25. B. Tech in Electronics and Communication Engineering (with specialization in Instrumentation Engineering)

25. (a) Mission of the Department

Mission Stmt - 1	Build an educational process that is well suited to local needs as well as satisfies the national and international accreditation requirements
Mission Stmt - 2	Attract the qualified professionals 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 institutes, and produce competent graduands.

25. (b) Program Educational Objectives (PEO)

The Program Educational Objectives for the Electronics and Communication Engineering (with specialization in Instrumentation 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 Instrumentation 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 Instrumentation 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 Instrumentation 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.

25. (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

25. (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	PSO - 1	PSO - 2	PSO - 3
PEO - 1	H		H			H	M	H			H		H		H
PEO - 2		H	M	H	M									H	M
PEO - 3					L			M		H			L	L	M
PEO - 4												H	M		
PEO - 5						L			M						M
PEO - 6						M			H						M

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

Program Specific Outcomes (PSO)

Graduates of baccalaureate degree program in ECE with Specialization in Instrumentation Engineering must demonstrate the ability to

PSO – 1	Apply concepts of automatic control, including measurement, feedback and feedforward regulation for the operation of continuous and discrete systems.
PSO – 2	Understand and utilize programmable logic controllers (PLC), distributed control systems (DCS) and supervisory control systems for control of manufacturing and processing systems.
PSO – 3	Utilize modern and effective management skills for performing investigation, analysis, and synthesis in the implementation of automatic control systems.

25. (e) Program Structure for B.Tech in Electronics and Communication Engineering (with specialization in Instrumentation 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 I

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	Massive Open Online Course- I	0	0	2	1
18ECP102L	Industrial Training - I				
18ECP103L	Seminar – I				
18ECP104L	Massive Open Online Course- II	0	0	2	1
18ECP105L	Industrial Training - II				
18ECP106L	Seminar – II				
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 & Practices	0	0	2	0
18PDM201L	Competencies in Social Skills	0	0	2	0
18PDM202L	Critical & Creative Thinking Skills	0	0	2	0
18PDM301L	Analytical & Logical Thinking Skills	0	0	2	0
18LEM101T	Constitution of India	1	0	0	0
18LEM104J	Value Education	1	0	1	0
18GNM101L	Physical & Mental Health using Yoga	0	0	2	0
18GNM102L	NCC / NSS / NSO	0	0	2	0
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					**0**

List of Professional Elective Courses (E)

Course Code	Course Title	Hours/ Week L	T	P	C
18ECE180J	Transducer Engineering	2	0	2	3
18ECE181T	Measurements and Instrumentation	3	0	0	3
18ECE182T	Automotive Instrumentation Systems	3	0	0	3
18ECE183T	Safety Instrumented System	3	0	0	3
18ECE280T	Industrial Instrumentation	3	0	0	3
18ECE281J	Process Dynamics and Control	2	0	2	3
18ECE282T	Modern Control System	3	0	0	3
18ECE283J	Programmable Logic Controller	2	0	2	3
18ECE284J	Graphical System Design in Virtual Instrumentation	2	0	2	3
18ECE380T	Instrumentation and Control in Process Industries	3	0	0	3
18ECE381T	Distributed Control System and SCADA	3	0	0	3
18ECE382T	Building Automation	3	0	0	3
18ECE383J	Instrumentation System Design	2	0	2	3
18ECE384T	Factory Instrumentation Networks	3	0	0	3
18ECE385T	IoT in Process Instrumentation and Automation	3	0	0	3
18ECE386T	MEMS-based Microsystems Analysis and Design	3	0	0	3
18ECE387T	Microsensors and Smart Devices	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 Signal 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

25. (f) Program Articulation for B.Tech in Electronics and Communication Engineering (with specialization in Instrumentation 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	Automatic Control	Control of manufacturing and processing systems	Effective Management Skills
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	*H*	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
18ECC102J	Electronic Devices	*H*	-	-	-	*H*	-	-	*L*	*H*	*M*	-	*M*	*L*	*L*	-
18ECC103J	Digital Electronic Principles	*H*	*M*	*H*	-	*H*	-	-	-	*H*	-	-	-	*M*	-	*L*
18ECC104T	Signals and Systems	*H*	*H*	*M*	*M*	*M*	-	-	-	-	-	-	-	*L*	-	*L*
18ECC105T	Electromagnetics and Transmission Lines	*M*	*H*	-	-		-	-	-	-	-	-	*L*		-	*M*
18ECC201J	Analog Electronic Circuits	*L*	*M*	*H*	-	*M*	-	-	-	*M*	-	-	*M*	*H*	*L*	
18ECC202J	Linear Integrated Circuits	*H*	*M*	*H*	-	*M*	-	-	-	*M*	-	-	-	*H*	*L*	*H*
18ECC203J	Microprocessor, Microcontroller and Interfacing Techniques	*M*	*M*	*M*	-	*H*	-	-	-	-	*H*	-	*H*	*L*	-	*M*
18ECC204J	Digital Signal Processing	*H*	*M*	*H*	-	-	-	-	-	-	-	-	-	*M*	-	*H*
18ECC205J	Analog and Digital Communication	*M*	*H*	*H*	*M*	*H*	-	-	-	*H*	*H*	-	*M*	*H*	*M*	*H*
18ECC206J	VLSI Design	*H*	*M*	*M*	-	*H*	-	-	-	*H*	*M*	*L*	*M*	-	-	*M*
18ECC301T	Wireless Communication	*H*	*H*	*H*	*H*	*M*	-	-	-	-	*M*	-	*M*	*M*	-	*H*
18ECC302J	Microwave & Optical Communications	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	-	*M*	-	*M*
18ECC303J	Computer Communication Networks	-	-	*M*	-	*L*	*L*	*M*	-	-	-	-	*M*	-	-	*H*
18ECC350T	Comprehension	*H*	*H*	*M*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*M*	*M*	*M*
18ECP101L/ 18ECP104L	Massive Open Online Course-I/II	-	-	-	-	-	*M*	*L*	-	-	*H*	-	*H*	-	*M*	-
18ECP102L/ 18ECP105L	Industrial Training-I/II	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*H*	*H*	*M*	*H*	*M*	*L*	*L*	*L*
18ECP103L/ 18ECP106L	Seminar-I/II	-	*M*	*M*	*H*	-	*M*	*H*	-	-	*H*	-	*M*	-	-	-
18ECP107L/ 18ECP108L	Minor Project / Internship (4-6 weeks)	*H*	*H*	*H*	*H*	*M*	*M*	*H*	*M*	*M*	*M*	*M*	*L*	*M*	*M*	*M*
18ECP109L/ 18ECP110L	Project / Semester Internship	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*
18ECE180J	Transducer Engineering	H	M	M	M	-	-	-	-	H	-	-	-	M	M	H
18ECE181T	Measurements and Instrumentation	H	M	M	L	-	-	-	-	-	-	-	-	L	L	-
18ECE182T	Automotive Instrumentation Systems	H	M	M	L	M	M	M		-	-	-	M	H	M	-
18ECE183T	Safety Instrumented System	M	L	L	-	-	H	M	H	-	-	-	-	-	-	-
18ECE280T	Industrial Instrumentation	H	M	M	L	-	-	-	-	-	-	-	-	L	L	-
18ECE281J	Process Dynamics and Control	H	H	H	M	M	-	-	-	H	-	-	-	H	H	H
18ECE282T	Modern Control System	H	H	H	M	H	-	-	-	-	-	-	H	H	M	
18ECE283J	Programmable Logic Controller	H	H	H	M	H	-	-	-	H	-	-	H	H	H	H
18ECE284J	Graphical System Design in Virtual Instrumentation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18ECE380T	Instrumentation and Control in Process Industries	H	L	M	-	-	-	M	-	-	-	-	-	H	H	-
18ECE381T	Distributed Control System and SCADA	H	M	M	-	H	-	-	-	-	-	-	H	H	H	-
18ECE382T	Building Automation	H	L	M	-	H	H	H	-	-	-	-	-	H	H	H
18ECE383J	Instrumentation System Design	H	H	H	H	M	-	-	-	H	-	-	-	L	M	-
18ECE384T	Factory Instrumentation Networks	H	L	L	H	-	M	-	M	-	-	-	-	M	M	M
18ECE385T	IoT in Process Instrumentation and Automation	H	L	M	H	M	-	-	-	-	-	-	H	H	M	H
18ECE386T	MEMS-based Microsystems Analysis and Design	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
18ECE387T	Microsensors and Smart Devices	H	H	M	H	M	H	-	-	H	-	-	H	H	-	H

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

25. (g) Implementation Plan for B. Tech in Electronics and Communication Engineering (with specialization in Instrumentation 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/ 18ECP102L/ 18ECP103L	Massive Open Online Course-I / Industrial Training-I / Seminar-I	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
18ECP104L/ 18ECP105L/ 18ECP106L	Massive Open Online Course-II / Industrial Training-II / Seminar-II	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
18ECP107L / 18ECP108L	Minor Project / Internship (4-6 weeks)	0	0	6	3
Total Learning Credits					16

Semester - VIII

Code	Course Title	Hours/ Week L	T	P	C
18ECP109L / 18ECP110L	Project / Semester Internship	0	0	20	10
Total Learning Credits					10

B. Tech in Electronics and Communication Engineering
(with Specialization in Instrumentation 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	-	-
CLO-2 :	Identify the standard test inputs, time domain specifications and calculate steady state error	1,2	85	80	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	-	-
CLO-4 :	Analyze the frequency domain specifications from bode and polar plots	2,3	90	85	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	Design a closed loop control system for specific application	1,2,3	80	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-6 :	Identification of controller parameters and tuning	1,2,3	85	85	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-

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
(with Specialization in Instrumentation Engineering)

2018 Regulations

Professional Core 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:
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:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)
CLO-1 :	Explain the operation, characteristics, parameters and specifications of semiconductor diodes and special diodes	1	60	70
CLO-2 :	Illustrate important applications of semiconductor diodes and special diodes.	2	60	70
CLO-3 :	Review bipolar transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	60	70
CLO-4 :	Review field-effect transistor construction, operation, characteristics and parameters, as well as its application in amplification and switching.	1	60	70
CLO-5 :	Construct a circuit, then make functional measurements to understand the operating characteristics of the device / circuit.	3	70	75
CLO-6 :	Solve specific design problem, which after completion will be verified using modern engineering tools such as PSPICE.	2	70	75

Program Learning Outcomes (PLO)	1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO–1: Professional Achievement	14 PSO – 2: Project Management Techniques	15 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 / SLO-2	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
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.anil@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
CLR-1 :	Understand binary codes, digital arithmetic operations and able to simplify Boolean logic expressions	1
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:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		1	2	3	Engineering Knowledge	Problem Analysis	Design & 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 :	Simplify Boolean expressions; carry out arithmetic operations with binary numbers; apply parity method for error detection and correction.	1	90	75	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Explain the operational characteristics / properties of digital ICs; implement gates as well as other types of IC devices using two major IC technologies, TTL and CMOS.	1	80	70	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Identify eight basic types of fixed-function combinational logic functions and demonstrate how the devices / circuits can be used in building complete digital systems such as computers.	2,3	90	75	-	M	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze and design Mealy and Moore models of sequential circuits using several types of flip-flops.	2,3	90	75	-	M	H	-	H	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Implement multiple output combinational logic circuits using PLDs; Explain the operation of a CPLD and FPGA.	2	80	75	-	M	H	-	L	-	-	-	-	-	-	-	-	-	-
CLO-6 :	Solve specific design problem, which after completion will be verified using modern engineering tools such as PSPICE / Logisim	2	90	75	-	M	H	-	H	-	-	-	H	-	-	-	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 / SLO-2	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
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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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 :	Understand the various classifications of Signals and Systems	1	65	60	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-2 :	Analyze Periodic and Aperiodic Continuous time Signals using Fourier series and Fourier Transform	2	65	60	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-3 :	Analyze and characterize the Continuous time system through Laplace transform and Convolution integral.	2	65	60	-	H	-	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-4 :	Analyze and characterize the Discrete time signals and system through DTFT, Convolution sum	2	65	60	-	H	M	-	-	-	-	-	-	-	-	-	-	-	-	
CLO-5 :	Analyze and characterize the Discrete time system using Z transform	2	65	60	-	H	M	-	-	-	-	-	-	-	-	-	-	-	L	
CLO-6 :	Apply the mathematical techniques used for continuous-time signal and discrete-time signal and system analysis	2	65	60	-	H	-	M	M	-	-	-	-	-	-	-	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	*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. 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			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
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:*																		
CLO-1 :	*Apply the concepts and knowledge to solve problems related to electric field.*	*2*	*60*	*60*	*M*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*L*
CLO-2 :	*Analyze the concepts of Magnetic field and Maxwell's equations in the real world application.*	*2*	*60*	*60*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	*L*
CLO-3 :	*Translate the phenomenon of guided wave propagation and its mode of propagation.*	*1*	*60*	*60*	*H*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	*L*
CLO-4 :	*Describe the importance of transmission line theory applicable to low frequency transmission lines.*	*1*	*60*	*60*	*M*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*L*
CLO-5 :	*Solve transmission line parameter and impedance matching through analytical and graphical methods.*	*2*	*60*	*60*	*M*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*
CLO-6 :	*Demonstrate 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*	*60*	*60*	*M*	*H*	-	-	-	-	-	-	-	-	-	*L*	-	-	*H*

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

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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	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)	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 :	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	70	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	70	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	70	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	70	70	L	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Design the basic circuit building blocks that are used in the design of IC amplifiers, namely current mirrors and sources	2,3	70	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	-	-	-	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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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			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 :	Infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques	3	80	70	H	M	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Elucidate and design the linear and non-linear applications of an opamp and special application ICs	3	85	75	-	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-3 :	Explain and compare the working of multivibrators using special application IC 555 and general purpose opamp	3	75	70	-	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Classify and comprehend the working principle of data converters and active filters	3	85	80	-	M	H	-	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	Illustrate the function of application specific ICs such as Voltage regulators, PLL and its application in communication	3	85	75	-	M	H	-	-	-	-	-	-	-	-	-	M	-	H
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	-	M	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	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
	SLO-2					
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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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			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 a basic concept of digital fundamentals to Microprocessor based personal computer system	1	60	70	-	H	-	-	L	-	-	-	-	-	-		-	-	-
CLO-2 :	Solve basic binary math operations using the microprocessor. / microcontroller	2	60	70	M	-	-	-		-	-	-	-	-	-	M	-	-	-
CLO-3 :	Demonstrate programming proficiency using the various addressing modes of the target microprocessor / microcontroller	3	60	70	-	M	H	-	H	-	-	-	-	-	-		-	-	L
CLO-4 :	Distinguish and analyze the properties of Microprocessors & Microcontrollers.	1	60	70	-	M	-	-		-	-	-	-	-	-	H	-	-	-
CLO-5 :	Illustrate their practical knowledge through laboratory experiments.	3	60	70	-	M	M	-	H	-	-	-	-	H	-		-	-	H
CLO-6 :	Design, interface and program memory chips and various peripheral chips with microprocessor / microcontroller	3	60	70	-	-	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 8086 processor kit; Learning the hardware features of the 8086 processor kit**	**Lab-4: General Purpose Programming in 8086**	**Lab-7: Interfacing DAC / ADC with 8086 / 8051**	**Lab-10: Programming timer / counter in 8086 / 8051**	**Lab-13: Simulation of 8051 using Keil Software**
	SLO-2					
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
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anil@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. Manikandan AVM, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

