile Network Architectures*
	SLO-2	*Moving Information Between Planes, Separation Importance*	*Mininet ,NOX/POX*	*Google's Protocol Buffers , Thrift ,JSON*	*Optical Networks*	*Dimensioning and Resource Allocation Problems*
S-6	**SLO-1**	*Distributed Control Planes-IP and MPLS, Creating the IP Underlay, Convergence Time*	*Trema, Ryu*	*I2RS 143 Modern Orchestration-OpenStack*	*SDN vs. P2P/Overlay Networks*	*Mobile Core Network Architecture*
	SLO-2	*Load Balancing ,High Availability, Creating the MPLS Overlay,Replication*	*Big Switch Networks/Floodlight,*	*CloudStack, puppet*	*SDN Applications-reactive versus Proactive Applications ,Analyzing Simple SDN Applications ,*	*SDN Mobile Core Network Architecture*
S-7	**SLO-1**	*Centralized Control Planes-Logical Versus Literal*	*Layer 3 Centric, L3VPN*	*Introduction to Network Function Virtualization, Virtualization and Data Plane I/O*	*A Simple Reactive Java Application,Background on Controllers*	*NFV Mobile Core Network Architecture*
	SLO-2	*ATM/LANE ,Route Servers*	*Path Computation Element Server*	*Services Engineered Path*	*Using the Floodlight Controller, Using the OpenDaylight Controller, Using the Cisco XNC Controller, Using the Hewlett-Packard Controller.*	*Data Plane Function Chains Analysis*
S-8	**SLO-1**	*Introduction to OpenFlow-Wire Protocol*	*Path Computation Element Server*	*Service Locations and Chaining*	*witch Considerations, Creating Network Virtualization Tunnels, Offloading Flows in the Data Center, Access Control for the Campus, Traffc Engineering for Service Providers*	*Control Plane Function Chains Analysis*
	SLO-2	*Replication ,FAWG (Forwarding Abstraction Workgroup)*	*Plexxi Plexxi Affinity*	*Non-ETSI NFV Work-Middlebox Studie*	*SDN Use Cases-Use Cases for Bandwidth Scheduling*	*requirements & challenges of SDN and NVF In 5G*
S-9	**SLO-1**	*Configuration and Extensibility, Architecture*	*Cisco OnePK*	Embrane/LineRate	*Big Data and Application Hyper-Virtualization for Instant CSPF*	*Existing Solutions*
	SLO-2	*Hybrid Approaches , Ships in the Night ,Dual Function Switches*	*Relationship to the Idealized SDN Framework*	*Platform Virtualization*	*use Cases for Input Traffic Monitoring, Classification, and Triggered Action*	*future directions*

Learning Resources	1. *Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014* 2. *SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013* 3. *Cho, Hsin-Hung, et al. "Integration of SDR and SDN for 5G." IEEE Access 2 (2014): 1196-1204.*	4. *Bouras, Christos, Anastasia Kollia, and Andreas Papazois. "SDN & NFV in 5G: Advancements and challenges." Innovations in Clouds, Internet and Networks (ICIN), 2017 20th Conference on. IEEE, 2017.* 5. *Arsany Basta; Andreas Blenk; Klaus Hoffmann; Hans Jochen Morper; Marco Hoffmann; Wolfgang Kellerer, Towards a Cost Optimal Design for a 5G Mobile Core Network Based on SDN and NFV,,IEEE Transactions on Network and Service Management, 2017, Volume: 14, Issue: 4 ,Pages: 1061 - 1075*

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

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

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

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

Course Code	18ECE321T	Course Name	RF AND MICROWAVE SEMICONDUCTOR DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC102J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Study microwave semiconductor materials and to understand the fundamental of electronic components under microwave signal			
CLR-2 :	Learn about microwave components and devices that are used in modern microwave radar and communication systems			
CLR-3 :	Know the characteristics and operation of microwave transistor.			
CLR-4 :	Know the fundamentals of RF power transistors and challenges			
CLR-5 :	Discuss the main issues and challenges encountered in developing the products at microwave frequencies			
CLR-6 :	Acquire deep understanding of development of RF and modern semiconductor devices			

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Understand the properties of Semiconductor Junction Diodes under microwave signals	3	80	75	H	-	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	Analyze the development of negative resistance characteristics in tunnel diode and transit time devices	3	80	70	H	-	-	M	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	Characterize the microwave components and circuits in terms of their performance parameters	3	75	70	H	-	-	H	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	Compare the characteristics of RF power transistors	3	80	75	H	-	-	M	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Appreciate IC packaging issues and challenges involved at microwave frequencies	3	80	70	H	-	H	-	-	-	-	-	-	-	-	-	H	-	M
CLO-6 :	Understand the concepts of RF and semiconductor devices and apply in the design of electronic systems.	3	80	70	H	H	-	-	-	-	-	-	-	-	-		H	-	H

		Semiconductor P-N Junction	Negative Resistance and Transit Time Devices	Microwave BJT Transistors	HEMT Transistors and RF Power Transistor	RF Package Design and Development
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Review of properties of semiconductors	Negative Resistance Devices	Microwave Transistor	Introduction to HEMT	Introduction to RF Package
	SLO-2	Review of properties of semiconductors	Negative Resistance Devices	High frequency limitations of BJT	Short channel effects	Introduction to RF Package
S-2	SLO-1	Transient and ac behavior of p-n junctions	Tunnel Diode, Tunneling process in p-n junction	Microwave bipolar transistors – introduction	Device operation	Thermal Management
	SLO-2	Transient and ac behavior of p-n junctions	V-I characteristics and device performance	Microwave bipolar transistors – operation	Device operation	Thermal Management
S-3	SLO-1	Effect of doping profile on the capacitance of p-n junctions	MIS tunnel diodes	Hetero junction bipolar transistors	Device design	Mechanical Design
	SLO-2	Effect of doping profile on the capacitance of p-n junctions	V-I characteristics and device performance	Basic principle of operation	Scaling issues	Mechanical Design
S-4	SLO-1	Noise in p-n junctions	Backward Diode	Kirk effect	Material Systems for HEMT Devices	Package electrical and electromagnetic Modeling
	SLO-2	Noise in p-n junctions	V-I Characteristics	High frequency response	GaAs HEMT	Package electrical and electromagnetic Modeling
S-5	SLO-1	Varactor diode	Transferred Electron Devices	MESFET	InP HEMT	Design verification
	SLO-2	Construction and Operation of Varactor Diode	Impact ionization	Principle of operation	Technology comparisons	Design verification

S-6	SLO-1	*Applications of Varactor Diode*	*IMPATT*	*Properties of semiconductor materials used in MESFET*	*Technology comparisons*	*Materials testing*
	SLO-2	*Schottky effect*	*Small-signal analysis of IMPATT diodes*	*MESFET Technology*	*Introduction of RF power transistor*	*Reliability testing*
S-7	SLO-1	*Schottky barrier diode*	*TRAPATT, BARITT Diodes*	*MESFET Modeling*	*Figure of Merit for RF Power Transistor*	*computer integrated Manufacturing*
	SLO-2	*Applications of Schottky Diode*	*Two-valley model of compound semiconductors*	*I-V Characteristics*	*Common RF power devices*	*computer integrated Manufacturing*
S-8	SLO-1	*Hetero junctions*	*vd-E characteristics*	*High frequency performance*	*Material properties*	*Thermal modeling*
	SLO-2	*Hetero junctions*	*Gunn Effect, modes of operation*	*MISFET-Introduction*	*State-of-the-art-wide bandgap microwave transistor data*	*Thermal analysis of resistance networks*
S-9	SLO-1	*Construction and operation of microwave PIN diode*	*small-signal analysis of Gunn diode*	*Operating characteristics of MISFET*	*Challenges to production*	*Introduction to computer aided design*
	SLO-2	*Applications*	*Power-frequency limit.*	*Operating characteristics of MISFET*	*Challenges to production*	*Benefits, limitations and applications of CAD*

Learning Resources	*1. Golio, M., "RF and Microwave Semiconductor Devices Handbook", CRC Press (2002).* *2Sze, S.M., and Ng, K.K., "Physics of Semiconductor Devices", 3rd Ed., Wiley-Interscience (2006).*	*3. Glover, I.A., Pennoek, S.R. and Shepherd P.R., "Microwave Devices, Circuits and Sub-Systems", 4th Ed., John Wiley & Sons (2005)* *4. Liao, S.Y., "Microwave Devices and Circuits", 4th Ed., Pearson Education (2002).*

Learning Assessment

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

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

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

Course Code	18ECE322T	Course Name	OPTOELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC102J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify the working and nature of optical wave
CLR-2 :	Identify the working and nature of optical semiconductors
CLR-3 :	Analyze the working principles of different photonic sources
CLR-4 :	Analyze the working principles of different photonic detectors
CLR-5 :	Create knowledge about various optoelectronic applications
CLR-6 :	Familiarize the concepts of optoelectronic integrated circuits

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 :	Review the basics of optics, optical semiconductors	2	85	80
CLO-2 :	Understand the working principle of different photonic sources	4	85	75
CLO-3 :	Familiarize the principle and operation of various detectors	4	85	75
CLO-4 :	Acquire knowledge of various optoelectronic modulators and switches	4	80	70
CLO-5 :	Explore the concepts of optoelectronic integrated circuits and components	4	80	70
CLO-6 :	Design and analyze the working of different components in optical system and use it for various applications.	4	80	70

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

Duration (hour)		WAVE NATURE OF LIGHT AND SEMICONDUCTOR OPTICS	SEMICONDUCTOR PHOTON SOURCES AND DISPLAY DEVICES	SEMICONDUCTOR PHOTON DETECTORS	OPTOELECTRONIC MODULATORS, INTERCONNECTS AND SWITCHES	OPTOELECTRONIC INTEGRATED CIRCUITS (OEIC) AND APPLICATIONS
		9	9	9	9	9
S-1	SLO-1	Light Waves In A Homogeneous Medium-Plane electromagnetic wave, Maxwell's wave equation	LED Principles- Homojunction LED, Heterostructure LED	Principle of Photo Detection	Electro-Optic Modulator: Principles, Electro optic effect	Introduction
	SLO-2	Refractive Index And Dispersion- Sellmeier equation and diamond, Cauchy equation and diamond	Quantum Well High Intensity LEDs	The PIN Photodiode	Single waveguide electro optic modulators	Need For Integration
S-2	SLO-1	Polarization Of Light	LED Materials and Structures	Avalanche Photodiode- Principles, Structures	Dual channel waveguide electro optic modulator	Slab and stripe waveguides
	SLO-2	Snell's law and Total internal reflection	LED Efficiencies and Luminous Flux	Responsivit, Efficiency	Electro optic modulator employing reflection or Diffraction	Basic IO structural elements
S-3	SLO-1	Reflection And Refraction	Manufacturing Process and Applications	Heterojunction Photodiodes	Integrated Optical Modulators: Phase and polarization modulation	IO devices: Optical disk read head
	SLO-2	Solving problems	Solving Problems	Schottky Junction Photodetectors	Mach Zehnder modulator, Coupled waveguide modulator	OIC temperature sensor
S-4	SLO-1	Superposition And Interference Of Waves	LASER: Threshold Condition	Solving problems	Acousto-Optic Modulator: Principles, Acousto optic effect, Raman nath and Bragg type modulators	IO high voltage sensor

	SLO-2	*Diffraction Principles- Fraunhofer diffraction, Diffraction Grating*	*Emission and Absorption of Radiation*	*Solving problems*	*Performance characteristics, Acousto optic frequency shifters*	*IO chemical sensor*
S-5	**SLO-1**	*Overview Of Semiconductors*	*Population Inversion*	*Metal-Semiconductor, Metal Photodiode*	*Solving problems*	*IO wavelength meters and spectrum analyzers*
	SLO-2	*Interaction of Photons With Charge Carriers*	*Principle of the Laser Diode*	*Phototransistors*	*Solving problems*	*RF Spectrum Analyzer*
S-6	**SLO-1**	*Hole Pair Formation And Recombination*	*Heterostructure Laser Diodes*	*Array Detectors*	*Faraday Rotation*	*Monolithic Wavelength-Multiplexed Optical Source*
	SLO-2	*Absorption In Semiconductors*	*Device Fabrication*	*Photoconductive detectors*	*Optical Isolators*	*Analog-To-Digital Converter*
S-7	**SLO-1**	*Effect Of Electric Field On Absorption*	*Solving problems*	*Noise In Photodetectors*	*Nonlinear Optics*	*Integrated-Optic Doppler Velocimeter*
	SLO-2	*Absorption In Quantum Wells*	*Display Device: Photo Luminescence*	*Noise In Photodetectors*	*Second Harmonic Generation*	*Guided Wave Devices*
S-8	**SLO-1**	*Radiation In Semiconductors*	*Cathode Luminescence, Electro Luminescence*	*Solving problems*	*Optical Interconnects*	*Guided Wave Devices*
	SLO-2	*Solving Problems*	*Injection Luminescence*	*Solving problems*	*Optical gates*	*OEIC: Transmitter*
S-9	**SLO-1**	*Heterojunctions*	*Plasma Displays*	*Charge Coupled Devices (CCD)*	*Photonic Switches*	*OEIC: Receiver*
	SLO-2	*Heterojunctions*	*LCD, Numeric Displays*	*Charge Coupled Devices (CCD)*	*Solving problems*	*OEIC phased array antenna driver*

Learning Resources	1. Kasap, "Optoelectronics & Photonics: Principles & Practices", 2nd edition, Pearson Education, 2013. 2. Pallab Bhattacharya "Semiconductor Optoelectronic Devices", 2nd Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2009. 3. B. E. A. Saleh and m.c. Teich, "Fundamentals Of Photonics," 2nd edition, John Wiley & Sons, Inc. 2007.	4. Robert G. Hunsperger, "Integrated Optics- Theory And Technology", Springer, 2009 5. J. Wilson and J F B Hawkes "Optoelectronics- An Introduction", 3rd edition, Pearson Education Taiwan Ltd, 2010. 6. A Ghatak and K Thyagarajan, "Introduction to Fiber Optics", Cambridge University Press 2006.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*40%*	-	*35%*	-	*35%*	-	*40%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*35%*	-	*35%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*20%*	-	*30%*	-	*30%*	-	*20%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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

Course Designers

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

Course Code	18ECE323T	Course Name	Advanced Optical Communication	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC302J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Introduce the advanced features of Fibers and light wave system
CLR-2 :	Illustrate the basics of light wave system and multichannel system
CLR-3 :	Understand the various dispersion compensation techniques
CLR-4 :	Gain the information on advanced RoF Systems
CLR-5 :	Improve the knowledge about the characterization of the Visible Light Communication
CLR-6 :	Utilize the concepts in optical communication for the understanding of engineering and technology

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	PSO 1 Professional Achievement	PSO 2 Project Management Techniques	PSO 3 Analyze & Research
CLO-1 :	Explain the concept of wave propagation and dispersion in single-mode fibers, loss and nonlinear of fiber and fiber design and fabrication.	2	80	70	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-2 :	Apply the concept of optical transmitter and receiver in single-mode semiconductor lasers, light-emitting diodes, transmitter design and receiver design	2	85	75	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-3 :	Demonstrate the concept of long-haul systems, computer-aided design, WDM light wave systems, WDM Components, time-division, subcarrier and code division multiplexing	2	75	70	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-4 :	Explain the loss and dispersion managements in EDFA - Raman amplifiers, dispersion compensating fibers Fiber Bragg gratings, dispersion-equalizing filters and optical phase conjugation	2	85	80	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-5 :	Apply the concept of advanced light wave system in demodulation schemes sensitivity degradation mechanisms and impact of nonlinear effects	2	85	75	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-6 :	Apply their idea in Optical communication module	2	80	70	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H

Duration (hour)		OPTICAL FIBERS and LIGHTWAVE SYSTEMS	LIGHTWAVE SYSTEMS AND MULTICHANNEL SYSTEMS	LOSS MANAGEMENT AND DISPERSION MANAGEMENT	RADIO OVER FIBER SYSTEMS	OPTICAL WIRELESS COMMUNICATION
		9	9	9	9	9
S-1	SLO-1	Geometrical-Optics Description	System Architectures	Compensation of Fiber Losses	Trends in Wireless Communications	Free-space optical wireless communication
	SLO-2	Wave Propagation	Working Principles	Erbium-Doped Fiber Amplifiers les	Basic Transmission problems and solutions	Free-space optical OFDM communication
S-2	SLO-1	Dispersion in Single-Mode Fibers	Design Guidelines	Raman Amplifiers	Regulation	Wireless optical CDMA communication systems
	SLO-2	Dispersion Induced Limitations	Long-Haul Systems	Optical Signal-To-Noise Ratio	Standardization	Comparison of Free-space optical OFDM & CDMA communication
S-3	SLO-1	Fiber Losses	Sources of Power Penalty	Electrical Signal-To-Noise Ratio	System concepts for the central processing of signals	Indoor wireless optical communication
	SLO-2	Nonlinear Optical Effects	Forward Error Correction	Receiver Sensitivity and Q Factor	Wireless Trends	outdoor wireless optical communication

S-4	**SLO-1**	*Fiber Design and Fabrication*	*Types of FEC*	*role of Dispersive and Nonlinear Effects*	*Architecture options,*	*Heterogeneous optical networks (HONs)*
	SLO-2	*multicore fibers*	*Computer-Aided Design*	*Periodically Amplified Lightwave Systems*	*global centralized Architecture*	*System Performance*
S-5	SLO-1 SLO-2	*multiclad fibers* *advantages and its applications*	*WDM* *DWDM*	*Dispersion Problem* *Its Solution*	*FUTON scenarios* *Optical Infrastructure*	*VLC System Model* *Advantages and its applications*
S-6	**SLO-1**	*Advanced Modulation Formats*	*Light wave Systems*	*Dispersion-Compensating Fibers*	*Concepts of Radio over Fiber systems*	*(RF) sensor network system*
	SLO-2	*Demodulation Schemes*	*WDM Components*	*Fiber Bragg Gratings*	*Features of ROF*	*Advantages and its applications*
S-7	**SLO-1**	*Shot Noise*	*System Performance Issues*	*Dispersion Equalizing Filters*	*Categories RoF systems*	*(FSO) sensor network system*
	SLO-2	*Bit-Error Rate*	*Time-Division Multiplexing*	*Optical Phase Conjugation*	*Performances RoF systems*	*Advantages and its applications*
S-8	**SLO-1**	*Sensitivity Degradation Mechanisms*	*Subcarrier Multiplexing*	*Channels at High Bit Rates*	*Applications of RoF Technology*	*Recent Advancement in Optical Wireless Communication*
	SLO-2	*Impact of Nonlinear Effects*	*Code-Division Multiplexing*	*Electronic Dispersion Compensation*	*Advantages of RoF Technology*	*Advantages and its applications*
S-9	**SLO-1**	*Recent Progress*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Ultimate Channel Capacity*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Learning Resources	1. *Nathan J. Gomes, Paulo P. Monteiro and Atilio Gameiro "Next Generation wireless communications using Radio over Fiber" John Wiley & Sons, Ltd, 2012* 2. *G.P. Agarwal, Fiber optic communication systems, 4nd Ed, John Wiley & Sons, New York, 2010*	3. *ShlomiArnon, John R. Barry, George K. Karagiannidis, Robert Schober, Murat Uysal, "Advanced Optical Wireless Communication Systems" Cambridge University Press, 2012* 4. *Shlomi Arnon, "Visible light Communication", Cambridge University Press, 2015*

Learning Assessment

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

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Course Code	18ECE240T	Course Name	WAVELETS AND SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC104T	Co-requisite Courses	Nil	Progressive Courses	18ECE341T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Learn about multiresolution analysis and wavelet signal processing			
CLR-2 :	Identify the families of wavelets required to apply the transformation to various real time applications			
CLR-3 :	Study the of discrete systems that employs wavelet transformation			
CLR-4 :	Study various filter banks of discrete systems used in wavelet transformation			
CLR-5 :	Analyze various real time applications that employs filter banks			
CLR-6 :	Acquire knowledge about wavelet transforms, types and applications of multiresolution analysis			

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Understand multi resolution analysis for discrete signals	3	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	Know the families of wavelets	3	80	70	H	-	M	-	-	-	-	-	-	-	-	-	-	-	M
CLO-3 :	Identify Discrete wavelet transform	3	75	70	M	M	M	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze and design filter banks	3	80	75	H	-	M	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Utilize wavelet transformations on various applications	3	80	70	H	-	M	L	-	-	-	-	-	-	-	-	-	M	H
CLO-6 :	Know about wavelet transforms, types and applications of multiresolution analysis	3	80	70	M	H	-	-	-	-	-	-	-	-	-	-	-	-	-

