ACADEMIC CURRICULA

Professional Elective Courses

ELECTRONICS AND COMMUNICATION ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE & TECHNOLOGY

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

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

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Restate python language to compute formula and scientific problem*	*1*	*60*	*60*
CLO-2 :	*Translate mathematical models and system using difference equations*	*1*	*60*	*60*
CLO-3 :	*Examine time sequence concept for generation and processing of audio signal by python*	*2*	*60*	*60*
CLO-4 :	*Demonstrate python language to solve Polynomials*	*2*	*60*	*60*
CLO-5 :	*Apply python language construct to compute probability by Monte Carlo Simulation ,game design and dynamic random motion creation*	*2*	*60*	*60*
CLO-6 :	*Solve statistical analysis , correlation coefficient analysis , Solving equations- Linear least squares solutions and signal processing problems using SciPy, numpy, matplotlib*	*2*	*60*	*60*

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

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

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

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

Learning Assessment

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

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

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

Course Code	18ECE202T	Course Name	MICRO- AND NANO-FABRICATION TECHNOLOGIES	Course Category	E	Professional Elective	L	T	P	C

						3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Examine the various layering Technologies*	*2*	*80*	*70*
CLO-2 :	*Show how the pattern generation is done using Lithography Techniques*	*2*	*85*	*75*
CLO-3 :	*Illustrate the knowledge on particle sources, Optics and Interaction*	*2*	*75*	*70*
CLO-4 :	*Explain the device and circuit fabrication Techniques*	*2*	*85*	*80*
CLO-5 :	*Infer about new and advances in fabrication Technologies*	*2*	*85*	*75*
CLO-6 :	*Examine the limitations and tools of micro, nanofabrication.*	*2*	*80*	*70*

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

Duration (hour)		Crystal Growth, Epitaxy, Oxidation	Lithographic Processes	Deposition, Diffusion, Ion implantation	Device Circuit Fabrication	Molecular Nanotechnology
		9	9	9	9	9
S-1	SLO-1	*Starting Materials*	*Photoreactive Materials*	*Vaccum Evaporation*	*Isolation*	*Directed Self Assembly*
	SLO-2	*Growth from Melt (Czochralski Technique)*	*Image Reversal*	*Sputter Deposition*	*Self Alignment*	*Device Assembly*
S-2	SLO-1	*Considerations for Paper Crystal Growth*	*Pattern Generation*	*Chemical Vapour Deposition*	*Local Oxidation-Trench Technique*	*Electrostatic*
	SLO-2	*Cystal Orientation, Crystal hardening Techniques*	*Mask Making*	*Growth Habit*	*Planarization*	*Templated self assembly*
S-3	SLO-1	*Doping, Dislocation*	*Pattern Transfer*	*Fims for protection & Masks*	*Metalization*	*Colloids & Nanoparticles*
	SLO-2	*Molecular Beam Epitaxy*	*Optical Printing*	*Self-aligned Masks*	*Gettering*	*Block Copolymers*
S-4	SLO-1	*Gas Source MBE*	*Advanced Techniques*	*Films for Doping*	*NIOS-based Micro Circuits*	*DNA Nanostructures*
	SLO-2	*Vapour Phase Epitaxy*	*Short Wave lengths*	*Dopart Sources*	*P,n Channel Transistors*	*Scanning probe lithography Techniques*
S-5	SLO-1	*VPE Process to Silicon*	*Multilayer Resists*	*Films for Ohmic contacts*	*Complementary Transistors*	*Local Anodic Oxidation*
5-6	SLO-2	*VPE Process for GaAs*	*Phase Shifting Masks*	*Wet Chemical etching*	*Memory Devices*	*Scribing*
S-7	SLO-1	*Liquid Phase Epitaxy*	*Electron Beam Techniques*	*Anisotropic Effects*	*SOI Devices*	*Atomic Manipulation*
	SLO-2	*LPE System*	*Lon-Beam Techniques*	*Dry Physical Etching*	*BJT based Silicon Micro Circuits*	*SPM Scanning Probe Microscopy*
S-8	SLO-1	*Thermal Oxidation of Silicon*	*X Ray Printing*	*Dry Chemical Etching*	*The buried layer*	*Erasable Electrostatic Lithography*
	SLO-2	*Kinetics of Oxide Growth*	*Problem areas- defects*	*Reactive Lon Etching*	*P-n-p Transistor*	*Limits to Nano Fabrication*
S-9	SLO-1	*Oxidation System*	*Feature size control & anisotropic Etch Mechanism*	*Penetration range &Transverse effects*	*Field Effect Transistor*	*Limits to MSO Devices*
	SLO-2	*Halogenic Oxidation*	*Lift off Techniques*	*Annealing*	*BICMOS Integrated Circuits*	*Limits for Pattern Generation*
	SLO-2	*Anodix OxidationPlasma Processes*	*Plasma reactor Relative Plasma etching*	*Ion Implantation systems High energy,*	*Self Aligned Technology The Hetero*	*Nanofabrication Tools*

			Technique	*high current Inplants*	*junction Bipolar Transistor*	

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

Learning Assessment

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

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

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

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Identify and Choose semiconductor materials for various applications	2	60	60
CLO-2 :	Interpret the characteristics of Junction devices	2	60	60
CLO-3 :	Modify and model the BJT parameters for better performance	2	60	60
CLO-4 :	Evaluate and optimize the performance of MOSFET	2	60	60
CLO-5 :	Build new devices with small channel	2	60	60
CLO-6 :	Explain the equations, approximations and techniques available for deriving a model with specified properties, for a general device characteristic with known qualitative theory	2	60	60

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

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

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

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

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE204J	Course Name	ARM-BASED EMBEDDED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Explore software development tools of ARM processor*			
CLR-2 :	*Acquire knowledge about peripherals for ARM chip such as A/D, PWM*			
CLR-3 :	*Obtain exposure towards timers and serial interfacing.*			
CLR-4 :	*Explore effective use of memory; network interfacing, Ethernet and wireless protocol supports*			
CLR-5 :	*Address ARM processor based audio signal processing.*			
CLR-6 :	*Develop ARM Cortex-M based embedded systems for networking and signal processing applications.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Relate "mbed" software and C language application for ARM Cortex-M processors.*	*1*	*65*	*60*
CLO-2 :	*Develop codes to interface A/D converter, PWM generation and digital input / output.*	*2*	*65*	*60*
CLO-3 :	*Experiment with program System timer, serial interface and LCD display.*	*2*	*65*	*60*
CLO-4 :	*Summarize the use of memory and program network interface.*	*2*	*65*	*60*
CLO-5 :	*Analyze audio signal processing applications on embedded platform.*	*3*	*65*	*60*
CLO-6 :	*Identify the use of "mbed" software pack on ARM Cortex-M processor for networking and simple signal processing.*	*3*	*65*	*60*

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

Duration (hour)		Cortex-M processor	Peripheral Interfacing-I	Peripheral Interfacing-II	Network Interfacing	Audio Signal Processing
		15	15	15	15	15
S-1	SLO-1	*Introducing embedded systems and mbed*	*Starting to Program Digital Input and Output*	*Introducing Synchronous Serial Communication*	*Memory organization*	*An Introduction to Digital Audio*
	SLO-2	*Introducing embedded systems and mbed*	*Voltages as Logic Values*	*I2C bus*	*Memory organization*	*USB MIDI on the mbed*
S-2	SLO-1	*ARM Cortex assembly language basics.*	*Introducing Analog output Data Conversion*	*Communicating With I2C-Enabled Sensors*	*Using Data Files With the mbed*	*Digital Audio Processing*
	SLO-2	*ARM Cortex assembly language basics.*	*Digital Output on the mbed*	*Asynchronous Serial Data Communication*	*Example mbed Data File Access*	*Digital Audio Filtering Example*
S 3-4	SLO-1	*Lab-1:Assembly language program, simulation -1*	*Lab 4: A/D conversion program*	*Lab 8: Multinode I2C Bus*	*Lab 10: Data logging*	*Lab 13: Audio signal generation*
	SLO-2					
S-5	SLO-1	*Cortex-M processor architecture and Basics : Programming exercises*	*Digital Input and Output.*	*LCD interfacing*	*Using External SD Card Memory With the mbed*	*Delay/Echo Effect*
	SLO-2	*Cortex-M processor architecture and Basics : Programming exercises*	*Digital Input and Output.*	*Using the mbed TextLCD Library*	*Using External USB Flash Memory With the mbed*	*Working With Wave Audio Files*
S-6	SLO-1	*Development Environment using the mbed*	*Switching Larger DC Loads*	*Time and Tasks in Embedded Systems*	*Introduction to Internet Communication*	*High-Fidelity Digital Audio With the mbed*
	SLO-2	*Development Environment using the mbed*	*Switching Larger DC Loads*	*Responding to External Events*	*The Ethernet Communication Protocol*	*High-Fidelity Digital Audio With the mbed*
S 7-8	SLO-1	*Lab 2: Assembly language program, simulation-2*	*Lab 5: Mini Project: Letter Counter*	*Lab 8: A/D output on LCD*	*Lab 11: Ethernet Communication*	*Lab 14: Model lab examination*
	SLO-2					

S-9	SLO-1	*Keil IDE and Debugging tools*	*Another Form of Analog Output: Pulse Width Modulation*	*An Introduction to Timers*	*Introducing Wireless Data Communication*	*Summary on Digital Audio and Digital Signal Processing*
	SLO-2	*Keil IDE and Debugging tools*	*Pulse Width Modulation on the mbed*	*Using the mbed Timer*	*Wireless Data Communication : Bluetooth and Zigbee*	*Summary on Digital Audio and Digital Signal Processing*
S-10	SLO-1	*C- language review*	*Design of PWM problem*	*Using the mbed Timeout and Ticker*	*Local Area Network Communications With the mbed*	*Review and discussions*
	SLO-2	*Embedded C , introduction*	*Design of PWM problem*	*The Real-Time Clock*	*Using RPC*	*Review and discussions*
S 11-12	SLO-1 SLO-2	*Lab 3: Parallel port programming, simulation*	*Lab 6: PWM waveform generation*	*Lab 9: Experimenting Interrupts, Timers*	*Lab 12: RPC Communication through ethernet*	*Lab 15: Final lab examination*

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

Learning Assessment

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

Course Code	18ECE205J	Course Name	FPGA-BASED EMBEDDED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Explore high volume embedded systems which are function specific*	1	2	3
CLR-2 :	*Relate FPGA knowledge to design circuits*			
CLR-3 :	*Select Xilinx FPGA IDE and design practice*			
CLR-4 :	Recall FPGA platforms			
CLR-5 :	Examine FPGA system design and practical issues			
CLR-6 :	*Develop designs using FPGAs/PSoCs for specific embedded modules and low-power designs*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*List Micro controller subsystems*	*2*	*60*	*65*
CLO-2 :	*Build system design with PSoCs*	*3*	*60*	*65*
CLO-3 :	*Classify Platform FPGAs*	*2*	*60*	*65*
CLO-4 :	*Make use of FPGA architecture design*	*3*	*60*	*60*
CLO-5 :	*Utilize Platform FPGA designs*	*3*	*60*	*60*
CLO-6 :	*Develop simple FPGA based systems*	*3*	*60*	*60*