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

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

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

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

		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 %	

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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 4-5	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 Demodulation**	**Lab-13: *Mini Project***
	SLO-2					

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/4 QPSK	Linear block codes
	SLO-2	Generation of Narrowband FM	*Noise in AM (Envelope Detection),*	Maximum likelihood receiver structure, Matched filter receiver	Generation, signal space diagram and detection of π/4 QPSK	Linear block codes
S-13	SLO-1	Demodulation of FM : Foster seely discriminator	*Noise in FM*	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
	SLO-2	Demodulation of FM : Foster seely discriminator	*Threshold effect, Pre-emphasis and De-emphasis*	Probability error of the Matched filter, Inter symbol interference, Eye pattern	Generation, signal space diagram and detection of QAM	Cyclic codes
S 14-15	SLO-1	**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*
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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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 :	Analyze 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	-	M	M	-	H	-	-	-	H	M	L	M	-	-	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	**Lab-0: Verilog Operators:**		**Lab-6:** Realization of VLSI multipliers - I		

	SLO-2	*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-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***	***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*
	SLO-2					
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*	*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*
	SLO-2					

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

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

S-7	**SLO-1**	Trunking and Grade of Service	Shadowing	Types of fading: Flat and Frequency selective fading	Equalizer and its mode	Multicarrier modulation
	SLO-2		Combined pathloss and shadowing			
S-8	**SLO-1**	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
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sandeep Kumar P, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

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

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
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 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 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*	-	-	-	-	-	-	-	-	-	-	*L*
CLO-2 :	*H*	*M*	*H*	*H*	-	-	-	-	-	-	-	-	*L*	-	*M*
CLO-3 :	*H*	*M*	*H*	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
CLO-4 :	*H*	*H*	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
CLO-5 :	*H*	*H*	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*M*
CLO-6:	*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 **Field effect transistor**	Attenuators and Phase Shifters	Attenuation measurements	Semiconductor Laser Diode, Laser Characteristics	Key link parameters
	SLO-2					

S-9-10	**SLO-1**	**Lab- 2 Study of power distribution in Directional coupler, E plane, H plane and Magic Tee**	**Lab- 5 Characteristics of filters, Microstrip patch antenna and parallel line coupler**	**Lab- 8 DC characteristics of LED and Laser diode**	**Lab- 11 Analysis of Analog optical link**	**Lab- 14 Practice Session**
	SLO-2					
S-11	**SLO-1**	IMPATT, TRAPATT and Tunnel diode	Rectangular Waveguides	Measurement of Scattering parameters	Optical Detectors: PIN and APD photo detector	Multichannel System: Need for multiplexing
	SLO-2					Operational principles of WDM, DWDM
S-12	**SLO-1**	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.,

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

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

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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 :	Express the basic services and concepts related to internetworking.	1	60	65	-	-	-	-	-	-	H	-	-	-	-	M	-	-	-
CLO-2 :	Explain the basic OSI model architecture and its lower layer functions.	1	60	65	-	-	M	-	-	-	L	-	-	-	-	-	-	-	H
CLO-3 :	Illustrate the various Network Layer concepts, mechanisms and protocols.	2	65	65	-	-	H	-	-	L	M	-	-	-	-	-	-	-	-
CLO-4 :	Describe the services and techniques of Transport Layer.	1	60	65	-	-	-	-	-	-	M	-	-	-	-	-	-	-	H
CLO-5 :	Discuss the various services and protocols in Application Layer.	1	60	65	-	-	M	-	-	-	-	-	-	-	-	-	-	-	H
CLO-6 :	Analyze the various Networking concepts and Routing protocols.	2	60	65	-	-	-	-	L	-	-	-	-	-	-	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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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECC350T	Course Name	COMPREHENSION	Course Category	C	Professional Core	L	T	P	C
							0	1	0	1

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Acquire skills to solve real world problems in Analog and Digital Electronics (Discrete & IC)*			
CLR-2 :	*Acquire skills to solve real world problems in Analog and Digital Communication*			
CLR-3 :	*Acquire skills to solve real world problems in Signals & Systems, and DSP*			
CLR-4 :	*Acquire skills to solve real world problems in Microprocessors & Microcontrollers, and VLSI Design*			
CLR-5 :	*Acquire skills to solve real world problems in Electromagnetics and Transmission Lines*			
CLR-6 :	*Acquire skills to solve real world problems in Microwave and Optical Communications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Practice and gain confidence and competence to solve problems in Analog and Digital Electronics (Discrete & IC)*	*3*	*85*	*80*
CLO-2 :	*Practice and gain confidence and competence to solve problems in Analog and Digital Communication*	*3*	*85*	*80*
CLO-3 :	*Practice and gain confidence and competence to solve problems in Signals & Systems, and DSP*	*3*	*85*	*80*
CLO-4 :	*Practice and gain confidence and competence to solve problems in Microprocessors & Microcontrollers, and VLSI Design*	*3*	*85*	*80*
CLO-5 :	*Practice and gain confidence and competence to solve problems in Electromagnetics and Transmission Lines*	*3*	*85*	*80*
CLO-6 :	*Practice and gain confidence and competence to solve problems in Microwave and Optical Communications*	*3*	*85*	*80*

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

Duration (hour)		3	3	3	3	3
S-1	SLO-1	***Tutorial on** Analog Electronics (Discrete & IC)*	***Tutorial on Digital Communication***	***Tutorial on Microprocessors & Interfacing***	***Tutorial on Transmission Lines***	***Tutorial on Optical Communication***
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*
S-2	SLO-1	***Tutorial on Digital Electronics***	***Tutorial on Signals and Systems***	***Tutorial on Microcontrollers & Interfacing***	***Tutorial on VLSI Design***	*Model Test*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Model Test*
S-3	SLO-1	***Tutorial on Analog Communication***	***Tutorial on Digital Signal Processing***	***Tutorial on Electromagnetics***	***Tutorial on Microwave Communication***	*Final Test*
	SLO-2	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Problem Solving*	*Final Test*

Learning Resources	*1. R.S.Khurmi, J.K.Gupta, Mechanical Engineering: Conventional and Objective Types, S.Chand & Co., 2018*	*2. R.K.Jain, Conventional & Objective Type Question & Answers on Mechanical Engineering for Competitions, Khanna Publishers, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 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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B. Tech in Electronics and Communication Engineering
(with Specialization in Instrumentation Engineering)

2018 Regulations

Professional Elective Courses (E)

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

Course Code	18ECE180J	Course Name	TRANSDUCER ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	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 :	Gain knowledge on methods of measurement, & know about various types of errors in instruments			
CLR-2 :	Know the behavior of transducers under static and dynamic conditions and to model the transducers			
CLR-3 :	Acquire knowledge on different types of resistive, inductive and capacitive transducers			
CLR-4 :	Identify the application of resistive, inductive and capacitive transducer			
CLR-5 :	Predict correctly the expected performance of various sensor			
CLR-6 :	Locate the different type of sensors used in real life applications and paraphrase their importance			

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 :	Apply the mathematical knowledge, science and engineering fundamentals to solve problems pertaining to various measurements	2	80	80	H	H	-	-	-	-	-	-	-	-	-	-	H	-	H
CLO-2 :	Determine the static and dynamic characteristics of transducer	2	85	80	H	H	-	M	-	-	-	-	-	-	-	-	H	-	H
CLO-3 :	Understand the resistive, inductive and capacitive transducers which are used for measuring various parameters	2	75	80	H	-	M	M	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	Have an adequate knowledge on the various miscellaneous transducers.	2	85	80	H	H	-	M	-	-	-	-	-	-	-	-	H	-	H
CLO-5 :	To demonstrate the various types of basic transducers.	2	85	80	H	-	H	-	-	-	-	-	H	M	-	-	H	-	H
CLO-6 :	Select the right transducer for the given application	2	85	80	H	-	H	H	-	-	-	-	H	M	-	-	H	-	H

		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	General configuration and description of measuring Instruments	Characteristics of instruments : Static characteristics: Accuracy, precision, resolution, sensitivity	Inductive sensor: common types- brief discussion with respect to material, construction and input output variable	Miscellaneous Transducers: Piezoelectric transducer	Smart Transducers: Smart Sensors, Components of Smart Sensors
	SLO-2	Basic methods of measurement	Characteristics of instruments : linearity, span and range, threshold, Hysterisis, Dead Time	Reluctance change type	Hall Effect transducer	General architecture of Smart Sensors
S-2	SLO-1	Functional Elements of Measurement Systems	Dynamic characteristics	Magnetostrictive type	Magneto elastic sensor	Evolution of Smart Sensors
	SLO-2	Definition, principles of sensing and transduction	Resistive Transducers: RTD Materials, Temperature measurement change in physical properties, 3 wire and 4 wire RTD	Mutual inductance change type	Digital transducers	Advantages of Smart Sensors
S-3	SLO-1	Lab1: Identifying the components of measuring instruments.	Lab 4: Characteristics of RTD	Lab 7: Characteristics of Thermistor	Lab10: Characteristics of Hall effect transducer	Lab13:Temperature measurement using LABVIEW and DAQ Hardware
	SLO-2					
S-4	SLO-1					
	SLO-2					
S-5	SLO-1	Units, Standards	Potentiometer Type- Forms, material	Transformer Type	Radiation sensors: Materials	Application area of Smart Sensors
	SLO-2	Unit conversions	Potentiometer Types- resolution, accuracy, sensitivity.	LVDT: Construction, material, output input relationship, I/O curve, discussion.	Radiation sensors: construction, response	MEMS sensor
S-6	SLO-1	Error: Classification of errors, Limiting error and probable error	Strain gauge: Theory, type, materials, design consideration, sensitivity	RVDT : Construction, material	Photo emissive cell types	NEMS sensor

	SLO-2	*Error analysis– Statistical methods*	*Derivation of gauge factor, variation with temperature, adhesive, rosettes*	*Synchros, Microsyn*	*Photovoltaic cells*	*Proximity sensors*
S-7	**SLO-1**	*Lab2:Determining the transfer function of a first order transducer*	*Lab 5: Characteristics of strain gauge*	*Lab 8: Characteristics of LVDT*	*Lab11: Characteristics of Synchros*	*Lab14:Displacement measurement using LABVIEW and DAQ Hardware*
	SLO-2					
S-8	**SLO-1**					
	SLO-2					
S-9	**SLO-1**	*Problems in Statistical methods- mean, median mode,variance*	*Thermistor: Material, shape, ranges and accuracy specification*	*Capacitive Transducers: Variable distance-parallel plate type*	*Photodiodes*	*Fiber optic sensors*
	SLO-2	*Problems in Statistical methods- standard deviation, probable error of one reading*	*Thermocouple:Thermo emf sensor: types, Laws of thermo couple. Reference junction compensation*	*Capacitive Transducers: variable area-parallel plate, cylindrical type, variable dielectric constant type*	*Light Dependent Resistor*	*Biosensors*
S-10	**SLO-1**	*Classification of transducers*	*Load cell-Principle, construction*	*Capacitive Transducers: calculation of sensitivity. Stretched diaphragm type*	*Geiger counters*	*Film sensors*
	SLO-2	*Selection of transducers*	*Hot-wire anemometer*	*Capacitor Microphone, response characteristics*	*Scintillation detectors*	*Environmental Monitoring sensors (Water Quality & Air pollution)*
S-11	**SLO-1**	*Lab3: Statistical Error analysis- Mean, SD, variance for an open loop response of thermocouple*	*Lab 6: Characteristics of Thermistor*	*Lab 9: Characteristics of capacitive transducer*	*Lab12: Characteristics of LDR*	*A mini project on MEMS / Nano/ smart/ fiber/ sensor using any software tools*
	SLO-2					
S-12	**SLO-1**					
	SLO-2					

Learning Resources	1. *Doeblin, E.O., "Measurement Systems: Applications and Design", 6th Edition, Tata McGraw-Hill Book Co., 2011.* 2. *Bentley, J. P., "Principles of Measurement Systems", 4th Edition, Addison Wesley Longman Ltd., UK, 2004.* 3. *Patranabis, D., "Sensors and Transducers", 2nd Edition, Prentice Hall India Pvt. Ltd, 2010.*	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	*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. D. Karthikeyan, Controls of Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com	1. **Mrs. N. Deepa**, SRMIST
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com	**2. Dr. A. Vimala Juliet, SRMIST**

Course Code	18ECE181T	Course Name	MEASUREMENTS AND INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Study the various techniques that are used to measure Current & Voltage
CLR-2 :	Study the various techniques that are used to measure power & energy
CLR-3 :	Design circuits to measure resistance, capacitance & inductance
CLR-4 :	Study different techniques to measure non-electrical quantities
CLR-5 :	Study the working of various display devices
CLR-6 :	Study the working of various recorders

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 techniques to measure current and voltage	2,3	80	80
CLO-2 :	Understand the techniques to measure power and energy	1,2	80	80
CLO-3 :	Design circuits for measuring resistance, inductance and capacitance	1	80	80
CLO-4 :	Understand the techniques to measure non electrical quantities	2,3	80	80
CLO-5 :	Apply knowledge of measurement and instrumentation in display a devices	3	80	80
CLO-6 :	Apply knowledge of measurement and instrumentation in recording devices	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 continous & 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
CLO-2 :	H	-	-	-	-	H	-	-	-	-	-	H	-	-	H
CLO-3 :	H	H	M	H	M	H	-	-	-	-	-	H	H	-	H
CLO-4 :	H	H	M	H	M	-	-	-	H	-	-	H	-	-	H
CLO-5 :	H	-	M	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	H	-	M	-	H	-	-	-	-	-	-	H	-	-	H

Duration (hour)		Learning Unit / Module 1 9	Learning Unit / Module 2 9	Learning Unit / Module 3 9	Learning Unit / Module 4 9	Learning Unit / Module 5 9
S-1	SLO-1	Introduction to measurements and Instrumentation. Classification of Instruments.	Introduction of power energy measurements	Introduction to measurement of resistance, capacitance, inductance and frequency	Introduction to measurement of Non-Electric Quantities	Introduction to display devices and recorders
	SLO-2	Galvanometer Introduction and its type.	Measurement of power in A.C. circuits	Classification of resistance types	Non-electric parameters	Digital display methods
S-2	SLO-1	D'Arsonval Galvanometer – construction, working and torque derivation.	Derivation of total power in A.C circuits	Methods of Low resistance measurement – Ammeter Voltmeter, Kelvins Double bridge method, Potentiometer.	Measurement of Pressure	Digital Storage Oscilloscope,
	SLO-2	PMMC – construction, working and torque derivation	Measurement of power in D.C. circuits	Methods of Medium resistance measurement	low and high pressure	Digital Voltmeter
S-3	SLO-1	Vibration galvanometer – construction, working and derivation	Derivation of total power in D.C. circuits	Substitution method & Voltmeter - ammeter method	Measurement of Vibration	Ramp type, integrating, potentiometric
	SLO-2	Introduction to Moving iron instruments	Introduction to Electrodynamic wattmeter	Wheatstone bridge method	Nature & its quantities	Recorders
S-4	SLO-1	Attraction type – construction and working	Electrodynamic wattmeter - Construction, Working and derivation	Methods of High resistance measurement	Measurement of Temperature	Continuous and discrete recorders
	SLO-2	Repulsion type– Construction and working	Errors in Electrodynamic wattmeter	Megger	Thermistor, thermocouple	Strip chart recorder
S-5	SLO-1	Electro dynamometer – working principle	Numerical Problem	Methods of Earth resistance measurements	Measurement of Radiation	X-Y recorder
	SLO-2	Dynamometer type Instrument-Construction and working	Power measurement in polyphase systems- basics	Introduction and general equations of A.C. Bridges	Pyrometers	UV Recorder
S-6	SLO-1	Induction type Instruments	Three Wattmeter method	Methods of Inductance measurements	Measurement of Flow	Direct recording