		Multiresolution Analysis (MRA)	Families of wavelets	Discrete Wavelet Transform (DWT)	Filter banks	Applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to multiresolution/ multiscale analysis	Orthogonal	Discretization in steps	Introduction to Variants of the wavelet transform	Transient analysis
	SLO-2	Introduction to multiresolution/ multiscale analysis	Orthogonal	Discretization in steps	Introduction to Variants of the wavelet transform	Transient analysis
S-2	SLO-1	Time-frequency analysis and wavelets	Biorthogonal wavelets	Discretization of scale	Implementational structures	Singularity detection
	SLO-2	Time-frequency analysis and wavelets	Biorthogonal wavelets	Discretization of scale	Implementational structures	Singularity detection
S-3	SLO-1	Piecewise constant approximation	Daubechies' family of wavelets	Generalized filter bank	The wavepacket transform	Biomedical signal processing applications
	SLO-2	Piecewise constant approximation	Daubechies' family of wavelets	Generalized filter bank	The wavepacket transform	Biomedical signal processing applications
S-4	SLO-1	Haar wavelet	Daubechies' family of wavelets	Discretization of translation	Computational efficiency in realizing filter banks	Efficient signal design and realization
	SLO-2	Haar wavelet	Conjugate Quadrature Filter Banks (CQF) and their design	Discretization of translation	Computational efficiency in realizing filter banks	Efficient signal design and realization
S-5	SLO-1	Building up the concept of dyadic Multiresolution Analysis (MRA)	Conjugate Quadrature Filter Banks (CQF) and their design	Generalized output sampling	Computational efficiency in realizing filter banks	Wavelet based modulation and demodulation
	SLO-2	Building up the concept of dyadic Multiresolution Analysis (MRA)	Conjugate Quadrature Filter Banks (CQF) and their design	Generalized output sampling	Polyphase components	Wavelet based modulation and demodulation
S-6	SLO-1	Relating dyadic MRA to filter banks	Data compression	Discretization of time/ space (independent variable)	Polyphase components	Applications in mathematical approximation

	SLO-2	*Relating dyadic MRA to filter banks*	*Data compression*	*Discretization of time/ space (independent variable)*	*Polyphase components*	*Applications in mathematical approximation*
S-7	SLO-1	*A review of discrete signal processing*	*Fingerprint compression standards*	*Going from piecewise linear to piecewise polynomial*	*The lattice structure*	*Applications to the solution of some differential equations.*
	SLO-2	*A review of discrete signal processing*	*Fingerprint compression standards*	*Going from piecewise linear to piecewise polynomial*	*The lattice structure*	*Applications to the solution of some differential equations.*
S-8	SLO-1	*Elements of multirate systems*	*JPEG-2000 standards*	*The class of spline wavelets*	*Solving Problems*	*Solving Problems*
	SLO-2	*Elements of multirate systems*	*JPEG-2000 standards*	*The class of spline wavelets*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	*Two-band filter bank design for dyadic wavelets.*	*Solving problems*	*A case for infinite impulse response (IIR) filter banks*	*The lifting scheme.*	*Solving Problems*
	SLO-2	*Two-band filter bank design for dyadic wavelets.*	*Solving problems*	*A case for infinite impulse response (IIR) filter banks*	*The lifting scheme.*	*Solving Problems*

Learning Resources

1. *M. Vetterli, J. Kovacevic, Wavelets and Subband Coding, Prentice Hall, 1995*
2. *S. Mallat, A Wavelet Tour of Signal Processing, 2nd ed., Academic Press, 1999*
3. *P.P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 1993*
4. *C.S.Burrus, Ramesh A. Gopinath, and Haitao Guo, Introduction to Wavelets and Wavelet Transforms: A Primer, Prentice Hall, 1997*
5. *Gilbert Strang, Truong Nguyen, Wavelets and Filter Banks, 2nd ed., Wellesley-Cambridge Press,1998.*
6. *Ingrid Daubechies, Ten Lectures on Wavelets, SIAM, 1992*
7. *Howard L. Resnikoff, Raymond O. Wells, "Wavelet Analysis: The Scalable Structure of Information", Springer, 1998*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE241J	Course Name	SIGNAL PROCESSING FOR AUDITORY SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC104T	Co-requisite Courses	Nil	Progressive Courses	18ECE343T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Learn basics of signal processing			
CLR-2 :	Know Feature Extraction technique used in Speech Processing			
CLR-3 :	Identify Frequency characteristics of Speech signal			
CLR-4 :	Construct the Digital model of speech signal			
CLR-5 :	Identify the Ethical issues of elements of music			
CLR-6 :	Learn the basic of speech signal processing and its model			

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Appreciate the functioning of the human vocal and auditory systems	3	80	75	H	-	H	-	H	-	-	-	-	-	-	-	M	-	H
CLO-2 :	Analyze the function of feature extraction in speech and audio signal processing using Time Domain Characteristics	3	80	70	H	-	H	-	-	M	-	M	-	-	-	-	M	-	H
CLO-3 :	Explore the frequency characteristics of speech signal	3	75	70	H	-	H	H	-	-	-	-	-	-	-	-	M	-	H
CLO-4 :	Apply appropriate Digital models for speech signal	3	80	75	H	-	-	-	H	-	-	-	-	-	-	-	H	M	M
CLO-5 :	Analyze the elements of music	3	80	70	-	-	-	M	-	-	-	-	-	-	-	-	M	-	H
CLO-6 :	Know about speech signal processing and its model	3	80	70	H	-	H	-	H	-	-	-	-	-	-	-	H	-	M

		Basic Audio Processing using MATLAB	Speech Signal Analysis in Time Domain	Speech Signal Analysis in Frequency Domain	Digital Models for Speech Signal	Time Elements in Music
Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to Digital audio	Speech signal analysis	Short Time Fourier analysis	Introduction to Acoustic Phonetics	Sound vibrations – pure tones and perception of pitch
	SLO-2	Capturing and converting sound	Segmental analysis	Filter bank analysis	Introduction to Acoustic Phonetics	Sound vibrations – pure tones and perception of pitch
S-2	SLO-1	Sampling of sound wave	Sub-segmental	Formant extraction	Acoustic theory of speech production:- Sound propagation	Auditory coding in the nervous system
	SLO-2	Handling audio in MATLAB	Supra segmental levels	Pitch Extraction	Acoustic theory of speech production:- Sound propagation	Auditory coding in the nervous system
S 3-4	SLO-1	Lab 1: Read & write a speech signal, Record a speech signal, playback, convert into a wave file, plot the speech signal, and spectrogram plot.	Lab 4: Short-term energy of a speech signal	Lab 7: Estimation of pitch period using simplified inverse filter tracking (SIFT) algorithm	Lab 10: Phoneme-level segmentation of speech	Lab 13:Feature Extraction of speech signal
	SLO-2					
S-5	SLO-1	Normalization	Time domain parameters of speech signal	Homomorphic speech analysis	Vocal tract transfer function of vowels	Subjective pitch and role of nervous system
	SLO-2	Audio processing	Time domain parameters of speech signal	Homomorphic speech analysis	Vocal tract transfer function of vowels	Subjective pitch and role of nervous system
S-6	SLO-1	Segmentation	Methods for extracting the parameters Energy	Formant and Pitch Estimation	Effect of nasal coupling	Acoustical energy –perception of loudness, pitch, timbre
	SLO-2	Analysis of window sizing	Methods for extracting the parameters Average Magnitude	Formant and Pitch Estimation	Excitation of sound in vocal tract	Pitch contour Musical Structure
S 7-8	SLO-1	Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot	Lab 5: Short-time Fourier transform magnitude spectrum	Lab 8: Estimation of pitch period using harmonic product spectrum	Lab 11: Estimation of sound in vocal tract	Lab 14: Speech production mechanism
	SLO-2					

S-9	SLO-1	*Visualization*	*Zero crossing Rate*	*Linear Predictive analysis of speech*	*Vocal tract transfer function of vowels*	*Detecting beats, rhythm, meter*
	SLO-2	*Sound generation*	*Zero crossing Rate*	*Linear Predictive analysis of speech*	*Vocal tract transfer function of vowels*	*Recognizing pitch – melody*
S-10	SLO-1	*Speech production mechanism*	*Silence Discrimination using ZCR and energy*	*Autocorrelation method, Covariance method*	*Effect of nasal coupling*	*Auditory streaming*
	SLO-2	*Speech production mechanism*	*Silence Discrimination using ZCR and energy*	*Solution of LPC equations*	*Excitation of sound in vocal tract*	*Tonality and context – algorithms*
S 11-12	SLO-1	*Lab 3: Cepstrum smoothed magnitude spectrum*	*Lab 6: (i)Linear prediction magnitude spectrum (ii) Estimation of formant frequencies using linear prediction*	*Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method*	*Lab 12: Sound vibrations*	*Lab 15:Study of Feature extraction and SVM classifier*
	SLO-2					

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

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE242J	Course Name	PATTERN RECOGNITION AND NEURAL NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	18ECE340T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Learn the concepts of pattern recognition			
CLR-2 :	Analyze few parameter estimation methods for pattern recognition			
CLR-3 :	Acquire knowledge on the fundamental neural networks			
CLR-4 :	Apply the neural network recurrence for pattern recognition studies			
CLR-5 :	Utilize the practical applications of neural networks in pattern recognition			
CLR-6 :	Understand the pattern and apply neural network based learning algorithm to analyze the data from real world applications			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Identify the fundamentals of recognition of patterns, regularities in data and classifiers	3	80	75	L	-	L	H	M	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Classify error estimation, such as definitions, test-set error estimation and training-set error estimation	3	80	70	M	-	-	H	-	-	-	-	-	-	-	-	-	-	H
CLO-3 :	Analyze the neuron model and fundamentals on learning algorithms	3	75	70	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Realize the error model and calculate the deviation with back propagation networks	3	80	75	M	-	M	H	-	-	-	-	-	-	-	-	M	-	H
CLO-5 :	Identify the applications of neural networks in the area of pattern recognition	3	80	70	L	-	M	H	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	Analyze and compare a variety of pattern classification techniques to real-world problems such as document analysis and recognition.	3	80	70	M	-	M	H	M	-	-	-	-	-	-	-	L	-	H

		Introduction To Pattern Recognition	Parameter Estimation Methods	Introduction to Neural Networks	ANN for Classification and Regression	ANN for Organization and Recognition
Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to Statistical Pattern Recognition	Introduction to parameter estimation	Introduction to neural networks	Introduction to Hopfield networks	Self-organizing map
	SLO-2	Overview of Pattern Classifiers	Maximum-Likelihood estimation	Neuron model	Hop-field network- architecture	SOM algorithm
S-2	SLO-1	Process of Classifier Design, Decision making theory	Maximum a Posteriori estimation	Learning methods of ANN, Supervised, Unsupervised and reinforced	Recurrent networks	Learning vector quantization
	SLO-2	Bayesian decision making	Bayesian estimation	Basic learning rules of ANN-	Sample recurrent network structure	Kohonen self-organizing map
S 3-4	SLO-1 / SLO-2	Lab1: Digitization of analog signals	Lab4: Programs on Estimation	Lab 7: Logic gate function description with Hebb rule	Lab 10: Programs on training a Hopfield network	Lab 13: programs on orthogonality and evaluating input and output for association
S-5	SLO-1	Bayes Classifier	Unsupervised learning and clustering	McCulloh pitt neuron	Associative memories- Introduction:	Feature selection
	SLO-2	Bayes Classifier for minimizing Risk	Clustering vs. Classification-Supervised vs. unsupervised	Problems on McCulloh pitt	Auto and hetero associative memory	Feature map classifier, applications
S-6	SLO-1	Estimating Bayes Error	Criterion functions for clustering Algorithms for clustering	Hebb learning rule	Bi directional memories	Architecture of Adaptive Resonance Theory
	SLO-2	Effect of sample size in estimation	K-Means clustering	Problems on Hebb learning rule	XOR problem	ATR1 algorithm
S 7-8	SLO-1 / SLO-2	Lab 2: Program to count the white pixels from the image	Lab 5: Loading a data set and selecting predictive features	Lab 8: Evaluating function with different learning rules	Lab 11: Programs on Auto and hetero association of memory	Lab 14: Character Recognition
S-9	SLO-1	Minimax Classifiers	Hierarchical methods of clustering	Single layer perceptron architecture Training algorithm	Back-propagation Algorithm	ART2 algorithm - Training

	SLO-2	*Neymann Classifiers*	*Comparison of methods, cluster distance and validation*	*Multilayer perceptron*	*Counter propagation networks- architecture*	*ART2- network architecture*
S-10	SLO-1	*Pearson Classifiers*	*Sequential Pattern Recognition*	*Adaline architecture*	*Simulated annealing*	*Hand written digit recognition*
	SLO-2	*Applications*	*Sequential Pattern Recognition*	*Madaline architecture*	*Boltzmann machine*	*Character recognition networks*
S 11-12	SLO-1 SLO-2	*Lab3: Analysis of a data set with classifiers*	*Lab 6: Programs on clustering technique*	*Lab 9 : XOR problem with Perceptron network*	*Lab 12: Evaluation of error in BPN*	*Lab 15: Mini Project*

Learning Resources	1. *Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer Verlag, 2016* 2. *Dionisis Cavouras , S.Theodoridis , K. Koutroumbas , A. Pikrakis , An Introduction to Pattern Classification: A Matlab Approach, Elsevier Science Publishing Co Inc, 2010* 3. *Martin T.Hagan, Neural network design, Cengage publications, 2010*	4. *Simon O. Haykin, Neural Network and Learning Machines, 3rd ed., Pearson Education, 2009* 5. *Ke-Lin Du ,M. N. S. Swamy, Neural Networks and Statistical Learning, Publisher Springer, 2014* 6. *Kosko B, Neural Networks and Fuzzy Systems: A dynamical system approach to machine intelligence, Prentice Hall, 2009*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE243J	Course Name	Digital Image and Video Processing	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Introduce the fundamentals of image processing and transforms
CLR-2 :	Understand the concepts of image enhancement and restoration
CLR-3 :	Acquire knowledge on image compression and segmentation methods
CLR-4 :	Gain knowledge on basics of video processing
CLR-5 :	Know about motion estimation methods in video processing
CLR-6 :	Utilize the concepts of image and video processing for practical applications

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Understand the basics of digital image processing fundamentals and transforms	1,2	95	70	L	-	-	-	-	-	-	-	-	-	-	H	M	-	-
CLO-2 :	Design 2D filters and apply it for image enhancement and restoration	2	90	70	M	H	-	H	H	-	-	-	-	-	-	H	M	-	H
CLO-3 :	Apply image compression and segmentation methods on digital images	2	90	65	M	H	-	H	H	-	-	-	-	-	-	H	-	-	H
CLO-4 :	Analyze the video formation techniques	1	95	70	H	H	-	H	H	-	-	-	-	-	-	H	-	-	H
CLO-5 :	Learn about the techniques for applying motion estimation in video coding	1,2	90	65	M	H	-	H	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	Apply the concepts of digital image, video processing and their applications	1,2	90	70	-	-	-	-	-	-	-	-	-	-	-	-	M	-	H

Duration (hour)		Digital Image Fundamentals and Image Transforms	Image Enhancement and Restoration	Image Compression and Segmentation	Basic Steps of Video Processing	2D Motion Estimation
		12	12	12	12	12
S-1	SLO-1	Origin of digital image processing	Some basic intensity transformation functions – image negatives, log transformations	Fundamentals of image compression- coding redundancy, spatial and temporal redundancy	Analog video signals, standard	2D motion estimation – Optical flow – 2D motion vs. apparent motion
	SLO-2	Fundamental steps in digital image processing	Piecewise linear transformation functions	Irrelevant information, measuring image information	Digital video signal, standard, Digital video processing	Correspondence and optical flow
S-2	SLO-1	Components of an image processing system	Histogram equalization, Matching	Image compression model, Lossless compression, Huffman coding	Time varying image formation models – 3D motion models	Occlusion problem
	SLO-2	Structure of human eye, Image formation	Local Histogram Processing	Arithmetic Coding, Run length coding	Rigid motion in Cartesian, Homogenous coordinates	Aperture problem, 2D motion field models
S- 3-4	SLO-1	***Lab 1: To learn MATLAB software and its basic commands for image processing***	***Lab 4: Histogram Modifications***	***Lab 7: Run length coding***	***Lab 10: Wavelet coding***	***Lab 13: Convert video into frames and process them***
	SLO-2					
S-5	SLO-1	Brightness adaptation and discrimination	Using histogram statistics for image enhancement	Lossy compression - Transform coding	Deformable motion	Block motion models- translational block motion
	SLO-2	Basic concepts in sampling and Quantization , Representing digital	Smoothing linear filters	Wavelet coding	Geometric image formation	Generalized/ Deformable block motion

		images				
S-6	**SLO-1**	*Neighbors of a pixel, Adjacency, Connectivity, Regions and Boundaries*	*Order statistics nonlinear filters*	*Image segmentation – detection of isolated points, line detection*	*Perspective projection*	*Block matching criteria, Matching procedures*
	SLO-2	*Distance Measures, A simple image formation model*	*Sharpening spatial filters*	*Edge models, Basic edge detection*	*Photometric image formation*	*Hierarchical motion estimation*
S- 7-8	**SLO-1**	***Lab 2: Fourier analysis of image***	***Lab 5: Image smoothing and sharpening***	***Lab 8: Basic edge detection operations***	***Lab 11: JPEG Compression***	***Lab 14:Filtering video signals***
	SLO-2					
S-9	**SLO-1**	*Fourier transform of sampled functions*	*Combined spatial enhancement methods*	*Region based segmentation – region growing*	*Photometric effects of 3D motion*	*Gradient based optimization*
	SLO-2	*Sampling theorem, Aliasing, Obtaining the DFT from the Continuous Transform of a Sampled Function*	*Homomorphic filtering, A model of image degradation/ restoration process*	*Region splitting and merging*	*Observation noise, Sampling structures of analog, digital video*	*Steepest Descent method*
S-10	**SLO-1**	*Properties of 2D DFT – Relationship between spatial and frequency interval, Translation and Rotation, Periodicity, symmetric properties*	*A model of image degradation/ restoration process, Noise models*	*Spatial, frequency domain techniques*	*2D fourier transform relations, Intra frame filtering- LMMSE filtering*	*Newton Raphson method, Transform coding , 3D waveform coding*
	SLO-2	*DWT, DCT*	*Singular value decomposition*	*Texture based segmentation*	*Median and weighted median filtering, Motion detection based filtering*	*Local vs. Global minima, Predictive coding*
S- 11 - 12	**SLO-1**	***Lab 3: Image filtering***	***Lab 6: Singular value decomposition***	***Lab 9: Repeat/Revision of experiments***	***Lab 12: Region based image segmentation***	***Lab 15: Mini project***
	SLO-2					

Learning Resources	1. *Rafael C Gonzalez, Richard E Woods, "Digital Image Processing"- 3rd Edition, Pearson Education 2008.* 2. *Yao wang, JoemOstarmann and Ya – quin Zhang, "Video processing and communication ",1st edition , PHI* 3. *M. Tekalp ,"Digital video Processing", Prentice Hall International*	4. *A.K. Jain, "Fundamentals of Digital Image Processing". Pearson education* 5. *William K Pratt, "Digital Image Processing", John Willey (2001).*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE244J	Course Name	DSP System Design	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	IEEE 1641-2010, IEEE 754, IEEE Standard. 1149.1		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Acquire knowledge on Floating and Fixed point Processor such as TMS320C6X for complex signal			
CLR-2 :	Learn and code TMS320C6x Assembly level programming for real time signal processing applications			
CLR-3 :	Design and coding DSP algorithm such as FFT, DFT, Convolution , IIR and FIR filters in TMS320C6x			
CLR-4 :	Gain knowledge on advance filter concepts and filter signal noise using Filter Bank, adaptive filters and analyzes such filters for high end designing.			
CLR-5 :	Design DSP system for real time applications.			
CLR-6 :	Utilize the concept of DSP for Engineering and Technology			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research	
CLO-1 :	Acquire in-depth knowledge on DSP architecture and instruction sets of TMS320C6X	L1	85	65	H	-	H	-	-	-	-	-	-	-	-	-	H	M	L	
CLO-2 :	Attain assembly programming knowledge and analyze using TMS320C6x	L1, L2	85	65	H	H		H	-	-	-	-	-	-	-	-	H	M	L	
CLO-3 :	Implement various DSP algorithm such as FFT, DFT, Convolution , IIR and FIR filters in TMS320C6x	L2, L3	85	65	-	H	-	H	-	-	-	-	-	-	-	-	M	L	H	
CLO-4 :	Acquire knowledge and analyze on Filter Banks and adaptive filters and analyze such filters.	L1, L2	85	65	-	H	H	-	H	-	-	-	H	-	-	-	M	L	H	
CLO-5 :	Gain knowledge on DSP system design based applications.	L3	85	65	H	-	-	-	H	-	-	-	H	-	-	-	M	L	H	
CLO-6 :	Apply the concept of DSP for real time applications				-	-	H	-	H	-	-	-	-	M	-	-	H	M	M	