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

Duration (hour)		Basics of Peripherals	PSoC Design	Xilinx Virtex 5 IDE	Platform FPGA Designs	Designing Simple FPGA based Systems
		15	15	15	15	15
S-1	SLO-1	*Embedded systems performance criteria - Interrupts*	*PSoC3/5 architecture overview*	*Design challenges, life cycle*	*Design quality: correctness, reliability, resilience.*	*Communication: Coprocessor model*
	SLO-2	*Embedded systems performance criteria - Interrupts*	*PSoC3 architecture details and 8051 instructions*	*Metrics: measures of success*	*Modules and interfaces*	*Network on chip model*
S-2	SLO-1	*Embedded systems performance criteria - DMA*	*Interrupts and interrupt lines*	*Spectrometer example using Xilinx IDE*	*Abstraction and state,*	*Transfer of state*
	SLO-2	*Latency and its problems*	*Interrupt priority and nesting*	*Spectrometer example using Xilinx IDE*	*Cohesion and coupling and control flow graph*	*Practical issues: profiling issues*
S 3-4	SLO-1	*Lab 1: Embedded sensors and sensing -1*	*Lab 4: PSoC Design -1*	*Lab 7: VHDL, Verilog Practice session -1*	*Lab 10: Sample design implementation*	*Lab 13: On-chip memory access, FIFOs*
	SLO-2					
S-5	SLO-1	*Embedded system subsystems: A/D conversion*	*The concept of memory and its connectivity to CPU*	*Xilinx Virtex 5 IDE*	*Origin of Platform FPGA Designs*	*Spatial design: Principles of parallelism*
	SLO-2	*Digital ports & its current capacity*	*Different DMA modes*	*Xilinx Virtex 5 IDE*	*Platform FPGA components*	*Granularity, degree of parallelism*
S-6	SLO-1	*Introduction to other digital interfaces*	*Clocking system: Internal master oscillator*	*PLD basics*	*Adding to platform FPGA systems*	*Spatial organizations*
	SLO-2	*Introduction to other digital interfaces*	*IMO, and sleep/wake up modes*	*FPGA configurations*	*Assembling custom compute cores*	*Spatial organizations*
S 7-8	SLO-1	*Lab 2: Embedded sensors and sensing - 2*	*Lab 5: PSoC Design -2*	*Lab 8: VHDL, Verilog Practice session -2*	*Lab 11: Building base systems*	*Lab 14: Model lab examination*
	SLO-2					

S-9	SLO-1	*Sensors and sensing principles. Optical, capacitive sensors*	*Clock distribution*	*Various slices in Virtex 5*	*Software design :root file system, cross-developmental tools*	*Managing bandwidth: Balancing*
	SLO-2	*Magnetic, RF sensors*	*Power management: Internal regulators*	*Various slices in Virtex 5*	*Monitors and boot loaders*	*Khan process network*
S-10	SLO-1	*Processing: Mathematical views.*	*Types of reset*	*Bit stream*	*Overview of partitioning platform*	*Platform FPGA bandwidth techniques*
	SLO-2	*Programmable logic and mixed signal design fundamentals*	*Intro to PSoC creator IDE*	*Programming FPGA*	*Analytical solution to partitioning*	*On-chip, off-chip memory*
S 11-12	SLO-1 SLO-2	*Lab 3: Programmable logic design*	*Lab 6: PSoC Design - 3*	*Lab 9: Sample design implementation*	*Lab 12: Creating IP core*	*Lab 15: Final lab examination*

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

Learning Assessment

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

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

Course Designers

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

Course Code	18ECE207J	Course Name	REAL TIME OPERATING SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Summarize concepts of C, assembly programming and IDE.*			
CLR-2 :	*Acquire knowledge of programming, the peripherals.*			
CLR-3 :	*Outline different RTOS principles*			
CLR-4 :	*Infer various advanced RTOS principles*			
CLR-5 :	*Develop sample projects using application programming*			
CLR-6 :	*Inspect how OS can be implemented on ARM processor.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Recall microprocessor instruction sets and their use.*	*1*	*65*	*60*
CLO-2 :	*Construct codes in assembly and C for embedded applications.*	*2*	*65*	*60*
CLO-3 :	*Illustrate the concepts and requirements of RTOS, in general basic OS principles.*	*2*	*65*	*60*
CLO-4 :	*Analyze the use RTOS in embedded programming*	*2*	*65*	*60*
CLO-5 :	*Apply the knowledge in related sample use cases.*	*3*	*65*	*60*
CLO-6 :	*Develop processor based embedded systems along with RTOS implementation.*	*2*	*65*	*60*

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

Duration (hour)		Cortex-M processor & 'C'	Peripheral Programming in 'C'	Concepts of RTOS	RTOS Implementation	RTOS Applications
		15	15	15	15	15
S-1	SLO-1	*Cortex-M processor architecture*	*Parallel I/O programming*	*Introduction to RTOS*	*Process management*	*Real time systems: Data acquisition system*
	SLO-2	*Cortex-M processor architecture*	*Sample programs*	*Introduction to RTOS*	*Dynamic linking and loading*	*Real time systems: Data acquisition system*
S-2	SLO-1	*ARM Cortex assembly language – part1*	*Interrupt processing basics*	*Concurrent programming*	*Spin-lock semaphore, cooperative scheduling*	*Performance metrics*
	SLO-2	*ARM Cortex assembly language – part2*	*System tick; periodic interrupts*	*Thread fundamentals*	*Thread rendezvous*	*Examples and discussions*
S 3-4	SLO-1	*Lab 1: Arm Assembly language programming*	*Lab 4: Interrupts and timers in C and assembly*	*Lab 7: Simple thread programming in RTOS – Wave form simulation*	*Lab 10: Semaphore implementation experiment in RTOS*	*Lab 13: Any application program using RTOS.*
	SLO-2					
S-5	SLO-1	*ARM Cortex microcontroller interface standards*	*UART programming*	*Shared resources and Critical sections*	*FIFO & Little's theorem*	*Solid state disk*
	SLO-2	*IDE software tools*	*UART programming*	*Consumer producer problem*	*Three semaphore implementation*	*Flash device driver*
S-6	SLO-1	*Pointers in C*	*Digital signal time measurement*	*Switching threads*	*Thread sleeping*	*SD card interface*
	SLO-2	*Arrays, structures and unions, Linked lists*	*Use of timers and compare, capture registers.*	*Profiling the OS*	*Deadlocks, monitors*	*Communication systems with Ethernet*
S 7-8	SLO-1	*Lab 2: C & assembly programming using Keil IDE and kit*	*Lab 5: Debugging hardware with target board – UART interface programming*	*Lab 8: Multi threaded application in RTOS – LED blinking with multi threads*	*Lab 11: Multi threaded application with Communication -1*	*Lab 14: Model lab examination*
	SLO-2					

S-9	SLO-1	*Embedded debugging tools in Keil IDE*	*SSI interface*	*Semaphores and implementation*	*Fixed scheduling*	*Application layer protocols for embedded systems*
	SLO-2	*Embedded debugging example with simulation*	*SSI programming with interrupt*	*Operations on semaphores*	*Fixed scheduling*	*CoAP, MQTT*
S-10	SLO-1	*Memory management -1*	*Analog I/O; A/D converter interfacing*	*Resource sharing*	*Kahn process networks*	*Discussions & Reviews*
	SLO-2	*Memory management -2*	*OS considerations of I/O devices*	*Thread Communications*	*Review*	*Discussions & Reviews*
S 11-12	SLO-1	*Lab 3: Practice: C & assembly programming using Keil IDE and kit*	*Lab 6: Debugging hardware with target board – Analog I/O programming*	*Lab 9 : Multi threaded application in RTOS, with semaphores*	*Lab 12: Multi threaded application with Communication -2*	*Lab 15: Final Lab Examination*
	SLO-2					

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

Learning Assessment

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

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

Course Designers

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

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

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning
CLR-1 :	*Identify Analog IC Design process flow and IC biasing*	1
CLR-2 :	*Analyze the operation and frequency response of CMOS single stage amplifiers*	2
CLR-3 :	*Analyze operation and frequency response of the Differential amplifiers and Op-amp*	3
CLR-4 :	*Create insights to the concepts of noises in amplifiers*	
CLR-5 :	*Utilize the concepts of oscillators and switched capacitor circuits*	
CLR-6 :	*Use commercial design tools for schematic entry, simulation, and layout*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Identify IC Biasing concepts*	*2*	*60*	*60*
CLO-2 :	*Analyze Single stage amplifiers*	*2*	*60*	*60*
CLO-3 :	*Analyze Differential Amplifiers and Op-amp*	*2*	*60*	*60*
CLO-4 :	*Identify the noises in Amplifiers*	*2*	*60*	*60*
CLO-5 :	*Identify oscillators and switched capacitors circuits*	*2*	*60*	*60*
CLO-6 :	*Solve practical and state of the art analog IC design problems to serve VLSI industries.*	*2*	*60*	*60*

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

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

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

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

Learning Assessment

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

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

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

Course Code	18ECE302T	Course Name	MEMS TECHNOLOGIES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Interpret the knowledge of MEMS devices principles and microfabrication techniques*	*1*	*60*	*60*
CLO-2 :	*Explain the essential concepts of electrical and mechanical applicable to MEMS.*	*1*	*60*	*60*
CLO-3 :	*Demonstrate the electrostatic and thermal sensing principles and actuating technique.*	*2*	*60*	*60*
CLO-4 :	*Model MEMS devices using piezoresistive, piezoelectric and magnetic sensing and actuating technique and microfluidic devices*	*2*	*60*	*60*
CLO-5 :	*Infer the application of polymers material used in MEMS application, also understand the design of optical and RF MEMS components.*	*2*	*60*	*60*
CLO-6 :	*Predict suitable MEMS packaging and testing methods.*	*2*	*60*	*60*

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

Duration (hour)		Introduction to mems and micro fabrication	Electrical and mechanical concepts of mems	Electrostatic and thermal principle sensing and actuation	Piezoresistive, piezoelectric and magnetic principle sensors and actuator	Polymer, optical, rf mems and its application
		9	9	9	9	9
S-1	SLO-1	*History of MEMS Development*	*Conductivity of semiconductors*	*Electrostatic sensing - Parallel plate capacitor*	*Piezoresistive sensors -piezoresistive sensor material*	*Polymers in MEMS- polymide,SU-8, Liquid crystal polymer (LCP)*
	SLO-2		*Problems on conductivity of semiconductors*	*Problems on electrostatic sensing*		
S-2	SLO-1	*Characteristics of MEMS – Miniaturization,*	*Crystal plane and orientation- Single crystal Si (FCC, Miller Indices and notation, crystal planes & characteristics, flats & wafer identification)*	*Electrostatic actuation Parallel plate capacitor*	*Stress in flexural cantilever and membrane*	*Polymers in MEMS- PDMS, PMMA , Parylene, Fluorocarbon*
	SLO-2	*Microelectronics integration - Mass fabrication with precision*		*Problems on electrostatic actuation*		
S-3	SLO-1	*Miniaturization and scaling*	*Stress and strain - definition , Relationship between tensile stress and strain*	*Electrostatic sensing and actuation- Application - Inertial, pressure and tactile sensor*	*Piezoelectric sensing and actuation- piezoelectric material properties*	*Optical MEMS-passive MEMS optical components-lenses-mirrors*
	SLO-2	*Sensors and Actuators- Energy domains and example devices for each*				
S-4	SLO-1	*Micro fabrication process - Bulk and Surface Micromachining*	*Stress and strain - definition , Relationship between tensile stress and strain*	*Electrostatic sensing and actuation- Application - parallel plate actuator comb drive*	*Quartz - PZT-*	*Actuation for active optical MEMS.*
	SLO-2				*PVDF -ZnO -Applications*	
S-5	SLO-1	*Silicon based MEMS processes- processing anisotropic wet etching*	*Flexural beam bending analysis under single loading condition*	*Problems on electrostatic sensing and actuation*	*Magnetic actuation- Principles- Deposition of magnetic materials*	*RF MEMS: Switches*