	SLO-2	*Construction and Working*	*Two & One Wattmeter method*	*problems*	*Ultrasonic flow transducer, electromagnetic flow meter*	*Audio recorder*
S-7	**SLO-1**	*Introduction to ammeter and voltmeter*	*Numerical Problems*	*Methods of Capacitance measurements*	*Measurement of Humidity*	*Advantages and Disadvantages*
	SLO-2	*Extension of ammeter ranges*	*Introduction to Single phase induction type energy meter*	*problems*	*Using Hygrometers*	*Video Recorder*
S-8	**SLO-1**	*Extension of voltmeter ranges*	*Single phase induction type energy meter - Construction, working principle*	*Methods of Mutual inductance*	*Measurement of Sound*	*Advantages and Disadvantages*
	SLO-2	*Calibration of ammeters*	*Testing of energy meters*		*Using microphones*	*Case Study on Plasma, LCD and Led Displays*
S-9	**SLO-1**	*Calibration of voltmeter*	*Phantom loading*	*Methods of Frequency measurements*	*Measurement of Level*	*Case Study on digital voice recorder*
	SLO-2	*summary*	*Meter testing circuits*	*problems*	*Ultrasonic method, capacitive methods*	*Summary*

Learning Resources	1. Sawhney, A.K., "A Course in Electrical & Electronic Measurements & Instrumentation", Dhanpat Rai and Co., New Delhi, 2015 2. Golding. E. W, and Widdis F.C, "Electrical Measurements and Measuring Instruments", 3rdEdition,A.H. Wheeler & Company, 2011. 3. Copper. W.D and Helfrick.. A.D, "Modern Electronic Instrumentation and Measurement Technique", 1 Edition, Pearson Education, India, 2013.	4. Bell, A.D., "Electronic Instrumentation and Measurements", 3rdEditionOxford University PressIndia, 2013 5. Northrop, R.B., "Introduction to Instrumentation and Measurements", 3rd Edition, CRC Press, 2017. 6. Carr, J.J., "Elements of Electronic Instrumentation and Measurement", Pearson Education India, 3rd edition, 2003.

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1.* ***Mr. C. Likith Kumar****, SRMIST*
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2.* ***Dr. A. Vimala Juliet****, SRMIST*

Course Code	18ECE182T	Course Name	AUTOMOTIVE INSTRUMENTATION SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Know about the basics of automotive systems and requirements.
CLR-2 :	Know about the principles behind various sensors and its application across a vehicle.
CLR-3 :	Know about various electrical systems pertaining to engine.
CLR-4 :	Know about different safety and security systems.
CLR-5 :	Know about different electronic systems in the body of the car.
CLR-6 :	Know about the sensors and various systems of automotive 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 (%)	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: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Understand the automotive domain and electronic systems in it.	1	80	75	H	H	-	-	L	-	-	-	-	-	-	H	H	-	H
CLO-2 :	Understand the effect of electromagnetic interference.	1-3	70	60	H	H	-	L	-	-	-	-	-	-	-	-	M	-	H
CLO-3 :	Identify the sensor and actuator technologies involved in a car.	1,2	90	80	H	H	M	L	M	-	-	-	-	-	-	H	H	H	-
CLO-4 :	Analyze the various electrical systems and electronics involved in it for upgraded operation.	2,3	90	80	H	H	M	L	M	-	-	-	-	-	-	H	M	-	H
CLO-5 :	Update his/her knowledge with new systems on safety, security and body of a car.	1,2	80	75	H	H	M	L	M	-	-	-	-	-	-	H	M	H	M
CLO-6 :	Understand the automotive problems and provide solutions through new system design.	1,3	80	70	H	H	-	-	L	-	-	-	-	-	-	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
		9	9	9	9	9
S-1	SLO-1	Introduction to Automotive Electronics	Intake Air Temperature (IAT) Sensor	Starting Systems – Requirements	Tire pressure monitoring systems	Power Windows
	SLO-2	Outline to Automotive Sensors	Engine Coolant Oil Temperature Sensor	Starter Motor – selection and working principle	Capacitive based Pressure Sensor	Smart Window Lift Control Module
S-2	SLO-1	Requirements in Automotive Sensor	Exhaust Gas Recirculation Temperature Sensor	Diagnosing Faults – Symptoms	Anti-lock braking system	Central Locking System
	SLO-2	Open and Closed Loop Control Strategies	Exhaust Gas Temperature Sensor	Testing Procedures	Anti-lock braking system	Power Seat
S-3	SLO-1	Shop safety – General safety	Manifold Absolute Pressure (MAP) Sensor	Charging systems – Requirements	Traction Control System	Automatic Wiper systems
	SLO-2	Electrical Safety	High Pressure Fuel Sensor, Engine Oil Pressure Sensor	Components and operation	Adaptive Cruise Control	Electronic Vehicle Immobilizer
S-4	SLO-1	Office Safety	Crankshaft Angular Position Sensor	Diagnosing Faults – Symptoms	Types of Adaptive Cruise Control	Oil Pressure Warning System
	SLO-2	Lifting Procedures	Cam Position Sensor	Testing Procedures	Types of Adaptive Cruise Control	Engine Overheat Warning System
S-5	SLO-1	Electrical wiring, Terminals & Switching	Piston Position Sensor	Ignition systems – Requirements	Parking guide systems	Speed Warning System
	SLO-2	Multiplexed Networking	Throttle Plate Angular Position	Conventional Ignition System	Air Bag System	Door Lock Indicators
S-6	SLO-1	Circuit Diagrams and Symbols	Knock Sensor	Electronic Ignition System	Reversible Seat Belt Pre-tensioner	Gear Neutral Indicator
	SLO-2	Electromagnetic Interference	Oxygen Concentration Sensor	Programmed Ignition System	Electronic Power Steering systems	Anti-Theft Alarm System

S-7	**SLO-1**	*Electromagnetic Compatibility*	*Mass Air Flow (MAF) Rate Sensor*	*Distributor less Ignition System*	*Vehicle Stabilization System*	*Brake Actuation Warning System*
	SLO-2	*Use of Diagnostic Equipment*	*Rain Sensor*	*Direct Spark Ignition System*	*Vehicle Stabilization System*	*Computer Controlled Air Conditioning Systems*
S-8	**SLO-1**	*Look Up Tables*	*Acceleration Sensor*	*Fuel Injection System – Requirements*	*Collision Avoidance System*	*On Board Diagnostics*
	SLO-2	*Applications*	*Yaw Rate Sensor*	*Components and operation*	*Collision Avoidance System*	*Roof Control Module*
S-9	**SLO-1**	*Case Study I*	*Chassis Level Sensor*	*Types of Fuel Injection System*	*Case Study II*	*Case study III*
	SLO-2	*Case Study I*	*Fuel Level Sensor*	*Types of Fuel Injection System*	*Case Study II*	*Case study III*

Learning Resources	1. *Tom Denton, Automotive Electricals / Electronics System and Components, 3rd ed., 2004* 2. *BOSCH, Automotive Electrics, Automotive Electronics: Systems & Components, BOSCH, 4th ed., 2005.*	3. *Jack Erjavec, A Systems Approach to Automotive Technology, Cengage Learning, 2009* 4. *Ronald K.Jurgen, Automotive Electronics Reliability, Vol 2, SAE International, 2010*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Mr. Arockia Vijay Joseph, SRMIST*
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*Mr. J. Sam Jebakumar SRMIST*

Course Code	18ECE183T	Course Name	SAFETY INSTRUMENTED SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Know the standard and regulation of SIS design.
CLR-2 :	Know the Corrective and Preventive maintenance of SIS.
CLR-3 :	Know the requirement of field device and the control components.
CLR-4 :	Know the failure diagnostic technique.
CLR-5 :	Acquire the knowledge on the software development model and Industrial application of SIS.
CLR-6 :	Know the function of safety life cycle and hazard analysis.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PSO 1: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Develop, operate and maintain the safety systems.	2,3	80	80	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-
CLO-2 :	Perform the corrective and preventive maintenance of SIS.	1,2	80	80	H	-	-	H	-	H	-	-	-	-	-	H	-	H	-
CLO-3 :	Understand the knowledge of field devices and reliability.	1	80	80	-	-	-	-	-	H	-	-	H	H	-	-	H	-	-
CLO-4 :	Evaluate the failure diagnostic technique.	3	80	80	-	H	H	-	-	-	-	-	-	-	-	-	-	H	-
CLO-5 :	Verify the skills of software development model for safety related system.	3	80	80	-	-	H	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	Gain knowledge on safety life cycle and function of protective layers.	3	80	80	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Industry Guidelines	Introduction to Safety Instrumentation	Importance of field device	Introduction of failure diagnostic mode	Selection of Technology
	SLO-2	Industry Standards and Regulations.	Hazards & risk	Impact of Field Devices on System Performance.	Equipment Failure mode	Relay systems-PLC based system
S-2	SLO-1	Set of Standards.HSE – PES, AIChE – CCPS,	Process Hazards Analysis (PHA)	Percentage Split of System Failures	Fail –Safe, Fail-danger, Annunciation	Safety PLCs
	SLO-2	IEC 61508, ANSI/ISA, OSHA (29 CFR 1910.119 - Process Safety Management of Highly Hazardous Chemicals)	Safety cycle	Issues relating to field devices. Wiring of Field Devices.	Reliability block diagram. Series system, Parallel systems, Fault trees, Fault tree symbols	Safety System Complexity
S-3	SLO-1	Technology Choices, Redundancy Choices, Field Devices, Test Intervals.	Shutdown/Interlock/Instrumented Systems (Safety Instrumented Systems – SIS).	Sensors	Comparison of Reliability block diagram and Fault tree	Communication with others system
	SLO-2	Design Lifecycle	Physical Protection	Switches, Transmitters	Fault tree AND gates ,fault tree OR gates	Software development models for safety related system
S-4	SLO-1	Hazard & Risk Analysis- HAZOP analysis	Mitigation Layers	Sensor Diagnostics	Approximation technique	Rapid prototyping, V model
	SLO-2	Allocation of Safety Functions to Protective Layers	Containment Systems	Smart Transmitters	Common mistakes	Water model, spiral model
S-5	SLO-1	Requirements	Scrubbers and Flares	Final Elements	Markov models	Implementation Procedure
	SLO-2	Develop Safety Specification	Fire and Gas (F&G) Systems	Valve Diagnostics	Markov solution technique	case study- Introduction
S-6	SLO-1	SIS Design & Engineering	Evacuation Procedures.	Smart Valve Positioners	Realistic safety instrumented system modeling	The Safety Lifecycle and Its Importance
	SLO-2	Installation , Commissioning	Diversification	Redundancy	Event tree analysis	Case Description: Furnace/Fired Heater Safety Shutdown System
S-7	SLO-1	Validation	Corrective and Preventive maintenance	Voting Schemes and Redundancy	Failure mode and effect analysis	Safety Instrumented system in PLC

	SLO-2	*Operations and Maintenance*	*Types of corrective and preventive maintenance*	*Design Requirements for Field Devices*	*Mathematical and statistical basis for risk analysis of technical systems*	*Safety Instrumented system in oil and gas facilities*
S-8	**SLO-1**	*Modifications. Decommissioning.*	*Mathematical models for performing corrective measures*	*Operator Interface requirement, Communication Interface requirement*	*Factory Acceptance Test*	*Nuclear plant safety discussion*
	SLO-2	*Process Hazard Analysis (PHA)*	*SIS Requirement for system behavior on detection of a fault*	*Final Element Design Requirements,*	*Spurious trip rate*	*Safety Instrumented system in DCS*
S-9	**SLO-1**	*Failure mode, Effects, and criticality analysis(FMECA), Probability of failure on demand(PFD)*	*Hardware fault Tolerance*	*Differences between using certified vs. proven-in-use devices*	*Risk Assessment*	*Installation, Commissioning and Pre-startup Tests*
	SLO-2	*Examples of usage of standards on specific applications.*	*SIS Integration: Architectural Issues*	*Circuit measures to increase the reliability*	*safety integrity levels (SIL)*	*Operation and Maintenance Procedures*

Learning Resources	1. Paul Gruhn, *Harry Cheddie, Safety Instrumented Systems: Design, Analysis and Justification, 2nd ed., International Society of Automation, 2005* 2. *William M.Goble, Harry Cheddie, Safety Instrumented Systems Verifications: Practical Probabilistic Calculations, ISA-2005*	3. *Roger L. Brauer, Safety and Health for Engineers, John Wiley Sons, 2006* 4. *B.S. Dhillon, Maintainability, Maintenance and Reliability for Engineers, CRC Press, 2006* 5. *Swapan Basu, "Plant Hazard analysis and Safety Instrumentation systems" Academic Press, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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. Mrs. K. Vibha, SRMIST*
2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. G Joselin Retna Kumar, SRMIST*

Course Code	18ECE280T	Course Name	INDUSTRIAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Acquire familiarity about various industrial instrumentation types, their parameters and different types of measurement techniques.*
CLR-2 :	*Gain knowledge about pressure measurement techniques.*
CLR-3 :	*Learn about the different techniques of measurement of flow.*
CLR-4 :	*Get exposed to the various techniques of measurement of level.*
CLR-5 :	*Gain knowledge about the temperature measurement techniques.*
CLR-6 :	*Familiarize the measuring devices used in industrial applications.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	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: Automatic control for continuous& discrete systems	PLO 14 PSO-2: Utilize PLC & DCS for control of systems	PLO 15 PSO-3: Effective management skills
CLO-1 :	*Understand the need for measurement in industries and the basic measurement techniques.*	3	80	75	H	H	-	H	H	-	-	H	L	-	H	H	M	H	L
CLO-2 :	*Elucidate the construction & working of various industrial devices used to measure pressure.*	3	80	70	H	H	H	H	H	-	-	H	L	-	H	H	H	H	L
CLO-3 :	*Summarize the different methods for flow measurement.*	3	75	70	H	H	H	H	H	-	-	H	L	-	H	H	H	H	L
CLO-4 :	*Illustrate the different methods for the measurement of level.*	3	80	75	H	H	H	H	H	-	-	H	L	-	H	H	H	H	H
CLO-5 :	*Analyze different techniques to measure temperature.*	3	80	70	H	H	H	H	H	-	-	H	L	-	H	H	H	H	H
CLO-6 :	*Analyze, formulate and select suitable sensor for the given industrial applications.*	3	80	70	H	H	-	H	H	-	-	H	L	-	H	H	M	H	H