Duration (hour)		Learning Unit / Module 1 – TMS320C6X Architecture	Learning Unit / Module 2 – TMS3206X Assembly Language	Learning Unit / Module 3 – Frequency Transforms	Learning Unit / Module 4 – Digital Filters	Learning Unit / Module 5 – DSP Applications
		15	15	15	15	15
S-1	SLO-1	***Architecture of TMS320C6X***	*TMS320C6X Assembly Language Operations*	*Digital filtering using the DFT*	*Filter banks – Decimation,*	*Dual tone Multi-Frequency (DTMF) Signaling*
	SLO-2	***Pipeline CPU***	*Individual Instruction Descriptions*	***Convolution and correlation***	*Inverse Decimation*	*Software Defined Radio (SDR)*
S-2	SLO-1	***VelociTI,*** *Functional Units,*	*Arithmetic operations, ,*	*Fast Fourier Transform –DIT*	*Perfect Reconstruction*	*QAM Transmitter and QAM Receiver*
	SLO-2	*Addressing modes,*	*logical operations,*	*Fast Fourier Transform –DIT*	*Analysis of M-Band filter Banks*	*Miscellaneous Projects–FSK Modem*
S-3	SLO-1	*Lab1: Generation of sequences (functional & random) (Matlab)*	*Lab 7: MAC operation using various addressing modes*	***Lab 13: Spectrum analysis using DFT(Matlab)***	***Lab 19: FIR Implementation using TMS Processor***	***Lab 25: Equalization (Matlab)***
	SLO-2					
S-4	SLO-1	***Lab 2: Correlation(Matlab)***	***Lab 8: MAC operation using various addressing modes***	***Lab 14: FFT Implementation(DSP processor)***	***Lab 20: FIR Implementation using TMS Processor***	***Lab 26: Equalization (Matlab)***
	SLO-2					
S-5	SLO-1	*TMS320C6X Instruction Sets,*	*Memory data operations*	*Fast Fourier Transform –DIF*	*Orthogonality and Biorthogonality in Filter banks*	*u-Law for Speech Companding,*
	SLO-2	*Assembler directives*	*Conditional Operations*	*Fast Fourier Transform DIF*	*QMF Filter banks and*	***Acoustic Direction Tracker***

S-6	**SLO-1**	*Multichannel Buffered Serial Ports*	*Floating Point –Data type operations,*	*IFFT*	*CQF Filter Banks*	*MultirateFilter,Neural Network for Signal Recognition*
	SLO-2	*Memory Considerations –Constraints*	*Floating Point –Data type operations*	*FIR filters*	*Transmultiplixers;*	***PID Controller,*** *Four-Channel Multiplexer for Fast Data Acquisition*
S-7	**SLO-1**	***Lab 3: Linear Convolution (Matlab)***	***Lab 9: MAC operation using various addressing modes***	***Lab 15: FIR filter design-Windowing Techniques(Matlab)***	***Lab 21: IIR implementation using TMS processor***	***Lab 27: Real time audio signal processing with Processor***
	SLO-2					
S-8	**SLO-1**	***Lab 4 :Circular convolution(Matlab)***	***Lab 10: Linear convolution(DSP processor)***	***Lab 16: FIR filter design-Windowing Techniques(Matlab)***	***Lab 22: IIR implementation using TMS processor***	***Lab 28: Real time audio signal processing with Processor***
	SLO-2					
S-9	**SLO-1**	*Instruction Operation and Execution notations*	*Fixed- Point Operations,*	*FIR filters*	*Structures and Programming Examples for Noise cancellation*	*Video Line Rate Analysis*
	SLO-2	*Overview of IEEE Standard single and Double Precision formats ,*	*Fixed- Point Operations*	*IIR filter*	*Adaptive Filters-Adaptive filters in DSP simulation software's and TMSC320C6x*	*DSP System Design*
S-10	SLO-1	*Q-format Number Representation on Fixed Point DSPs, Finite Word length effects on Fixed point DSPS*	*Pipeline Operations overview*	*IIR filter*	*Software simulation of FIR*	*MP3 Player*
	SLO-2	*Floating point number representation, , Overflow and Scaling*	*Interrupts-overview.*	*FIR and IIR filter design using TMS320C6x*	*IIRFilters and Filter banks*	*DSP Automotive application*
S-11	SLO-1	*Lab 5: Study of architecture of Digital Signal Processor*	***Lab 11: Circular convolution(DSP processor)***	*Lab 17: IIR filter design-Bilinear and Impulse Invariance Technique(Matlab)*	***Lab 23: Multirate filters***	***Lab 29:*** *Real time audio signal processing with Processor*
	SLO-2					
S-12	SLO-1	***Lab 6: Study of architecture of Digital Signal Processor***	***Lab 12: Waveform generation(DSP processor)***	***Lab 18: IIR filter design-Bilinear and Impulse Invariance Technique(Matlab)***	***Lab 24: Finite Word Length Effect***	***Lab 30: Real time audio signal processing with Processor***
	SLO-2					

Learning Resources	1. **B Venkataramani, M Bhaskar, "Digital Signal Processors: Architecture,Programming and Applications", TMH Publishers, 2nd edition, 2017** 2. **Paulo S. R.DinizEduardo A. B. da Silva and Sergio L. Netto, "Digital Signal Processing System Analysis and Design", Cambridge University Press, 2nd Edition.2010** 3. **Nasser Kehtarnavaz, Namjin Kim, "Digital Signal Processing System-Level Design Using LabVIEW", Newgen Elsevier Publication, 2nd edition, 2014**	4. **RulphChassaing - "DSP Applications Using C and the TMS320C6x DSK" John Wiley & Sons, Inc. 2002.** 5. **Nasser Kehtarnavaz , "Real-Time Digital Signal ProcessingBased on the TMS320C6000", Newnes, 2005.**

Learning Assessment

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

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

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Course Code	18ECE245T	Course Name	ADAPTIVE SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC204J	Co-requisite Courses	Nil	Progressive Courses	18ECE342T
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Have an insight on basics of random processes
CLR-2 :	Gain knowledge on the applications of adaptive filters
CLR-3 :	Have an introduction on LMS techniques
CLR-4 :	Analyze the types of LMS algorithm
CLR-5 :	Have an introduction on RLS algorithm
CLR-6 :	Understanding on need and design of adaptive filters using different algorithms

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	To review the basics of statistical signal processing	1	95	70	H	-	-	-	-	--	-	-	--	-		-	-	-	-
-CLO-2 :	To understand about the need for adaptive filters and learn the design of it.	1,2	95	70	H	M	M	H	-	--	-	-	--	-		-	-	L	M
CLO-3 :	To acquire knowledge on LMS algorithms and constraints associated with it.	2,3	85	65	H	H	H	H	L							M	-	M	M
CLO-4 :	To learn the variants of LMS algorithm and design of lattice structures	2	85	65	H	M	H	H	-	--	-	-	--	-		-	-	M	M
CLO-5 :	To gain knowledge on design of RLS filters and others aspects of filter design	1,2	85	65	H	M	M	H	L	-	-	-	-	-	-	M	-	M	M
CLO-6 :	To understand the applications of adaptive signal processing and algorithms in designing the adaptive filters	1,2	85	65	H	H	H	H	L	-	-	-	-	-	-	M	-	H	H

Duration (hour)		Introduction to Stochastic Process	Adaptive Filters	Least Mean Square Algorithm	Variants of LMS Algorithm And Lattice Structures	Recursive Least Square Algorithm
		9	9	9	9	9
S-1	SLO-1	Introduction to random process	Introduction to adaptive filters	Least mean square algorithm	Sign LMS algorithm	Recursive adaptive filters
	SLO-2	Variables, vectors	Block diagram of adaptive structure with shift variant filter	Derivation	Normalized LMS	Principle of RLS algorithm
S-2	SLO-1	Ensemble averages	Properties of adaptive filter	Properties of LMS adaptive filters	Leaky LMS	FIR RLS filter algorithm
	SLO-2	Time averages	Error sequence generation in adaptive filters	Properties of LMS adaptive filters	Block LMS	Derivation
S-3	SLO-1	Stationarity and Stationary random process	Channel Equalization- Block diagram of communication system with Channel equalization	Complex LMS algorithm	FFT based implementation of block LMS	Sliding window RLS
	SLO-2	Wide sense stationarity	Echo cancellation	Convergence of LMS algorithm	FFT based implementation of block LMS	Derivation
S-4	SLO-1	Power Spectral Density	Concept of adaptive noise cancelling	Learning curve for adaptive filters	Comparison of variants on LMS for some practical problem	Comparing variants of RLS using MATLAB program
	SLO-2	Properties of PSD	Beam forming with pilot signals	Sample MATLAB program for LMS convergence and plotting learning curve	Comparison of variants on LMS for some practical problem	Comparing variants of RLS using MATLAB program
S-5	SLO-1	Sample problems on WSS random process	System modeling using adaptive filters	Performance analysis of LMS adaptive filters by varying step size (MATLAB)	Lattice filters introduction	Kalman filters
	SLO-2	Sample problems on WSS random process	System Identification structure	Performance analysis of LMS adaptive filters by varying step size (MATLAB)	Advantages of Lattice structures	Kalman filters

S-6	SLO-1	*Filtering of random process*	*System inversion using adaptive filters*	*Weight error correlation matrix*	*Forward linear prediction*	*Sample problems on RLS algorithms*
	SLO-2	*Filtering of random process*	*Interference cancellation in multi sensor systems*	*LMS misadjustment definition*	*Forward linear prediction*	*Sample problems on RLS algorithms*
S-7	SLO-1	*Autocorrelation Structures*	*Minimization of mean square error*	*Effects of misadjustment factor*	*Backward linear prediction*	*Non linear adaptive filters*
	SLO-2	*Covariance Structures*	*Derivation on MMSE*	*Sample problems for designing adaptive filters using LMS*	*Backward linear prediction*	*Introduction to Neural networks*
S-8	SLO-1	*Eigen value decomposition*	*Steepest Descent algorithm*	*Sample problems on step size*	*Reflection coefficients of forward and backward predictors*	*Neural networks and multilayer perceptorns*
	SLO-2	*Eigen value analysis of autocorrelation matrices*	*Linear prediction example*	*Sample problems on step size*	*Relation between forward and backward prediction coefficients*	*Neural networks and multilayer perceptorns*
S-9	SLO-1	*Ergodicity*	*Wiener filters*	*Stability analysis of LMS algorithms*	*Properties of Lattice structures*	*Adaptive IIR filtering*
	SLO-2	*Ergodic random process*	*Optimization solution in wiener filters*	*Stability analysis of LMS algorithms*	*Updating predictor coefficients*	*Adaptive IIR filtering*

Learning Resources	1. S. Haykin ,Adaptive Filter Theory, Prentice-Hall, 4-th edition, 2001. 2. Ali H. Sayed ,Fundamentals of Adaptive Filtering, John Wiley, 2003. 3. D. Manolakis, V. Ingle, S. Kogan,Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, 1999.	4. B. Widrow, S. Stearns,Adaptive Signal Processing, Prentice-Hall, 1985 5. Monson H. Hayes,Statistical Digital Signal Processing and Modeling, Edition: 1st, 2008.

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE340T	Course Name	MACHINE PERCEPTION WITH COGNITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE242J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Have an insight on image and color fundamentals
CLR-2 :	Analyze the various shapes and regions for the image description
CLR-3 :	Acquire knowledge on the texture analysis of an image
CLR-4 :	Identify the relation between the templates to match the image requirements
CLR-5 :	Know the practical applications of computer vision in images understanding

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 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	PSO 1 Professional Achievement	PSO 2 Project Management Techniques	PSO 3 Analyze &Research
CLO-1 :	To outline the fundamentals of image and color models	1	90	85	H		L		M	H							L	L	M
CLO-2 :	Understand the basic shapes and region based image modeling	1	85	85		H						H					M	H	M
CLO-3 :	Analyze the various textures for image synthesis	1&2	85	80			M			M		H					L	M	M
CLO-4 :	Identify the objects based on template relations	1&2	85	75							H	M	M				L	M	M
CLO-5 :	To apply the image understanding knowledge for image recognition	2&3	85	80	H	M						H	M				L	M	H
CLO-6:	To understand the principles of image modeling and synthesis with image recognition	1,2,3	85	80	M	H	H	H	M								*M*	*M*	*H*

Duration (hour)		Learning Unit / Module 1 Basic Audio Processing	Learning Unit / Module 2 Human Auditory System	Learning Unit / Module 3 Speech Signal Analysis in Time Domain	Learning Unit / Module 4 Speech Signal Analysis in Frequency Domain	Learning Unit / Module 5 Speech and Audio processing applications
		12	12	12	12	12
S-1	SLO-1	Review of Image processing methods	Binary Shape analysis	Representing textures	Finding objects by voting on relation between templates	Face detection
	SLO-2	Review of Image processing methods	Binary Shape analysis	Representing textures	Interest points, Simple voting, Voting on raltions.	Face detection
S-2	SLO-1	Introduction to image formation	Connectedness	Extracting image Structure with filter banks	Relational reasoning using probabilistic framework	Face recognition
	SLO-2	Introduction to image formation	Object labeling and counting	Extracting image Structure with filter banks	Growing Assemblies Incrementally, Detection, Pruning	Face recognition
S-3	SLO-1	Image models	Size filtering	Representing texture using statistics of filter output	Frames and probability models	Eigen faces
	SLO-2	Camera models	Distance functions	Representing texture using statistics of filter output	Representing coordinate frames	Active appearence
S-4	SLO-1	Sample programs for reading images, understanding pixels	Skeletons and thinning	Analysis using oriented pyramids	Using probability model for detecting the frames	3D shape models of face surveillance
	SLO-2	Sample programs for reading images, understanding pixels	Deformable shape analysis	Laplacian pyramids	Building probability models for frame invariant	3D shape models of face surveillance
S-5	SLO-1	Shadows	Boundary tracking procedures	Filters in the spatial frequency domain	Classifiers to prune search	Foreground separation

	SLO-2	*Color representation*	*Boundary tracking procedures*	*Filters in the spatial frequency domain*	*Identifying acceptable assemblies*	*Background separation*
S-6	**SLO-1**	*Human color perception*	*Shape models*	*Oriented pyramids*	*Sample examples for prune search*	*Particle filters*
	SLO-2	*Human color perception*	*Shape recognition*	*Oriented pyramids*	*Hidden Markov model*	*Particle filters*
S-7	**SLO-1**	*Image color*	*Centroidal profiles*	*Synthesizing textures for rendering*	*Computing, Maximizing parameters*	*Champer matching, tracking and occlusions*
	SLO-2	*Image color*	*Handling occlusions*	*Synthesizing textures for Homogeneity*	*Varieties of HMM*	*Champer matching, tracking and occlusions*
S-8	**SLO-1**	*Handling Color Images (MATLAB)*	*Boundary descriptors*	*Synthesis by sampling local models*	*Background subtraction*	*Combining views from multiple cameras*
	SLO-2	*Handling Color Images (MATLAB)*	*Boundary descriptors*	*Synthesis by sampling local models*	*Sample programs on background subtraction*	*Human gait*
S-9	**SLO-1**	*Surface Color*	*Region descriptors*	*Shape from texture planes*	*Hough transform*	*Constructing 3D models from image sequences*
	SLO-2	*Surface Color*	*Region descriptors*	*Texture from shape planes*	*Sample problems on Hough transforms*	*Scene modeling from registered and unregistered images*

Learning Resources	1. E. R. Davies, "Computer & Machine Vision", Fourth Edition, Academic Press, 2012. 2. R. Szeliski, "Computer Vision: Algorithms and Applications", Springer 2011. 3. Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012	4. Mark Nixon and Alberto S. Aquado, "Feature Extraction & Image Processing for Computer Vision", Third Edition, Academic Press, 2012 5. D. L. Baggio et al., "Mastering OpenCV with Practical Computer Vision Projects", Packt Publishing, 2012 6. Jan Erik Solem, "Programming Computer Vision with Python: Tools and algorithms for analyzing images", O'Reilly Media, 2012.

Learning Assessment

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

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

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Course Code	18ECE341T	Course Name	Multimedia Compression Techniques	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE240T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Learn about probability model and coding theory
CLR-2 :	Understand about lossless compression
CLR-3 :	Understand about Lossy data compression
CLR-4 :	Learn about the encoding methods
CLR-5 :	Compression Techniques and their applications

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	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	PSO 1 Professional Achievement	PSO 2 Project Management Techniques	PSO 3 Analyze &Research
CLO-1 :	Understand the fundamental concepts of probability model and practical limits specified by coding theory	L1&L2	90	68	H	H		M	M	M		M				M	H	M	H
CLO-2 :	Learn about rate-distortion theory and what they reveal about efficient information transfer	L2&L3	86	68	H	H		M	M	M		M				M	H	M	H
CLO-3 :	Understand the fundamental approaches towards lossy image compression	L2&L3	86	68	H	M		H	M	M		M				M	M	M	H
CLO-4 :	Analyze image, video and audio in the frequency domain to identify important components to be encoded	L2	85	63	H	M		H	H	M		H				M	M	L	H
CLO-5 :	Applications of various compression techniques	L2&L3	85	63	M	M		M	M	H		M				M	H	M	M
CLO-6:	Learn about data compression and encoding methods	L1,L2,L3	90	68	H	M		M	M	M		H				M	H	M	H

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		9	9	9	9	9
S-1	SLO-1	The discrete memory less information source	Mathematical Preliminaries for Lossless	Rate distortion function	Vector Quantization	Transform Coding: Introduction, Karhunen-Loeve transform, , , , Image compression – EZW, SPIHT, JPEG 2000- Analysis/Synthesis Schemes.
	SLO-2	Kraft inequality; optimal codes	Mathematical Preliminaries for Lossless Compression	Rate distortion function	LBG algorithm	Karhunen-Loeve transform
S-2	SLO-1	Source coding theorem-Entropy	Huffman Coding	Properties of RD	Tree structured VQ	Karhunen-Loeve transform
	SLO-2	Joint Entropy and Conditional Entropy	Huffman Coding	Properties of RD	Structured VQ	discrete cosine transform,
S-3	SLO-1	Relative Entropy	Optimality of Huffman codes	Calculation of RD for the binary source and the Gaussian source	Variations of VQ	discrete cosine transform,
	SLO-2	Mutual Information	Extended Huffman Coding	Calculation of RD for the binary source and the Gaussian source	Gain shape VQ	discrete Walsh Hadamard transform
S-4	SLO-1	Chain Rules	Adaptive Huffman Coding	Rate distortion theorem	Mean removed VQ	discrete Walsh Hadamard transform
	SLO-2	Data-Processing Inequality	Arithmetic Coding	Rate distortion theorem	Classified VQ	Quantization and coding of transform coefficients
S-5	SLO-1	Fano's Inequality Symmetric Channels	Adaptive Arithmetic coding	Converse of the Rate distortion theorem	Multistage VQ	Quantization and coding of transform coefficients
	SLO-2	Fano's Inequality Symmetric Channels	Run Length Coding	Quantization problem	Adaptive VQ	JPEG

S-6	**SLO-1**	Properties of Channel Capacity, Jointly Typical Sequences	Dictionary Techniques	Scalar Quantization- Uniform Quantizer	Trellis coded quantization Transforms.	JPEG
	SLO-2	Properties of Channel Capacity, Jointly Typical Sequences	Lempel Ziv coding	Scalar Quantization- Uniform Quantizer	Trellis coded quantization Transforms.	MDCT
S-7	**SLO-1**	Channel Coding Theorem	Applications	Adaptive Quantization	Basic algorithm	MDCT
	SLO-2	Channel Coding Theorem	Predictive Coding	Adaptive Quantization	Prediction in DPCM	Image compression – EZW-Analysis/Synthesis Schemes
S-8	**SLO-1**	Fano's Inequality	Prediction with Partial Match	Non-uniform Quantization	Prediction in DPCM	Image compression – SPIHT-Analysis/Synthesis Schemes
	SLO-2	Fano's Inequality	Burrows Wheeler Transform	Non-uniform Quantization	Adaptive DPCM	Image compression – JPEG 2000-Analysis/Synthesis Schemes
S-9	**SLO-1**	Converse to the Coding Theorem	Dynamic Markov Compression	Entropy coded Quantization	Adaptive DPCM	Audio coding:-MPEG audio coding
	SLO-2	Converse to the Coding Theorem	Dynamic Markov Compression	Entropy coded Quantization	Delta Modulation	Audio coding:-MPEG audio coding

Learning Resources	1. K. Sayood, "Introduction to Data Compression",3rd Edition, Morgan Kaufmann Publishers, 2006. 2. N. Jayant and P. Noll, "Digital Coding of Waveforms: Principles and Applications to Speech and Video", ISBN10 0132119137, Prentice Hall, USA, 1984. 3. D. Salomon, "Handbook of Data Compression", 5th Edition, Springer-Verlag London Limited 2010.	4. Ze.Nian. Li and M.S. Drew, "Fundamentals of Multimedia",2nd Edition, Pearson Education (Asia) Pvt. Ltd., 2004. 5. M.Rabbani: "Digital image compression techniques", 1st Edition, SPIE Press Book, 1991.