	SLO-2	*Isotropic wet etching*				
S-6	SLO-1	*Dry etching (plasma etching, ion milling, RIE, DRIE)*	*Types of beam, longitudinal strain under pure bending*	*Thermal sensing and Actuations- sensors and actuators based on thermal expansion*	*Design and fabrication of magnetic coil*	*RF MEMS - Filters, oscillators*
	SLO-2	*Photolithography,*				
S-7		*Thin film deposition -sputtering, evaporation,*	*Deflection of beam- Spring constant*	*Thermocouples*	*Microfluidics – Concepts of fluid mechanics*	*MEMS Packaging*
		Thin film deposition - LPCVD, PECVD	*Problems: Deflection of beam- Spring constant*	*Thermal resistors*		
S-8	SLO-1	*Thin film deposition - sputtering, evaporation, LPCVD, PECVD*	*Torsional deflection, intrinsic stress*	*Application of thermal sensors – Inertial, Flow, Infrared.*	*Microfluidics –Application: Channels, valves*	*MEMS Testing*
	SLO-2	*Thin film deposition - plating, spin-on*				
S-9	SLO-1	*New material and fabrication processing techniques*	*Resonance and quality factor*	*Problems on thermal sensing and actuation*	*Microfluidics – Application valves*	*Reliability issues in MEMS packaging*
	SLO-2	*Points of consideration for processing structural and sacrificial material.*				

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

Learning Assessment

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

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

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

Course Code	18ECE303T	Course Name	NANOELECTRONIC DEVICES AND CIRCUITS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Realize the importance of scaling of devices.*	*2*	*80*	*70*
CLO-2 :	*Identify the difference of nano devices from conventional devices.*	*2*	*85*	*75*
CLO-3 :	*Analyze the performance measures of various devices*	*2*	*75*	*70*
CLO-4 :	*Choose appropriate application of the device*	*2*	*85*	*80*
CLO-5 :	*Understand the design considerations of nano circuits*	*2*	*85*	*75*
CLO-6 :	*Apply the design concepts of nano circuits in real time applications*	*2*	*80*	*70*

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

Duration (hour)		Introduction to Nano Devices	Silicon MOSFETs- Novel Materials and Alternative Concepts	Nano Devices – Principles and Techniques	Nano- CMOS scaling Problems and Implications	Mixed Signal Circuit Design
		9	9	9	9	9
S-1	SLO-1	*MOS transistor- A First Glance at the Device*	*SOI MOSFET, partially depleted*	*Classical transport: classical resistance and conductance*	*Design Methodology in the Nano-CMOS Era*	*Design Considerations – Device Modeling*
	SLO-2	*The MOS Transistor under Static Condition*	*Fully depleted SOI*	*Quantum ballistic transport: quantum Resistance and conductance*	*Innovations needed to continue performance scaling -*	*Passive Components*
S-2	SLO-1	*MOS Transistor Capacitances- Channel Capacitance*	*Strained channel MOSFET,*	*Coulomb blockade effect*	*Sub-100-nm Scaling Challenges- Back-End-of-Line Challenges (Metallization)-*	*Design Using Thin Oxide Devices – Design Using Thick Oxide Devices*
	SLO-2	*Junction Capacitance*	*Hi-k gate dielectric, Metal gate electrode*	*Single Electron Transistor*	*Interconnect scaling-copper wire technology*	*Low-Voltage Techniques*
S-3	SLO-1	*The Actual MOS Transistor—Some Secondary Effect*	*Double gate MOSFET*	*Performance of the single-electron transistor*	*Low –k dielectric challenges-future global interconnect technologies*	*Design Procedures*
	SLO-2	*Challenges in Nanoscale MOSFETs*	*FinFET*	*SET technology and Field effect transistors*	*Front-End-of-Line Challenges (Transistors)-Quantum effects model*	*Electrostatic Discharge Protection*
S-4	SLO-1	*Scaling of transistor dimensions*	*Tunnel Effect*	*Carbon Nano Tube(CNT)*	*Polysilicon gate , Metal gate electrodes,*	*Multiple-Supply Concerns*
	SLO-2	*Moore's law*	*Tunneling through a potential barrier*	*Electronic properties of CNT*	*Direct tunneling gate leakage-Parasitic capacitance*	*Noise Isolation*
S 5-6	SLO-1	*Short Channel Effects (SCE) : Sub-threshold Conduction,*	*Potential energy profiles for material interfaces*	*Geometrical structure, Electronic structure of CNT Transport properties*	*Reliability concerns*	*Guard Ring Structures Isolated NMOS Devices*
	SLO-2					
S-7	SLO-1	*Drain Induced Barrier Lowering*	*Metal -insulator, metal -semiconductor*	*CNTFET, comparison of Si MOSFET with*	*Process Control Reliability*	*Epitaxial Material versus Bulk Silicon –*

				CNTFET		
	SLO-2	*Velocity Saturation, Hot electrons*	*Metal –insulator -metal junctions*	*FeFET*	*Lithographic Issues*	*Decoupling*
S-8	SLO-1	*Emergence of new materials,*	*Tunneling Diode*	*Principle of Spintronics*	*Mask Data Explosion*	*Power Busing*
	SLO-2	*Hi-k materials and its issues*	*Resonant Tunneling diode*	*Spin valves, SpinFET*	*New Breed of Circuit*	*Integration Problems*
S-9	SLO-1	*Metal gate, copper interconnect and*	*Three-terminal resonant tunneling devices*	*Magnetic Tunnel Junctions*	*Physical Design – Modeling Challenges*	*Corner Regions*
	SLO-2	*Low-k interlayer dielectric*	*Inverter and logic OR gates based on RTD*	*MRAM*	*Need for Design Methodology Changes*	*Neighboring Circuitry*

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

Learning Assessment

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

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

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

Course Code	18ECE304T	Course Name	MICROWAVE INTEGRATED CIRCUITS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Create the insights of microwave circuits*			
CLR-2 :	*Analyze matching networks and filter design*			
CLR-3 :	*Identify and implement amplifiers and oscillators*			
CLR-4 :	*Layout the types of mixers and control circuits*			
CLR-5 :	*Understand techniques used to fabricate and measurement of MICs*			
CLR-6 :	*Introduce Analyze and realize microwave circuits and its techniques*			

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

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

Duration (hour)		Introduction to MIC	Matching Circuits	Microwave Amplifiers and Oscillators	Mixers and Microwave Diodes	MIC Measurement Techniques
		9	9	9	9	9
S-1	SLO-1	*Introduction to MICs*	*Circuit Representation of two port RF/Microwave Networks*	*Introduction to amplifiers*	*Introduction to Mixers*	*Microwave Integrated Circuits : Introduction to SOC, SOP*
	SLO-2			*Stability considerations in active networks*		
S-2	SLO-1	*Frequency Bands*	*Low Frequency Parameters*	*Gain Consideration in Amplifiers*	*Mixer Types*	*MIC Materials.*
	SLO-2	*Lumped versus Distributed Circuits*	*High Frequency Parameters*			
S-3	SLO-1	*Behavior of finite length transmission lines*	*Transmission Matrix*	*Noise Consideration in active networks*	*Conversion Loss*	*Hybrid versus Monolithic MICs*
	SLO-2					
S-4	SLO-1	*General Characteristics of PC Boards*	*ZY Smith Chart*	*Broadband Amplifier design*	*SSB Mixers*	*Multichip Module Technology*
	SLO-2			*Low Noise Amplifier Design*	*DSB Mixers*	
S-5	SLO-1	*Transmission Lines on PC Boards*	*ZY Smith Chart*	*Introduction to oscillators*	*Design of Mixers: Single Ended Mixers*	*Fabrication Techniques*
	SLO-2					
S-6	SLO-1	*Passives made from Transmission Lines*	*Design of Matching Circuits using Lumped Elements*	*Oscillator versus Amplifier Design*	*Single Balanced Mixers*	*Miniaturization techniques*
	SLO-2					
S-7	SLO-1	*Resonators*	*Design of Matching Circuits using Lumped Elements*	*Oscillation conditions*	*Sub Harmonic Diode Mixers*	*Test fixture measurements*
	SLO-2		*Matching Network Design using Distributed Elements*			
S-8	SLO-1	*Combiners and Splitters*	*Matching Network Design using Distributed Elements*	*Design and stability considerations of Microwave Transistor Oscillators.*	*Microwave Diodes*	*Probe station measurements*
	SLO-2					
S-9	SLO-1	*Couplers*	*Filter design*	*Design and stability considerations of*	*Phase Shifters and PIN Diode*	*Thermal and cryogenic*

	SLO-2			*Microwave Transistor Oscillators.*	*Attenuators*	*measurements*

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

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

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

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

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

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning
CLR-1 :	*Acquire knowledge on hardware architecture of ARM Cortex-M core*	1
CLR-2 :	*Explore the AHB architecture*	2
CLR-3 :	*Select AHB peripherals for interfacing*	3
CLR-4 :	Experiment with high speed peripherals	
CLR-5 :	Develop applications with CMSIS	
CLR-6 :	*Understand and learn to use ARM Cortex-M processor architecture, and deice level programming.*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Explain hardware and register architecture of ARM Cortex-M based processors*	*1*	*65*	*60*
CLO-2 :	*Classify AHB and its signals*	*1*	*65*	*60*
CLO-3 :	*Choose and program high speed peripherals*	*2*	*65*	*60*
CLO-4 :	*Assess high speed peripherals with case study.*	*3*	*65*	*60*
CLO-5 :	*Interpret program device driver and create libraries.*	*3*	*65*	*60*
CLO-6 :	*Survey system programming of ARM Cortex-M based processor.*	*2*	*65*	*60*