Duration (hour)		Force, Acceleration and Speed Measurement	Pressure Measurement	Level Measurement	Flow Measurement	Temperature Measurement
		9	9	9	9	9
S-1	SLO-1	*Introduction to industrial symbols and standards*	*Units of pressure and vacuum*	*Need for level Measurement*	*General concepts - Laminar flow, Reynolds's number*	*Definitions and standards*
	SLO-2	*Classification of industry*	*Need for pressure measurement*	*Visual level indicators*	*Effect of temperature and pressure on flow rate measurement*	*Primary and secondary fixed points*
S-2	SLO-1	*Definitions of Process variable*	*Manometer Dynamics*	*Purge method*	*Calibration of flow meters.*	*Calibration of thermometer*
	SLO-2	*Unit conversions*	*Types- U tube, Inclined Tube and Well type Manometers*	*Buoyancy method*	*Head type flow measurement -Principle*	*Different types of filled in system thermometer*
S-3	SLO-1	*Types of measurement required*	*Elastic Pressure Sensor Instruments – Bourdon Tube Pressure Gauge, Capsule Gauge*	*Resistance, Capacitance and inductive probes*	***Orifice , Venturi tube***	*Sources of errors in filled in systems and their compensation*
	SLO-2	*Detectors, probe analyzers, actuators*	*Diaphragm gauges, bellows and force balance type sensors*	*Ultrasonic type*	***Pitot Tubes, Flow nozzle***	*Bimetallic thermometers*
S-4	SLO-1	*Measurement of force*	*Electronic Pressure / DP transmitters-capacitive type*	*Laser type*	***Variable Area Flow meters-Principle***	*Review of RTD and* ***Thermistors***
	SLO-2	*Different types of load cells –* ***Magneto-elastic*** *load cell, Strain gauge load cell*	*Piezo - resistive and resonating wire type*	*Optical fiber, Thermal type*	***Rotameters***	*Signal conditioning of industrial RTDs and their characteristics*
S-5	SLO-1	***Acceleration Measurement***	*Vacuum pressure Measurements- Mcleod Gauge*	*Radar, Radiation type*	***Electrical Type Flow meters-Principle***	*Three lead and four lead RTDs.*

	SLO-2	*Strain gauges, **Piezoelectric***	*Pirani gauge*	*Solid level measurement*	*Electromagnetic type, **Ultrasonic type***	*Thermocouples – Laws of thermocouple*
S-6	**SLO-1**	*Translational and rotational displacement using potentiometers*	*Thermocouple gauge*	*Boiler drum level measurement :– Differential pressure method*	*Positive displacement type*	*Fabrication of industrial thermocouples*
	SLO-2	*Differential transformers*	*Knudsen gauge*	*Hydrastep method*	***Nutating disc, Reciprocating piston***	*Commercial circuits for cold junction compensation*
S-7	**SLO-1**	*Mechanical type vibration instruments – Seismic instrument as an accelerometer*	*Ionization gauge- cold cathode and hot cathode types*	*Miscellaneous Measurement,*	*Mass flow meters - Coriolis type*	*Pyrometers:Total radiation pyrometers*
	SLO-2	*Vibrometer*	*Thermal conductivity gauge*	*Humidity – Dry and wet bulb psychrometers*	*Thermal, Impeller type*	*Selective radiation pyrometers*
S-8	**SLO-1**	*Speed measurement – Revolution counter*	*Testing and calibration of pressure gauges*	*Resistive and capacitive type hygrometers*	*Weirs, Flumes*	*Optical pyrometer*
	SLO-2	*D.C and A.C tachogenerators*	*Dead weight tester*	*Moisture measurement in solids-Conductivity sensor-Microwave and IR sensors.*	*Open channel flow measurement*	*Two colour radiation pyrometers*
S-9	**SLO-1**	*Stroboscope.*	*Discussion of device types and models used in practical industrial applications*	*Discussion of device types and models used in practical industrial applications*	*Discussion of device types and models used in practical industrial applications*	*Discussion of device types and models used in practical industrial applications*
	SLO-2	*Discussion of device types and models used in practical industrial applications*	*Installation Requirements*	*Installation Requirements*	*Installation Requirements*	*Installation Requirements*

Learning Resources	1. *Liptak B.G., "Instrument Engineers Handbook (Measurement)", Chilton book Co., McGraw Hill, publishing Ltd., 19th Revised edition-2011.* 2. *A.K. Sawhney , "A course in Electrical and Electronic Measurements and instrumentation Dhanpatrai co., 19th Revised edition-2011. Reprint 2014* 3. *Patranabis D, "Principles of industrial Instrumentation", Tata McGraw Hill, 3rd Edition, New Delhi, Reprint 2010*	4. *Tony R. Kuphaldt, "Lessons In Industrial Instrumentation ", Version 2.02, 2014* 5. *Singh S. K., "Industrial Instrumentation& Control", Tata McGraw Hill, 2nd Edition, Reprint 2007* 6. *NPTEL video lectures on "Industrial Instrumentation" by Prof. AlokBarua, IIT Kharagpur*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE281J	Course Name	PROCESS DYNAMICS AND CONTROL	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Impart fundamental knowledge on the dynamics and mathematical modeling of various processes
CLR-2 :	Introduce the effect of various control actions and the tuning techniques of controllers.
CLR-3 :	Impart knowledge on final control elements
CLR-4 :	Get exposed different types of advanced control schemes
CLR-5 :	Explore the computer as controller in digital control system.
CLR-6 :	Identify the different type of control schemes used in process industries and paraphrase their importance

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Analyze and mathematically model the process systems	3	80	75	H	H	M	H	H	-	-	H	H	-	H	H	M	L	L
CLO-2 :	Select and optimize the tuning of a controller	3	80	70	H	H	H	H	H	-	-	H	H	-	H	H	H	L	L
CLO-3 :	Demonstrate the working and application of different type of actuators and control valves	3	75	70	H	H	H	H	H	-	-	H	H	-	H	H	H	M	L
CLO-4 :	Understand and analyze the various advanced control schemes	3	80	75	H	H	H	H	H	-	-	H	H	-	H	H	H	M	H
CLO-5 :	Design suitable digital controllers for the process	3	80	70	H	H	H	M	H	-	-	H	H	-	H	H	H	H	H
CLO-6 :	Recommend the right choice of control schemes for the application	3	80	70	H	H	M	H	H	-	-	H	H	-	H	H	M	H	H

Duration (hour)		Process Dynamics	Control Action and Tuning of controllers	Final Control Elements	Advanced Control Schemes	Digital Control System
		12	12	12	12	12
S-1	SLO-1	Need for process control	Basic control actions	I/P converter	Feedback and Feed-forward control	Introduction to state space ,Basic building blocks of computer control system
	SLO-2	The process control loop	Characteristics of ON- OFF controllers	P/I converter	Application of feed forward control in various processing units	Data loggers
S-2	SLO-1	Need for process modeling	Characteristics of Single speed floating controllers	Pneumatic actuators	Split-range control	Data acquisition systems
	SLO-2	Servo and Regulatory operation	P+I, P+D and P+I+D control modes	Electric actuators	Application of cascade control in various processing units	Supervisory control , SCADA, Direct digital control
S 3-4	SLO-1	Lab1: Identify the components of the process control loop.	Lab 4: Design the on-off, P,PI and PID controller for the Pressure Process	Lab 7: Determine the characteristics of I/P and P/I converter	Lab10: Tune the PID Controller for mathematically described process using ZN method	Lab13:Determine the state model for the mechanical system using MATLAB
	SLO-2					
S-5	SLO-1	Continuous and batch processes	Practical forms of PID controller	Control Valves	Inferential control	Review of z transforms
	SLO-2	Self-regulation, Degrees of freedom	Auto/manual transfer, Reset windup	Characteristic of Control Valves:- Inherent characteristics	Ratio control	Digital PID , Position and velocity form
S-6	SLO-1	Mathematical model of level, flow processes	Evaluation criteria- Quarter Decay Ratio, IAE, ISE and ITAE	Installed characteristics	Cascade control.	Implementation of digital controllers
	SLO-2	Interacting and non interacting systems	Selection of Time Integral performance Criteria	Modeling of control valves and types	Fuzzy controllers	Design of Deadbeat controller, Dahlin's controller
S 7-8	SLO-1	Lab 2 : Determine the characteristics of interacting system	Lab 5: Design the on-off control, P,PI and PID controller for the flow Process	Lab 8: Determine the characteristics of Pneumatically Actuated Control Valve	Lab11: Tune the PID Controller for mathematically described process using ZN open loop method	Lab14:Design the Deadbeat algorithm for the given system using MATLAB
	SLO-2					

S-9	**SLO-1**	*Laws and assumptions governing gas process*	*Tuning – Process reaction curve method*	*Valve Positioner and its importance*	*Adaptive controllers*	*Multi-loop multivariable control , Introduction*
	SLO-2	*Mathematical models of pressure processes*	*Z-N open loop tuning techniques*	*Control valve sizing*	*Model predictive control*	*Interaction between control loops*
S-10	**SLO-1**	*Laws and assumptions governing thermal process*	*Continuous cycling method*	*Cavitation and flashing*	*Smith predictor control scheme*	*The Relative Gain Array (RGA)*
	SLO-2	*Mathematical models of thermal processes*	*Damped oscillation method*	*Selection criteria*	*Internal model control (IMC) ,P& I diagram*	*Decoupling of control loops*
S 11-12	**SLO-1** / **SLO-2**	*Lab3: Determine the characteristics of non interacting system*	*Lab 6: Design on-off control, P,PI and PID controller for the level Process*	*Lab 9: Determine the characteristics of Pneumatically Actuated Control Valve (with and without Positioner)*	*Lab12: Compare the responses of simple and cascade control system using MATLAB*	*Case study : Design of computerized multi loop controller*

Learning Resources	1. Seborg ,D.E., Mellichamp, D.P., Edgar, T.F., and Doyle,F.J., III, "Process Dynamics and Control", John Wiley and Sons, 4thEdition 2016 2. *Stephanopoulos. G" Chemical Process Control - An Introduction to Theory and Practice", Prentice Hall of India,2nd Edition,2015* 3. *Gopal, M., "Digital Control and State Variable Methods", Tata McGraw Hill,2003*	4. *D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 3rd Edition, 2013* 5. *Bela.G.Liptak., "Process Control and Optimization"., Instrument Engineers' Handbook., volume 2,CRC press and ISA, 2005* 6. *Curtis D. Johnson Process Control Instrumentation Technology, 8th Edition, Pearson, 2006* 7. *NPTEL video lectures on "Chemical Process Control" by Prof. SujitJogwar, IITM.* 8. *P.W. Murrill.,"Fundamentals of Process Control Theory", 3rd Edition*-ISA Books

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE282T	Course Name	MODERN CONTROL SYSTEM	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Know and design various conventional compensators.
CLR-2 :	Know and develop mathematical modeling using state space technique.
CLR-3 :	Know and analyze the system using state space analysis techniques.
CLR-4 :	Know the importance of structural properties and to analyze the stability of the system.
CLR-5 :	Study the state space control methodologies for various systems.
CLR-6 :	Know and design modern control techniques which are linear.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Design cascade compensators in time domain and design PID controllers in time domain.	3	80	75	H	H	H	-	L	-	-	H	-	-	-	H	H	-	H
CLO-2 :	Understand and develop state space model for different systems	3	80	70	H	L	H	-	H	-	-	H	-	-	-	-	M	-	H
CLO-3 :	Analyze the controllability and observability of a system and to design controllers and observers.	3	75	70	H	H	-	H	H	-	-	H	-	-	-	-	M	-	H
CLO-4 :	Implement procedure to find the structural properties of any linear system	3	80	75	H	H		H	H	-	-	H	-	-	-	-	M	-	H
CLO-5 :	Understand the procedure of applying the control methodology on various linear systems	3	80	70	H	H	H	H	H	-	-	H	-	-	-	H	M	-	H
CLO-6 :	Design and apply linear based modeling and modern control methods for different linear systems.	3	80	70	H	H	H	-	L	-	-	-	-	-	-	H	H	-	H

Duration (hour)		Linear Control Design	State Space Analysis	Controllability And Observability	Controller Design For Linear System	Applications
		9	9	9	9	9
S-1	SLO-1	Design specifications	Concept of State variables	Concept of Stability	Pole placement using feedback	State space Modeling of Inverted Pendulum
	SLO-2	Compensator configuration (series and feedback)-	Concept of State space model	Computation of Stability of State space model	Eigen value placement theorem	
S-2	SLO-1	Design cascade compensators - lag by using time domain	Relationship between transfer function and State space model	Concept of Controllability	Selection of desired poles	State space Modeling of Ball and Beam system
	SLO-2	Design feedback compensators - lag by using time domain	State space representation of linear continuous time systems using physical variables	Computation of Controllability of State space model	Eigen structure assignment	
S-3	SLO-1	Design cascade compensators - lead by using time domain	State space representation of linear continuous time systems using phase variables	Concept of Observability	State controller design exercise	State space Modeling of Translational Mechanical Systems
	SLO-2	Design feedback compensators - lead by using time domain	State space representation of linear continuous time systems using canonical variables	Computation of Observability of State space model		
S-4	SLO-1	Compensator design exercises	Conversion of transfer function to various state space representations	Computation of structural properties using Controllability & Observability	State controller design exercise	State space Modeling of Rotational Mechanical Systems
	SLO-2	Compensator design exercises				

S-5	**SLO-1**	*Design cascade compensators – lead-lag by using time domain*	*Diagonalization*	*Computation of structural properties using eigen decomposition*	*State controller design exercise*	*Modeling exercises for Translational and Rotational Mechanical Systems*
	SLO-2	*Design feedback compensators – lead-lag by using time domain*	*State space representation of discrete time systems*			
S-6	**SLO-1**	*Design specifications – PID Controllers*	*Solution of state equations – from differential equations*	*Concept of Pole Placement by state feedback*	*Optimal Control – Linear Quadratic Regulation (LQR)*	*State space Modeling of Electrical Systems*
	SLO-2	*Effect of PID on linear systems*		*Concept of State Observers*	*Infinite Horizon Regulator*	
S-7	**SLO-1**	*Design of PD controller using time domain*	*Solution of state equations – from Transfer Functions*	*Control System Design Via Pole Placement by state feedback*	*Receding Horizon Regulator*	*Modeling exercises for Electrical Systems*
	SLO-2	*PD Controller design exercises*			*Receding Horizon Regulator - Design Parameters*	
S-8	**SLO-1**	*Design of PI controller using time domain*	*Concepts of state transition matrix.*	*Effect of state feedback*	*Controller Design with Reference Input*	*State space Modeling of Field controlled DC Motor*
	SLO-2	*PI Controller design exercises*	*Computation of state transition matrix*		*Tracking/ Servo Control using State Feedback*	
S-9	**SLO-1**	*Design of PID controller using time domain*	*Computation of state transition matrix*	*State feedback Controller design exercises*	*State controller with reference input design exercise*	*State space Modeling of Armature controlled DC Motor*
	SLO-2	*PID Controller design exercises*				