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE342T	Course Name	ACOUSTICAL SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE245T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	ISO/TC 43/SC 1, ISO/TC 43/SC 2		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	learn what is acoustic and its basic sound equations, and how acoustics transmission, reflection, absorption when subjected to various mediums
CLR-2 :	learn how does human auditory system and hearing function.
CLR-3 :	learn what is acoustic echo, and how to control such echo due to noise and cancel echo using various algorithms.
CLR-4 :	learn what are the various types of transducers used for acoustic measurements
CLR-5 :	knowwhich transducers can be used in various applications of acoustics.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	To understand the basics of acoustic such as Sound equation, Transmission, Reflection, Absorption under various mediums	L1	80	65
CLO-2 :	To acquire knowledge on human auditory system and hearing	L1	85	65
CLO-3 :	To understand and analyze acoustic echo, noise control and cancel echo using various algorithms.	L1, L2	85	65
CLO-4 :	To understand about various types of transducers used for acoustic measurements	L1	85	65
CLO-5 :	To gain knowledge on various applications of acoustics.	L1, L3	85	65
CLO-6	Speech processing analysis in different environment	L1, L2, L3	85	65

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

Duration (hour)		Basics of Acoustic Engineering	Auditory System and Hearing	Acoustic Echo and Noise control	Transducers for Acoustic Measurements	Applications of Acoustics
		9	9	9	9	9
S-1	SLO-1	*Introduction to acoustic*	Anatomy of the auditory systems	Human Perception of Echoes	Fundamental properties of Transducers	Architectural acoustics – Sound in enclosures
	SLO-2	*Introduction to acoustic*	Anatomy of the auditory systems	Human Perception of Echoes	Fundamental properties of Transducers	Reverberation time
S-2	SLO-1	Harmonic Plane Waves	Physiology of the auditory systems	Echo Problem	Condenser Microphones	Sound absorption materials
	SLO-2	Harmonic Plane Waves	Physiology of the auditory systems	Echo Problem	Condenser Microphones	Measurements of acoustic output in living rooms
S-3	SLO-1	Energy Density	Function of the auditory systems	Adaptive Filters for Echo Cancellation	Dynamic Pressure Microphones	Acoustic Factors in architectural design
	SLO-2	Energy Density	Function of the auditory systems	Adaptive Filters for Echo Cancellation	Dynamic Pressure Microphones	Environmental acoustics – Introduction
S-4	SLO-1	Acoustic Intensity	Physiological measures	*LMS algorithm*	Dynamic Pressure Microphones	Weighted sound level
	SLO-2	Specific Acoustic Impedance	Physiological measures	*NLMS algorithm*	Dynamic Pressure difference Microphone	speech interference

S-5	**SLO-1**	Spherical Waves	Physiological measures	Least Squares Algorithms	Dynamic Pressure difference Microphone	Highway noise
	SLO-2	Spherical Waves	Auditory processing models	Least Squares Algorithms	Piezo ceramic accelerometer	Aircraft noise rating
S-6	SLO-1	Decibel Scales	Auditory processing models	Recursive Least Squares Algorithms	Piezo ceramic accelerometer	Virtual Sound--
	SLO-2	; Rays and Waves	Auditory processing models	Recursive Least Squares Algorithms	Piezo ceramic accelerometer	Sound localization cues
S-70	SLO-1	Transmission-Incidence	Auditory processing models	Affine Projection algorithm	Laser Doppler velocimeter	synthetic 3D Audio
	SLO-2	Transmission-Incidence	Auditory processing models	Affine Projection algorithm	Laser Doppler velocimeter	synthetic 3D Audio
S-8	SLO-1	Reflection	Speech Intelligibility	Noise cancellation using Affine Projection algorithm	Laser Doppler velocimeter	Seismology- Signal Model in seismic processing
	SLO-2	Absorption	Speech Intelligibility	Noise cancellation using Affine Projection algorithm	Capacitive sensors	*Optical sensor* Signal Model in seismic processing*s*
S-9	SLO-1	Viscosity	signal processing in hearing aids	Fast Affine Projection Algorithm (FAP).	Capacitive sensors	Underwater and Oceanographic acoustics
	SLO-2	Thermal conduction	signal processing in hearing aids	Fast Affine Projection Algorithm (FAP)	Capacitive sensors	Inverse Problems in underwater acoustics

Learning Resources	1. Lawrance E Kinseler, Fundamental of Acoustic, , Wiley 4th Edition. 2. Steven L. Gay, Jacob Benesty, Acoustic Signal Processing for Telecommunication, Springer; 2001 edition (March 31, 2000)	3. Havelock, David; Kuwano, Sonoko, Vorländer, Michael (Eds.), Handbook of Signal Processing in Acoustics, Springer; 2008 edition.

Learning Assessment

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

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

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

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Course Code	18ECE343T	Course Name	Automatic Speech Recognition	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECE241J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understand the basic Techniques of Speech Recognition			
CLR-2 :	Analyze the different Statistical models			
CLR-3 :	Modeling different speech recognition systems			
CLR-4 :	Evaluation of dialogue system design			
CLR-5 :	Analyzing the Stochastic Approaches to dialogue			
CLR-6 :	Utilize the concepts in signal processing for the understanding of engineering and technology			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)															
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO–1: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research	
CLO-1 :	Understand the basic techniques in speech signal processing broadly used in the area of speech recognition	2	80	63	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-2 :	Learn how hidden Markov models can be used as generative models for speech and how they can be trained	2	85	68	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-3 :	To help in understanding account for commercial as well as research-oriented applications within speech recognition	2	75	68	H	-	-	H	-	-	-	-	-	-	-	-	-	-	-	
CLO-4 :	To understand basic understanding of dialogue system design and evaluation	2	85	68	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-5 :	Implement simple dialogue systems and Stochastic Approaches	2	85	68	H	-	H	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-6 :	Apply the speech recognition techniques in real time applications.	2	80	68	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Duration (hour)		Distance Measurements For Comparing Speech Patterns	Statistical Models For Speech Recognition	Architecture of Continuous Speech Recognition System	Understanding of Spoken Dialogue Systems	Natural Language Generation and Stochastic Process
		9	9	9	9	9
S-1	SLO-1	Feature, Feature Extraction and Pattern Comparison Techniques	Introduction to Perceptual Motivated Representations	Introduction to speech recognition	Simple models of dialogue structure:	Natural language generation for dialogue systems
	SLO-2	Feature, Feature Extraction and Pattern Comparison Techniques	Perceptual Motivated Representations	Introduction to speech recognition	Simple models of dialogue structure:	Natural language generation for dialogue systems
S-2	SLO-1	Speech Distortion measures-Mathematical	Formant Frequencies – Role of Pitch – Pitch Detection of Speech and Music	Large vocabulary continuous speech recognition	Trees and finite state approaches	Text-to-speech synthesis
	SLO-2	Speech Distortion measures-Mathematical	Formant Frequencies – Role of Pitch – Pitch Detection of Speech and Music	Large vocabulary continuous speech recognition	Trees and finite state approaches	Text-to-speech synthesis
S-3	SLO-1	Perpectual-Log spectral distance	Channel Vocoders and Predictive Coding Scalar Waveform Coders	Architecture of large vocabulary continuous speech recognition system	Dialogue acts, key phrase reactive approaches	Use of speech synthesizers in dialogue systems
	SLO-2	Perpectual-Log spectral distance	Channel Vocoders and Predictive Coding Scalar Waveform Coders	Architecture of large vocabulary continuous speech recognition system	Dialogue acts, key phrase reactive approaches	Use of speech synthesizers in dialogue systems
S-4	SLO-1	Cepstral Distances, Weighted Cepstral distances and Filtering	Scalar Frequency Domain Coders	Architecture of large vocabulary continuous speech recognition system	Information retrieval-based approaches	Dialogue system evaluation
	SLO-2	Likelihood Distortions	Code excited linear Prediction	Architecture of large vocabulary continuous speech recognition system	Information retrieval-based approaches	Dialogue system evaluation
S-5	SLO-1	Spectral distortion using a Warped	Low – Bit rate Speech coders	Acoustics model	Voice XML	Stochastic approaches to dialogue

	SLO-2	Frequency scale	Speech Recognition			
S-6	**SLO-1**	LPC, PLC and MFCC Coefficients	Hidden Markov Models (HMM) – Practical Issues in Using HMMs – HMM Limitations	Language model	Speech recognition	Dialogue policy design and training
	SLO-2	LPC, PLC and MFCC Coefficients	Hidden Markov Models (HMM) – Practical Issues in Using HMMs – HMM Limitations	Language model	Speech recognition	Dialogue policy design and training
S-7	**SLO-1**	Time Alignment and Normalization	Acoustic Modeling – Phonetic Modeling, Language Modeling	n-gram model	Use of speech recognizers in dialogue systems	MDP reinforcement learning
	SLO-2	Time Alignment and Normalization	Acoustic Modeling – Phonetic Modeling, Language Modeling	n-gram model	Use of speech recognizers in dialogue systems	MDP reinforcement learning
S-8	SLO-1	Dynamic Time warping	Speaker Recognition Algorithm	context dependent sub word units	Natural language understanding	POMDP reinforcement learning
	SLO-2	Dynamic Time warping	Speaker Recognition Algorithm	context dependent sub word units	Natural language understanding	POMDP reinforcement learning
S-9	SLO-1	Multiple Time-Alignment Paths	Signal Enhancement for Mismatched Conditions	Applications and present status	Natural language understanding	Simulated users
	SLO-2	Multiple Time-Alignment Paths	Signal Enhancement for Mismatched Conditions	Applications and present status	Natural language understanding	Simulated users

Learning Resources	1. Huang, A. Acero, H-W. Hon, "Spoken Language Processing: A guide to theory, algorithm and system development", Prentice Hall 2001 2. Rabiner and Juang, "Fundamentals of Speech Recognition", Prentice Hall, 1993 3. F. Jelinek, "Statistical Methods for Speech recognition", MIT Press, 1997	4. Jurafsky, Daniel, and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Speech Recognition, and Computational Linguistics", 2nd edition. Prentice-Hall, 2009. 5. Jokinen and McTear, "Spoken Dialogue Systems, Morgan & Claypool, Synthesis Lectures on Human Language Technologies", Morgan & Claypool Publishers, 2009

Learning Assessment

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

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

Course Designers

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

B. Tech in Electronics and Communication Engineering

2018 Regulations

OpenElective Courses (O)

Department of Electronics and Communication Engineering
SRM Institute of Science and Technology

SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECO101T	Course Name	Short Range Wireless Communication	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	The purpose of this course is to introduce practically all aspects of radio communication including wave propagation, antennas, transmitters, receivers, design principles, telecommunication regulations	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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	To cover the various forms of signals used for information transmission and modulation, and overall wireless system properties.	2	80	70	L	-	-	-	-	-	-	-	-	-	-	-	-	H	-
CLO-2 :	To present various component types that can be used to implement a short-range radio system.	2	85	75	-	-	M	L	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	To describe the various kinds of transmitters and receivers.	2	75	70	-	-	H	M	-	-	-	-	-	-	-	-	-	H	-
CLO-4 :	To covers regulations and standards of ISM band communications	2	85	80	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	To covers some of the most important new developments in short-range radio like UWB and Visible light.	2	85	75	-	-	L	M	-	-	-	-	-	-	-	-	-	-	H

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

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

Learning Resources

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

Learning Assessment

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

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

Course Designers

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

Course Code	18EC0102J	Course Name	Electronic Circuits and Systems	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	Understand the operation, characteristics, parameters and specifications of semiconductor diodes and demonstrate its important applications	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Review the transistor (BJT & FET) construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Identify different configurations of op-amp analyze the parameters of op-amp and observe the frequency response of operational-amplifier.	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Understand & demonstrate different applications based on operational-amplifier and special linear ICs	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Understand the basic concepts and techniques of telecommunication systems and networks	1	80	70	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Understand how circuit behavior can be studied with a computer, using a circuit simulation software	2	90	80	-	-	H	-	H	-	-	-	-	L	-	M	L	-	-

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

S-6	**SLO-1**	*Basic operation of Zener diode and its VI characteristics*	*Characteristics*	*Clipper &Clamper*	*555 Timer IC: Basic Operation*	*Networks: RS-232, circuit switching*
	SLO-2	*Zener diode as a voltage regulator*	*Parameters*	*Log & Antilog amplifiers*	*Astable Operation*	*Message switching, TCP/IP*
S-7	**SLO-1**	***Lab-2: VI Characteristics of Zener Diode***	***Lab-5: Design & Analysis of CS-JFET Amplifier***	***Lab-8: Op-amp Circuits-I***	***Lab-11: 555 Timer Operation & Applications***	***Lab-14: Demonstration of Pulse Modulation***
	SLO-2					
S-8	**SLO-1**					
	SLO-2					
S-9	**SLO-1**	*BJTs: Structure & Operation*	*MOSFET as an amplifier*	*Instrumentation amplifier*	*Monostable Operation*	*Radio Transmission: Electromagnetic Spectrum, ground waves, sky waves*
	SLO-2	*Characteristics & Parameters*	*MOSFET as a switch*	*Comparator*	*Applications of 555 Timer*	*antennas, directional transmissions,*
S-10	**SLO-1**	*CE BJT amplifier operation*	*MOSFET Biasing (Voltage-Divider Biasing)*	*Comparator applications*	*Applications of 555 Timer*	*Transmitters, Receivers*
	SLO-2	*Differential amplifier operation*	*CS-MOSFET amplifier operation*	*Schmitt trigger*	*Voltage-Controlled Oscillators*	*Mobile telephones*
S-11	**SLO-1**					
	SLO-2	***Lab-3: Applications of PN Junction diode and Zener diode***	***Lab-6: Design & Analysis of CS-MOSFET Amplifier***	***Lab-9: Op-amp Circuits-II***	***Lab-12: VCO Operation***	***Mini Project / Model Practical Examination***
S-12	**SLO-1**					
	SLO-2					

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

Learning Assessment

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

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. Rajesh Agarwal, SRM IST*

Course Code	18ECO103T	Course Name	Modern Wireless Communication System	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Discuss the fundamentals of transmission in wireless systems	2,3	80	75
CLO-2 :	Provide an overview of various approaches to communication networks	2,3	80	85
CLO-3 :	Study the numerous different-generation technologies with their individual pros and cons	2,3	85	85
CLO-4 :	Discuss about the principles of operation of the different access technologies like FDMA, TDMA, SDMA and CDMA and their pros and cons.	2,3	85	80
CLO-5 :	Learn about the various mobile data services and short range networks.	2,3	85	80
CLO-6 :	Gain knowledge on *Fundamentals, Techniques and Networks of Wireless Communication Systems*	2,3	85	80

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

Duration (hour)		Transmission Fundamentals	Network Concepts	Personal Communication Services	3G and Beyond	Mobile Data Services and Short- Range Network
		9	9	9	9	9
S-1	SLO-1	*Cellphone Generations*	*Communication Networks*	*Personal communication Introduction, HSCSD, GPRS, D-AMPS, CDMA One, CDMA Two, Packet Data Systems*	*3G Introduction*	*Mobile Data Services Introduction Messaging, wireless web, WAP, site design Short-Range Wireless Networks: Unlicensed spectrum, WLANs, cordless telephony, IrDA, Bluetooth Smart Phones: Future phones, mobile OSs, smart phone applications.*
	SLO-2	*1G and 2G*	*LANs*	*GSM*	*IMT-2000 Introduction*	*Data Services*
S-2	SLO-1	*2.5G*	*MANs*	*GSM*	*IMT-2000*	*Messaging*
	SLO-2	*3G*	*WANs*	*HSCSD*	*IMT-2000*	*Wireless web*
S-3	SLO-1	*4G Transmission Introduction*	*Circuit switching*	*HSCSD*	*W-CDMA Introduction*	*WAP*
	SLO-2	*4G Transmission Fundamentals*	*Packet switching*	*GPRS*	*W-CDMA*	*Site design*

S-4	**SLO-1**	*Time domain concepts*	*ATM Cellular Networks Introduction*	*GPRS*	*CDMA 2000 Introduction*	*Short-Range Wireless Networks*
	SLO-2	*Frequency domain concepts*	*Cells*	*D-AMPS*	*EDGE*	*Unlicensed spectrum*
S 5-6	**SLO-1**	*Radio Media*	*Duplexing*	*D-AMPS*	*EDGE*	*WLANs*
	SLO-2					
S-7	**SLO-1**	*Analog Vs Digital*	*Multiplexing*	*CDMA Introduction*	*Wi-Fi Introduction*	*Cordless telephony*
	SLO-2	*Channel capacity*	*Voice coding*	*CDMA One*	*Wi-Fi*	*IrDA*
S-8	**SLO-1**	*Transmission media*	*Multiple Access Techniques: FDMA*	*CDMA One*	*WiMAX Introduction*	*Bluetooth Smart Phones*
	SLO-2	*Signaling Schemes*	*TDMA, SDMA*	*CDMA Two*	*WiMAX*	*Future phones*
S-9	**SLO-1**	*Carrier-based signaling,*	*CDMA*	*CDMA Two*	*OFDM*	*Mobile OSs*
	SLO-2	*Spread-spectrum signaling*	*Spectral efficiency*	*Packet Data Systems*	*MIMO*	*Smart phone applications*

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

Learning Assessment

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

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

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Course Code	18ECO104J	Course Name	Audio and Speech Signal Processing	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Understand the functioning of the human vocal and auditory systems in terms of signal processing	1	90	68
CLO-2 :	Analyze the function of feature extraction in speech and audio signal processing using Time Domain Characteristics	2	85	67
CLO-3 :	Understand the frequency characteristics of speech signal	2	85	68
CLO-4 :	Understand the Digital models for speech signal	1&2	85	65
CLO-5 :	Understand the elements of music	2&3	85	66
CLO-6:	Understand Speech signal processing in time and frequency domain and their models.	1,2,3	85	68

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

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

	SLO-2	*Analysis of window sizing*	*Sound intensity and Decibel sound levels*	*Average ,Magnitude*	*Linear Predictive analysis of speech*	*Speech enhancement using spectral subtraction method*
S-7	SLO-1	***Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot***	***Lab 5: Short-time Fourier transform magnitude spectrum***	***Lab 8: Estimation of pitch period using harmonic product spectrum***	***Lab 11:To study the quantization and aliasing effect of speech signal***	***Lab 14: Short term speech analysis***
	SLO-2					
S-8	SLO-1					
	SLO-2					
S-9	SLO-1	*Visualization*	*Concept of critical band*	*Zero crossing Rate*	*Autocorrelation method, Covariance method*	*Introduction to Text to speech conversion*
	SLO-2	*Sound generation*	*Uniform filter bank , Non- uniform filter bank*	*Silence Discrimination using ZCR and energy*	*Solution of LPC equations*	*Introduction to Musical instrument classification*
S-10	SLO-1	*Speech production mechanism, Charistics of speech*	*Mel scale and bark scale,*	*Short Time Auto Correlation Function*	*Durbin's Recursive algorithm, Application of LPC parameters*	*Musical Information retrieval.*
	SLO-2	*Understanding of speech*	*Speech perception: vowel perception*	*Pitch period estimation using Auto Correlation Function*	*Pitch detection using LPC parameters, Formant analysis*	*Sample Programs*
S-11	SLO-1	***Lab 3:Cepstrum smoothed magnitude spectrum***	***Lab 6: (i)Linear prediction magnitude spectrum, (ii) (ii) Estimation of formant frequencies using linear prediction***	***Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method***	***Lab 12:*: Speech signal to symbol transformation using wavesurfer**	***Lab 15: Study of Praat***
	SLO-2					
S-12	SLO-1					
	SLO-2					