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

Duration (hour)		ARM Cortex-M architecture	ARM Internal bus	ARM pheripherals	SOC programming	Case studies
		12	12	12	12	12
S-1	SLO-1	*Introduction to Programmable SoC*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*Programming an SOC using C language Programming an SOC using C language*	*Graphics LCD interfacing*
	SLO-2	*Introduction to Programmable SoC*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*		*Graphics LCD interfacing*
S-2	SLO-1	*ARM architecture*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*APB Bus*	*Board support package*
	SLO-2	*ARM architecture*	*AMBA 3 AHB Lite architecture*	*AHB UART peripheral*	*APB Bus*	*Board support package*
S 3-4	SLO-1	*Lab-1:ARM Keil IDE usage – sample ARM program.*	*Lab 4: Study of AHB peripheral*	*Lab 7: Multinode I2C Bus*	*Lab 10: Making a device driver*	*Lab 13: Case study – 2*
	SLO-2					
S-5	SLO-1	*ARM Register architecture*	*AHB SRAM controller*	*AHB timer*	*ARM CMSIS*	*Ethernet interfacing*
	SLO-2	*ARM Register architecture*	*AHB SRAM controller*	*AHB timer*	*ARM CMSIS*	*Ethernet interfacing*
S-6	SLO-1	*ARM assembly language*	*AHB SRAM controller*	*AHB-APB bridge*	*Device drivers*	*Ethernet interfacing*
	SLO-2	*ARM assembly language*	*Review and discussions*	*AHB-APB bridge*	*Device drivers*	*Ethernet interfacing*
S 7-8	SLO-1	*Lab 2: Assembly language programming of ARM processor using Keil IDE*	*Lab 5: ARM memory management*	*Lab 8: Application of timers*	*Lab 11: Using CMSIS*	*Lab 14: Model lab examination*
	SLO-2					
S-9	SLO-1	*ARM Cortex-M Architecture -1*	*AHB VGA peripheral*	*Fast GPIO programming*	*Application programming*	*Student Seminar / discussions*
	SLO-2	*ARM Cortex-M Architecture -1*	*AHB VGA peripheral*	*Fast GPIO programming*	*Application programming*	*Student Seminar / discussions*
S-10	SLO-1	*ARM Cortex-M Architecture -2 (pipelines)*	*AHB VGA peripheral*	*Interrupt mechanism of ARM*	*Case study - 1*	*Student Seminar / discussions*
	SLO-2	*ARM Cortex-M Architecture -2*	*AHB VGA peripheral*	*Interrupt mechanism of ARM*	*Case study - 2*	*Student Seminar / discussions*
S 11-12	SLO-1	*Lab 3: Parallel port programming*	*Lab 6: Graphics application*	*Lab 9: Experimenting Interrupts, Timers*	*Lab 12: Study of USB interface*	*Lab 15: Final lab examination*
	SLO-2					

Learning Resources	1. *Steve Furber, "ARM System on a Chip Architecture – 2nd Edition", Pearson Education, 2000.* 2. *"AMBA -3 APB Protocol", ARM Limited, 2003.*	4. *"AMBA -3 AHB Lite Protocol", ARM Limited, 2003.* 5. *Theory/Lab teaching materials, "Introduction to SoC kit", ARM Education media, 2018.*

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

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

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Course Code	18ECE306J	Course Name	ARM BASED DIGITAL SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Recall theory and application of discrete time signals*	*1*	*60*	*60*
CLO-2 :	*Solve problems using Z-transforms, DFT and FFT.*	*2*	*60*	*60*
CLO-3 :	*Analyze FiR filter concepts and implement in C.*	*2*	*60*	*60*
CLO-4 :	*Inspect IIR filter concepts and implement in C*	*2*	*60*	*60*
CLO-5 :	*Appraise adaptive filter design theory, methods and its uses.*	*3*	*60*	*60*
CLO-6 :	*Apply the theory and implementation aspects of DSP in ARM Cortex-M based processor platform.*	*2*	*60*	*60*

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

Duration (hour)		Basics of digital signals	Transforms for DSP	FIR filters	IIR filters	DSP applications
		12	12	12	12	12
S-1	SLO-1	*DT Signals-basics properties &Operations on DT signals*	*Z-Transform Properties*	*Design of Finite Impulse Response Filters-Symmetric and Antisymmetric FIR filters*	*Frequency Response and Characteristics of Analog Filters*	*Introduction-Steepest Descent Method-Least Mean Squares Method*
	SLO-2	*DT Signals-basics properties &Operations on DT signals*	*Z-Transform Properties*	*Design of Finite Impulse Response Filters-Symmetric and Antisymmetric FIR filters*	*Frequency Response and Characteristics of Analog Filters*	*Introduction-Steepest Descent Method-Least Mean Squares Method*
S-2	SLO-1	*DT systems-Properties of DT Systems – LTI system*	*Inverse Z-Transform-solving Difference Equation*	*Design of Linear- Phase FIR filters Using window methods*	*IIR Filter Design by Impulse Invariance*	*Adaptive Filters: Prediction and System Identification*
	SLO-2	*DT systems-Properties of DT Systems – LTI system*	*Inverse Z-Transform-solving Difference Equation*	*Design of Linear- Phase FIR filters Using window methods*	*IIR Filter Design by Impulse Invariance*	*Adaptive Filters: Prediction and System Identification*
S 3-4	SLO-1	*Lab 1: Introduction- Keil MDK-ARM application development Environment.*	*Lab 4: LTI System Implementation*	*Lab 7: Filter Structures in the CMSIS-DSP Library*	*Lab 10: IIR Filter Structures in the CMSIS-DSP Library*	*Lab 13: CMSIS Implementation of the LMS and Normalized LMS methods*
	SLO-2					
S-5	SLO-1	*Convolution and Correlation*	*DFT-review; problems*	*Design of Linear- Phase FIR filters Using window methods*	*Design of Butterworth filter using Bilinear Transformation*	*Adaptive Filters: Equalization and Noise Cancellation*
	SLO-2	*Convolution and Correlation*	*DFT-review; problems*	*Design of Linear- Phase FIR filters Using window methods*	*Design of Butterworth filter using Bilinear Transformation*	*Adaptive Filters: Equalization and Noise Cancellation*
S-6	SLO-1	*CT-to DT Conversion Sampling Theorem in the Time Domain*	*DIT-FFT Radix 2 butterfly derivation - problems*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Bilinear Transformation*	*Adaptive Filters: Adaptive FIR Filter*
	SLO-2	*CT-to DT Conversion Sampling Theorem in the Time Domain*	*DIT-FFT Radix 2 butterfly derivation - problems*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Bilinear Transformation*	*Adaptive Filters: Adaptive FIR Filter*
S 7-8	SLO-1	*Lab 2: Digital Signals-operations on*	*Lab 5: Calculating the DFT-FFT*	*Lab 8: FIR Filter Design*	*Lab 11: IIR Filter Design*	*Lab 14: Model Practicals*

	SLO-2	*Digital Signals*				
S-9	SLO-1	*Sampling Theorem in the Frequency Domain-Aliasing*	*Filtering in the FD-Circular & Convolution*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Impulse Invariance*	*Review, Problems and Discussions*
	SLO-2	*Sampling Theorem in the Frequency Domain-Aliasing*	*Filtering in the FD-Circular & Convolution*	*Design of Optimum Equiripple Linear-Phase FIR filters*	*Chebyshev Filter Designs based on the Impulse Invariance*	*Review, Problems and Discussions*
S-10	SLO-1	*Reconstruction in the Frequency Domain & time Domain*	*Filtering in the FD-Linear Convolution*	*Filter Design using Software*	*Filter Design using Software*	*Review, Problems and Discussions*
	SLO-2	*Reconstruction in the Frequency Domain & time Domain*	*Filtering in the FD-Linear Convolution*	*Filter Design using Software*	*Filter Design using Software*	*Review, Problems and Discussions*
S 11-12	SLO-1	*Lab 3: A-D & D-A conversion-Changing the Sampling Frequency*	*Lab 6: Filtering in the Frequency Domain*	*Lab 9: Implementing a FIR Filter using Different Structures*	*Lab 12: Implementing a Filter using Different Structures*	*Lab 15: University practicals*
	SLO-2					

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

Learning Assessment

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

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

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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. Mr. U. Hari, SRMIST*

Course Code	18ECE307J	Course Name	APPLIED MACHINE LEARNING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Explain Genetic Algorithm for evolutionary learning*	*1*	*60*	*60*
CLO-2 :	*Use reinforcement learning*	*2*	*60*	*60*
CLO-3 :	*Apply linear model of linear regression and SVM for classification problem*	*2*	*60*	*60*
CLO-4 :	*Experiment neural network and CNN for classification problem*	*2*	*60*	*60*
CLO-5 :	*Demonstrate Decision Trees , clustering For classification problem*	*2*	*60*	*60*
CLO-6 :	*Analyze probability model of Bayesian decision theory and HMM for classification problem*	*2*	*60*	*60*

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

Duration (hour)		Introduction to Machine Learning and Linear Model	Multiplayer Perceptrons and Decision Tree	Clustering, SOM and HMM	Bayes Network, Reinforcement Learning and CNN	Genetic Algorithm and Application of ML
		12	12	12	12	12
S-1	SLO-1	*Introduction to Machine learning: Types of Machine Learning - Supervised Learning – Unsupervised, Learning*	*Multiplayer, Perceptrons*	*Clustering*	*Bayesian decision theory*	*The Genetic Algorithm*
	SLO-2	*Reinforcement learning , The Curse of dimensionality*	*Multiplayer, Perceptrons*	*K-Means clustering*	*Bayesian decision theory*	*The Genetic Algorithm*
S-2	SLO-1	*Bias and Variance, Learning Curve*	*Multiplayer, Perceptrons*	*Hierarchical clustering*	*Bayesian estimation*	*Facial Expression Recognition*
	SLO-2	*Classification, Error and noise, linear regression*	*Multiplayer, Perceptrons*	*Agglomerative clustering*	*Bayes network*	*Human Emotion Research*
S-3,4	SLO-1	*Lab 1: Linear Regression*	*Lab 4: Multiplayer, Perceptrons*	*Lab 7: K-Means clustering*	*Lab 10: Bayes Network*	*Lab 13: Genetic Algorithm*
	SLO-2					
S-5	SLO-1	*Support Vector Machines*	*Example of using MLP*	*Vector Quantization*	*Reinforcement learning*	*Facial Expression Recognition System*
	SLO-2	*Support Vector Machines*	*Example of using MLP*	*Vector Quantization*	*Reinforcement learning*	*Facial Expression Recognition System*
S-6	SLO-1	*Support Vector Machines*	*Example of using MLP*	*The Self-Organizing Feature Map*	*Reinforcement learning*	*Speech Emotion Recognition*
	SLO-2	*Support Vector Machines*	*Example of using MLP*	*The Self-Organizing Feature Map*	*Reinforcement learning*	*Speech Emotion Recognition*
S-7,8	SLO-1	*Lab 2: Support Vector Machines*	*Lab 5: MLP application*	*Lab 8: SOFM*	*Lab 11: Reinforcement learning*	*Lab 14: Speech Emotion Recognition Basic classification*
	SLO-2					
S-9	SLO-1	*Basics of neural network*	*Decision Trees- classification*	*HMM*	*Understanding Convolutions*	*Neural Network Multi-Layer Perceptron Modeling For Surface Quality Prediction in Laser Machining*
	SLO-2	*Perceptrons*	*Regression tree,*	*HMM*	*Understanding Convolutions*	

S-10	SLO-1	*LINEAR SEPARABILITY*	*Pruning, rule from tree and data*	*HMM*	*CNN Building Blocks*	*Machine Learning in Cybersecurity- Supervised Learning for Misuse/Signature Detection*
	SLO-2	*Perceptrons and introduction to Multiplayer, Perceptrons*	*Multivariate tree*	*HMM*	*CNN Building Blocks*	*Machine Learning in Cybersecurity- Supervised Learning for Misuse/Signature Detection*
S-11,12	SLO-1	*Lab 3: Perceptrons*	*Lab 6: Decision Trees*	*Lab 9: HMM*	*Lab 12: CNN*	*Lab 15: Mini project*
	SLO-2					

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

Learning Assessment"

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

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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	18ECE220T	Course Name	ADVANCED MOBILE COMMUNICATION SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