Learning Resources	1. *Katsuhiko Ogata, "Modern Control Engineering"-fifth edition, Prentice Hall of India Private Ltd, New Delhi, 2009.* 2. *Kirk D.E, "Optimal control theory-an introduction", Dover Publications, 2004.* 3. *Richard .C, Dorf and Robert.H.Bishop, "Modern Control System Engineering", Pearson Education (US), United States, 2010.*	4. *Gopal. M, "Modern Control System theory", New age international(P) ltd, 2012.* 5. *Nagarath, I.J. and Gopal, M., "Control Systems Engineering", New Age InternationalPublishers, 2010.* 6. *NPTEL Video Lecture Notes on "Advanced Linear Continuous Control Systems "by Prof. Yogesh Vijay Hote, IIT Roorkee. https://nptel.ac.in/courses/108107115/*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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. Mr. Arockia Vijay Joseph, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mr. P. Jekan, SRMIST*

Course Code	18ECE283J	Course Name	PROGRAMMABLE LOGIC CONTROLLER	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Study the hardware components of Programmable Logic Controller
CLR-2 :	Understand the need of programming languages for PLC
CLR-3 :	Explore the ladder logic program for control application
CLR-4 :	Identify applications of timers and counters in process automation
CLR-5 :	Locate the malfunctions and troubleshooting various types of errors in Programmable Logic Controller
CLR-6 :	Provide the knowledge of Commissioning, Maintenance and their importance in industry.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)
CLO-1 :	Select right I/O modules in PLC for process control	3	80	75
CLO-2 :	Develop ladder logic program for control application	3	80	70
CLO-3 :	Use timers and counters in process automation	3	75	70
CLO-4 :	Interpret data compare instruction in PLC program	3	80	75
CLO-5 :	Troubleshoot the input and output malfunctions in PLC	3	80	70
CLO-6 :	Select a right PLC for the given application	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: 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	L	-	-	-	-	-	-	L	-	-	H	H	H	H
CLO-2 :	H	H	H	H	H	-	-	H	H	M	-	H	H	H	H
CLO-3 :	H	H	H	H	H	-	-	H	H	M	-	H	H	H	H
CLO-4 :	H	H	H	H	H	-	-	H	H	M	-	H	H	H	H
CLO-5 :	H	H	-	H	H	-	-	-	H	H	-	H	M	H	H
CLO-6 :	H	H	-	-	-	-	-	H	H	-	M	M	H	H	H

Duration (hour)		PLC Hardware Components	PLC Programming and Wiring	Timers and Counters	Data manipulation and Math instructions	Troubleshooting
		12	12	12	12	12
S-1	SLO-1	***Evolution of Programmable logic controllers***	*PLC programming languages-Ladder Logic*	*Timer Instructions*	*Data manipulation*	*Electrical Noise*
	SLO-2	***Architecture of a PLC***	*Function Block Diagram, Instruction List*	*On-Delay timer instruction*	*Data transfer operations*	*Leaky Inputs and Outputs*
S-2	SLO-1	*Principles of Operation*	*Instruction Addressing*	*Off-delay timer instruction*	*Data compare instructions*	*Grounding*
	SLO-2	*PLCs versus Computers*	*Branch Instructions*	*Retentive Timer*	*Data manipulation programs*	*Voltage Variations and Surges*
S 3-4	SLO-1 SLO-2	***Lab1: PLC Wiring***	***Lab 4: Traffic light control system***	***Lab 7: HMI Programming***	***Lab10: Lift control***	***Lab13: Electro pneumatic direction control***
S-5	SLO-1	*PLC size and application*	*Electromagnetic Control Relays*	*Cascading Timers*	*Numerical Data I/O Interfaces*	*Program Editing and Commissioning*
	SLO-2	*Discrete I/O modules*	*Contactors*	*Up-Counter*	*Closed-Loop Control*	*Preventive Maintenance*
S-6	SLO-1	*Sinking and sourcing*	*Manually Operated Switches*	*One-Shot Instruction*	*Math Instructions*	*Troubleshooting*
	SLO-2	*Analog I/O modules*	*Mechanically Operated Switches*	*Down-Counter*	*Addition Instruction*	*Processor Module*
S 7-8	SLO-1 SLO-2	***Lab 2 :Water level control system***	***Lab 5: Sequential operation of motor***	***Lab 8: DC motor speed control system***	***Lab11: Car parking system***	***Lab14: Stamping machine control***

S-9	**SLO-1**	*Special I/O modules*	*Proximity Sensor, Magnetic Reed Switch*	*Cascading Counters*	*Subtraction Instruction*	*Input Malfunctions*
	SLO-2	*I/O Specifications*	*Light Sensors, Velocity and Position Sensors*	*Combining Counter and Timer Functions*	*Multiplication Instruction*	*Output Malfunctions*
S-10	**SLO-1**	*Human Machine Interfaces (HMIs)*	*Output Control Devices, Seal-In Circuits, Electrical Interlocking Circuits*	*High-Speed Counters*	*Division Instruction*	*Comparative study of Industrial PLCs.*
	SLO-2	*Alarms, Graphics Library*	*Converting Relay Schematics into PLC Ladder Programs*	*Problems*	*Other Word-Level Math Instructions*	
S 11-12	**SLO-1** / **SLO-2**	***Lab3: Material handling system***	***Lab 6: Bottle filling system***	***Lab 9: Temperature control system***	***Lab12: Flow control system***	***Lab15: Servo controller programming***

Learning Resources	1. *Frank D. Petruzella, "Programmable Logic Controller",Tata McGraw Hill 5th Edition, 2017.* 2. *Bolton. W, "Programmable Logic Controllers", 6thEdition, Elsevier Newnes, 2016.* 3. *John W. Webb, Ronald A. Reis, "Programmable Logic Controllers", Principles and Applications, Prentice Hall, 5th Edition, 2011* 4. *Gary Dunning, "Programmable Logic Controllers", Cengage Learning, 3rdEdition, 2009.* 5. *John R. Hackworth, "Programmable logic controllers Programming Methods and Applications", Pearson, 1stEdition, 2006* 6. *NPTEL Video Lecture Notes on "Industrial Automation and Control "by Prof. S. Mukhapadhyay, IIT Kharagpur*

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com	1. Mr. J. Sam Jebakumar, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com	2. Dr. G. Joselin Retna Kumar, SRMIST

Course Code	18ECE284J	Course Name	GRAPHICAL SYSTEM DESIGN IN VIRTUAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Study the concepts of Virtual instrumentation and to learn the programming concepts in VI.
CLR-2 :	Study about the various measurement systems and their data acquisition methods in real time.
CLR-3 :	Study about the various Instrument Interfacing concepts.
CLR-4 :	Explore various control techniques using VI software
CLR-5 :	Explore various remote accessing techniques
CLR-6 :	Get exposed with various analysis tools for Process control applications.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Identify the purpose and need of virtual instrumentation in process control Industries	1,2	80	70	H	-	-	-	-	-	-	-	H	-	-	-	H	-	-
CLO-2 :	Measure the parameters using various data acquisition methods.	2,3	85	75	H	H	-	-	-	-	-	H	H	-	H	H	H	-	-
CLO-3 :	Implement the available interfacing instruments	2,3	75	70	H	H	H	H	H	-	-	-	H	-	H	H	H	H	-
CLO-4 :	Implement various control techniques using VI software	2,3	85	80	H	H	H	H	H	-	-	H	H	-	H	H	H	H	H
CLO-5 :	Apply remote accessing Techniques	2,3	85	75	H	H	H	H	H	-	-	-	H	H	H	H	H	-	H
CLO-6 :	Develop a system for an engineering application.	2,3	80	70	H	H	H	H	H	-	-	H	H	H	H	H	H	H	H

Duration (hour)		Programming Concepts in LabVIEW	Measuring Concepts in Virtual Instrumentation	Controlling Concepts in Virtual Instrumentation	Final Control Elements and its implementation	Signal Processing and Applications
		12	12	12	12	12
S-1	SLO-1	Historical perspective, Need of VI, Advantages of VI, Virtual Instruments versus Traditional Instruments	Components of Measuring System,Origin of signals	Introduction to Non continuous controllers in LabVIEW	Final Control Operation	PC based digital storage oscilloscope
	SLO-2	Review of software in Virtual Instrumentation ,Software environment Architecture of VI, Introduction to the block diagram and Front panel Pallets	Transducer, Sensors, Differences between chemical sensors, physical sensors, Biosensors. Selection criteria	Introduction to continuous controllers in LabVIEW	Fundamentals of Mechatronic Actuators	Sensor Technology
S-2	SLO-1	Creating and saving a VI, Front Panel Tool Bar, Block diagram Tool Bar, Palettes	General Conditioning Functions, A/D Control ,D/A Control in VI platform	Design of ON/OFF controller	Position-Controlled Actuators	Oscillators, counters
	SLO-2	Creating sub VI, Creating an ICON, Building a connector pane, Displaying VI'S Placing and Saving Sub VI'S on block diagram Example of full adder circuit using half adder circuit	Introduction to MyRIO ,Applications of MyRIO	P,PI,PID controllers for a mathematically described processes using VI software.	open-loop and closed-loop actuator position control in a hands-on application	Signal and image processing Techniques
S-3,4	SLO-1 SLO-2	**Lab 1: Verification of Arithmetic Operations & Verification of Half Adder**	**Lab 4 :Design a VI to measure angle with my RIO using Y-axis onboard accelerometer**	**Lab 7: To apply on-off controller using QNET HVAC in virtual instrumentation platform**	**Lab 10: To apply Position Controlled actuators**	**Lab 13: To Design of DSO**
S-5	SLO-1	Loops-For Loop,	Introduction to PC Buses	Modeling of level process	Manipulator Importance, Operation of Manipulators	Spectrum Analyzer
	SLO-2	While Loop	Local Buses-ISA, PCI,	Basic control of level process in LabVIEW	Types of Manipulators Selection Criteria,	Waveform Generator

S-6	***SLO-1***	*Arrays*	*RS232, RS422*	*Modeling of Reactor Processes*	*Controlling techniques on Manipulators*	*Data visualization from multiple locations*
	SLO-2	*Clusters, plotting data*	*RS485*	*Basic control of Reactor process in LabVIEW*	*Controlling techniques on Manipulators*	*Distributed monitoring and control*
S-7,8	***SLO-1***	***Lab 2:Program to find Addition of First n natural numbers using for loop***	***Lab 5:To implement Speed Control of DC Motor (QNET)***	***Lab 8:Continous Control of any process using LabVIEW***	***Lab 11:To apply PID to Control Manipulators***	***Lab 14:Real time spectrum analysis using LabVIEW***
	SLO-2					
S-9	***SLO-1***	*Charts, Graphs, Formula nodes,*	*Interface Buses-USB,PXI*	*Case studies on development of HMI in VI*	*Remote access using LabVIEW*	*Vision and Motion Control*
	SLO-2	*Case and Sequence Structures*	*VXI,*	*Case studies on development of HMI in VI*	*Different types of Protocols*	*Examples on Integrating Measurement with vision and motion*
S-10	***SLO-1***	*Acquiring Data Using Hardware*	*SCXI*	*Case studies on development of SCADA in VI*	*Case study on TCP/IP Protocol application*	*NI Motion control*
	SLO-2	*DAQ Devices*	*PCMCIA*	*Case studies on development of SCADA in VI*	*Case studies on web publishing tool*	*Speed control system*
S-11,12	***SLO-1***	***Lab 3:Design a Voltmeter by using AO to generate a signal and AI to acquire the signal using DAQ***	***Lab 6: Simple Modeling of QNET Rotary Inverted Pendulum***	***Lab 9:Controlling of Rotary Inverted Pendulum***	***Lab 12:Online process control using LabVIEW using TCP/IP and web publishing***	***Lab 15 :Minor Project***
	SLO-2					

Learning Resources	1. ***Nadovich, C., "Synthetic Instruments Concepts and Applications", Elsevier, 2005.*** 2. ***Bitter, R., Mohiuddin, T. and Nawrocki, M., "Labview Advanced Programming Techniques", CRC Press, 2nd Edition, 2007.*** 3. ***Gupta, S. and Gupta, J. P., "PC Interfacing for Data Acquisition and Process Control", 2nd Edition, Instrument Society of America, 1994*** 4. ***Liptak,"Instrument Engineers Handbook Process Measurement and Analysis",* Elsevier, 2005** 5. ***Jamal, R. and Picklik, H., "Labview – Applications and Solutions", National Instruments Release.*** 6. ***Johnson, G., "Labview Graphical programming", McGraw-Hill, Newyork, 1997.*** 7. ***Wells, L.K. and Travis, J., "Labview for Everyone", Prentice Hall, NewJersey, 1997.*** 8. ***Buchanan, W., "Computer Busses", CRC Press, 2000.***

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE380T	Course Name	INSTRUMENTATION AND CONTROL IN PROCESS INDUSTRIES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Learn various methods involved in the petroleum industries.
CLR-2 :	Import the knowledge of control and measurement used in iron and steel industries.
CLR-3 :	Study the various instruments and the role of instrumentation in paper industries.
CLR-4 :	Learn the measurement and control in thermal industries.
CLR-5 :	Study the industry standards and safety consciousness in process industries.
CLR-6 :	Import the knowledge of chemical process hazards in industries.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Understand the basics of petrochemical industries.	3	80	75	H	-	-	-	-	-	-	-	H	-	-	H	H	-	-
CLO-2 :	Apply knowledge in working of various instruments that are used in iron and steel industries.	3	80	70	H	H	-	-	-	-	-	H	H	-	-	H	H	-	H
CLO-3 :	Acquire the knowledge of analyzers and measurement of density, level in paper industries.	3	75	70	H	H	M	-	-	-	-	H	H	-	-	H	H	H	H
CLO-4 :	Understand the operation of boiler in thermal industries.	3	80	75	H	H	M	H	-	-	-	H	H	-	-	H	H	H	H
CLO-5 :	Understand the process safety in chemical industries.	3	80	70	H	H	M	H	-	H	-	-	H	-	-	H	M	M	H
CLO-6 :	Apply the knowledge of process hazards in industries.	3	80	70	H	-	-	-	-	H	-	-	-	-	-	H	-	M	H

Duration (hour)		Instrumentation in Petroleum Industry	Measurement and control in Iron and Steel Industry	Instrumentation and control in Paper Industry	Boiler operation and control in Thermal Industry	Industrial Safety Management
		9	9	9	9	9
S-1	SLO-1	Introduction to petroleum	Introduction: Steel Production	Conventional and non-conventional raw materials for paper manufacture	Introduction to power generation	Introduction to process safety
	SLO-2	Petroleum exploration Methods	Basic oxygen furnace	Different pulping processes	Importance of instrumentation & control in power generation	Importance of Safety consciousness in Indian Chemical Industries
S-2	SLO-1	Magnetic Survey	Blast furnace	Continuous and batch digesters	Classification of instruments in power plant	Industry Standards and Regulations.
	SLO-2	Drilling process	Rolling process	Chemical recovery process	Building blocks	Set of Standards. HSE – PES, AIChE – CCPS,
S-3	SLO-1	Rotary Drilling	Hot rolling process	Conversion process	Combined Heat and Power System	Process hazard analysis
	SLO-2	Petroleum production	Cold rolling process	Identification of various process parameters	Control Loops in Boiler	Chemical process hazards
S-4	SLO-1	Petroleum refining and unit operations in refinery	Temperature measurement	pH measurement	Combustion Control,	Material hazards
	SLO-2	Constituents of crude oil	Pressure measurement	Density measurement	Air/fuel ratio control	Energy hazards
S-5	SLO-1	Atmospheric distillation of crude oil	Shape and thickness measurement	Level measurement	Steam flow measurement	Chemical interaction hazards
	SLO-2	Vacuum distillation process	Analyzers in iron and steel industry	Special applications for control	Smoke, density measurement	Layers of protection