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

Learning Assessment

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Level 1	Remember	*20%*	*20%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Understand										
Level 2	Apply	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*	*20%*
	Analyze										
Level 3	Evaluate	*10%*	*10%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*	*15%*
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers

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

Course Code	18ECO105T	Course Name	Underwater Acoustics	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

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

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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	*Acquire in-depth knowledge and analyze on Sound Navigation and Ranging (SONAR) equations and it characteristics.*	*L1*	*85*	*65*	M	-	-	-	-	-	-	-	-	-	-	M	L		
CLO-2 :	*Analyze Ocean Acoustic Processing and sound wave propagation.*	*L2*	*85*	*65*	M	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CLO-3 :	*Acquire knowledge and analyze Underwater reverberation and various types of noises.*	*L1&L2*	*85*	*65*	M		H	H	H	-	-	-	-	-	-	L	H	M	H
CLO-4 :	*Acquire knowledge on working of underwater Acoustic transducers.*	*L1*	*85*	*65*	H	H	H	H	H	-	-	-	-	-	-	L	H	H	H
CLO-5 :	*Gain knowledge and apply SONAR concepts for underwater applications.*	*L1& L3*	*85*	*65*	L		H	H	-	-	-	-	-	-	-	L	H	M	H
CLO-6 :	*Understand the development and dynamics of underwater acoustic engineering*	*L2 &L3*	*85*	*65*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Duration (hour)		**Learning Unit / Module 1 Sound Navigation and Ranging (SONAR)**	**Learning Unit / Module 2 Ocean Acoustic Processing and sound wave propagation**	**Learning Unit / Module 3 Reverberation and Noises**	**Learning Unit / Module 4 Acoustic Transduction**	**Learning Unit / Module 5 SONAR Application**
		9	**9**	**9**	**9**	**9**
S-1	SLO-1	*Introduction to SONAR equation,*	*Processing ocean sound-Sampling rules*	*Reverberation-Scattering, back scattering strength and target strength*	*Piezoelectric transducer-Introduction*	*Echo sounder*
	SLO-2	*Source Intensity, Source Directivity*	*Spatial sampling and Temporal sampling*	*Surface and bottom scattering*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Echo Sounder*
S-2	SLO-1	*Transmission loss*	*Filter operations-Finite Fourier transformation*	*Volume scattering, bottom scattering, reverberation target strength*	*Piezoelectric transducer-33-Mode longitudinal vibrator*	*Sub-bottom profiling*
	SLO-2	*Transmission loss*	*Filter operations-Time domain view of Band pass filtering. convolution operations, frequency domain*	*Calculation of reverberation for use in the sonar equation, Volume reverberation level*	*Electrostrictive transducers*	*Fishing sonars*
S-3	SLO-1	*Target Strength*	*Gated Signals-Dependence of Spectrum on ping carrier periodicity*	*Reverberation frequency spread and Doppler gain potential-Power spectral density of a CW pulse*	*Electrostrictive transducers*	*Side scan terrain mapping sonar*
	SLO-2	*Reflection Intensity Loss Coefficient*	*Power spectra of random signal-Signal having random characteristics, Spectral density,*	*Environmental frequency sampling*	*Magnetostrictive transducers*	*Side scan terrain mapping sonar*
S-4	SLO-1	*Sea-floor Loss,*	*Radom signal simulations-Intensity spectral density, Spectral smoothing*	*Frequency spreading due to transmitter and receiver motion*	*Magnetostrictive transducers*	*Acoustic positioning and navigation*
	SLO-2	*Sea-surface Loss*	*Matched filters and autocorrelation*	*Frequency spreading due to target,*	*Electostatic Transducers*	*Acoustic positioning and navigation*

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

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

Learning Assessment

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

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

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Course Code	18ECO106J	Course Name	PCB Design and Manufacturing	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Explore the terminologies of PCB design and Electronic components.
CLR-2 :	Understand the design and other consideration involved in PCB design
CLR-3 :	Understand the PCB design consideration for special application circuits
CLR-4 :	Design a PCB layout using CAD tool
CLR-5 :	Explore various PCB manufacturing techniques
CLR-6 :	

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 (Level of Thinking (Bloom))	Learning 2 (Expected Proficiency (%))	Learning 3 (Expected Attainment (%))
CLO-1 :	Identify the various types of PCB and electronics components packaging	1	80	70
CLO-2 :	Select suitable design and consider appropriate parameters involved in PCB design	1,2	80	70
CLO-3 :	Apply the appropriate design rules in designing PCB for special application circuits	1,2	80	70
CLO-4 :	Design and develop a PCB layout using CAD tool	1,2, 3	80	70
CLO-5 :	Identify and select the required PCB manufacturing technology	1,2, 3	80	70
CLO-6 :				

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

		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	Nomenclature of a Printed Circuit Board	PCB Design Considerations - Important Design Elements	Design Rules for Analog Circuits	Schematic Capture - Introduction schematic capture tool	Image Transfer Techniques- Screen Printing, Pattern Transferring Techniques
	SLO-2	Classification of Printed Circuit Boards	PCB Design Considerations - Important Performance Parameters			
S-2	SLO-1	Manufacturing of basic PCB - Single-and Double-sided Plated Through-holes	PCB Design Considerations - Mechanical Design Considerations	Design Rules for Digital Circuits	Schematic Capture - Simulation of simple electronic circuit	Image Transfer Techniques- Printing Inks, Photo Printing, Laser Direct Imaging (LDI)
	SLO-2	Manufacturing of Multi-layer Boards - Flexible Boards, Challenges in modern PCB Design and Manufacture, PCB Standards	PCB Design Considerations - Mechanical Design Considerations		Schematic Capture - Schematic to layout transfer	Copper Clad Laminates - Properties of Laminates, Types of Laminates, Evaluation of Laminates
S-3	SLO-1	Study of electronic components- Passive electronic components	Design and analysis of RL and RC time constants. Schematic in CAD tool	Schematic and PCB Layout in CAD tool. **Regulated power supply design.- Full wave rectifier circuit design with fixed voltage regulator**	**PCB Layout Design of single digit pulse counter using PCB design tool.**	**Mini Project - PCB Layout Design of electronic turn ON/OFF timer using IC555 using PCB design tool.**
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	Types, Symbols, Packaging shapes and terminal details of Electronic Components –Resistors, Thermistors Capacitors, Inductors	PCB Design Considerations - Electrical Design Considerations	Design Rules for High Frequency Circuits	PCB Layout Design - Conception Level Introduction	Etching Techniques – wet Etching chemicals
	SLO-2	Diodes, Light Emitting Diodes (LED), Photodiode,	PCB Design Considerations - Conductor Patterns, Component Placement Rules	Design Rules for Fast Pulse Circuits	PCB Layout Design - Specifying Parts, Packages and Pin Names, Libraries	Etching Techniques - Mechanical Etching
S-6	SLO-1	Transistors, Field-effect Transistors, Insulated Gate Bipolar Transistor (IGBT),	Fabrication and Assembly Considerations	Design Rules for Microwave Circuits	PCB Layout Design - Checking foot prints of the components, Part list, Net list,	PCB Assembly Process - Through-hole

		Thyristor			*Making Net list Files*	
S-7	**SLO-1**	*Study of electronic components- active devices, analog and digital integrated circuits (IC)*	*Design and analysis of RLC circuits. Schematic in CAD tool*	*Schematic and PCB Layout in CAD tool.* ***Regulated power supply design. -Full wave rectifier circuit design with fixed voltage regulator***	***PCB Design of single digit pulse counter: Schematic and PCB layout using PCB design tool.***	***Mini Project - Manufacture the PCB for electronic turn ON/OFF timer using IC555and construct and test the designed circuit.***
	SLO-2					
S-8	**SLO-1**					
	SLO-2					
S-9	**SLO-1**	*Digital Integrated Circuits, Random Access Memory*	*Environmental Factors, Cooling Requirements*	*Design Rules for High-density Interconnection Structures*	*PCB Layout Design - Mounting Holes, Adding Text, PCB Layout*	*PCB Assembly Process - Surface Mount, Mixed Technologies*
	SLO-2	*Read Only Memory*	*Packaging Density*			
S-10	**SLO-1**	*Microcontrollers, Surface Mount Devices*	*Layout Design*	*Electromagnetic Interference/Compatibility (EMI/EMC)*	*PCB Layout Design - DRC, Pattern Transfer, Layout printing*	*PCB Assembly Process - Soldering*
	SLO-2	*Transformer, Relays, Connectors*				
S-11	**SLO-1**	*Study of testing and measuring Instruments: Logic analyzer, spectrum analyzer, IC tester (Analog and Digital), LCR meters*	*PCB Layout Design - of RL, RC and RLC circuits*	*Schematic and PCB Layout in CAD tool.* ***Regulated power supply design. Full wave rectifier circuit design with fixed voltage regulator***	***Mini Project - PCB Layout Design of electronic turn ON/OFF timer using IC555 using PCB design tool.***	***Mini Project - Manufacture the PCB for electronic turn ON/OFF timer using IC555and construct and test the designed circuit.***
	SLO-2					
S-12	**SLO-1**					
	SLO-2					

Learning Resources

1. *Raghbir Singh Khandpur, "Printed Circuit Boards: Design, Fabrication, and Assembly" McGraw-Hill Electronic Engineering, 2006.*
2. *Charles A. Harpe, "High Performance Printed Circuit Boards", McGraw Hill Professional, 2000.*
3. *Bruce R. Archambeault, James Drewniak, "PCB Design for Real-World EMI Control", Volume 696 of The Springer International Series in Engineering and Computer Science, Springer Science & Business Media, 2013.*
4. *Kraig Mitzner, "Complete PCB Design Using OrCAD Capture and PCB Editor", Newnes/Elsevier, 2009.*
5. *Douglas Brooks "Signal Integrity Issues and Printed Circuit Board Design", Prentice Hall PTR, 2003.*
6. *Mark I. Montrose "Printed Circuit Board Design Techniques for EMC Compliance : A handbook for designers" Wiley, 2 Edition, 2015.*
7. *Esim open source tool : http://esim.fossee.in/*
8. *TINA/Orcad User manual*

Learning Assessment

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

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

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

Course Code	18ECO107T	Course Name	Fiber Optics and Optoelectronics	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Review the basic theorems related to fiber optic communication, and attain knowledge of types of optical fibers	2	80	70
CLO-2 :	Understand the optical signal distortion factors in optical fiber communication	2	85	75
CLO-3 :	Familiarize the principle and operation of various display devices, light sources and detectors	2	75	70
CLO-4 :	Acquire knowledge of various optoelectronic modulators and amplifiers	2	85	80
CLO-5 :	Understand the various optoelectronic integrated circuits	2	85	75
CLO-6:	Acquire fundamental concepts related to optical communication and optoelectronic devices	2	80	75

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

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

						considerations
S-5	SLO-1	Solving Problems	Waveguide dispersion	Quantum efficiency and LED power – External quantum efficiency and total LED power	Optical switching and logic devices- tunable threshold logic gate – Switching speed and energy.	Integrated transmitters and receivers – PIN-HBT photoreceivers
	SLO-2	Solving Problems	Signal distortion in single mode fibers	Solving Problems	Optical Amplifiers – General applications of optical amplifiers	Integrated transmitters and receivers – OEIC transmitters – equivalent circuit for integrated receivers
S-6	SLO-1	Ray optics	Polarization mode dispersion	Semiconductor laser diode	Semiconductor optical amplifiers – Basic configuration	Integrated transmitters and receivers – Complex circuits and arrays
	SLO-2	Types of rays	Polarization mode dispersion, Intermodal dispersion	Modes and threshold condition	Semiconductor optical amplifiers – Optical gain - Limitations	Integrated transmitters and receivers - optical control and microwave oscillators
S-7	SLO-1	Optical fiber modes	Intermodal dispersion	Photo detection principle	Erbium doped fiber amplifiers – energy level diagram and amplification mechanism	Guided wave devices – Waveguide and couplers
	SLO-2	Optical fiber configurations	Solving Problems	PIN Photodiode	Erbium doped fiber amplifiers – EDFA configuration	Guided wave devices – Active guided wave devices
S-8	SLO-1	Single mode fibers	Solving Problems	PIN photodiode - Avalanche Photodiode	Solving Problems	Guided wave devices – Mach Zehnder Interferometers
	SLO-2	Multimode Fibers	Pulse Broadening in Graded Index Waveguides	Avalanche Photodiode	Solving Problems	Active couplers
S-9	SLO-1	Step Index Fibers	Mode Coupling	Noise mechanism in photodetectors	Fiber Raman Amplifiers – Configuration – Forward pumping	Active Couplers
	SLO-2	Graded Index Fibers	Design Optimization of Single Mode Fibers	Solving Problems	Fiber Raman Amplifiers – Backward pumping	Active Couplers

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

Learning Assessment

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

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

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Course Code	18ECO108J	Course Name	EMBEDDED SYSTEM DESIGN USING ARDUINO	Course Category	O	Open elective courses	L	T	P	C
							2	O	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Get to know about ARDUINO hardware details and environment
CLR-2 :	To understand the core elements of ARDUINO programming language
CLR-3 :	Create insights to the concepts of serial communication
CLR-4 :	To use common input and output devices
CLR-5 :	Apply the ARDUINO programming into real time applications
CLR-6 :	

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Analyze the programming skill	2	80	70
CLO-2 :	Apply the real time data's into digital	2	85	75
CLO-3 :	Interact with almost many devices	2	75	70
CLO-4 :	Learn techniques to handle timer delays and IO devices	2	85	80
CLO-5 :	Use and modifying the existing libraries	2	85	75
CLO-6 :				

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

Duration (hour)		12	12	12	12	12
S-1	SLO-1	Introduction to arduino platform	Introduction To Arduino C	Analog And Serial Communication	IO Programming	Case Studies
	SLO-2	Block diagram	Arduino C Data Types .	Introduction To Analog Communication	Introduction To Timer/Counters	Wireless Communication Using Zigbee
S-2	SLO-1	AT mega 328p architecture	Decision Making in C	Pulse Width Modulation	Introduction To Timer/Counters	Bluetooth
	SLO-2	AT mega 328p architecture	Decision Making in C	RS232	Timer programming	Robotics -Motor And Sensor
S 3-4	SLO-1	Lab 1 Getting Started With Adriano	Lab 4 -Sensor Interfacing For Temperature Monitoring	Lab 7: Actuators – Stepper Motor	Lab10:Interrupt Programming	Lab 13:Mini Project
	SLO-2	CCS And AVR Studio 7 Blinking Led	Lab 4 -Sensor Interfacing For Displacement Measurement	Lab 7: Actuators – Stepper Motor	Lab10:Interrupt Programming	Lab 13:Mini Project
S-5	SLO-1	Pin function	Program Loops in C	I2C	Timer programming	Security-RFID, Infrared
	SLO-2	Overview of main features-I/O ports	Functions in C	I2C	Timer programming	Security-RFID, Infrared
S-6	SLO-1	Features-timers,interrupts	Introduction to Pointers	I2C	Timer programming	Bio medical application
	SLO-2					
S 7-8	SLO-1	Lab 2 GPIO LED	Lab 5: PWM BASED SERVO MOTOR INTERFACING	Lab 8: DC MOTOR	Lab11:Watch Dog Timer	Lab14:Model Practical
	SLO-2	Switch Based Led Control	Lab 5: PWM Based Servo Motor Interfacing	Lab 8: DC MOTOR	Lab11:Watch Dog Timer	Lab14:Model Practical

S-9	**SLO-1**	*Features-PWM,SERIAL PORT*	*Using Pointers Effectively*	*SPI Protocol*	*Interrupts*	*Bio medical application*
	SLO-2	*Features-ADC*	*Structures, Unions, and Data Storage*	*SPI Protocol*	*Interrupt programming*	*Bio medical application*
S-10	**SLO-1**	*Introduction to Arduino IDE*	*Arduino Libraries*	*Interfacing with sensors*	*External interrupt*	*GPS Navigation*
	SLO-2	*Writing ,saving,compiling with IDE.*	*Arduino Libraries*	*Interfacing with sensors*	*External interrupt*	*GPS Navigation*
S11-12	**SLO-1**	*Lab 3:DISPLAY INTERFACE-7 SEGMENT*	*Lab 6:SERIAL COMMUNICATION*	*Lab 9: Repeat/Revision Of Experiments*	*Lab 12 : I2C*	*Lab:15 University Practical*
	SLO-2	*LCD 16x2 Matrix*	*Lab 6:Serial Communication*	*Lab 9: Repeat/Revision Of Experiments*	*Lab 12: I2C*	*Lab:15 University Practical*

Learning Resources	1.Michael-Margolis,Arduino-Cookbook., Revised edition, O'Reilly,1st edition, 2011 2. D.Dale.Wheat, Arduino.Internals, TIA publication, 5th edition, 2011	3. James M. Fiore, Embedded Controllers Using C and Arduino, ARDUINO open source community, 2018 4. Jack Purdum ,Beginning C for Arduino, Apress, 2012

Learning Assessment

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

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

Course Designers

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

Course Code	18ECO109J	Course Name	Embedded System Design using Raspberry Pi	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	**Learning**			**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: Professional Achievement	PSO – 2: Project Management Techniques	PSO – 3: Analyze & Research
CLO-1 :	*Apply python for* Raspberry Pi	*2*	*80*	*70*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	*H*	-	-
CLO-2 :	*Analyze data sheet and functioning of sensors*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*H*
CLO-3 :	*Apply python programming on GPIO of* Raspberry Pi *and interfacing of sensor*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-4 :	*Apply python programming on GPIO of* Raspberry Pi *to interfacing of actuators*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*H*	-	-
CLO-5 :	*Apply python programming on GPIO of* Raspberry Pi *to interfacing input and display device*	*2*	*85*	*75*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	-	*H*	-	-
CLO-6 :	*Apply technology of node js ,cloud service and MQTT Protocol for IOT application*	*2*	*80*	*70*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	-	-	*H*

Duration (hour)		**Learning Unit / Module 1** **Basic python programming**	**Learning Unit / Module 2** **Programming interrupts –Motor control, switches and keyboard interface**	**Learning Unit / Module 3** **Sensor interface and programming**	**Learning Unit / Module 4** **Temperature sensor and display interface programming**	**Learning Unit / Module 5** **Publishing sensor data on web service**
		12	**12**	**12**	**12**	**12**
S-1	**SLO-1**	*Python Basics- Editing Python Programs with IDLE,Variables, displaying Output, Reading User Input , Arithmetic, Creating Strings*	*Programming with Interrupts*	*Detecting Movement-PIR sensor*	*Measuring Temperature Using a Digital Sensor*	*publish sensor data on web service-building a home security dash board*
	SLO-2	*Concatenating (Joining) Strings, Converting Numbers to Strings, Converting Strings to Numbers ,Find the Length of a String, Find the Position of One String Inside Another, Extracting Part of a String, Replacing One String of Characters with Another Inside a String ,Converting a String to Upper- or Lowercase*	*Programming with Interrupts*	*Data sheet analysis of PIR sensor*	*Data sheet analysis Digital Temperature Sensor*	*publish sensor data on web service-building a home security dash board*
S-2	**SLO-1**	*Running Commands Conditionally, Comparing Values, Logical Operators,*	*Controlling GPIO Outputs Using a Web Interface*	*Adding GPS to the Raspberry Pi*	*Measuring Distance-ultrasonic rangefinder*	*MQTT Protocol*
	SLO-2	*Repeating Instructions an Exact Number of Times ,Repeating Instructions Until Some Condition Changes , Breaking Out of a*	*Controlling GPIO Outputs Using a Web Interface*	*Data sheet analysis of GPS*	*Data sheet analysis ultrasonic rangefinder*	*MQTT Protocol- installation and setting account ,token creation ,reading sensor data and pushing to thingsboard*