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

Program Learning Outcomes (PLO)														
1	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	-	*M*	*M*	-	-	-	-	-	-	-	-	*H*	-	*M*
M	-	*H*	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
H	-	*M*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
M	-	-	*M*	-	-	-	-	-	-	-	-	*M*	-	*H*
M	-	*M*	*H*	-	-	-	-	-	-	-	-	*M*	-	*H*
												M		*H*

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

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

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

Learning Assessment

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

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

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

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

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

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

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

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

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

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

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

Learning Assessment

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

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

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

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Express about Ad hoc Networks and various routing protocols used in Ad hoc networks	1	60	70
CLO-2 :	Discuss the various functional areas such as MAC Layer and QOS	1	60	65
CLO-3 :	Interpret the energy management protocols in Ad hoc Networks	1	60	65
CLO-4 :	Explain about the Sensor network and its associated protocols.	1	60	65
CLO-5 :	Describe about the hybrid networks and its routing protocols.	1	60	65
CLO-6 :	Paraphrase the various types of adhoc networks and sensor networks	1	60	65

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

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

		model		*protocol*		
S-6	SLO-1	*Tree Based Routing*	*INSIGNIA-QOS framework*	*Minimum power consumption Technique*	*Exposure*	*Pricing in Ad hoc Wireless Networks*
	SLO-2	*Mesh Based Routing*	*Operation of INSIGNIA framework, Advantages and disadvantages*	*Minimum battery cost Routing*	*Recent Trends in Sensor Networks-Energy Efficient Design, synchronization*	*Power control scheme in Hybrid Wireless Networks, Issues in using variable power in IEEE 802.11*
S-7	SLO-1	*Energy Efficient Multicasting-Routing protocols*	*INORA-Coarse feedback scheme,*	*Higher Layer solution*	*Transport Layer Issue*	*Power optimization scheme*
	SLO-2	*Cluster Adaptation of Multicast protocols*	*Class based fine feedback scheme*	*System power management scheme, Processor power management*	*Security-Localized Encryption and Authentication protocols (LEAP)*	*Load Balancing in Hybrid Wireless Networks*
S-8	SLO-1	*Multicast with QOS Guarantees-Real Time Multicasting Protocols*	*SWAN-Model*	*Power saving Mode Power Aware Multi-Access Signaling*	*Intrusion Tolerant Routing in Wireless Sensor Network (INSENS)*	*Preferred Ring Based Routing Scheme*
	SLO-2	*Priority Scheduling Protocols*	*Advantages and Disadvantages*	*Addition of separate signaling scheme*	*Real –Time communication*	*Preferred inner Routing Scheme(PIRS)*
S-9	SLO-1	*Application Dependent Multi Cast Routing-Role Based,*	*Proactive RTMAC framework*	*Device power Management Scheme-Low Power Design of Hardware*	*SPEED Protocol*	*Preferred outer Ring Routing Scheme (PORS)*
	SLO-2	*Content Based, Location Based*	*Advantages and Disadvantages*	*Hard Disk Drive (HDD) power consumption*	*RAP protocols*	*Preferred Destination/Source Ring Based Routing Scheme*

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

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

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

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

Course Code	18ECE223T	Course Name	SATELLITE COMMUNICATION AND BROADCASTING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Demonstrate the principles, concepts and operation of satellite communication systems*	*2*	*60*	*65*
CLO-2 :	*Discuss about the satellite orbits, link design, link availability and interference*	*2*	*60*	*65*
CLO-3 :	*Analyze the concepts of Satellite systems in relation to other terrestrial systems*	*2*	*65*	*65*
CLO-4 :	*Illustrate the performance of various channel access schemes for satellite communication*	*2*	*60*	*65*
CLO-5 :	*Explain the applications of satellites and compression standards adopted in satellite communication*	*2*	*60*	*65*
CLO-6 :	*Analyze the Satellite communication and Broadcasting systems.*	*2*	*60*	*65*

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
M	-	-	-	-	-	H	-	-	-	-	-	-	-	-
-	-	M	-	-	-	H	-	-	-	-	-	-	-	-
-	-	M	-	-	-	H	-	-	-	-	-	-	-	-
-	-	M	-	-	-	H	-	-	-	-	-	-	-	-
-	-	M	-	-	-	H	-	-	-	-	-	-	-	-
-	-	M	-	-	-	H	-	-	-	-	-	-	-	-

Duration (hour)		Satellite Orbit	Link Design	Space and Earth Segment	Multiple Access Techniques for Satellite Communication	Broadcast and Services
		9	9	9	9	9
S-1	SLO-1	*Satellite Orbit*	*Link Design*	*Space Segment*	*Concepts of Multiple Access techniques, types*	*Concept of Broadcasting satellites*
	SLO-2	*Kepler's law*	*EIRP*	*Basic concept of space segmen*	*Single Access*	*Direct Broadcasting Satellite*
S-2	SLO-1	*Earth - Orbiting satellites terms*	*Transmission Losses*	*Power Supply*	*Pre assigned FDMA*	*Orbital Spacing*
	SLO-2	*Types of satellites*	*Link Power Budget equation*	*Altitude control*	*Demand Assigned FDMA*	*Power ratings*
S-3	SLO-1	*Orbital elements*	*System Noise*	*Station keeping*	*SPADE system*	*Frequency and polarization*
	SLO-2	*Orbit Perturbations*	*Carrier to noise ratio*	*Thermal Control*	*TWT amplifier operation*	*Transponder Capacity*
S-4	SLO-1	*Inclined Orbits*	*Types of FEC*	*TT&C Subsystems*	*Downlink analysis*	*Bit rate*
	SLO-2	*Sun synchronous orbits*	*Computer-Aided Design*	*Antenna subsystem*	*TDMA*	*MPEG*
S-5	SLO-1	*Constellation:Geo stationary satellites*	*Uplink*	*Transponders*	*Reference bursts*	*Forward Error Correction*
	SLO-2	*Non geostationary constellation*	*Saturation flux density, input backoff*	*Wideband Receiver*	*Preamble, Postamble*	*Outdoor Unit*
S-6	SLO-1	*Launching of Geostationary satellites*	*Down Link*	*Earth Segment*	*Carrier recovery*	*Indoor Unit*
	SLO-2	*Launch vehicle Types*	*Output backoff, TWTA output*	*Basic concept of Earth segment*	*Network synchronization*	*Downlink Analysis*
S-7	SLO-1	*Antenna Look angles*	*Effects of rain*	*Receive only home TV system*	*Pre assigned TDMA*	*Uplink Analysis*
	SLO-2	*Sun transit outage*	*Inter modulation Noise*	*Community antenna TV system*	*Demand assigned TDMA*	*Satellite Mobile services*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*CDMA*	*VSAT*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Direct Sequence Spread Spectrum , CDMA throughput*	*GPS*
S-9	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Learning Resources	1. *Dennis Roddy, "Satellite Communications", Tata Mc-Graw Hill Publications, 4th Edition, 13th Reprint, 2014* 2. *TIMOTHY PRATT, CHARLES BOSTIAN JERMEY ALLNUTT, Satellite Communications, John Wiley, Singapore, 2nd Edition, reprint 2013.*	3. *MadhavendraRichharia, Leslie David, "Satellite Systems for Personal Applications Concepts and Technology", Wiley-Blackwell, 1st Edition, 2010.* 4. *Louis J. IppolitoJr, "Satellite Communications Systems Engineering", John Wiley and Sons , Ltd, Publication, 1st Edition, 2008*

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

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

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

Course Code	18ECE225T	Course Name	INFORMATION THEORY AND CODING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Illustrate about various source coding schemes*	2	65	70
CLO-2 :	*Apply variable length codes for source coding*	2	65	70
CLO-3 :	*Apply linear block codes for error detection and correction*	2	65	70
CLO-4 :	*Apply convolution codes for performance analysis & cyclic codes for error detection and correction.*	2	65	70
CLO-5 :	*Analyze the channel performance using Information theory*	2	65	70
CLO-6 :	*Analyze any type of channel and select coding techniques to improve channel performance*	2	65	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	PSO - 2	PSO – 3
-	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*
-	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*
-	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	-
-	*H*	-	-	-	-	-	-	-	-	-	-	-	*M*	-
-	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*
-	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*

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

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

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

Learning Assessment

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

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

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

Course Code	18ECE226T	Course Name	OPTICAL COMPONENTS, SYSTEMS AND NETWORKS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Familiarize with the fundamentals of light transmission through fiber*	*2*	*80*	*70*
CLO-2 :	*Understand how signal degrades inside the fiber due to physical effects and externally due to various factors like alignment, splicing and connecterization*	*2*	*85*	*75*
CLO-3 :	*Understand the operation of optical sources, amplifiers and detectors and thereby build transmitter and receiver circuits*	*2*	*75*	*70*
CLO-4 :	*Familiarize with optical measurements for performance analysis*	*2*	*85*	*80*
CLO-5 :	*Design a basic optical communication system*	*2*	*85*	*75*
CLO-6 :	*Acquire fundamental concepts on multichannel system and related components*	*2*	*80*	*70*

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

Duration (Hour)		Optical Fibers and transmission characteristics	Optical Sources, Amplifier and Transmitter	Optical Detectors and receivers	Optical modulators, switches and OEICs	Optical Communication systems
		9	9	9	9	9
S-1	SLO-1	*Elements of Optical fiber Communication, Optical spectral bands*	*Introduction to Luminescence: Photo, electro, cathodo, injection luminiscence*	*Photo detection principle*	*Electro optic modulators*	*Point to point links*
	SLO-2	*Optical fiber structure, Light Propagation in Optical fibers: Ray theory , Total Internal reflection, Skew rays, Fiber types: SI, GI, MM, SM*	*Plasma display, LCD*	*Photoconductor,*	*Acousto optic modulators*	*Digital and analog systems design considerations*
S-2	SLO-1	*Overview of Modes, Cutoff wavelength and V number,*	*LED: Choice of material,*	*Noise in photoconductors, SNR*	*Interferometry modulators*	*Digital link design,*
	SLO-2	*Problems on v-number*	*LED Structures; Surface and Edge emitters,*	*Response time*	*Semiconductor optical amplifiers*	*Links power budget*
S-3	SLO-1	*Wave Equations for Step index fiber, Modal equation, Modes in SI fibers*	*Quantum efficiency and power, LED Characteristics*	*Problems on response time and SNR*	*Optical switching and logic devices*	*Rise time budget*
	SLO-2	*Problems on V-number, modes*	*Problems on LED quantum efficiency*	*Problems on Photoconductor*	*Problems on modulators*	*Overview of analog links*
S-4	SLO-1	*Special Fibers introduction, Polarization Maintaining fibers,*	*Semiconductor Laser Diode, Operating principles,*	*Photodiode: PIN Photodiode*	*Optical switching*	*Radio over fibers*
	SLO-2	*Photonic Crystal fibers, Dispersion compensated fiber*	*Emission absorption and radiation*	*Avalanche photodiode*	*Logic devices*	*Key link parameters*
S-5	SLO-1	*Attenuation Introduction*	*Population inversion*	*Detector performance parameters*	*Hybrid integration*	*Multichannel systems*
	SLO-2	*Material Adsorption, Scattering, bending and core cladding losses*	*Optical feed- back, Threshold condition*	*Detectors for long wavelength operation*	*Monolithic integration*	*Need for multiplexing*
S-6	SLO-1	*Problems*	*External Quantum efficiency, LASER*	*Wavelength selective detection*	*Comparison of hybrid and*	*Operating principle of WDM*