S-6	**SLO-1**	*Thermal conversion process*	*Oxygen analyzer*	*Digester blow tank control*	*Turbine speed and vibration measurement*	*Types of safeguard*
	SLO-2	*Control of distillation column*	*Blast furnace and stove combustion control system*	*Dryer temperature control.*	*Use of feed forward and cascade control in process industries*	*Safety performance measurement tools*
S-7	**SLO-1**	*Temperature control.*	*Casting mold Level Control*	*Fuel gas oxygen analyzer*	*Instrumentation and control in reactors*	*Techniques used to reduce explosion hazards*
	SLO-2	*Pressure control*	*Computer Applications*	*Dissolved oxygen analyzer*	*Sodium analyzer*	*Hazard identification techniques*
S-8	**SLO-1**	*Level measurement of petroleum*	*Data logging applied to Steel Making*	*Computer applications: Direct Digital Control*	*Flue gas analyzer*	*Fault tree analysis*
	SLO-2	*Temperature measurement of petroleum*	*Steel rolling mill Control*	*Distributed control system in power plant*	*Fuel composition analyzer*	*Operation and maintenance*
S-9	**SLO-1**	*Case Study: An. Application for Petroleum Refineries.*	*Case Study on iron and steel manufacturing process.*	*Case Study: Water Treatment for Paper and Pulp Industry*	*Case Study: Chandrapura Thermal Power Station*	*Case Study: Safety in Explosive*
	SLO-2	*Case Study: Control of an Industrial Distillation Column*	Case Study: *Analysis of the Production Processes in a Steel Factory*	*Case Study: Boiler Materials for the Pulp and Paper Industry*	*Case Study:Boiler tube failures*	*Case Study: Chemical splash at* process *plant.*

Learning Resources	1. *Mian.M.A, "Petroleum Engineering Handbook for the Practicing Engineer", Gulf Professional Publishing, 2005.* 2. *Liptak, Bela G, "Instrumentation in the Processing Industries" , Chilton Publishers, 1973.* 3. *Considine D. M.," Process/Industrial Instruments and control Handbook", McGraw Hill, 6th Edition2019.*	4. *Sam .G.Duke low, "The Control of boilers" , instrument Society of America,1991.* 5. *Paul Gruhn& Harry Cheddie,* ***Safety Instrumented Systems: Design, Analysis and Justification, 2nd Edition, International Society of Automation,2005.***

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	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, Controls of Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Ms. A.Asuntha, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. A. Vimala Juliet, SRMIST*

Course Code	18ECE381T	Course Name	DISTRIBUTED CONTROL SYSTEM AND SCADA	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Give basic knowledge in SCADA in the field of automation
CLR-2 :	Understand the communication modules used in SCADA
CLR-3 :	Give basic knowledge in different architectures of DCS
CLR-4 :	Explore the local control unit of distributed control system
CLR-5 :	Impart adequate information in the interfaces used in DCS
CLR-6 :	Learn the applications of DCS in process industries

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Understand the elements of SCADA system	3	80	75	H	-	-	-	-	H	-	-	-	-	-	H	M	H	-
CLO-2 :	Develop any application based on SCADA along with GUI using SCADA software.	3	80	70	H	-	-	-	-	H	-	-	-	-	H	H	-	H	-
CLO-3 :	Understand evolution and architecture of DCS and hierarchical control in DCS	3	75	70	H	H	M	H	M	H	-	M	M	-	H	H	H	H	H
CLO-4 :	Demonstrate interfacing of hardware and software of computer based automation system.	3	80	75	H	H	M	H	M	-	-	M	H	-	H	H	M	H	H
CLO-5 :	Select and use the most appropriate automation technologies for a given application	3	80	70	H	-	M	-	H	-	-	H	H	-	H	H	M	H	H
CLO-6 :	Evaluate computer based automation system used in industries ranging from discrete, continuous process to hybrid processes.	3	80	70	H	-	-	-	-	H	-	H	H	-	H	H	H	H	H

Duration (hour)		SCADA Elements	Communication	DCS Architecture	Operator interface	DCS Application
		9	9	9	9	9
S-1	SLO-1	SCADA basics introduction	SCADA communication introduction	DCS - basics	DCS operator interfaces- introduction	DCS Application in Power plant
	SLO-2	Elements of SCADA	Communication system components	Evolution of Distributed Control System	Operator Interface Requirements	Automation strategy
S-2	SLO-1	Functionality of SCADA	Structure of a SCADA Communications Protocol	DCS Architecture	Low-level Operator Interface	Distributed system structure
	SLO-2	Process example	Field/RTU communication	Local control unit	Continuous control station	Application functions
S-3	SLO-1	History of SCADA	Analog electronic controllers	I/O module(Analog & Digital)	Manual Loader Station	DCS Application in cement plant
	SLO-2	Development from Telemetry	Communication Topology	Basic elements	Indicator/Logic Station	System architecture
S-4	SLO-1	Key features	RTU/MTU communication	Architectural parameters	Smart annunciators	DCS Application in iron plant
	SLO-2	Real time systems	System components	Types of architecture	High level Operator interface	System architecture
S-5	SLO-1	Analog signals measurement	Communication Protocols	CPU, Memory	Architectural Models	DCS Application in steel plant

	SLO-2	*Control techniques*	*Operator interface*	*Local control unit languages*	*Hardware Elements*	*System architecture*
S-6	**SLO-1**	*Discrete signals measurement*	*Monitoring alarms*	*Language requirements*	*Operator displays*	*DCS Application in Paper and pulp industry*
	SLO-2	*Control techniques*	*Status points*	*Functional blocks*	*Engineering interface- Introduction*	*System architecture*
S-7	**SLO-1**	*Remote terminal unit*	*Control interfacing*	*Problem-oriented languages*	*System configuration requirements*	*DCS Application in petroleum-refining industry*
	SLO-2	*Analog and Discrete control*	*Parallel operator interface*	*High-level languages*	*Diagnosis of System Problems*	
S-8	**SLO-1**	*Monitoring signals*	*SCADA Development for any one typical application*	*Process interfacing issues*	*Low-level engineering interface*	*DCS Application in oil and gas processing industry.*
	SLO-2	*Master terminal unit*		*Security design issues*	*System configuration*	
S-9	**SLO-1**	*Process configuration*	*Programming for GUI development using SCADA software*	*Process input/output design issues*	*High-level engineering interface*	*DCS Application in water treatment plant*
	SLO-2	*Application*		*Remote I/O and communication modules*	*System configuration*	*System architecture*

Learning Resources	1. Stuart Boyer A, "*SCADA : Supervisory control and data Acquisition*", Fourth Edition, ISA-The Instrumentation, Systems, and Automation Society, 2010 2. Dobrivojie Poppovik, Vijay P Bhatkar, "*Distributed Computer Control Systems in Industrial Automation"* CRC Press, 1990	3. Michael Lucas, "*Distributed Control Systems*", Van Nostrand Reinhold Co., 1986 4. IDC Technologies, "*Practical Distributed Control Systems (DCS) for Engineers and Technicians*"2012 5. Krishna Kant, Computer Based Industrial Control, 2nd Edition, Prentice Hall of India, New Delhi, 2010

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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, Controls of Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	*1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	*1. Dr. G. JoselinRetna Kumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mr. J. SamJeba Kumar, SRMIST*

Course Code	18ECE382T	Course Name	BUILDING AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Give basic knowledge in intelligent building and building automation systems
CLR-2 :	Gain Knowledge on different sensors and measurement systems in BMS system
CLR-3 :	Know the basic concepts of HVAC Air handling unit
CLR-4 :	Understand the basic concepts of HVAC terminal unit
CLR-5 :	Explore the BAS Architecture
CLR-6 :	Present an overview of different communication protocols

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the need of intelligent buildings and automation systems	3	80	75
CLO-2 :	Measure the parameters and design of sensors	3	80	70
CLO-3 :	Design different Air handling units	3	75	70
CLO-4 :	Understand and design terminal units	3	80	75
CLO-5 :	Familiarize with the components of BAS architecture	3	80	70
CLO-6 :	Select the communication protocol for a particular application	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: Automatic control for continuous& discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
H	-	-	-	-	H	H	-	-	-	-	H	H	H	H
H	-	-	-	-	H	H	-	-	-	H	H	-	M	H
H	H	M	H	M	H	M	H	-	-	H	H	H	M	H
H	H	M	H	M	-	M	H	H	-	-	H	-	M	H
H	-	M	-	H	-	M	H	-	-	-	H	-	M	H
H	-	-	-	-	H	-	H	-	H	M	H	H	-	H

Duration (hour)		Introduction to Building automation systems	Comfort parameters	HVAC Basic Concepts- Air handling unit	Terminal Unit	BAS Architecture
		9	9	9	9	9
S-1	SLO-1	Introduction to intelligent building	Temperature	Concept of Air handling unit	Concept of Variable Air Volume (VAV) system	BAS Hierarchy
	SLO-2	intelligent architecture	Enthalpy, Entropy	components in AHU	different types of VAV	Field level components
S-2	SLO-1	structure	Heat Transfer - Conduction, Convection, Radiation	different types of dampers	Design, working	Direct Digital Control (DDC)
	SLO-2	Facility management vs. intelligent buildings	Working Principle, Characteristics of RTD	Working, configuration,	series fan powered	Supervisory Controller
S-3	SLO-1	Lifecycle of building	Thermistor, Thermocouple	different types of AHU	parallel fan powered	Server, Operator Workstation (OWS)
	SLO-2	Evolution of intelligent buildings	Bimetallic strip	Design and working	pressure dependent	Different communication protocol
S-4	SLO-1	Introduction to BAS	Humidity, Specific Humidity,	Operation of different modes in AHU	supply-exhaust VAV	addressing concepts
	SLO-2	Different systems of BAS	Relative Humidity, Due point, Saturation point	humidification	dual duct VAV	Open Protocols -BACnet, LON
S-5	SLO-1	HVAC	Working principle of relative humidity sensors	dehumidification	Design, working, use of radiation coil	Profibus, Modbus
	SLO-2	HVAC Applications	mounting for humidity sensors in BAS	static pressure control	chilled beam	M-bus

S-6	**SLO-1**	*Security system*	*Psychrometric chart*	*volume matching*	*CRAC unit, VRV systems*	*Proprietary Protocols- N2, CBUS*
	SLO-2	*Field Devices*	*Pressure, Static Pressure, Velocity pressure, Absolute Pressure*	*cooling, heating,*	*unit heater, Fan coil unit and unit ventilator*	*Wireless filed devices*
S-7	**SLO-1**	*Fire alarm system*	*Gauge Pressure, Vacuum Pressure, Differential Pressure, Sealed Pressure*	*economizer mode*	*Chilled water system*	*controllers*
	SLO-2	*Types of Detectors*	*Working Principle of Different types of Pressure Sensors*	*Heat recovery techniques*	*Concept of refrigeration cycle, components used in refrigeration cycle*	*routers*
S-8	**SLO-1**	*Modules*	*Working of principle of different air flow sensors*	*plate heat exchanger*	*different types of chilled water system*	*coordinators*
	SLO-2	*Indicating Devices*	*Working of principle of different water flow sensors*	*heat recovery wheel*	*Working and design of different types of boilers*	*Benefits of a Wireless BAS*
S-9	**SLO-1**	*lighting systems*	*Measurement of CO2 level*	*AHU for different applications*	*Working and design of different types of heat exchanger*	*Wireless Field Bus*
	SLO-2		*Working principal of BTU meter*			*Basic Reference Model (BRM)*

Learning Resources	1. Smart Buildings by Jim Sinopoli, Butterworth-Heinemann imprint of Elsevier, 2nd Edition., 2010 2. Intelligent Building Systems by Albert Ting-Pat So, WaiLok Chan, Kluwer Academic publisher, 3rd Edition., 2012.	*3.* Design of Special Hazards and Fire Alarm Systems by Robert Gagnon, Thomson Delmar Learning; 2nd Edition, 2007.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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.G.JoselinRetna Kumar, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Mr.J.SamJeba Kumar, SRMIST*

Course Code	18ECE383J	Course Name	INSTRUMENTATION SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Impart knowledge on basic signal conditioning circuits.
CLR-2 :	Familiarize students on the requirements of industry.
CLR-3 :	Obtain adequate knowledge on process parameter optimization.
CLR-4 :	Gain expertise to handle basic instruments in Industry.
CLR-5 :	Acquire knowledge of piping diagram in Industry.
CLR-6 :	Bridge the gap between industrial requirements and operational constraints.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO 1: Automatic control for continuous& discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Apply mathematical knowledge, science, engineering fundamentals to design circuits pertaining to various process measurements	3	80	75	H	H	H	M	-	-	-	-	-	-	-	M	H	-	-
CLO-2 :	Design signal conditioning circuits for various process parameters.	3	80	70	H	H	-	M	H	-	-	-	H	-	L	-	M	M	H
CLO-3 :	Optimize the performance of process output.	3	75	70	H	-	M	M	M	-	H	M	-	-	-	-	-	-	M
CLO-4 :	Select optimal sensor for process measurement.	3	80	75	H	M	-	M	-	M	M	-	-	-	-	-	-	M	-
CLO-5 :	Choose type of indication circuits for industry.	3	80	70	H	-	H	-	-	-	M	-	H	M	-	-	H	-	L
CLO-6 :	Analyze and select the suitable sensing and transduction unit.	3	80	70	H	H	-	-	-	-	-	-	-	-	-	-	H	M	H

Duration (hour)		Review of Signal Conditioning circuits	Design of Level and Pressure Measurement	Design of Flow measurements and Control Valve	Design of Transmitters and final control element	Design of indicators and Logic circuits
		12	12	12	12	12
S-1	SLO-1	Requirements of Signal Conditioning	Electronic PID controller Design.	Study of Orifice, Venturi and Rotameter.	2 wire and 3 wire transmitter	Alarm circuit design
	SLO-2	Analog, Digital and adaptive filter design	P,I,D modes of operation Solving numerical..	Review of design requirements.	Thermocouple based temperature transmitter	Annunciator circuit design
S-2	SLO-1	V/I and I/V Converter design. Design of amplifiers – Pre amplifier	Composite modes – PI, PD and PID.	Design of Orifice.	Design of transmitter	Interlocks
	SLO-2	Instrumentation Amplifier, Bridge and Isolation Amplifier.	Realization using composite modes.	Design of Rotameter.	Capacitance based flow transmitter	Overview of Programmable logic controllers
S 3-4	SLO-1	***Lab1: Design of Active Filters – LPF, HPF and BPF.***	***Lab 4: Design, Fabrication and Testing of Analog PID Controller.***	***Lab 7: Development of Software Program for sizing Orifice.***	***Lab10: Design, Fabrication and Testing of 2-wire Analog Transmitter.***	***Lab 13: Sequential controller using PLD***
	SLO-2					
S-5	SLO-1	Signal conditioning circuits for temperature measurement. – RTD.	Requirements of Pressure Measurement.	Design constraints.	Level transmitter	Microprocessor based PID controller
	SLO-2	Design of RTD	***Bourdon tube, Bellows, Diaphragms***	Study of Valve characteristics and valve body	Flapper nozzle amplifier characteristics	Study of recorders
S-6	SLO-1	Signal Conditioning for Thermocouple.	Factors affecting sensitivity.	Design of Actuator and positioner	Pneumatic actuator	Numerical in alarm circuit
	SLO-2	Design of thermocouple	Adjustment of set point, bias and controller settings	Control Valve sizing	Hydraulic actuator	Real time case study