		Loop, Defining a Function in Python				
S-3-4	**SLO-1**	***Lab 1: Arithmetic and string***	***Lab 7: Programming on interrupts***	***Lab 13: Programming on PIR sensor***	***Lab 19: Programming on Digital Temperature Sensor***	***Lab 25: Publish sensor data on web service***
	SLO-2	***Lab 2: Loop***	***Lab 8: Programming on Web Interface***	***Lab 14: Programming on GPS***	***Lab 20: Programming on ultrasonic rangefinder***	***Lab 26: Publish sensor data on web service***
S-5	**SLO-1**	*Creating a List , Accessing Elements of a List, Find the Length of a List , Adding Elements to a List , Removing Elements from a List,*	*Controlling Servo Motors using PWM*	*Using Resistive Sensors*	*Logging to a USB Flash Drive*	*basic of java scripts –node.js*
	SLO-2	*Creating a List by Parsing a String, Iterating over a List, Enumerating a List, Sorting a List, Cutting Up a List.Applying a Function to a List*	*Controlling the Speed of a DC Motor*	*Measuring Light*	*Logging to a USB Flash Drive*	*Modules-HTML module*
S-6	**SLO-1**	*Creating a Dictionary ,Accessing a Dictionary, Removing Things from a Dictionary,*	*Controlling the Direction of a DC Motor*	*Detecting Methane*	*Using a Four-Digit LED Display*	*Modules –file –event*
	SLO-2	*Iterating over Dictionaries*	*Using a Unipolar Stepper Motor*	*Data sheet analysis of gas sensor*	*Displaying Messages on an I2C LED matrix with data sheet discussion*	*Modules –file –event*
S-7-8	**SLO-1**	***Lab 3: Program on list***	***Lab 9: Programming on Stepper Motor***	***Lab 15: Programming on light sensor***	***Lab 21: Programming on Four-Digit LED Display***	***Lab 27: Programming on node js HTML module***
	SLO-2	***Lab 4: Program on Dictionary***	***Lab 10: Programming on DC Motor***	***Lab 16: Programming on Gas sensor***	***Lab 22: Programming on I2C LED matrix***	***Lab 28: Programming on node js file and event module***
S-9	**SLO-1**	*Controlling Hardware-Connecting an LED-Controlling the Brightness of an LED*	*Using a Bipolar Stepper Motor*	*Measuring a Voltage using MCP3008 And data sheet of MCP3008*	*Displaying Messages on an Alphanumeric LCD*	*LED blinking using node.js*
	SLO-2	*a Buzzing Sound*	*Building a Simple Robot Rover*	*Using Resistive Sensors with an ADC*	*Displaying Messages on an Alphanumeric LCD*	*LED blinking using node.js*
S-10	**SLO-1**	*Switching a High-Power DC Device Using a Transistor*	*Digital Inputs-Connecting a Push Switch-Toggling with a Push Switch-Using a Two-Position Toggle or Slide Switch*	*Measuring Temperature with an ADC*	*Cloud service for IOT*	*building java script client using MQTT broker*
	SLO-2	*Switching a High-Power Device Using a Relay*	*Using a Rotary (Quadrature) Encoder and Using a Keypad*	*Measuring Acceleration and data sheet discussion of Acceleration sensor*	*Cloud service for IOT*	*building java script client using MQTT broker*
S-11, 12	**SLO-1**	***Lab 5: LED blinking and Brightness control***	***Lab 11: Programming on Switch***	***Lab 17: Programming on ADC***	***Lab 23: Programming on an Alphanumeric LCD***	***Lab 29: Programming on LED blinking using node.js***
	SLO-2	***Lab 6: Switching a High-Power DC Device***	***Lab 12: Programming on Keypad***	***Lab 18: Programming on Measuring Acceleration***	***Lab 24: Programming on an Alphanumeric LCD***	***Lab 30: Building java script client using MQTT broker***

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

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

	Total	100 %	100 %	100 %	100 %	100 %

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

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

Course Code	18ECO110J	Course Name	3D Printing Hardware and Software	Course Category	E	*Professional Elective*	L	T	P	C
							2	0	2	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	1	2	3
CLO-1 :	*Apply the 3D printing tools for components design*	*1*	*80*	*60*
CLO-2 :	*Able to optimistically select the 3D design software and hardware for the given problem*	*1*	*80*	*60*
CLO-3 :	*Capability to solve 3D design components design problems*	*2*	*75*	*60*
CLO-4 :	*Choose the contemporary technology available for 3D design and printing*	*3*	*80*	*60*
CLO-5 :	*Apply various post processing methods involved in 3D printing technology*	*2*	*80*	*60*
CLO-6 :	*Ability to develop the skillset on 3D component design and development using contemporary commercial software and hardware available.*	*2*	*80*	*60*

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

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

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

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

Learning Assessment

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

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

Course Code	18ECO121T	Course Name	BASIC BIOMEDICAL ENGINEERING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical 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 :	Analyze the scopes and roles of Biomedical Engineering			
CLR-2 :	Utilize biomedical instrumentation modules			
CLR-3 :	Utilize medical imaging principles and its applications			
CLR-4 :	Analyze the scope of biomechanics and its applications			
CLR-5 :	Utilize biomaterials and its applications			
CLR-6 :	Gain the knowledge about Biomedical Engineering			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Analyze the areas in which biomedical engineers can work	2	85	75	-	-	-	-	-	-	-	-	-	-	-	L	-	-	L
CLO-2 :	Analyze the basic biomedical instrumentation unit	3	85	75	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-3 :	Analyze basic medical imaging principles	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Apply the concepts of biomechanics on human body	3	85	75	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-5 :	Identify domains where biomedical engineers can work	3	85	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Analyze the applications of Biomedical Engineer	3	85	75	M	-	-	-	-	-	-	-	-	-	-	L	-	-	L

Duration (hour)		Introduction to Biomedical Engineering	Biomedical Instrumentation	Medical Imaging system	Biomechanics	Biomaterials
		9	9	9	9	9
S-1	SLO-1	Evolution of the modern health care system	Introduction: Bioinstrumentation	X-Ray production	Introduction: Principal Areas of Biomechanics	Biomaterials Introduction
	SLO-2	Modern Healthcare system	Basic Bioinstrumentation System	X-Ray Imaging principle	Fundamentals of biomechanics and qualitative analysis	Classification of Biomaterials
S-2	SLO-1	What is Biomedical Engineering	Physiological Systems of the body	Application of X-ray imaging	Kinematics of Human Body Models	Properties of Biomaterials: Mechanical
	SLO-2	Roles played by the Biomedical Engineers	Sources of Biomedical Signals	CT-Imaging principle	Kinetics of Human Body Models	Properties of Biomaterials: Chemical
S-3	SLO-1	Types of Biomedical Engineering	Origin of Bioelectric Signals	CT-Imaging Applications	Modelling of Bio systems	Properties of Biomaterials: Biological
	SLO-2	Surgical instruments and medical devices	Origin of Bioelectric Signals	MRI- Introduction	Tissue Biomechanics	Biomedical alloys and its medical applications- titanium
S-4	SLO-1	Biomaterials	Various Electrodes used for picking the biomedical signals	MRI Imaging principles	Modelling in Cellular Biomechanics	Biomedical alloys and its applications- Stainless steel, Cobalt-Chromium alloys
	SLO-2	Biomechanics	Various Electrodes used for picking the biomedical signals	MRI Imaging principles	Fluid mechanics	Introduction to ceramics
S-5	SLO-1	Tissue Engineering	ECG Introduction	MRI Imaging Applications	Mechanics of the musculoskeletal system impact	Alumina, Zirconia
	SLO-2	Neural Engineering	ECG system Block diagram and its uses	Ultrasound basics	Mechanics of Blood Vessels	Titanium, Hydroxyapatite
S-6	SLO-1	Telehealth	EEG Introduction	Ultrasound Imaging	Cardiac Biomechanics	Glass ceramics

	SLO-2	*Bio signal processing*	*EEG system Block diagram and its uses*	*Ultrasound Application*	*Biomechanics of Chest and Abdomen*	*Introduction to polymers*
S-7	**SLO-1**	*Medical Imaging*	*EMG Introduction*	*fMRI Imaging*	*Cochlear Mechanics*	*Types of polymers*
	SLO-2	*Computational modelling*	*EMG system Block diagram and its uses*	*fMRI Imaging Application*	*Dynamics of Human Body Models*	*Biodegradable polymers and its applications*
S-8	**SLO-1**	*BioMEMS*	*Cardiac pacemakers and its uses*	*PET- Imaging*	*Gait analysis*	*Composites and its applications*
	SLO-2	*Mobile POCT*	*Cardiac Defibrillators and its uses*	*PET Imaging Application*	*Biomechanics in physical education*	*Wound-Healing process*
S-9	**SLO-1**	*Professional Status of Biomedical Engineering*	*Patient Monitoring System IntroPduction*	*SPECT Imaging*	*Biomechanics in strength and conditioning*	*Biomaterials for artificial valve, Ear*
	SLO-2	*Professional Societies*	*Patient Monitoring System Block diagram and its uses*	*SPECT Imaging Application*	*Biomechanics in sports medicine and rehabilitation*	*Biomaterials for artificial Skin, Eye*

Learning Resources	1. *Anthony Y. K. Chan, Biomedical Device Technology: Principles and Design, Charles C Thomas publisher, 2008* 2. *R.S Khandpur, Handbook of Biomedical Instrumentation, 3rd ed., McGraw Hill, 2014* **3.** *Joseph J. Carr, John M.Brown, Introduction to Biomedical Equipment Technology, 4th ed., Pearson, 2002*	4. *John Enderle, Joseph Bronzino, Introduction to Biomedical Engineering, Academic Press, 2011* 5. *Andrew R Webb, Introduction to Biomedical Imaging, Wiley-IEEE Press, 2003* 6. *Sujata V. Bhat, Biomaterials, 2nd ed., Alpha Science International, 2005*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECO122T	Course Name	HOSPITAL INFORMATION SYSTEMS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical 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 :	Utilize the planning and organizational activities of Hospitals			
CLR-2 :	Analyze the concepts in clinical and diagnostic services			
CLR-3 :	Utilize the policies and procedures about support services and material management			
CLR-4 :	Utilize the features in staff and safety management in hospital			
CLR-5 :	Analyze the reporting system and recent advancement in hospital administration			
CLR-6 :	Apply all the advanced application the field of telemedicine			

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: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Analyze the role of hospitals and ensure proper healthcare delivery	2	85	75	L	-	-	-	-	M	-	-	-	-	-	-	L	-	-
CLO-2 :	Suggest appropriate technologies and services in clinical and diagnostic field	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CLO-3 :	Analyze the supportive services and the use of proper material management	3	85	75	M	-	-	-	-	-	M	L	-	-	-	-	M	-	L
CLO-4 :	Identify objectives of staff management and ensure safety management in hospitals	3	85	75	M	-	-	-	-	-	-	L	-	-	-	L	L	-	-
CLO-5 :	Implement the advance technologies and effectively evaluate the healthcare information	3	85	75	L	-	-	-	-	M	-	L	L	-	-	-	L	L	L
CLO-6 :	Implement the various standards in hospital and healthcare services	3	85	75	L	-	-	-	-	M	-	-	-	-	-	-	L	-	-

Duration (hour)		Planning and designing of hospitals	Inpatient and Outpatient services	Material management services	Management services in hospitals	Patient record and advancement in healthcare services
		9	9	9	9	9
S-1	SLO-1	Hospital as a social system	Design and planning of emergency department	Pharmacy services- goals of hospital pharmacy services	Human resource management- Human resource development	Medical record management- Importance of medical record
	SLO-2	Primary health care and hospitals	Health information and counselling	Staff organization and divisions of hospital pharmacy services	Hospital staff skill development	Methods of record keeping
S-2	SLO-1	Hospital planning and design-Guiding principles in planning	Outpatient services –Types and functions of outpatient department	Benefits of formulatory system	Nursing management-Functions of nursing management	Electronic medical record-Benefits and drawbacks
	SLO-2	Regionalization of Hospital service	Physical features of outpatient department	Other services of hospital pharmacy	Nursing management- organizational structure	Record retention and disposal
S-3	SLO-1	Role of health promotion approach in hospitals	Ward/Indoor services-Components of the ward system	Transport services-Types of ambulance	Biomedical waste management- Types and Composition of Biomedical Waste	Office management -skills required by the office staff
	SLO-2	Health promoting hospital system	Design of special units	Communication and physical facilities of ambulance service	Categories of biomedical waste	Functions of office management
S-4	SLO-1	Healthy hospital environment	Operation theatre services-Planning and designing of Operation theatres	Staff transport services	Concept of total quality management	Operations research in hospitals-Phases of operation research
	SLO-2	Components of healthy hospital environment	Types of Operation theatres	Other transport services in hospitals	Types of approaches in quality management	Operations research in hospitals- Tools and techniques of operations research

S-5	**SLO-1**	*Creating manpower services*	*Policies and procedures of operation theatres*	*Medicolegal services- Steps for Medicolegal Examination*	*Quality assessment and management tools*	*Emerging health insurance – components of health insurance*
	SLO-2	*Hospital engineering: Key to efficient healthcare services*	*Assessing operation theatre utilisation*	*Problems faced by healthcare professionals in medicolegal service*	*Clinical audit*	*Emerging health insurance-Types of health insurance*
S-6	**SLO-1**	*Designing disabled friendly hospitals-Barriers faced and implications in Persons with disabilities*	*Clinical laboratory services-Introduction and role of laboratory medicine*	*Food safety in hospitals-Need of food safety*	*Quality improvement-Cause and effect method*	*Advantages and common problems of health insurance schemes*
	SLO-2	*Need for disabled-friendly health services*	*Testing procedure in clinical laboratory*	*Sources of food contamination*	*Pareto analysis*	*Role of health and hospital administrators in Health insurance*
S-7	**SLO-1**	*Barrier-Free Environment to Universal Design*	*Radio diagnosis and imaging services-Planning and equipments of radiology department*	*Materials management- Principles of material management*	*Failure mode and effect analysis*	*Telemedicine clinic –functions and classification of telemedicine*
	SLO-2	*Overcoming the barriers*	*Advancement in radiology service*	*Concepts of Inventory control*	*Triggers of quality improvement strategy in a hospital*	*Challenges for telemedicine*
S-8	**SLO-1**	*Energy conservation- Classification*	*Radiation oncology service-Radiotherapy facilities*	*Modern techniques for inventory control*	*Occupational safety-Roles and responsibilities*	*Growth of mobile phones and potential of mobile health*
	SLO-2	*Types of energy streams in hospitals*	*Nuclear medicine services-Categorization and nuclear medicine department*	*Integrated concept for materials management*	*Prevention of hazards specific to health sector*	*Mobile health and its applications*
S-9	**SLO-1**	*Need for energy conservation*	*Planning of nuclear medicine department*	*Purchase and procurement system-Essentials for procurement process*	*Hospital security-Physical security*	*Challenges in implementing information and Communication technology in healthcare*
	SLO-2	*Energy conservation opportunities in hospitals*	*Ancillary requirements*	*Purchase system*	*Organizational chart of security wing*	*Information and communication technology applications in healthcare*

Learning Resources	1. *SonuGoel, Anil Kumar Gupta, Amarjeet Singh, Hospital administration A problem- solving approach, 1st ed., Elsevier, 2014*	2. *Sakharkar B M, Principles of hospital administration and planning, 2nd ed., Jaypee Brothers Medical Publishers, 2009* 3. *Kunders G D, Hospitals: Facilities planning and management, 1st ed., Tata Mcgraw Hill, 2008*

Learning Assessment

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

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

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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO123T	Course Name	BIOMEDICAL IMAGING	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical 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 :	Utilize the working principle of X-ray imaging			
CLR-2 :	Analyze the principle behind tomographic imaging and the reconstruction techniques			
CLR-3 :	Interpret the theory behind nuclear medicine and utilize the working of imaging modalities in nuclear medicine			
CLR-4 :	Analyze the physics of ultrasound and the different imaging modes using ultrasound			
CLR-5 :	Utilize the physical principle of nuclear magnetic resonance and magnetic resonance image reconstruction			
CLR-6 :	The learner will be to gain knowledge in the working principle of imaging modalities using X-ray, computed tomography, nuclear medicine, ultrasound and magnetic resonance imaging.			

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: Problem Solving at the Interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Analyze the physics and principle behind the working of X-ray imaging	2	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Identify the principle behind working of tomographic imaging and reconstruction procedures.	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Analyze the working principle of nuclear medicine imaging modalities	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Identify the physics of ultrasound and the modes of ultrasound imaging	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Explain the physical principle of magnetic resonance imaging and the instrumental components involved in MR imaging	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Understand the basic principle and working of medical Imaging systems	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		X-ray	Computed Tomography	Ultrasound	Magnetic Resonance Imaging	Nuclear medicine
		9	9	9	9	9
S-1	SLO-1	General principles of Imaging with X-rays	Introduction: Tomographic Imaging	Characteristics of sound: Propagation, wavelength, frequency and speed	Principles of NMR Imaging	Radionuclide decay terms and relationship
	SLO-2	X-ray Production –X-ray source	Comparison between tomographic and planar imaging	Pressure, Intensity and dB scale	Free Induction decay	Nuclear transformation
S-2	SLO-1	X-ray tube current, tube output	Basic principle: Technique of producing CT images	Interaction of ultrasound with matter: Acoustic impedance, reflection, refraction	Excitation, Emission	Radionuclide production
	SLO-2	Beam intensity, X-ray Energy Spectrum	Contrast scale	Scattering, Attenuation	Relaxation times-T1 & T2	Radiopharmaceuticals
S-3	SLO-1	Coherent and Compton scattering	System components: first generation, second generation, third generation,	Transducers: Piezoelectric materials, resonance transducers	Spin echo technique	Radiation detection and measurement: types of detectors, Gas-filled detectors
	SLO-2	Photoelectric effect	Fourth, fifth and spiral/helical CT	Damping block, matching layer, Resolution	Spin echo contrast weighting	Scintillation detectors
S-4	SLO-1	Linear and Mass attenuation coefficient of X-rays in tissue	X-ray source, types of detectors	Transducer arrays	T1 weighted image	Semiconductor detectors
	SLO-2	Instrumentation for Planar X-ray Imaging: Collimators	Gantry and slip ring technology, Collimation and filtration	Multi-element linear array scanners	T2 weighted image	Pulse height spectroscopy
S-5	SLO-1	Antiscatter grids Intensifying screens	Processing system	Multi-linear and phased array	Gradient recalled sequence	Non-imaging detector applications

	SLO-2	*X-ray films*	*Iterative reconstruction, back projection reconstruction*	*Generation and detection of ultrasound*	*Proton density weighted images, pulse sequence for fast imaging*	*Counting statistics*
S-6	**SLO-1**	*Instrumentation for computed and digital radiography*	*Filtered back projection*	*Basic pulse echo apparatus: A-scan*	*Slice selection gradient*	*Nuclear imaging*
	SLO-2	*X-ray Image characteristics: Signal to Noise ratio*	*Helical /Spiral CT: Helical pitch*	*B-Mode*	*Frequency encode gradient*	*Anger scintillation camera*
S-7	**SLO-1**	*Spatial resolution, Contrast to Noise ratio*	*Basic reconstruction approaches*	*M-mode*	*Phase encode gradient*	*Basic principle :Emission computed tomography*
	SLO-2	*X-ray contrast agents, X-ray angiography*	*Slice sensitivity profile*	*Echocardiograph*	*2D spin echo data acquisition*	*Single photon emission computed tomography*
S-8	**SLO-1**	*X-ray Fluoroscopy*	*Multislice CT*	*Duplex scanner*	*Basic NMR components: Main magnet, RF transmitter/receiver*	*Positron emission tomography*
	SLO-2	*X-ray mammography*	*Detector configuration*	*Intravascular imaging*	*Body coils, gradient coils*	*Imaging techniques and scanner instrumentation*
S-9	**SLO-1**	*Dual energy Imaging*	*Measurement of X-ray dosage*	*Artefacts: Refraction, shadowing and enhancement*	*fMRI : Basic principle*	*Dual modality: PET/CT*
	SLO-2	*Abdominal X-ray scans*	*Methods for dose reduction*	*Reverberation*	*BOLD concept, MR spectroscopy*	*Working and applications*

Learning Resources	*1. R.S.Khandpur, Handbook of Biomedical instrumentation, 3rd ed., Tata McGraw Hill, 2014*	*2. Jerrold T. Bushberg, John M. Boone, The essential physics of medical imaging, 3rd ed., Lippincott Williams & Wilkins, 2011*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1.* Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu	***1. Dr. T. Jayanthi, SRMIST***
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3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO124T	Course Name	HUMAN ASSIST DEVICES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical 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 :	Utilize the latest technology and device used for assisting human disability			
CLR-2 :	Analyze various devices used for mobility			
CLR-3 :	Utilize the various assist device used for hearing			
CLR-4 :	Utilize the various assist device used for vision			
CLR-5 :	Utilize the various assist device used in orthopaedic			
CLR-6 :	Analyze the working principles of cardiac assist devices and Artificial kidney			