			Characteristics		*monolithic*	
	SLO-2	*Overview of Signal dispersion in fibers*	*Problems on LASER quantum efficiency*	*Fundamental receiver operation*	*Slab waveguides*	*Operating principle of DWDM*
S-7	SLO-1	*Dispersion limitations, Intermodal dispersion*	*Single mode Laser: VCSEL*	*Front end amplifier and decision circuit*	*Strip waveguides*	*WDM components*
	SLO-2	*Intra-Modal dispersion: Material dispersion,*	*Introduction to Fiber Amplifiers*	*Functional block diagram of receiver circuit*	*Guided wave devices*	*Couplers/splitters*
S-8	SLO-1	*Waveguide dispersion and PMD*	*EDFA*	*Measurement standards, basic test equipment*	*Active filters*	*Lsolators and circulators*
	SLO-2	*Problems on Dispersion*	*SOA*	*Optical spectrum analyzer*	*Problems*	*Machzender interferometer*
S-9	SLO-1	*Non linear effects : Non linear scattering, Kerr effects*	*Modulation characteristics and Driver circuits*	*Oprtical power meter*	*Integrated Transmitter*	*Fabry perot filters*
	SLO-2	*Fiber alignment and Joint Loss, Fiber Splices Optical fiber connectors, Expanded Beam Connectors*	*Functional block diagram of a Transmitter module*	*OTDR*	*Integrated Receivers*	*Optical MEMS*

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

Learning Assessment

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

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

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

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Explain about the SDN architecture and its benefits*	*1*	*65*	*65*
CLO-2 :	*Discuss about SDN controllers*	*1*	*65*	*65*
CLO-3 :	*Express about the programming of SDN elements*	*1*	*65*	*65*
CLO-4 :	*Interpret NVF for next generation networks and 5G*	*1*	*65*	*65*
CLO-5 :	*Describe about the possible applications of SDN*	*1*	*65*	*65*
CLO-6 :	*Discuss about the standard OpenFlow*	*1*	*65*	*65*

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	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
H	-	-	-	-	-	-	-	-	-	-	-	-	-	*M*
H	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-
H	-	-	-	-	-	-	-	-	-	-	-	-	-	*M*
H	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
H	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-

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

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

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

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

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

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

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Understand the properties of Semiconductor Junction Diodes under microwave signals	3	80	75
CLO-2 :	Analyze the development of negative resistance characteristics in tunnel diode and transit time devices	3	80	70
CLO-3 :	Characterize the microwave components and circuits in terms of their performance parameters	3	75	70
CLO-4 :	Compare the characteristics of RF power transistors	3	80	75
CLO-5 :	Appreciate IC packaging issues and challenges involved at microwave frequencies	3	80	70
CLO-6 :	Understand the concepts of RF and semiconductor devices and apply in the design of electronic systems.	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	PSO - 2	PSO – 3
CLO-1 :	Understand the properties of Semiconductor Junction Diodes under microwave signals	H	-	-	H	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	Analyze the development of negative resistance characteristics in tunnel diode and transit time devices	H	-	-	M	-	-	-	-	-	-	-	-	H	-	-
CLO-3 :	Characterize the microwave components and circuits in terms of their performance parameters	H	-	-	H	-	-	-	-	-	-	-	-	H	-	H
CLO-4 :	Compare the characteristics of RF power transistors	H	-	-	M	-	-	-	-	-	-	-	-	M	-	-
CLO-5 :	Appreciate IC packaging issues and challenges involved at microwave frequencies	H	-	H	-	-	-	-	-	-	-	-	-	H	-	M
CLO-6 :	Understand the concepts of RF and semiconductor devices and apply in the design of electronic systems.	H	H	-	-	-	-	-	-	-	-	-		H	-	H

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

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

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

Learning Assessment

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

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mr. E. Siva Kumar, 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	18ECE322T	Course Name	OPTOELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Review the basics of optics, optical semiconductors*	2	85	80
CLO-2 :	*Understand the working principle of different photonic sources*	4	85	75
CLO-3 :	*Familiarize the principle and operation of various detectors*	4	85	75
CLO-4 :	*Acquire knowledge of various optoelectronic modulators and switches*	4	80	70
CLO-5 :	*Explore the concepts of optoelectronic integrated circuits and components*	4	80	70
CLO-6 :	*Design and analyze the working of different components in optical system and use it for various applications.*	4	80	70

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

Duration (hour)		Wave nature of light and semiconductor optics	Semiconductor photon sources and display devices	Semiconductor photon detectors	Optoelectronic modulators, interconnects and switches	Optoelectronic integrated circuits (oeic) and applications
		9	9	9	9	9
S-1	SLO-1	*Light Waves In A Homogeneous Medium-Plane electromagnetic wave, Maxwell's wave equation*	*LED Principles- Homojunction LED, Heterostructure LED*	*Principle of Photo Detection*	*Electro-Optic Modulator: Principles, Electro optic effect*	*Introduction*
	SLO-2	*Refractive Index And Dispersion-Sellmeier equation and diamond, Cauchy equation and diamond*	*Quantum Well High Intensity LEDs*	*The PIN Photodiode*	*Single waveguide electro optic modulators*	*Need For Integration*
S-2	SLO-1	*Polarization Of Light*	*LED Materials and Structures*	*Avalanche Photodiode-Principles, Structures*	*Dual channel waveguide electro optic modulator*	*Slab and stripe waveguides*
	SLO-2	*Snell's law and Total internal reflection*	*LED Efficiencies and Luminous Flux*	*Responsivit, Efficiency*	*Electro optic modulator employing reflection or Diffraction*	*Basic IO structural elements*
S-3	SLO-1	*Reflection And Refraction*	*Manufacturing Process and Applications*	*Heterojunction Photodiodes*	*Integrated Optical Modulators: Phase and polarization modulation*	*IO devices: Optical disk read head*
	SLO-2	*Solving problems*	*Solving Problems*	*Schottky Junction Photodetectors*	*Mach Zehnder modulator, Coupled waveguide modulator*	*OIC temperature sensor*
S-4	SLO-1	*Superposition And Interference Of Waves*	*LASER: Threshold Condition*	*Solving problems*	*Acousto-Optic Modulator: Principles, Acousto optic effect, Raman nath and Bragg type modulators*	*IO high voltage sensor*
	SLO-2	*Diffraction Principles- Fraunhofer diffraction, Diffraction Grating*	*Emission and Absorption of Radiation*	*Solving problems*	*Performance characteristics, Acousto optic frequency shifters*	*IO chemical sensor*

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

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

Learning Assessment

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

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

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

Course Code	18ECE323T	Course Name	ADVANCED OPTICAL COMMUNICATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	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
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Explain the concept of wave propagation and dispersion in single-mode fibers, loss and nonlinear of fiber and fiber design and fabrication.*	*2*	*80*	*70*	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-2 :	*Apply the concept of optical transmitter and receiver in single-mode semiconductor lasers, light-emitting diodes, transmitter design and receiver design*	*2*	*85*	*75*	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-3 :	*Demonstrate the concept of long-haul systems, computer-aided design, WDM light wave systems, WDM Components, time-division, subcarrier and code division multiplexing*	*2*	*75*	*70*	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-4 :	*Explain the loss and dispersion managements in EDFA - Raman amplifiers, dispersion compensating fibers Fiber Bragg gratings, dispersion-equalizing filters and optical phase conjugation*	*2*	*85*	*80*	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-5 :	*Apply the concept of advanced light wave system in demodulation schemes sensitivity degradation mechanisms and impact of nonlinear effects*	*2*	*85*	*75*	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H
CLO-6 :	*Apply their idea in Optical communication module*	*2*	*80*	*70*	H	H	M	H	H	-	L	-	-	H	-	-	H	M	H

Duration (hour)		Optical fibers and lightwave systems	Lightwave systems and multichannel systems	Loss management and dispersion management	Radio over fiber systems	Optical wireless Communication
		9	9	9	9	9
S-1	SLO-1	*Geometrical-Optics Description*	*System Architectures*	*Compensation of Fiber Losses*	*Trends in Wireless Communications*	*Free-space optical wireless Communication*
	SLO-2	*Wave Propagation*	*Working Principles*	*Erbium-Doped Fiber Amplifiers les*	*Basic Transmission problems and solutions*	*Free-space optical OFDM Communication*
S-2	SLO-1	*Dispersion in Single-Mode Fibers*	*Design Guidelines*	*Raman Amplifiers*	*Regulation*	*Wireless optical CDMA Communication systems*
	SLO-2	*Dispersion Induced Limitations*	*Long-Haul Systems*	*Optical Signal-To-Noise Ratio*	*Standardization*	*Comparison of Free-space optical OFDM & CDMA Communication*
S-3	SLO-1	*Fiber Losses*	*Sources of Power Penalty*	*Electrical Signal-To-Noise Ratio*	*System concepts for the central processing of signals*	*Indoor wireless optical Communication*
	SLO-2	*Nonlinear Optical Effects*	*Forward Error Correction*	*Receiver Sensitivity and Q Factor*	*Wireless Trends*	*Outdoor wireless optical Communication*
S-4	SLO-1	*Fiber Design and Fabrication*	*Types of FEC*	*Role of Dispersive and Nonlinear Effects*	*Architecture options,*	*Heterogeneous optical networks (HONs)*
	SLO-2	*Multicore fibers*	*Computer-Aided Design*	*Periodically Amplified Lightwave Systems*	*Global centralized Architecture*	*System Performance*

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

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

Learning Assessment

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

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

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	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
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Discuss about multi resolution analysis for discrete signals	2	80	75	H	H	-	-	-	-	-	-	-	-	-	-	H	-	-
CLO-2 :	Summarize the families of wavelets	1,2	80	70	H	-	M	-	-	-	-	-	-	-	-	-	H	-	M
CLO-3 :	Identify Discrete wavelet transform	2	75	70	M	M	M	-	-	-	-	-	-	-	-	-	M	-	-
CLO-4 :	Analyze and design filter banks	3	80	75	H	-	M	-	-	-	-	-	-	-	-	-	H	-	-
CLO-5 :	Utilize wavelet transformations on various applications	3	80	70	H	-	M	L	-	-	-	-	-	-	-	-	H	M	H
CLO-6 :	Provide an outline about wavelet transforms, types and applications of multiresolution analysis	2	80	70	M	H	-	-	-	-	-	-	-	-	-	-	M	-	-

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

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

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

Learning Assessment

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

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

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

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

						2	0	2	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Describe the functioning of the human vocal and auditory systems*	*1,2*	*80*	*75*
CLO-2 :	*Illustrate the function of feature extraction in speech and audio signal processing using Time Domain Characteristics*	*2*	*85*	*75*
CLO-3 :	*Explore the frequency characteristics of speech signal*	*3*	*80*	*70*
CLO-4 :	*Apply appropriate Digital models for speech signal*	*3*	*80*	*75*
CLO-5 :	*Analyze the elements of music*	*2*	*80*	*70*
CLO-6 :	*Provide an outline about speech signal processing and its model*	*2*	*80*	*70*