S 7-8	**SLO-1**	***Lab 2 :Design of Instrumentation Amplifier.***	***Lab 5: Design of V/I and I/V converter.***	***Lab 8: Development of Software Program for sizing Rotameter.***	***Lab11: Design of multi channel data acquisition system***	***Lab 14: Functional constraints and specification in industry***
	SLO-2					
S-9	**SLO-1**	*Cold junction compensation and Linearization.*	*Air purge Level Measurement*	*Design of Control valve factor and plug area.*	*Characteristics of pumps*	*Operating console and control room panel design.*
	SLO-2	*Design of cold junction compensation circuits.*	*Design of air purge system*	*Selection of material for body and trim.*	*Instruments used in pumping practices*	*Instrument symbols and signals*
S-10	**SLO-1**	*Zero and Span adjustment in Temperature Transmitters.*	*Capacitive based level Measurement.*	*Cavitation and flashing in Control valve*	*Pump operation and maintenance*	*Mini project on any process application.*
	SLO-2	*Temperature indicators and selection criteria for temperature sensing instruments.*	*Design of capacitance based level measurement.*	*Characteristics of control valve for typical applications*	*Selection of pumps*	*Discussion on project*
S 11-12	**SLO-1**	***Lab3: Design of regulated power supply.***	***Lab 6: Design of signal conditioning circuits for level measurements.***	***Lab 9: Study of control valve characteristics***	***Lab12: Study of P&I diagrams***	***Lab 15: Process application***
	SLO-2					

Learning Resources	1. *C.D.Johnson, ""Process Control Instrumentation Technology", 8th Edition, Prentice Hall, 2015.* 2. *Bentley, J. P., Principles of Measurement Systems, Pearson Education, 2015.* 3. *Beta G.Liptak, "Instrument Engineers Handbook – Process Control and Optimization". 4th Edition. CRC Press. 2008.*	4. *N.A.Anderson,* Instrumentation for Process Measurment and Control, Chilton Company, 2003. 5. *R.W.Miller, " Flow measurement engineering Handbook", McGraw hill. New York, 1996.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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. D. Karthikeyan, Controlsoft Engineering India Pvt Ltd, karthikeyan.d@controlsoftengg.in	1. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com	1.S.Sharanya SRM IST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com	2.Dr.G.Joselin Retna Kumar

Course Code	18ECE384T	Course Name	FACTORY INSTRUMENTATION NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Educate on the basic concepts of data networks
CLR-2 :	Introduce the basics of inter-networking and serial communications
CLR-3 :	Provide details on HART and Field buses
CLR-4 :	Know different techniques on Modbus, PROFIBUS and other communication protocols
CLR-5 :	Present an overview of industrial Ethernet
CLR-6 :	Study the working of computer busses and protocols

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Understand the basic concepts of data networks	3	80	75	H	H	-	-	M	H	-	-	-	-	-	H	H	-	H
CLO-2 :	Analyze the techniques of inter-networking and serial communications	3	80	70	H	-	-	H	-	H	-	-	-	-	-	H	-	M	H
CLO-3 :	Understand the protocols and layers of HART and field bus	3	75	70	H	-	M	H	M	H	-	H	-	H	M	H	M	H	H
CLO-4 :	Analyze the techniques of MODBUS, PROFIBUS and other communication protocol	3	80	75	H	H	M	H	M	-	-	H	H	H	H	H	-	H	H
CLO-5 :	Utilize the concept of industrial Ethernet	3	80	70	H	-	M	-	H	-	-	H	-	H	H	H	H	H	H
CLO-6 :	Analyze the working of computer busses and protocols	3	80	70	H	-	M	-	-	H	-	H	-	H	-	H	H	H	H

Duration (hour)		OSI Model	Inter-Networking	HART and Field bus	PROFIBUS and Modbus	Industrial Ethernet
		9		9	9	9
S-1	SLO-1	Introduction to Modern instrumentation	Introduction to RS-232	Introduction to HART and smart instrumentation	Introduction to PROFIBUS	Introduction to Industrial Ethernet
	SLO-2	Introduction to control systems	RS-422 and RS-423	HART protocol	PROFIBUS protocol stack	10 Mbps Ethernet
S-2	SLO-1	Open systems interconnection (OSI) model	Electrical characteristics of RS 232	Physical layer- Analog 4–20 mA	Physical layer (layer 1)	Media systems
	SLO-2	Representation of the OSI model	Examples	Digital frequency shift keying (FSK)	Type A cable	10Base5, 10Base2, 10BaseT
S-3	SLO-1	Protocols	Communications between two nodes	Data link layer	Type B cable	Signaling methods
	SLO-2	Basic structure of an information frame defined by a protocol	Transmission and reception of characters	HART protocol implementation of OSI model layer	Data link layer (layer 2)	Medium access control
S-4	SLO-1	Standards	Simple no-handshaking communications	Application layer- Universal commands	Hybrid medium access control	Frame transmission
	SLO-2	EIA-232 interface standard	Software handshaking	Common practice commands, Device specific commands	Application layer	Frame reception
S-5	SLO-1	EIA-485 interface standard	Hardware handshaking	Troubleshooting	Introduction to Modbus	MAC frame format
	SLO-2	Interoperabiltity, Interchangeability	Two-way communications with handshaking	HART cable length calculation	Modbus protocol structure	Differences between IEEE 802.3 and Blue Book Ethernet (V2)

S-6	**SLO-1**	*Mod bus*	*DTE-DCE connections (PC to modem)*	*Introduction to foundation field bus*	*Function codes*	*IEEE 802.2 LLC*
	SLO-2	*Data Highway Plus protocol structure*	*Exercises*	*Physical layer*	*Read coil or digital output status (function code 01) and Read digital input status (function code 02)*	*Reducing collisions*
S-7	**SLO-1**	*DeviceNet*	*Introduction to RS-485 (ISO 8482)*	*Wiring rules*	*Read holding registers (function code 03) and Reading input registers (function code 04)*	*Design rules*
	SLO-2	*Profibus*	*RS-485 connecting to multiple nodes*	*Encoding rule, permeable and delimiters*	*Force single coil (function code 05)*	*Length of the cable segments*
S-8	**SLO-1**	*Introduction to OLE for process control*	*Line drivers*	*Data link layer*	*Preset single register (function code 06)*	*100 Mbps Ethernet*
	SLO-2	*Common problems and solutions*	*Unbalanced digital interface circuit (RS-423) and balanced digital interface circuit (RS-422)*	*Data link layer: packet format*	*Troubleshooting*	*Media access: full-duplex*
S-9	**SLO-1**	*General comments on troubleshooting*	*RS-232/485 converter*	*Application layer*	*Common Problems and Discussion*	*Auto-negotiation*
	SLO-2	*Specific Methodology*	*Exercises*	*User layer*	*Modbus Plus protocol overview*	*Fiber optic cable distances 100BaseFX*

Learning Resources	1. *Steve Mackay, Edwin Wrijut, Deon Reynders, John Park, "Practical Industrial Data Networks Design, Installation and Troubleshooting", Newnes Publication, Elsevier 1st edition, 2004.* 2. *Ian Verhappen and Augusto Pereira , "Foundation Field bus", 4th Edition, Feb 29, 2012* 3. *William Buchanan, "Computer Buses", CRC Press, 2000.*	4. *Andrew S. Tanenbaum, David J. Wetherall, "Computer Networks", Prentice Hall of India Pvt. Ltd., 5th Edition. 2011.* 5. *A. Behrouz Forouzan, "Data Communications & Networking", 3rd edition, Tata Mc Graw hill,2006.*

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE385T	Course Name	IoT IN PROCESS INSTRUMENTATION AND AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Impart fundamental knowledge on the concepts of Internet of Things with its Architecture.
CLR-2 :	Provide an overview of various techniques that are using Internet of Things in Industry applications.
CLR-3 :	Understand the working of Internet of Things in Industry with the advanced Industry 4.0 platforms.
CLR-4 :	Understand the application of Internet of Things in Automation
CLR-5 :	Gain knowledge on the operation of Engineering in IoT Automation with arrowhead framework.
CLR-6 :	Explore the working of IoT in various real-time industries

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			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 :	Understand the basic concepts of IoT, Architecture and Its Applications	3	85	80	H	-	-	-	-	-	-	-	-	-	-	H	-	H	-
CLO-2 :	Analyze the techniques to apply IoT for Industry	3	85	75	H	H	H	H	H	-	-	H	-	-	-	H	-	H	-
CLO-3 :	Apply the knowledge of different techniques of IoT in industry with an advanced platform of Industry 4.0	3	80	80	H	H	H	H	H	H	-	-	-	-	-	H	-	H	H
CLO-4 :	Develop the knowledge of IoT in Automation.	3	85	80	H	H	H	H	H	-	-	-	H	-	-	H	-	H	H
CLO-5 :	Apply the knowledge of Engineering in IoT Automation System	3	80	75	H	-	H	-	H	-	-	H	-	-	-	H	H	H	H
CLO-6 :	Design the IoT based real-time projects	3	85	85	H	-	H	H	H	H	H	H	H	H	H	H	H	H	H

Duration (hour)		IoT – Landscape, System Architectures	Industrial Internet of Things(IIoT)	IIoT Platforms	IoT Automation	Engineering of IoT Automation System
		9	9	9	9	9
S-1	SLO-1	Introduction to IoT	Introduction to IIoT	Introduction to IIoT Conceptual diagram	From DCS and SCADA to IoT	Engineering of an Arrowhead domain facility
	SLO-2	Applications and Architectures	IIoT Architecture	Middleware Architecture	Automation System Architectures	Engineering Tool Interoperability
S-2	SLO-1	Wireless Networks, Devices	Communication Methods for IoT Devices	Functions of Middleware Platforms	Automation System Properties	Component based Engineering Method
	SLO-2	Security and Privacy	IoT Reference Model by ITU	IIoT WAN and Protocol	Communication within Automation Systems	Life Cycle Dimensions
S-3	SLO-1	Event-Driven Systems	IoT Business Model by ITU	IIoT Device for M2M	Current Trends in Automation System	Data Model
	SLO-2	IoT System Architectures	Designing Industrial Internet Systems	Securing the Industrial Internet	Automation System Security	Design Guidelines for Component based Engineering
S-4	SLO-1	Protocols Concepts	OSI Table	Security in Manufacturing	Future Automation System Requirements	Safety and Security Engineering of IoT Automation System
	SLO-2	IoT- Oriented Protocols	Web 2.0 Layers	OT Manufacturing Network	Next Generation Automation	Security Analysis
S-5	SLO-1	Data bases & Time Bases	IP Layers vs IIoT Layers	OT vs IT Security Domains	Internet of Things	ETSI and STRIDE method
	SLO-2	IoT Device Design Space	Modern Communication Protocols	Defining Industry 4.0	System of Systems	Safety Analysis
S-6	SLO-1	Cost of Ownership	Wireless Communication Technologies	Characteristics of Industry 4.0	Service Oriented Architecture	FMEA / FMECA Analysis

	SLO-2	*Power Consumption*	*Proximity Network Communication Protocols*	*Industry 4.0 Design Principles*	*Local Automation Cloud Concept*	*Engineering Scenarios*
S-7	**SLO-1**	*Cost per Transistor and Chip Size*	*Access Network Technology*	*Building Blocks of Industry 4.0*	*Local Cloud Properties*	*Efficient Deployment of IoT Sensors*
	SLO-2	*Duty Cycle and Power Consumption*	*Ethernet, IP Routing*	*Industry 4.0 Reference Architecture*	*Local Cloud Establishment*	*Network Deployment tool*
S-8	**SLO-1**	*Platform Design*	*TCP/IP*	*Smart Factories - Introduction*	*Automation Support*	*Cost of Wireless Sensor Network*
	SLO-2	*IoT Network Model*	*Application Programming Interface*	*Smart Factory Production line*	*Latency in Local Clouds*	*Swift Deployment and Configuration*
S-9	**SLO-1**	*Single and Multi – Hub Networks*	*API – Technical Perspective with Example*	*Smart Manufacturing*	*Security in Local Clouds*	*Deployment Procedure*
	SLO-2	*Physical Networks*	*Summary*	*Real World Smart Factories*	*System of System Scalability*	*Replacement of Device*

Learning Resources	1. *DimiriosSerpanos and Marilyn Wolf, Internet-of-Things (IoT) Systems, Architectures, Algorithms, Methodologies, Springer, 2018.* 2. *Alasdair Gilchrist, Industry 4.0 – The Industrial Internet of Things, Apress, 2016.* 3. *"IoT Automation Arrowhead Framework", Jerker Delsing, CRC Press, Taylor & Francis Group, 2017.*	4. *Patel Chintan, Internet of Things Security: Challenges, Advances, and Analytics, Auerbach Publications, 2019.* 5. *Jeschke S Brecher, Song C, Industrial Internet of Things – Cyber Manufacturing Systems, Springer, 2017.* 6. *Stamatios Manesis, George Nikolakopoulos, Introduction to Industrial Automation, CRC Press, Taylor & Francis Group, 2018.*

Learning Assessment

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

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

Course Designers

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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. Joselin Retna Kumar, SRMIST*

Course Code	18ECE386T	Course Name	MEMS-BASED MICROSYSTEM ANALYSIS AND DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Study the basics of microfabrication and its techniques
CLR-2 :	Impart the knowledge ofmechanicalmicrosensors
CLR-3 :	Understand the mechanism for various actuators
CLR-4 :	Know the behavior of fluid at the micro level, working of microfluidic devices and its fabrication techniques
CLR-5 :	Identify the correct interfacing circuits for microsystem
CLR-6 :	Know the working and readout mechanism for microdevices or microsystems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Apply the knowledge of micro technology to fabricate micro devices	3	80	80
CLO-2 :	Design a microsensor based on an application with a suitable working principle.	3	80	80
CLO-3 :	Design, analyse and optimise the microactuator for different applications.	3	80	80
CLO-4 :	Design a microfluidic device for automobile, medical, electronics and industrial applications	3	80	80
CLO-5 :	Design an interfacing circuit for reading output from microsystems	3	80	80
CLO-6 :	Develop a microsystem for a specific application	3	80	80

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: Automatic control for continuous& discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	H	H	-	H	H	-	-	H	H	-	-	H	M	-	H
CLO-2 :	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-3 :	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-4 :	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-5 :	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H
CLO-6 :	H	H	H	H	H	-	-	H	H	-	-	H	M	-	H