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: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
CLO-1 :	Comprehend the assistive technology (AT) used for mobility	2	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-2 :	Analyze the Assist technology used for hearing	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	-	L	-
CLO-3 :	Evaluate the Assist technology used for sensory impairment of vision	3	85	75	-	-	-	-	-	-	-	-	-	-	-	-	-	L	-
CLO-4 :	Evaluate the assist device used in orthopedic	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	L	-
CLO-5 :	Analyze the latest use of assist technology in health care	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-6 :	Design the prosthetic heart valves and pacemaker	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Basic assessment and evaluation for mobility	Basic ear anatomy, Mechanism of hearing	Anatomy of eye	Anatomy of upper & lower extremities -	Basic Anatomy and physiology of heart.
	SLO-2	Basic assessment and evaluation for mobility	Common tests audiograms	Categories of visual impairment	Classification of amputation types	Cardiac assist devices
S-2	SLO-1	Manual wheelchairs	Air conduction, Bone conduction	Intraocular Devices	Prosthesis prescription	Intra-Aortic Balloon Pump (IABP),
	SLO-2	Electric power wheelchairs	Masking techniques,	Extraocular Devices	Hand and arm replacement	Prosthetic heart valves
S-3	SLO-1	Power assisted wheelchairs	SISI	Permanent Vision Restoration	Different types of models, externally powered limb prosthesis	Evaluation of prosthetic valve
	SLO-2	Wheel chair standards & tests -	Hearing aids principles	Non-Permanent Vision Restoration	Different types of models, externally powered limb prosthesis	Heart pacemaker
S-4	SLO-1	Wheel chair transportation	Drawbacks in the conventional unit	Voice Control Sound Control.	Foot orthosis	CABG
	SLO-2	Control systems, navigation in virtual space by wheelchairs	DSP based hearing aids	Sensor Technology Adapted for the Vision Impaired	Pediatric orthoses	Extracorporeal support
S-5	SLO-1	Wheel chair seating and pressure ulcers.	Cochlear Implants	Libraille	Wrist-hand orthosis	Vascular prosthesis
	SLO-2	EOG based voice controlled wheelchair	Internal Hearing Aid	GRAB	feedback in orthotic system	Vascular prosthesis
S-6	SLO-1	BCI based wheelchair	External Hearing Aid	mathematical Braille	Components of upper limb prosthesis	Artificial heart

	SLO-2	*Fuzzy logic expert system for automatic tuning of myoelectric prostheses*	*Permanent Hearing Restoration*	*Blind mobility aids*	*Components of lower limb prosthesis*	*Intermittent positive pressure breathing (IPPB) type assistance for lungs*
S-7	**SLO-1**	*Intelligent prosthesis*	*Non-Permanent Hearing Restoration*	*Reading writing & graphics access,*	*Lower extremity- and upper extremity-orthoses*	*Dialysis for kidneys*
	SLO-2	*Intelligent prosthesis*	*Touch Tactile Haptic Technology*	*Orientation & navigation Aids*	*Lower extremity- and upper extremity-orthoses*	*Artificial Kidney*
S-8	**SLO-1**	*Future trends in assistive technology*	*Sound Coding Translation*	*Wearable Assistive Devices for the Blind*	*functional electrical stimulation*	*Haemodialysis*
	SLO-2	*virtual reality based training system for disabled children*	*Acoustic Transducers Hearing Quality*	*Wearable tactile display for the fingertip.*	*Sensory assist devices*	*Membrane dialysis*
S-9	**SLO-1**	*Information technology, telecommunications,*	*Electric Electronic Stimulation*	*Cortical implants*	*Sensory assist devices*	*Portable dialysis monitoring and functional parameter*
	SLO-2	*new media in assisting healthcare*	*Hearing Enhancement*	*Retinal implants*	*Slints – materials used*	*Latest use of assistive technology for chronic heart diseases and healthcare*

Learning Resources

1. *Levine S.N. Advances in Bio-medical engineering and Medical physics, 1st ed., Vol. I, II, IV, Interuniversity publications, 1968.*
2. *Marion. A. Hersh, Michael A. Johnson, Assistive Technology for visually impaired and blind, 1st ed., Springer Science & Business Media, 2010*
3. *Kopff W.J, Artificial Organs, 1st ed., John Wiley and Sons, 1976*
4. *Daniel Goldstein, Mehmet Oz, Cardiac assist Devices, Wiley, 2000*
5. *Kenneth J. Turner, Advances in Home Care Technologies: Results of the match Project, 1st ed., Springer, 2011*
6. *Albert M.Cook, Webster J.G, Therapeutic Medical Devices, Prentice Hall Inc.,1982*
7. *Gerr .M. Craddock Assistive Technology-Shaping the future, 1st ed., IOS Press, 2003*
8. *Brownsell, Simon, et al,. A systematic review of lifestyle monitoring technologies, Journal of telemedicine and telecare 17.4 (2011): 185-189*
9. *Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph.D, Bronzino, Clinical Engineering, 1st ed., CRC Press, 2010*
10. *Pascal Verdonck, Advances in Biomedical Engineering, 1st ed., Elsevier, 2009*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECO125T	Course Name	QUALITY CONTROL FOR BIOMEDICAL DEVICES	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering with specialization in Biomedical 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 :	Utilize Quality, Quality control measures essential for an organization			
CLR-2 :	Utilize the quality management principles and good management practices			
CLR-3 :	Utilize the various quality control tools			
CLR-4 :	Utilize the various quality management tools			
CLR-5 :	Analyze the various standards applicable to healthcare globally and nationally			
CLR-6 :	Implement the global standards in healthcare			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Analyze the underlying concepts of quality and quality control concepts of an organization	2	85	75
CLO-2 :	Evaluate the various quality management principles and good management practices	3	85	75
CLO-3 :	Evaluate various tools of quality control	3	85	75
CLO-4 :	Analyze the various quality management tools	3	85	75
CLO-5 :	Analyze the various standards applicable to healthcare globally and nationally	3	85	75
CLO-6 :	Analyze the outcomes of implementing global standards	3	85	75

Program Learning Outcomes (PLO)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1: Problem Solving at the interface of Engg. & Medicine	PSO-2: Design & Develop Medical Devices	PSO-3: multidisciplinary research for health care solu.
-	-	-	-	-	-	-	-	-	-	-	L	-	-	L
L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M	-	-	-	-	-	-	-	-	-	-	L	-	-	L

Duration (hour)		Introduction to quality	TQM principles	Statistical process control	TQM tools	Quality systems
		9	9	9	9	9
S-1	SLO-1	Definition of Quality	Customer satisfaction – Customer Perception of Quality	The seven tools of quality	Benchmarking	ISO 9000 Systems
	SLO-2	Dimensions of Quality	Customer Complaints	Cause-and-effect diagram	Reasons to Benchmark	ISO 9000 Systems
S-2	SLO-1	Quality Planning	Service Quality	Check sheet	Benchmarking Process	ISO 9000:2000 Quality System – Elements
	SLO-2	Quality Planning	Customer Retention	Check sheet	Benchmarking Process	ISO 9000:2000 Quality System – Elements
S-3	SLO-1	Quality costs	Employee Involvement	Control chart	Quality Function Deployment (QFD)	Need for Accreditation of hospitals
	SLO-2	Quality costs	Motivation	Control chart	Quality Function Deployment (QFD)	Need for Accreditation of hospitals
S-4	SLO-1	Basic concepts of Total Quality Management	Empowerment	Histogram	House of Quality	FDA Regulations
	SLO-2	Principles of TQM	Teams and Team Work	Histogram	House of Quality	FDA Regulations
S-5	SLO-1	Leadership – Concepts	Recognition and Reward	Pareto chart	QFD Process - Benefits	Joint Commission
	SLO-2	Role of Senior Management	Performance Appraisal	Pareto chart	QFD Process - Benefits	Joint Commission

S-6	**SLO-1**	*Quality Council*	*Juran Trilogy*	*Scatter diagram*	*Total Productive Maintenance (TPM) – Concept*	*Regulatory Bodies of India*
	SLO-2	*Quality Statements*	*Juran Trilogy*	*Scatter diagram*	*Total Productive Maintenance*	*Medical Council of India*
S-7	**SLO-1**	*Strategic Planning*	*PDSA Cycle*	*Stratification*	*Improvement Needs*	*Pharmacy Council Of India*
	SLO-2	*Strategic Planning*	*PDSA Cycle*	*Stratification*	*Improvement Needs*	*Pharmacy Council Of India*
S-8	**SLO-1**	*Deming Philosophy*	*Kaizen*	*Six sigma*	*FMEA*	*Indian Nursing Council*
	SLO-2	*Deming Philosophy*	*Kaizen*	*Six sigma*	*FMEA*	*Indian Nursing Council*
S-9	**SLO-1**	*Barriers to TQM Implementation*	*5S*	*Six sigma*	*Stages of FMEA*	*Dental Council of India*
	SLO-2	*Barriers to TQM Implementation*	*5S*	*Six sigma*	*Stages of FMEA*	*Homeopathy Central Council*

Learning Resources	1. *Rose J.E, Total Quality Management, Kogan Page Ltd., 1993* 2. *Cesar A. Cacere, Albert Zana,The Practise of clinical Engineering, Academic Press,1997* 3. *Greg Bounds, Beyond Total Quality Management-Toward the emerging paradigm, McGraw Hill, 2013*	4. *Joseph J.Carr, Elements of Electronics Instrumentation and Measurement, 2nd ed., Pearson Education, 2003* 5. *Jerrold T. Bushberg, John M. Boone, The essential physics of medical imaging, 3rd ed., Lippincott Williams & Wilkins, 2011*

Learning Assessment

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

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

Course Designers

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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. D. Ashok Kumar, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO126T	Course Name	Sports Biomechanics	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

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

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

	SLO-2	*Stretch–Shortening Cycle of Muscle Function*	*Fundamentals of movement*	*Identifying critical features of a movement*	*Determinants of Successful Ski-Jumping Performance*	*Induced Muscle Injury*
S-5	SLO-1	*Biomechanical Foundations of Strength*	*Linear motion and the centre of mass*	*The use of videography in recording sports movements*	*Principles of Throwing*	*Manual Wheelchair Propulsion*
	SLO-2	*Power Training*	*The geometry of angular motion and the coordination of joint rotations*	*The use of videography in recording sports movements*	*The Flight of Sports Projectiles*	
S-6	SLO-1	*Factors Affecting Preferred Rates of Movementin Cyclic Activities*	*Forces in sport*	*Recording the movement*	*Javelin Throwing: an Approach to Performance Development*	*Sports after Amputation*
	SLO-2	*The Dynamics of Running*	*Combinations of forces on the sports performer*	*Experimental procedures -Two dimensional videography*		
S-7	SLO-1	*Resistive Forces in Swimming*	*Momentum and the laws of linear motion*	*Experimental procedures -Three dimensional videography*	*Shot Putting*	*Biomechanics of Dance*
	SLO-2	*Propulsive Forces in Swimming*	*Force–time graphs as movement patterns*	*Data processing*	*Hammer Throwing: Problems and Prospects*	
S-8	SLO-1	*Performance-Determining Factors in Speed Skating*	*Determination of the centre of mass of the human body*	*Projectile motion*	*Hammer Throwing:Problems and Prospects*	*Biomechanics of Martial arts*
	SLO-2	*Cross-Country Skiing: Technique*	*Fundamentals of angular kinetics and Generation and control of angular momentum*	*Linear velocities and accelerations caused by rotation*	*Hitting*	
S-9	SLO-1	*Cross-Country Skiing: Equipment*	*Measurement of force*	*Rotation in three-dimensional space*	*Kicking*	*Biomechancis of YOGA*
	SLO-2	*Factors Affecting Performance*	*Measurement of pressure*	*Rotation in three-dimensional space*	*Simple concept problems*	

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

Learning Assessment

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

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

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. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECO131J	Course Name	VIRTUAL INSTRUMENTATION	Course Category	O	Open Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Study the concepts of Virtual instrumentation and to learn the programming concepts in VI.			
CLR-2 :	Study about the various real time data acquisition methods.			
CLR-3 :	Study about the various Instrument Interfacing concepts.			
CLR-4 :	To study the programming techniques for various control techniques using VI software			
CLR-5 :	To study various analysis tools for Process control applications.			
CLR-6 :	To study various real time measurement systems			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO 1: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	An ability to understand the purpose of virtual instrumentation and understand the construction of VI	1,2	80	70	H												H		
CLO-2 :	An ability to understand and apply various data acquisition methods.	2	85	75	H												H	H	
CLO-3 :	An ability to understand and implement the available interfacing instruments	2	75	70	H	H	H	H	H								H	H	H
CLO-4 :	An ability to understand and implement various control techniques using VI software	2,3	85	80	H	H	H	H	H								H		H
CLO-5 :	An ability to understand and develop a program foran engineering application.	2,3	85	75	H	H	H	H	H				H	H	H	H	H	H	
CLO-6 :	An ability to understand and implement various measurement systems	2,3	80	70	H	H	H	H	H				H	H	H	H	H	H	

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		12	12	12	12	12
S-1	SLO-1	Historical perspective, Need of VI, Advantages of VI, Virtual Instruments versus Traditional Instruments	A/D Converters, Organization of the DAQ VI system -	Introduction to PC Buses	Introduction to Non continuous controllers in LabVIEW	PC based digital storage oscilloscope
	SLO-2	Review of software in Virtual Instrumentation ,Software environment Architecture of VI, Introduction to the block diagram and Front panel Pallets	D/A Converters, Types of D/A	Local Buses-ISA, PCI,	Introduction to continuous controllers in LabVIEW	Sensor Technology
S-2	SLO-1	Creating and saving a VI, Front Panel Tool Bar, Block diagram Tool Bar, Palettes	plug-in Analog Input/output cards - Digital Input and Output Cards,	RS232, RS422	Design of ON/OFF controller	Applications of sensor Technology
	SLO-2	Creating sub VI, Creating an ICON, Building a connector pane, Displaying VI'S, Placing and Saving Sub VI'S on block diagram, Example of full adder circuit using half adder circuit	Organization of the DAQ VI system -	RS485	Proportional controller for a mathematically described processes using VI software	Signal processing Techniques
S-3	SLO-1	***Lab-1:*** Front Panel controls and Indicator	***Lab-12:*** Measurement of diode I-V characteristics using LabVIEW	***Lab-17:*** Load cell Data acquisition using RS232	***Lab-22:*** On-off temperature controller using LabVIEW	***Lab-28:*** Design of DSO
	SLO-2	***Lab-2:*** Verification of Arithmetic Operations				
S-4	SLO-1	***Lab-3:*** Verification of Half Adder	***Lab-13:*** Temperature measurement using LabVIEW and DAQ hardware.		***Lab-23:*** Continuous Control of temperature using LabVIEW	***Lab-29:*** Analysis of different signal Filters using LabVIEW
	SLO-2	***Lab-4:*** Verification of Full adder.				

S-5	**SLO-1**	*Loops-For Loop,*	*Opto Isolation need*	*Interface Buses-USB,PXI*	*Modeling of level process*	*Spectrum Analyzer*
	SLO-2	*While Loop*	*Performing analog input and analog output*	*VXI,*	*Basic control of level process in LabVIEW*	*Waveform Generator*
S-6	**SLO-1**	*Arrays,*	*Scanning multiple analog channels*	*SCXI*	*Modeling of Reactor Processes*	*Data visualization from multiple locations*
	SLO-2	*Clusters, plotting data*	*Issues involved in selection of Data acquisition cards*	*PCMCIA*	*Basic control of Reactor process in LabVIEW*	*Distributed monitoring and control*
S-7	**SLO-1**	***Lab-5:** Program to find Addition of First n natural numbers using for loop*	***Lab-14:** Flow measurement in water using LabVEW and DAQ hardware*	***Lab-18:** DC motor control using VXI*	***Lab-24:** On-off Level controller using LabVIEW*	***Lab-30:** Real time spectrum analysis using LabVIEW*
	SLO-2	***Lab-6:** Program to find Addition of First n odd numbers using while loop.*				
S-8	**SLO-1**	***Lab-7:** Implementation of Array functions.*		***Lab-19:** GPIB with VISA functions*	***Lab-25:** Continuous Control of pressure controller using LabVIEW*	***Lab-31:** Arbitratory Waveform Generator using LabVIEW*
	SLO-2	***Lab-8:** Calculation of BMI using cluster*				
S-9	**SLO-1**	*Charts*	*Data acquisition modules with serial communication*	*Instrumentation Buses - Modbus and GPIB*	*Case studies on development of HMI in VI*	*Vision and Motion Control*
	SLO-2	*Graphs*	*Design of digital voltmeters with transducer input*	*Networked busses – ISO/OSI*	*Case studies on development of HMI in VI*	Examples on Integrating Measurement with vision and motion
S-10	**SLO-1**	*Case and Sequence Structures*	*Timers and Counters*	*Reference model,*	*Case studies on development of SCADA in VI*	NI Motion control
	SLO-2	*Formula nodes, String and File Input/Output.*	*Timers and Counters*	*Ethernet and TCP / IP Protocols*	*Case studies on development of SCADA in VI*	Speed control system
S-11	**SLO-1**	***Lab-9:** Monitoring of temperature using Charts and Graphs*	***Lab-15:** Design of digital voltmeters with transducer input using LabVIEW*	***Lab-20:** Online temperature control using LabVIEW using TCP/IP*	***Lab-26:** On-off pressure controller using LabVIEW*	***Lab-32:** Minor Project*
	SLO-2	***Lab-10:** Program for implementing Seven segment display*				
S-12	**SLO-1**	***Lab-11:** Program to perform Traffic light control*	***Lab-16:** Pressure measurement using LabVEW and DAQ hardware DAQ.*	***Lab-21:** Online temperature control using Web publishing tool*	***Lab-27:** Continuous Control of pressure controller using LabVIEW*	
	SLO-2					

Learning Resources	1. *Nadovich, C., Synthetic Instruments Concepts and Applications, Elsevier, 2005* 2. *Bitter, R., Mohiuddin, T. and Nawrocki, M., Labview Advanced Programming Techniques, 2nd ed., CRC Press, 2007* 3. *Gupta, S. and Gupta, J. P., PC Interfacing for Data Acquisition and Process Control", 2nd ed., Instrument Society of America, 1994*	4. *Jamal, R., Picklik, H., Labview – Applications and Solutions, National Instruments Release.* 5. *Johnson, G., Labview Graphical programming, McGraw-Hill, 1997* 6. *Wells, L.K., Travis, J., Labview for Everyone, Prentice Hall, 1997* 7. *Buchanan, W., Computer Busses, CRC Press, 2000*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. K. A. Sunitha, SRMIST*

2. V. Venkateswaran, Instrumentation Consultant,vvenkat99@gmail.com	2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com	2. Mrs. A. Brindha, SRMIST

Course Code	18ECO132T	Course Name	ANALYTICAL INSTRUMENTATION	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the principle and theory of analytical instruments
CLR-2 :	Understand the quantitative analysis of dissolved components
CLR-3 :	Study the concept of separation science and its applications
CLR-4 :	Study the various spectroscopic techniques and its instrumentation
CLR-5 :	Identify and solve engineering problems associated with Radiation Techniques
CLR-6 :	Understand the working of Analytical Instrument and their importance in industries

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Apply the principles and theory of instrumental analysis	1,2	80	70
CLO-2 :	Apply the principles of various chemical analysis instruments in industries	1,2	85	75
CLO-3 :	Analyze and understand the operation of various radio chemical methods of analysis	1,2	75	70
CLO-4 :	To analyze and understand the operation of instruments based on optical properties	1,2	85	80
CLO-5 :	To identify and solve engineering problems associated with Radiation Techniques	1,2	85	75
CLO-6 :	To understand the working of analytical Instruments in industries	1,2	80	70

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO 1: Automatic control for continous & discrete systems	14 PSO-2: Utilize PLC & DCS for control of systems	15 PSO-3: Effective management skills
CLO-1 :	H	H	L	L	H	H	H						H	H	L
CLO-2 :	H	H	L	L	H	H							H	H	L
CLO-3 :	H	H	L	L	H	H							H	H	L
CLO-4 :	H	H	L	L	H	H							H	H	L
CLO-5 :	H	H	L	L	H	H							H	H	L
CLO-6 :	H	H	L	L	H	H							H	H	L