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

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

S 7-8	SLO-1	*Lab 2: Convert into a wave file, plot the speech signal, and spectrogram plot*	*Lab 5: Short-time Fourier transform magnitude spectrum*	*Lab 8: Estimation of pitch period using harmonic product spectrum*	*Lab 11: Estimation of sound in vocal tract*	*Lab 14: Speech production mechanism*
	SLO-2					
S-9	SLO-1	*Visualization*	*Zero crossing Rate*	*Linear Predictive analysis of speech*	*Vocal tract transfer function of vowels*	*Detecting beats, rhythm, meter*
	SLO-2	*Sound generation*	*Zero crossing Rate*	*Linear Predictive analysis of speech*	*Vocal tract transfer function of vowels*	*Recognizing pitch – melody*
S-10	SLO-1	*Speech production mechanism*	*Silence Discrimination using ZCR and energy*	*Autocorrelation method, Covariance method*	*Effect of nasal coupling*	*Auditory streaming*
	SLO-2	*Speech production mechanism*	*Silence Discrimination using ZCR and energy*	*Solution of LPC equations*	*Excitation of sound in vocal tract*	*Tonality and context – algorithms*
S 11-12	SLO-1	*Lab 3: Cepstrum smoothed magnitude spectrum*	*Lab 6: (i)Linear prediction magnitude spectrum (ii) Estimation of formant frequencies using linear prediction*	*Lab 9: Pitch and duration modification using time-domain pitch synchronous overlap and add (TD-PSOLA) method*	*Lab 12: Sound vibrations*	*Lab 15:Study of Feature extraction and SVM classifier*
	SLO-2					

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

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

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

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

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

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

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Demonstrate the fundamentals of recognition of patterns, regularities in data and classifiers	1	80	70
CLO-2 :	Review the error estimation, such as definitions, test-set error estimation and training-set error estimation	1	80	70
CLO-3 :	Discuss the neuron model and fundamentals on learning algorithms	2	75	70
CLO-4 :	Realize the error model and calculate the deviation with back propagation networks	2	80	70
CLO-5 :	Review the applications of neural networks in the area of pattern recognition	2	80	70
CLO-6 :	Analyze a variety of pattern classification techniques to real-world problems such as document analysis and recognition.	2	80	70

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

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

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

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

Learning Assessment

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

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

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

Course Code	18ECE243J	Course Name	DIGITAL IMAGE AND VIDEO PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Introduce the fundamentals of image processing and transforms*			
CLR-2 :	*Discuss the concepts of image enhancement and restoration*			
CLR-3 :	*Acquire knowledge on image compression and segmentation methods*			
CLR-4 :	*Summarize basics of video processing*			
CLR-5 :	*Apply motion estimation methods in video processing*			
CLR-6 :	*Utilize the concepts of image and video processing for practical applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Demonstrate the basics of digital image processing fundamentals and transforms*	*1,2*	*80*	*70*
CLO-2 :	*Design 2D filters and apply it for image enhancement and restoration*	*3*	*80*	*70*
CLO-3 :	*Apply image compression and segmentation methods on digital images*	*3*	*80*	*65*
CLO-4 :	*Define the video formation techniques*	*2*	*80*	*70*
CLO-5 :	*Compile various motion techniques used in video coding*	*2*	*75*	*65*
CLO-6 :	*Apply the concepts of digital image, video processing and their applications*	*2,3*	*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	PSO - 2	PSO – 3
L	-	-	*M*	-	-	-	-	-	-	-	*H*	*M*	-	-
H	*H*	-	*H*	*H*	-	-	-	-	-	-	*H*	*M*	-	*H*
M	*H*	-	*H*	*H*	-	-	-	-	-	-	*H*	-	-	*H*
H	*M*	-	*H*	*H*	-	-	-	-	-	-	*H*	-	-	*M*
H	*M*	-	*H*	*H*	-	-	-	-	-	-	*H*	-	-	*H*
M	-	-	-	-	-	-	-	-	-	-	-	*M*	-	*M*

Duration (hour)		Digital Image Fundamentals and Image Transforms	Image Enhancement and Restoration	Image Compression and Segmentation	Basic Steps of Video Processing	2D Motion Estimation
		12	12	12	12	12
S-1	SLO-1	*Origin of digital image processing*	*Some basic intensity transformation functions – image negatives, log transformations*	*Fundamentals of image compression- coding redundancy, spatial and temporal redundancy*	*Analog video signals, standard*	*2D motion estimation – Optical flow – 2D motion vs. apparent motion*
	SLO-2	*Fundamental steps in digital image processing*	*Piecewise linear transformation functions*	*Irrelevant information, measuring image information*	*Digital video signal, standard, Digital video processing*	*Correspondence and optical flow*
S-2	SLO-1	*Components of an image processing system*	*Histogram equalization, Matching*	*Image compression model, Lossless compression, Huffman coding*	*Time varying image formation models – 3D motion models*	*Occlusion problem*
	SLO-2	*Structure of human eye, Image formation*	*Local Histogram Processing*	*Arithmetic Coding, Run length coding*	*Rigid motion in Cartesian, Homogenous coordinates*	*Aperture problem, 2D motion field models*
S- 3-4	SLO-1	*Lab 1: To learn MATLAB software and its basic commands for image processing*	*Lab 4: Histogram Modifications*	*Lab 7: Run length coding*	*Lab 10: Wavelet coding*	*Lab 13: Convert video into frames and process them*
	SLO-2					
S-5	SLO-1	*Brightness adaptation and discrimination*	*Using histogram statistics for image enhancement*	*Lossy compression - Transform coding*	*Deformable motion*	*Block motion models- translational block motion*
	SLO-2	*Basic concepts in sampling and Quantization , Representing digital images*	*Smoothing linear filters*	*Wavelet coding*	*Geometric image formation*	*Generalized/ Deformable block motion*
S-6	SLO-1	*Neighbors of a pixel, Adjacency, Connectivity, Regions and Boundaries*	*Order statistics nonlinear filters*	*Image segmentation – detection of isolated points, line detection*	*Perspective projection*	*Block matching criteria, Matching procedures*
	SLO-2	*Distance Measures, A simple image*	*Sharpening spatial filters*	*Edge models, Basic edge detection*	*Photometric image formation*	*Hierarchical motion estimation*

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

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

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

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

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

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

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Demonstrate the knowledge on DSP architecture and instruction sets of TMS320C6X*	*2*	*75*	*70*
CLO-2 :	*Review the assembly programming knowledge using TMS320C6x*	*1*	*75*	*70*
CLO-3 :	*Apply the program concepts of DSP algorithm such as FFT, DFT, Convolution , IIR and FIR filters in TMS320C6x*	*2*	*75*	*70*
CLO-4 :	*Analyze on Filter Banks and adaptive filters and analyze such filters.*	*2*	*75*	*70*
CLO-5 :	*Review the knowledge on DSP system design based applications.*	*1*	*75*	*70*
CLO-6 :	*Apply the concept of DSP for real time applications*	*2*	*75*	*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	PSO - 2	PSO – 3
H	-	*H*	-	-	-	-	-	-	-	-	-	-	-	-
-	*H*	-	-	-	-	-	-	-	-	-	-	*H*	-	-
-	*H*	-	-	-	-	-	-	-	-	-	-	-	-	-
-	*H*	-	-	*H*	-	-	-	-	-	-	-	-	*L*	-
-	-	-	-	*H*	-	-	-	-	-	-	-	-	-	-
-	-	-	-	*H*	-	-	-	-	-	-	-	-	*M*	*M*

Duration (hour)		TMS320C6X Architecture	TMS3206X Assembly Language	Frequency Transforms	Digital Filters	DSP Applications
		15	15	15	15	15
S-1	SLO-1	*Architecture of TMS320C6X*	*TMS320C6X Assembly Language Operations*	*Digital filtering using the DFT*	*Filter banks – Decimation,*	*Dual tone Multi-Frequency (DTMF) Signaling*
	SLO-2	*Pipeline CPU*	*Individual Instruction Descriptions*	*Convolution and correlation*	*Inverse Decimation*	*Software Defined Radio (SDR)*
S-2	SLO-1	*VelociTI, Functional Units,*	*Arithmetic operations, ,*	*Fast Fourier Transform –DIT*	*Perfect Reconstruction*	*QAM Transmitter and QAM Receiver*
	SLO-2	*Addressing modes,*	*Llogical operations,*	*Fast Fourier Transform –DIT*	*Analysis of M-Band filter Banks*	*Miscellaneous Projects--FSK Modem*
S-3	SLO-1	*Lab1: Generation of sequences (functional & random) (Matlab)*	*Lab 7: MAC operation using various addressing modes*	*Lab 13: Spectrum analysis using DFT(Matlab)*	*Lab 19: FIR Implementation using TMS Processor*	*Lab 25: Equalization (Matlab)*
	SLO-2					
S-4	SLO-1	*Lab 2: Correlation(Matlab)*	*Lab 8: MAC operation using various addressing modes*	*Lab 14: FFT Implementation(DSP processor)*	*Lab 20: FIR Implementation using TMS Processor*	*Lab 26: Equalization (Matlab)*
	SLO-2					
S-5	SLO-1	*TMS320C6X Instruction Sets,*	*Memory data operations*	*Fast Fourier Transform –DIF*	*Orthogonality and Biorthogonality in Filter banks*	*U-Law for Speech Companding,*
	SLO-2	*Assembler directives*	*Conditional Operations*	*Fast Fourier Transform DIF*	*QMF Filter banks and*	*Acoustic Direction Tracker*
S-6	SLO-1	*Multichannel Buffered Serial Ports*	*Floating Point –Data type operations,*	*IFFT*	*CQF Filter Banks*	*MultirateFilter,Neural Network for Signal Recognition*
	SLO-2	*Memory Considerations –Constraints*	*Floating Point –Data type operations*	*FIR filters*	*Transmultiplixers;*	*PID Controller, Four-Channel Multiplexer for Fast Data Acquisition*
S-7	SLO-1	*Lab 3: Linear Convolution (Matlab)*	*Lab 9: MAC operation using various addressing modes*	*Lab 15: FIR filter design-Windowing Techniques(Matlab)*	*Lab 21: IIR implementation using TMS processor*	*Lab 27: Real time audio signal processing with Processor*
	SLO-2					
S-8	SLO-1	*Lab 4 :Circular convolution(Matlab)*	*Lab 10: Linear convolution(DSP*	*Lab 16: FIR filter design-Windowing*	*Lab 22: IIR implementation using TMS*	*Lab 28: Real time audio signal*

	SLO-2		*processor)*	*Techniques(Matlab)*	*processor*	*processing with Processor*
S-9	SLO-1	*Instruction Operation and Execution notations*	*Fixed- Point Operations,*	*FIR filters*	*Structures and Programming Examples for Noise cancellation*	*Video Line Rate Analysis*
	SLO-2	*Overview of IEEE Standard single and Double Precision formats ,*	*Fixed- Point Operations*	*IIR filter*	*Adaptive Filters-Adaptive filters in DSP simulation software's and TMSC320C6x*	*DSP System Design*
S-10	SLO-1	*Q-format Number Representation on Fixed Point DSPs, Finite Word length effects on Fixed point DSPS*	*Pipeline Operations overview*	*IIR filter*	*Software simulation of FIR*	*MP3 Player*
	SLO-2	*Floating point number representation, , Overflow and Scaling*	*Interrupts-overview.*	*FIR and IIR filter design using TMS320C6x*	*IIRFilters and Filter banks*	*DSP Automotive application*
S-11	SLO-1	*Lab 5: Study of architecture of Digital Signal Processor*	*Lab 11: Circular convolution(DSP processor)*	*Lab 17: IIR filter design-Bilinear and Impulse Invariance Technique(Matlab)*	*Lab 23: Multirate filters*	*Lab 29: Real time audio signal processing with Processor*
	SLO-2					
S-12	SLO-1	*Lab 6: Study of architecture of Digital Signal Processor*	*Lab 12: Waveform generation(DSP processor)*	*Lab 18: IIR filter design-Bilinear and Impulse Invariance Technique(Matlab)*	*Lab 24: Finite Word Length Effect*	*Lab 30: Real time audio signal processing with Processor*
	SLO-2					