Duration (hour)		Micromachining Technology	Mechanical Microsensors	Microactuators	Microfluidics	Interface Circuitry and Microsystems
		9	9	9	9	9
S-1	SLO-1	Introduction	Introduction	Introduction	Introduction	Introduction
	SLO-2	Bulk Micromachining	Automotive	Actuators: Transducers with Mechanical Output	Properties of Fluids	Microsensor Systems
S-2	SLO-1	Wet Etching	Computers and Peripherals	Transduction Mechanisms	Volumes and Length Scales	Microsensor System Applications - Automotive Sensors
	SLO-2	High-Aspect-Ratio Micromachining	Consumer Products	Scaling Advantages and Issues	Mixtures, Physical Properties	Biomedical Sensors
S-3	SLO-1	Surface Micromachining	Medical and Biological Applications	Electrical Microactuators	Vapour Pressure, Surface Tension	Sensors for Household Appliances, Building Control
	SLO-2	Basic Process Sequence	Inertial Sensors	Electrostatic Forces	Electrical Properties, Optical Properties, Transport Phenomena	Industrial Control
S-4	SLO-1	Deposition , Sputtering and Etching	Accelerometers	Electrostatic Systems	Physics of Microfluidic Systems	Environmental Sensors
	SLO-2	Epi-Micromachining	Yaw-Rate Sensors	Forces in Electrostatic Systems	Navier-Stokes Equations	Interface Circuit Architecture
S-5	SLO-1	SIMPLE, SCREAM	Pressure Sensors	Scaling Properties	Laminar Flow, Dynamic Pressure	Requirements and Specifications
	SLO-2	Black Silicon, MELO	Fundamentals	Electrostatic Microactuator Configurations	Fabrication Technologies	Analog Front-End

S-6	**SLO-1**	*Porous Silicon*	*Bulk-Micromachined Pressure Sensors*	*Gap-Closing Electrostatic Microactuators& Examples*	*Silicon, Plastics,*	*Voltage Output - Current or Charge Output*
	SLO-2	*SIMOX*	*Surface-Micromachined Pressure Sensors*	*Constant-Gap Electrostatic Microactuators& Examples*	*Quartz, Glass*	*Impedance Variation*
S-7	**SLO-1**	*Epi-Po1y*	*Signal Generation*	*Hybrid Electrostatic Microactuators*	*Microarrays*	*A/D Converter*
	SLO-2	*Release and Stiction*	*Force and Torque Sensors*	*Electrostatic Induction, Issues and Challenges*	*Concept, Fabrication, Particle-Based Microarray Concepts*	*Types of converters*
S-8	**SLO-1**	*IC Compatibility Issues*	*Linking the Macro World to the Micro World*	*Piezoelectric Microactuators*	*Micropumps*	*Digital Processing and Output Interface*
	SLO-2	*Compatible Bulk Micromachining*	*Fabrication*	*Piezoelectric Energy Density*	*Microdisplacement Pumps, Charge-Induced Pumping Mechanisms, Other Pumping Mechanisms*	*Digital Signal Processing*
S-9	**SLO-1**	*Compatible Surface Micromachining*	*Protection*	*Piezoelectric Microactuator Configurations & Design Issues*	*Microanalytical Chips*	*Wired Output Interfaces*
	SLO-2	Compatible Epi-Micromachining	*Test and Calibration*	*Electrostriction, Electrets, and E1ectrorheo1ogical Fluids*	*Lab-on-a-Chip Systems, Chip-Based Capillary Electrophoresis*	*Wireless Output Interfaces*

Learning Resources

1. Jan G. Korvink, Oliver Paul, "MEMS: A Practical Guide to Design, Analysis and Applications", William Andrew, Inc. & Springer, 2006
2. Chang Liu, "Foundations of MEMS", Pearson; 2nd edition, 2011
3. Mohamed Gad-el-Hak, "MEMS: Design and Fabrication", CRC Press; 1st edition, 2005.
4. Julian W. Gardner, "Micro sensors, MEMS, and Smart Devices", John Wiley & Sons Inc, 2001
5. John A. Pelesko, "Modeling MEMS and NEMS", CRC Press; 1stedition, 2002
6. Stephen Beeby, "MEMS Mechanical Sensors", ARTECH HOUSE, INC 2004

Learning Assessment

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

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

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Course Code	18ECE387T	Course Name	MICRO SENSORS AND SMART DEVICES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	To realize the importance of micro sensors and actuators
CLR-2 :	To learn the operating principle of various micro sensors
CLR-3 :	To analyze the applications of various micro fabrication techniques
CLR-4 :	To understand the different packaging techniques
CLR-5 :	To appreciate the significance of available MEMS based smart devices
CLR-6 :	To recognize recent developments and challenges in MEMS

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	Appreciate the importance of sensors and actuators based on MEMS technology	3	80	75	H	-	-	-	-	H	-	-	-	-	-	H	H	-	H
CLO-2 :	Understand the fabrication and machining techniques of MEMS devices	3	80	70	H	-	-	-	-	H	-	-	-	-	-	H	-	-	H
CLO-3 :	Familiarize with the concepts of packaging and interfaces in MEMS devices	3	75	70	H	H	M	H	M	H	-	-	-	-	-	H	H	-	H
CLO-4 :	Appreciate the significance of general micro fabrication processes	3	80	75	H	H	M	H	M	-	-	-	H	-	-	H	-	-	H
CLO-5 :	Differentiate between the working principle of various micro sensors	3	80	70	H	-	M	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	Analyze recently developed smart devices employing MEMS technology	3	80	70	H	-	-	-	-	H	-	-	-	-	-	H	H	-	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to Microelectronics	*Micro thermal Sensors-overview*	*Micro machining techniques*	*MEMS Packaging*	*Smart Devices-Overview*
	SLO-2	*Evolution& History of MEMS*	*TEG and Thermopiles*	*Significance and types*	*Objectives in Packaging*	*Functionalities*
S-2	SLO-1	*Overview of Micro system technology*	*Micro radiation Sensors-overview*	*Bulk MMC-overview*	*Flip chip assembly*	*Features & requirements*
	SLO-2	*Broad applications of Micro systems*	*Implementation*	*Principle and block diagram*	*Ball grid array*	*Broad applications*
S-3	SLO-1	*Miniaturization & Scaling laws*	*Micro mechanical Sensors-overview*	*Surface MMC-overview*	*wire bonding techniques*	*Airbag deployment*
	SLO-2	*Micro devices -examples*	*Vibration sensor -Accelerometer*	*Principle and block diagram*	*Types*	*Tire pressure monitoring*
S-4	SLO-1	*Types of Micro Sensors*	*Micro pressure Sensors-overview*	*LIGA process-overview*	*surface bonding techniques*	*GPS-Gyro sensor*
	SLO-2	*Types of Micro actuators*	*Parameter measurement*	*Principle and block diagram*	*Types*	*Micro Energy harvesters*
S-5	SLO-1	*Si and other substrates*	*Micro humidity Sensors-overview*	*Photolithography*	*sealing*	*Smart home automation*
	SLO-2	*Special MEMS Materials& properties*	*Types of Sensing film & measurement*	*Process Description, implementation*	*Different types of sealing*	*MEMS devices in agriculture*
S-6	SLO-1	*Polymer materials*	*Micro SAW Sensors-overview*	*Ion implantation and oxidation*	*Process design*	*Blood pressure monitor*
	SLO-2	*Electro active polymers*	*Implementation*	*Process Description, implementation*	*Block diagram*	*Heart Parameter monitors*

S-7	**SLO-1**	*Shape memory alloys*	*Micro magnetic Sensors-overview*	*PVD-CVD*	*Interferences*	*RF MEMS technology*
	SLO-2	*Shape memory polymers*	*Si gnificance & measurement*	*Process Description, implementation*	*Types of interferences*	*Optical Mirrors*
S-8	**SLO-1**	*Piezoelectric materials*	*Micro bio chemical Sensors-overview*	*Wet and dry etching*	*Electronic Interfacing*	*Micro fluidics*
	SLO-2	*Ceramic materials*	*Parameter measurement*	*Isotrophic and Anisotrophic*	*Electro mechanical interfacing*	*LOC module*
S-9	**SLO-1**	*Case study-1*	*Micro optical Sensors-overview*	*Case study-1*	*Case study-1*	*Case study-1*
	SLO-2	*Case study -2*	*Types & Implementation*	*Case study -2*	*Case study -2*	*Case study -2*

Learning Resources	*1. Marc Madou,"Fundamentals of Microfabrication" CRC Press* *2. Tai Ran Tsu,"MEMS and Microsystems: Design Manufacture", Tata McGraw Hill*	*3. Vardhan Gardener,"Micro sensors and smart devices", John Wiley & Sons*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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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B. Tech in Electronics and Communication Engineering
(with Specialization in Instrumentation Engineering)

2018 Regulations

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

Learning Resources

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

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Anuj Kumar, Bombard*ier 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 %		-	

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. 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	*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	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: Level of Thinking (Bloom)	Expected Proficiency (%)	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					
	SLO-2	***Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot***	***Lab 5: Short-time Fourier transform magnitude spectrum***	***Lab 8: Estimation of pitch period using harmonic product spectrum***	***Lab 11:To study the quantization and aliasing effect of speech signal***	***Lab 14: Short term speech analysis***
S-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					
	SLO-2	***Lab 3:Cepstrum smoothed magnitude spectrum***	***Lab 6: (i)Linear prediction magnitude spectrum, (ii) (ii) Estimation of formant frequencies using linear prediction***	***Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method***	***Lab 12*:: Speech signal to symbol transformation using wavesurfer**	***Lab 15: Study of Praat***
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

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

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, important observation with respect to reverberation*	*Electostatic Transducers*	*Acoustic positioning and navigation*

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

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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. S. Dhanalakshmi, SRMIST***
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

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:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	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 :				

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											
M		L												
M			L											
M			M	H										
L				H										

Duration (hour)		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
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), Thyristor	Fabrication and Assembly Considerations	Design Rules for Microwave Circuits	PCB Layout Design - Checking foot prints of the components, Part list, Net list, Making Net list Files	PCB Assembly Process - Through-hole
S-7	SLO-1		Design and analysis of RLC circuits. Schematic in CAD tool	Schematic and PCB Layout in CAD tool.		**Mini Project - Manufacture the PCB for electronic turn ON/OFF timer using**
	SLO-2					

S-8	**SLO-1**	*Study of electronic components- active devices, analog and digital integrated circuits (IC)*		***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.***	***IC555and construct and test the designed circuit.***
	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.,

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	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
CLR-1 :	Analyze the basic laws and theorems of light associated with the optical fiber communication and the classification of optical fibers	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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
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	
H	H	-	-	-	-	-	-	-	-	-	-	-			H
H	-	M	-	-	-	-	-	-	-	-	-	-	-	-	M
H	M	M	-	-	-	-	-	-	-	-	-	-	-	-	L
H	-	M	-	-	-	-	-	-	-	-	-	-	-	-	H
H	-	M	L	-	-	-	-	-	-	-	-	-	-	-	L
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 Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. Sathiyan, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	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	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	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 :				

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	H	-	-	-	H	-	H	-	H	H	-
H	H	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	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 SLO-2	Features-timers,interrupts	Introduction to Pointers	I2C	Timer programming	Bio medical application
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 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.anil@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:
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 Loop, Defining a Function in Python	Controlling GPIO Outputs Using a Web Interface	Data sheet analysis of GPS	Data sheet analysis ultrasonic rangefinder	MQTT Protocol- installation and setting account ,token creation ,reading sensor data and pushing to thingsboard

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

Learning Resources	1. *Simon Monk, "Raspberry Pi Cookbook", O'Reilly Media, Inc, 2014.* 2. *Volker Ziemann, "A Hands-On Course in Sensors Using the Arduino and Raspberry Pi, CRC Press, 2018.*	3. *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	*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. 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:
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:	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 3D printing tools for components design	1	80	60	M				M										
CLO-2 :	Able to optimistically select the 3D design software and hardware for the given problem	1	80	60	M				H										
CLO-3 :	Capability to solve 3D design components design problems	2	75	60	M			M										M	
CLO-4 :	Choose the contemporary technology available for 3D design and printing	3	80	60			M											M	L
CLO-5 :	Apply various post processing methods involved in 3D printing technology	2	80	60		H													
CLO-6 :	Ability to develop the skillset on 3D component design and development using contemporary commercial software and hardware available.	2	80	60											M			M	

Duration (hour)		Introductions to 3D design tools	Three-dimensional (3D) Modeling	3D Design Fundamentals and Projects	3D Printing and its Technologies	Post Processing - Product Visualization and Print Cleaning
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 %		-	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. S. Karuppudaiyan, Mechanical, SRMIST
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	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 Introduction*	*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	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
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.,

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. D. Ashokkumar**, 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. Mr. P. Muthu, SRMIST***
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	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***
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	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	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
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	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
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 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: Problem Solving at the interface of Engg. & Medicine	PLO 14 PSO-2: Design & Develop Medical Devices	PLO 15 PSO-3: multidisciplinary research for health care solu
CLO-1 :	Analyze the underlying concepts of quality and quality control concepts of an organization	2	85	75	-	-	-	-	-	-	-	-	-	-	-	L	-	-	L
CLO-2 :	Evaluate the various quality management principles and good management practices	3	85	75	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
CLO-3 :	Evaluate various tools of quality control	3	85	75	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-4 :	Analyze the various quality management tools	3	85	75	L	-	-	-	-	-	-	-	-	-	-	-	-	-	L
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	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.,

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

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*20 %*	-	*20 %*	-	*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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. 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 (%)	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: Automatic control for continous & discrete systems	PSO-2: Utilize PLC & DCS for control of systems	PSO-3: Effective management skills
CLO-1 :	Apply the principles and theory of instrumental analysis	1,2	80	70	H	H	L	L	H	H	H						H	H	L
CLO-2 :	Apply the principles of various chemical analysis instruments in industries	1,2	85	75	H	H	L	L	H	H							H	H	L
CLO-3 :	Analyze and understand the operation of various radio chemical methods of analysis	1,2	75	70	H	H	L	L	H	H							H	H	L
CLO-4 :	To analyze and understand the operation of instruments based on optical properties	1,2	85	80	H	H	L	L	H	H							H	H	L
CLO-5 :	To identify and solve engineering problems associated with Radiation Techniques	1,2	85	75	H	H	L	L	H	H							H	H	L
CLO-6 :	To understand the working of analytical Instruments in industries	1,2	80	70	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 Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 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. 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 %	

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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			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 :	To demonstrate the various types of basic sensors.	2,3	80	80	H	-	H	-	-	H	H	H	-	-	-	H	H	-	-
CLO-2 :	Understand the inductive and capacitive sensors which are used for measuring various parameters.	1,2	80	80	H	-	-	H	-	H	-	-	-	-	-	H	-	H	-
CLO-3 :	Understand the thermal and radiation sensors	1	80	80	-	-	-	-	-	H	-	-	H	H	-	-	H	-	-
CLO-4 :	Have an adequate knowledge on the various magnetic sensors	3	80	80	-	H	H	-	-	-	-	-	-	-	-	-	-	H	-
CLO-5 :	To demonstrate the various types of basic sensors measuring non electrical quantity	3	80	80	-	-	H	-	H	-	-	-	-	-	-	H	-	-	H
CLO-6 :	Select the right transducer for the given application	3	80	80	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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2. V. Venkateswaran, Instrumentation Consultant, vvenkat99@gmail.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*Dr. G. Joselin Retna Kumar, SRMIST*

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	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: Automatic control for continuous& discrete systems	PLO 14 PSO-2: Utilize PLC & DCS for control of systems	PLO 15 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
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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
(with Specialization in Instrumentation 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'