Duration (hour)		Learning Unit / Module 1	Learning Unit / Module 2	Learning Unit / Module 3	Learning Unit / Module 4	Learning Unit / Module 5
		9	9	9	9	9
S-1	SLO-1	Introduction to Chemical instrumental analysis	Dissolved oxygen analyzer, Importance of measuring dissolved oxygen in Industry, Principle working	Chromatography, Importance, Basic working of Chromatography	Spectral methods of analysis- Properties or parameters of electromagnetic radiation	NMR spectrometers ,Importance and basic working of NMR Spectroscopy
	SLO-2	Spectral method of analysis	Working of Dissolved oxygen analyzer	Gas chromatography Instrumentation	Electromagnetic spectrum Types of spectrometers	Magnetic assembly, Probe unit, Instrument stabilization
S-2	SLO-1	Electro analytical and seperative methods	sodium analyzer, Importance of measuring sodium in Industry, Principle working	Basic parts of a gas chromatography	Beer's law UV-visible spectrophotometers Transmittance and absorbance	Types of NMR spectrometer, Minimal type
	SLO-2	Instrumental methods of analysis-basic components and their classification	Working of sodium analyzer	Carrier gas supply Sample injection system	Beer's law Application of beer's law	Multipurpose NMR,Wideline
S-3	SLO-1	Sampling systems	Silica analyzer, Importance of measuring Silica in Industry, Principle working	Chromatographic column, Selection of column	Derivations of beer's law	Applications of NMR Spectrometer
	SLO-2	Importance of Sampling system in chemical Industries and Safety aspects	Working of Silica Analyzer	Thermal compartment, Detection system, Recording system	Single beam and double beam instruments	Mass Spectrometers, Basic working and Importance
S-4	SLO-1	PH Measurement, Principle of PH measurement & Importance of PH measurement in Industries	Moisture measurement Importance of Moisture measurement	Liquid chromatography-Principles, types and applications	IR spectrophotometers Instruments of IR	Components of Mass Spectrometers
	SLO-2	Types of Electrodes, Reference Electrodes and types	Types of Moisture measurement	High pressure liquid chromatography	Types of IR Components required for three types of IR	Types of Mass spectrometers Magnetic Sector analyzer, Double focusing spectrometers
S-5	SLO-1	Secondary Electrodes and Types	Oxygen analyzer Methods of oxygen analyzers and importance	Instrumentation or basic component of HPLC	Instruments of dispersive instrument , IR Radiation Sources and types	Time of flight analyzers, Quadrupole Mass analyzers

	SLO-2	*Indicator electrodes*	*Paramagnetic oxygen analyzer* *Electro analytical method*	*Solvent reservoir and its treatment system*	*Importance of Monochromators and types of Monochromators*	*Application of mass spectrophotometers*
S-6	**SLO-1**	*pH meters* *direct reading type pH meter* *null detector type pH meter*	*CO monitor,Importance of measuring CO*	*Pumping system, Types of working systems and Importance*	*Samples And Sample Cells* *detectors*	*nuclear radiation detectors, importance of measurement*
	SLO-2	*ion selective electrodes* *Types of ion selective electrodes* *Glass membrane electrodes* *Liquid membrane electrodes* *Solid membrane Electrodes*	*Types of CO monitor*	*Pulse dampers*	*FTIR spectrometers, Main components* *Advantages, disadvantages*	*GM counter*
S-7	**SLO-1**	*Biosensors* *Features of Biosensor* *Block diagram of bio sensor*	*NO2 analyzer, Importance of NO_2 measurement*	*Sample injection system and types*	*Types of sources* *Selection factors*	*Working setup, advantages of GM Counter*
	SLO-2	*Applications of Biosensors in industries*	*Types of NO_2 measurement*	*Liquid chromatographic column working , Types of Column thermostats*	*Types of detectors* *Selection factors*	*proportional counter, Basic Principle*
S-8	**SLO-1**	*conductivity meters ,Importance in Chemical Industries*	*H_2S analyzer, Importance of H_2 S Measurement*	*Detection system types*	*atomic absorption spectrophotometer instruments for atomic absorption spectroscopy*	*Working setup, advantages of GM Counter*
	SLO-2	*Types of Conductivity meters*	*Types of H_2S measurement*	*Types of Recording system*	*radiation source* *chopper*	*solid state detectors, Basic Principle*
S-9	**SLO-1**	*Air pollution Monitoring Instruments*	*Dust and smoke measurement-* *dust measurement and Importance* *Types of dust measurement*	*Application of HPLC, Advantages of HPLC over gas chromatography*	*production of atomic vapor by flame, Parts by flame photometer* *Emission system*	*Working setup, advantages of Solid state detectors*
	SLO-2	*Estimation of Air pollution*	*Thermal analyzer , Importance of Thermal analyzers, Types of Thermal analyzer*	*Detectors types, Factors Influencing the Selection of Detectors*	*Monochromators* *And types, Types of Detectors and recording systems and their selection criteria*	*scintillation counter, Basic principle*

Learning Resources	1. *Khandpur. R.S, "Handbook of Analytical Instruments", Tata McGraw Hill publishing Co. Ltd., 2006* 2. *Bella. G, Liptak, "Process Measurement and analysis"., CRC press LLC.,2003.* 3. *Francis Rousseau and Annick Rouesssac "Chemical analysis Modern Instrumentation Methods and Techniques", John wiley & sons Ltd.2007.*	4. *James W.Robinson,"Undergraduate Instrumental Analysis", Marcel Dekker., 2005.* 5. *Dwayne Heard, "Analytical Techniques for atmospheric measurement", Blackwell Publishing, 2006.*

Learning Assessment

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

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Course Designers

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2. V. Venkateswaran, Instrumentation Consultant,vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*Mrs. A. Brindha, SRMIST*

Course Code	18ECO133T	Course Name	LOGIC AND DISTRIBUTED CONTROL SYSTEM	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand basic components of PLC
CLR-2 :	Understand the use of timers and counters in process automation
CLR-3 :	Understand DCS architecture
CLR-4 :	Understand operator and engineering interface in DCS
CLR-5 :	Understand HART signal standard and Field bus
CLR-6 :	Understand Field bus signal standard.

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: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Select PLC based on I/O's	2,3	80	80	H	M	L	-	-	-	-	-	M	-	M	L	M		M
CLO-2 :	Apply timers and counters in process automation	1,2	80	80	H	H	H	H	H	-	L	-	H	M	L	L	H	H	H
CLO-3 :	Select LCU based on application	1	80	80	H	M	-	-	-	-	-	-	L	-	-	L	M	L	M
CLO-4 :	Analyse data's in Operator displays	3	80	80	H	H	-	H	-	-	-	-	H	M	-	L	H	L	M
CLO-5 :	Interpret industrial data communication modes	3	80	80	H	-	-	-	-	-	-	-	-	L	-	L	H	-	L
CLO-6 :	Gain knowledge on field bus	3	80	80	H	L	-	-	-	-	-	-	-	-	-	L	H	-	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Programmable logic controllers	PLC Programming Languages	Evolution of DCS	Operator Interfaces Requirements	Introduction to HART
	SLO-2	PLC vs Computer	Ladder Diagram	Hybrid System Architecture	Process Monitoring	Evolution of Signal standard
S-2	SLO-1	Parts of a PLC	Functional block	Central Computer system Architecture	Process Control	HART Networks: Point-to-Point
	SLO-2	Architecture	Sequential Function Chart	DCS Architecture	Process Diagnostics	Multi-drop
S-3	SLO-1	PLC size and Application.	Instruction List	Comparison of Architecture	Process Record Keeping	Split range control valve
	SLO-2	Fixed and Modular I/O	Structured Text	Local Control Unit Architecture	Low Level Operator Interface	HART Field Controller Implementation
S-4	SLO-1	Discrete Input Modules	Wiring Diagram	Architectural Parameters	High Level Operator Interface	Hart Commends: Universal
	SLO-2	Discrete Output Modules	Ladder logic Program	Comparison Of LCU Architecture	Hardware Elements In The Operator Interface	Common Practice
S-5	SLO-1	Analog Input Modules	On-Delay Timer Instruction	LCU Language Requirements	Operator Input And Output Devices	Device Specific
	SLO-2	Analog Output Modules	Off-Delay Timer Instruction	Function Blocks	Operator Display Hierarchy	Wireless Hart
S-6	SLO-1	Special I/O Modules	Retentive Timer	Function Block Libraries	Plant-Level Display	Field Bus Basics
	SLO-2	High Speed Counter Module	Cascading Timer	Problem-Oriented Language	Area- Level Display	Field Bus Architecture
S-7	SLO-1	Power Supplies	Up-Counter	LCU Process Interfacing Issues	Group- Level Display	Field Bus Standard
	SLO-2	Isolators	Down-Counter	Security Requirements	Loop- Level Display	Field Bus Topology
S-8	SLO-1	Input/output Devices: Switches	Cascading Counters	Security Design Approach	Engineering Interface Requirements	H1 Field Bus
	SLO-2	sensors	Combining Counter And Timer Functions	On-Line Diagnostics	Requirement For Operator Interface Configuration	H2 Field Bus
S-9	SLO-1	Relays	Math Operation	Redundant Controller Design	Low Level Engineering Interface,	Interoperability
	SLO-2	Solenoid valve	Program	One-On-One, One-On-Many Redundancy	High Level Engineering Interfaces	Interchangeability

Learning Resources	1. Frank D. Petruzella, Programmable Logic Controller, Tata McGraw Hill Fifth Edition, 2017 2. Bolton. W, Programmable Logic Controllers,6th Edition, Elsevier Newnes, Sixth Edition 2016. 3. Krishna Kant, Computer Based Industrial Control, Second edition, Prentice Hall of India, New Delhi,2015	4. Bowten, R HART Application Guide, HART Communication foundation, 2015. 5. Berge, J, Field Busses for process control: Engineering, operation, maintenance, ISA press,2015

Learning Assessment

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

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

Course Designers

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Course Code	18ECO134T	Course Name	SENSORS AND TRANSDUCERS	Course Category	O	Open Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Gain knowledge on classification, and characteristics of transducers
CLR-2 :	Acquire the knowledge of different types of inductive and capacitive sensors
CLR-3 :	Acquire the knowledge of different types of thermal and radiation sensors
CLR-4 :	Acquire the knowledge of different types of magnetic sensors
CLR-5 :	Acquire the knowledgeof different types of sensors measuring non-Electrical quantity
CLR-6 :	Locate the Applications of sensors in industries and home appliances

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 (Level of Thinking (Bloom))	Learning 2 (Expected Proficiency (%))	Learning 3 (Expected Attainment (%))
CLO-1 :	To demonstrate the various types of basic sensors.	2,3	80	80
CLO-2 :	Understand the inductive and capacitive sensors which are used for measuring various parameters.	1,2	80	80
CLO-3 :	Understand the thermal and radiation sensors	1	80	80
CLO-4 :	Have an adequate knowledgeon the various magnetic sensors	3	80	80
CLO-5 :	To demonstrate the various types of basic sensors measuring non electrical quantity	3	80	80
CLO-6 :	Select the right transducer for the given application	3	80	80

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO 1: Automatic control for continuous& discrete systems	14 PSO-2: Utilize PLC & DCS for control of systems	15 PSO-3: Effective management skills
CLO-1 :	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-
CLO-2 :	H	-	-	H	-	H	-	-	-	-	-	H	-	H	-
CLO-3 :	-	-	-	-	-	H	-	-	H	H	-	-	H	-	-
CLO-4 :	-	H	H	-	-	-	-	-	-	-	-	-	-	H	-
CLO-5 :	-	-	H	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to sensors/ transducers, Principles	Introduction to Inductive sensor	Thermal sensors: Introduction	Magnetic sensors: Introduction	Measurement of Non-Electrical quantity: Introduction
	SLO-2	Classification based on different criteria	Sensitivity and linearity of the sensor	Thermal Expansion type.	Villari effect	Flow Measurement – Introduction.
S-2	SLO-1	Characteristics of measurement systems	Transformer type transducer	Acoustics temperature sensors.	Wiedmann effect	Ultrasonic Flow Meters.
	SLO-2	Static characteristics Accuracy, Precision, Resolution, Sensitivity	Electromagnetic transducer	Thermo-emf sensor.	Hall effect	Hot Wire Anemometers.
S-3	SLO-1	Dynamic characteristics.	Magnetosrtictive transducer	Materials for thermos-emf sensors.	Construction,	Electromagnetic Flow meters.
	SLO-2	Environmental Parameters	Materials used in inductive sensor	Thermocouple construction	performance characteristics,	Principle and types.
S-4	SLO-1	Characterization and its type	Mutual Inductance change type	Types.	and its Application	Measurement of Displacement.
	SLO-2	Electrical characterization.	LVDT: Construction.	Thermo-sensors using semiconductor device	Introduction to smart sensors	Introduction and types.
S-5	SLO-1	Mechanical Characterization.	Material, input output relationship,	Pyroelectric thermal sensors	Film sensors: Introduction	Measurement of Velocity/ Speed.
	SLO-2	Thermal Characterization	Synchros-Construction	Introduction	Thick film sensors	Introduction and types.
S-6	SLO-1	Optical Characterization.	Capacitive sensor: Introduction	characteristics	Microelectromechanical systems	Measurement of Liquid Level.
	SLO-2	Errors and its classification.	Parallel plate capacitive sensor	Application	Micromachining.	Introduction and types.

S-7	**SLO-1**	*Selection of transducers.*	*Variable thickness dielectric capacitive sensor*	*Radiation sensors.*	*Nano sensors*	*Measurement of Pressure.*
	SLO-2	*Introduction to mechanical sensors*	*Electrostatic transducer*	*Introduction*	*Applications: Industrial weighing systems: Link–lever mechanism.*	*Introduction and types.*
S-8	**SLO-1**	*Resistive potentiometer and types*	*Piezoelectric elements*	*Characteristics*	*Load cells – pneumatic, elastic and their mounting.*	*Measurement of Vibration.*
	SLO-2	*Strain gauge: Theory, type, design consideration, sensitivity.*	*Ultrasonic Sensors*	*Geiger counters*	*different designs of weighing systems.*	*Introduction and types.*
S-9	**SLO-1**	*Resistive transducer: RTD, materials used in RTD*	*Calculation of sensitivity.*	*Scintillation detectors*	*conveyors type.*	*Application of sensors in industries*
	SLO-2	*Thermistor: thermistor material, shape*	*Capacitor microphone, response characteristics*	*Application on radiation sensors*	*weighfeeder type.*	*Application of sensors in home appliances*

Learning Resources	1. *Patranabis, D., "Sensors and Transducers", 2nd Edition, Prentice Hall India Pvt. Ltd, 2010.* 2. *Doeblin, E.O., "Measurement Systems: Applications and Design", 6thEdition, Tata McGraw-Hill Book Co., 2011.* 3. *Bentley, J. P., "Principles of Measurement Systems", 4th Edition, Addison Wesley Longman Ltd., UK, 2004.*	4. *Murthy, D.V.S., "Transducers and Instrumentation", Prentice Hall of India Pvt. Ltd., New Delhi, 2010.* 5. *Neubert H.K.P., "Instrument Transducers – An Introduction to their performance and Design", Oxford University Press, Cambridge, 2003.*

Learning Assessment

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

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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: Automatic control for continuous& discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Appreciate the fundamental concepts in MEMS technology	2,3	80%	80%	H	-	-	-	-	H	-	-	-	-	-	H	H	-	H
CLO-2 :	Understand the fabrication and machining techniques of MEMS devices	1,2	80%	80%	H	-	-	-	-	H	-	-	-	-	-	H	-	-	H
CLO-3 :	Familiarize with the concepts of packaging of MEMS devices	1	80%	80%	H	-	-	H	-	H	-	-	-	-	-	H	H	-	H
CLO-4 :	Appreciate the significance of micro fabrication processes	3	80%	80%	H	-	-	H	-	-	-	-	-	-	-	H	-	-	H
CLO-5 :	Design and Simulate simple structures using MEMS software	3	80%	80%	H	-	H	H	H	-	-	H	H	-	-	H	H	-	H
CLO-6 :	Analyze recent trends and developments in MEMS technology	3	80%	80%	H	-	-	H	-	-	-	-	-	-	-	H	H	-	H

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

S-6	**SLO-1**	*Chemical, Biomedical type Micro sensors*	*Diffusion process*	*LIGA process- description merits and demerits*	*Types of surface bonding – Adhesive*	*IR and Gas sensing*
	SLO-2	*Piezoelectric type of Micro sensors*	*Wet etching methods*	*Implementation*	*soldering, SOI type of bonding*	*Thermal sensors*
S-7	**SLO-1**	*Thermal, SMA, Piezoelectric actuators*	*Properties of etchants*	*Process Design-block diagram and description*	*Anodic bonding and lift off process*	*Micro power generation*
	SLO-2	*Electro static type Micro Actuators*	*Dry etching methods*	*Electro-mechanical design, Thermo-electric design*	*Precautions to be taken*	*Micro TEG*
S-8	**SLO-1**	*Micro devices- operation of Micro gears and micromotors*	*Production of plasma*	*CAD- block diagram description and implementation*	*Types of sealing- Micro shells, Hermetic sealing*	*Chemical sensors*
	SLO-2	*Micro devices –operation of Micro valves and pumps*	*Etch stop methods*		*Micro 'O' rings,Reactive seal*	*Micro humidity sensors*
S-9	**SLO-1**	*Case study*	*Case study*	*Case study*	*Selection of packaging materials*	*Micro pressure sensors*
	SLO-2				*Material requirements*	*Paper MEMS*

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

Learning Assessment

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

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

Course Designers

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

B. Tech in Electronics and Communication Engineering

2018 Regulations

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

Department of Electronics and Communication Engineering

SRM Institute of Science and Technology
SRM Nagar, Kattankulathur – 603203, Kancheepuram District, Tamilnadu

Course Code	18ECP109L / 18ECP110L	Course Name	PROJECT / SEMESTER INTERNSHIP	Course Category	P	*Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)*	L	T	P	C
							0	0	20	10

Pre-requisite Courses	*Nil*	Co-requisite Courses	Nil	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**	*As required for the project work*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To prepare the student to gain major design and or research experience as applicable to the profession*
CLR-2 :	*Apply knowledge and skills acquired through earlier course work in the chosen project*
CLR-3 :	*Make conversant with the codes, standards , application software and equipment*
CLR-4 :	*Carry out the projects within multiple design constraints*
CLR-5 :	*Incorporate multidisciplinary components*
CLR-6:	*Acquire the skills of comprehensive report writing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*
CLO-1 :	*Design a system / process or gain research insight into a defined problem as would be encountered in engineering practice taking into consideration its impact on global, economic, environmental and social context.*

Learning Assessment					
Continuous Learning Assessment	Assessment tool	Review I	Review II	Review III	Total
	Weightage	5%	20%	25%	50%
Final Evaluation	Assessment tool	Project Report	Viva Voce *		Total
	Weightage	20%	30%		50%

* Student has to be present for the viva voce for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP107L	Course Name	MINOR PROJECT	Course Category	P	*Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)*	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	Nil	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**	*As required for the project work*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Prepare the student to formulate an engineering problem within the domain of the courses undergone*
CLR-2 :	*Seek solution to the problem by applying codes / standards/ software or carrying out experiments or through programming*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*
CLO-1 :	*Identify a small part of major system or process, understand a problem associated with it and find solution or suggest a procedure leading to its solution.*

Learning Assessment					
Continuous Learning Assessment	Assessment tool	Review I	Review II	Final Review *	Total
	Weightage	20%	30%	50%	100%

* Student has to be present for final review for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP102L / 18ECP105L	Course Name	Industrial Training I / II	Course Category	P	*Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)*	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co-requisite Courses	Nil	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Communication Engineering*	**Data Book / Codes/Standards**	*As exposed to during the duration of training*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide an exposure to the students on the practical application of theoretical concepts in an industry or research institute*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*
CLO-1 :	*Gain confidence to carry out supervisory, managerial, and design roles in an industrial context.*

Learning Assessment			
Continuous Learning Assessment	Assessment tool	Final review	
	Weightage	Training Report	Presentation *
		75%	25%

* Student has to be present for the presentation for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP108L	Course Name	Internship	Course Category	P	Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)	L	T	P	C
							0	0	6	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering	Data Book / Codes/Standards	As exposed to during the duration of internship		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Provide an exposure to the students on the practical application of theoretical concepts in an industry or research institute and also to gain hands on experience in the context of design, production and maintenance

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1 :	Gain confidence to carry out supervisory, managerial, and design roles in an industrial context or research environment

Learning Assessment			
Continuous Learning Assessment	Assessment tool	Final review	
	Weightage	Training Report	Presentation*
		75%	25%

* Student has to be present for the presentation for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'

Course Code	18ECP103L / 18ECP106L	Course Name	Seminar I / II	Course Category	P	Project Work, Seminar, Internship In Industry / Higher Technical Institutions (P)	L	T	P	C
							0	0	2	1

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify an area of interest within the program or a related one (multidisciplinary), carry out a literature survey on it, gain understanding and present the same before an audience.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:
CLO-1 :	Carry out a self-study of an area of interest and communicate the same to others with clarity.

Learning Assessment			
Continuous Learning Assessment	Assessment tool	Presentation	
	Weightage	Presentation material	Presentation skills / ability to answer questions / understanding of the topic*
		60%	40%

* Student has to be present for the presentation for assessment. Otherwise it will be treated as non-appearance for the examination with final grade as 'Ab'