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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	18ECE245T	Course Name	ADAPTIVE SIGNAL PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Review the basics of statistical signal processing*	*1*	*85*	*70*
CLO-2 :	*Understand the need for adaptive filters and learn the design of it.*	*1*	*85*	*70*
CLO-3 :	*Demonstrate the knowledge on LMS algorithms and constraints associated with it.*	*2*	*85*	*75*
CLO-4 :	*Determine the variants of LMS algorithm and design of lattice structures*	*2*	*85*	*75*
CLO-5 :	*Analyze knowledge on design of RLS filters and others aspects of filter design*	*2*	*85*	*75*
CLO-6 :	*Understand the applications of adaptive signal processing and algorithms in designing the adaptive filters*	*1*	*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	PSO - 2	PSO – 3
H	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-
-	*M*	-	-	-	-	-	-	-	-	-	-	-	-	*M*
-	*H*	*H*	-	-	-	-	-	-	-	-	-	-	-	-
-	*M*	-	-	-	-	-	-	-	-	-	-	-	*M*	-
-	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
-	-	*H*	-	-	-	-	-	-	-	-	-	*M*	-	-

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

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

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

Learning Assessment

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

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, 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. 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	18ECE340T	Course Name	MACHINE PERCEPTION WITH COGNITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Have an insight on image and color fundamentals*			
CLR-2 :	*Analyze the various shapes and regions for the image description*			
CLR-3 :	*Acquire knowledge on the texture analysis of an image*			
CLR-4 :	*Identify the relation between the templates to match the image requirements*			
CLR-5 :	*Know the practical applications of computer vision in images understanding*			
CLR-6 :	*Have an insight on image and color fundamentals*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*			
CLO-1 :	*Demonstrate the fundamentals of image and color models*	*2*	*80*	*75*
CLO-2 :	*Understand the basic shapes and region based image modeling*	*2*	*85*	*75*
CLO-3 :	*Analyze the various textures for image synthesis*	*2*	*85*	*70*
CLO-4 :	*Discuss the objects based on template relations*	*2*	*85*	*75*
CLO-5 :	*Apply the image understanding knowledge for image recognition*	*2*	*85*	*70*
CLO-6 :	*Review the principles of image modeling and synthesis with image recognition*	*2*	*85*	*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	PSO - 2	PSO – 3
H	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	*H*	-	-	-	-	-	-	-	-	-	-	*M*	-	-
-	-	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*
-	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
-	-	*M*	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	*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	*Review of Image processing methods*	*Binary Shape analysis*	*Representing textures*	*Finding objects by voting on relation between templates*	*Face detection*
	SLO-2	*Review of Image processing methods*	*Binary Shape analysis*	*Representing textures*	*Interest points, Simple voting, Voting on raltions.*	*Face detection*
S-2	SLO-1	*Introduction to image formation*	*Connectedness*	*Extracting image Structure with filter banks*	*Relational reasoning using probabilistic framework*	*Face recognition*
	SLO-2	*Introduction to image formation*	*Object labeling and counting*	*Extracting image Structure with filter banks*	*Growing Assemblies Incrementally, Detection, Pruning*	*Face recognition*
S-3	SLO-1	*Image models*	*Size filtering*	*Representing texture using statistics of filter output*	*Frames and probability models*	*Eigen faces*
	SLO-2	*Camera models*	*Distance functions*	*Representing texture using statistics of filter output*	*Representing coordinate frames*	*Active appearence*
S-4	SLO-1	*Sample programs for reading images, understanding pixels*	*Skeletons and thinning*	*Analysis using oriented pyramids*	*Using probability model for detecting the frames*	*3D shape models of face surveillance*
	SLO-2	*Sample programs for reading images, understanding pixels*	*Deformable shape analysis*	*Laplacian pyramids*	*Building probability models for frame invariant*	*3D shape models of face surveillance*
S-5	SLO-1	*Shadows*	*Boundary tracking procedures*	*Filters in the spatial frequency domain*	*Classifiers to prune search*	*Foreground separation*
	SLO-2	*Color representation*	*Boundary tracking procedures*	*Filters in the spatial frequency domain*	*Identifying acceptable assemblies*	*Background separation*

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

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	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. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE341T	Course Name	MULTIMEDIA COMPRESSION TECHNIQUES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Summarize probability models and discuss on coding theory*			
CLR-2 :	*Implement lossless compression*			
CLR-3 :	*Discuss on Lossy data compression*			
CLR-4 :	*Apply the encoding methods*			
CLR-5 :	*Carry out the Compression Techniques and their applications*			
CLR-6 :	*Summarize probability models and discuss on coding theory*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Summarize the fundamental concepts of probability model and to state the practical limits specified by coding theory*	*1,2*	*85*	*80*
CLO-2 :	*Outline rate-distortion theory and to discuss about efficient information transfer mechanism*	*2*	*85*	*75*
CLO-3 :	*Show the fundamental approaches towards lossy image compression*	*1,2*	*80*	*75*
CLO-4 :	*Analyze image, video and audio in the frequency domain to identify important components to be encoded*	*2*	*80*	*70*
CLO-5 :	*Analyze the Applications of various compression techniques*	*3*	*80*	*70*
CLO-6 :	*Examine various data compression and encoding methods*	*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
CLO-1 :	*H*														*L*
CLO-2 :	*H*	*H*	*M*											*L*	*H*
CLO-3 :	*H*	*M*	*L*										*M*	*M*	*H*
CLO-4 :	*H*	*M*	*M*	*H*									*H*		*H*
CLO-5 :	*M*	*M*	*L*	*H*									*H*	*L*	*M*
CLO-6 :	*H*	*M*	*M*										*H*	*M*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*The discrete memory less information source*	*Mathematical Preliminaries for Lossless*	*Rate distortion function*	*Vector Quantization*	*Transform Coding: Introduction, Karhunen-Loeve transform, Image compression – EZW, SPIHT, JPEG 2000- Analysis/Synthesis Schemes.*
	SLO-2	*Kraft inequality; optimal codes*	*Mathematical Preliminaries for Lossless Compression*	*Rate distortion function*	*LBG algorithm*	*Karhunen-Loeve transform*
S-2	SLO-1	*Source coding theorem-Entropy*	*Huffman Coding*	*Properties of RD*	*Tree structured VQ*	*Karhunen-Loeve transform*
	SLO-2	*Joint Entropy and Conditional Entropy*	*Huffman Coding*	*Properties of RD*	*Structured VQ*	*Discrete cosine transform,*
S-3	SLO-1	*Relative Entropy*	*Optimality of Huffman codes*	*Calculation of RD for the binary source and the Gaussian source*	*Variations of VQ*	*Discrete cosine transform,*
	SLO-2	*Mutual Information*	*Extended Huffman Coding*	*Calculation of RD for the binary source and the Gaussian source*	*Gain shape VQ*	*Discrete Walsh Hadamard transform*
S-4	SLO-1	*Chain Rules*	*Adaptive Huffman Coding*	*Rate distortion theorem*	*Mean removed VQ*	*Discrete Walsh Hadamard transform*
	SLO-2	*Data-Processing Inequality*	*Arithmetic Coding*	*Rate distortion theorem*	*Classified VQ*	*Quantization and coding of transform coefficients*
S-5	SLO-1	*Fano's Inequality Symmetric Channels*	*Adaptive Arithmetic coding*	*Converse of the Rate distortion theorem*	*Multistage VQ*	*Quantization and coding of transform coefficients*
	SLO-2	*Fano's Inequality Symmetric Channels*	*Run Length Coding*	*Quantization problem*	*Adaptive VQ*	*JPEG*
S-6	SLO-1	*Properties of Channel Capacity, Jointly Typical Sequences*	*Dictionary Techniques*	*Scalar Quantization- Uniform Quantizer*	*Trellis coded quantization Transforms.*	*JPEG*
	SLO-2	*Properties of Channel Capacity, Jointly Typical Sequences*	*Lempel Ziv coding*	*Scalar Quantization- Uniform Quantizer*	*Trellis coded quantization Transforms.*	*MDCT*

S-7	SLO-1	*Channel Coding Theorem*	*Applications*	*Adaptive Quantization*	*Basic algorithm*	*MDCT*
	SLO-2	*Channel Coding Theorem*	*Predictive Coding*	*Adaptive Quantization*	*Prediction in DPCM*	*Image compression – EZW-Analysis/Synthesis Schemes*
S-8	SLO-1	*Fano's Inequality*	*Prediction with Partial Match*	*Non-uniform Quantization*	*Prediction in DPCM*	*Image compression – SPIHT-Analysis/Synthesis Schemes*
	SLO-2	*Fano's Inequality*	*Burrows Wheeler Transform*	*Non-uniform Quantization*	*Adaptive DPCM*	*Image compression – JPEG 2000-Analysis/Synthesis Schemes*
S-9	SLO-1	*Converse to the Coding Theorem*	*Dynamic Markov Compression*	*Entropy coded Quantization*	*Adaptive DPCM*	*Audio coding:-MPEG audio coding*
	SLO-2	*Converse to the Coding Theorem*	*Dynamic Markov Compression*	*Entropy coded Quantization*	*Delta Modulation*	*Audio coding:-MPEG audio coding*

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

Learning Assessment

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

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

Course Designers

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

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

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Discuss physics behind sound equations, characteristics of sound in various mediums.*			
CLR-2 :	*Describe human auditory system and hearing function.*			
CLR-3 :	*Express acoustic echo in a mathematical form, and to control or cancel echo that arises due to using various algorithm.*			
CLR-4 :	*Summarize the various types of transducers used for acoustic measurements*			
CLR-5 :	*Analysis of transducers for various applications of acoustics.*			
CLR-6 :	*Discuss physics behind sound equations, characteristics of sound in various mediums.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Summarize the basics of acoustic and to paraphrase the mechanism like Transmission, Reflection, Absorption under various mediums*	*1,2*	*80*	*80*
CLO-2 :	*Explain human auditory system and hearing*	*1,2*	*85*	*75*
CLO-3 :	*Illustrate acoustic echo, noise control and cancel echo using various algorithms.*	*2*	*85*	*75*
CLO-4 :	*Demonstrate various types of transducers used for acoustic measurements*	*2*	*85*	*80*
CLO-5 :	*Outline on the various applications of acoustics.*	*2,3*	*85*	*70*
CLO-6 :	*Outline speech processing analysis in different environment*	*2*	*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
M	-	-	-											*M*
M	-	-	-										*M*	*H*
H	*H*	*H*	-									*M*	*M*	*H*
H	*M*	*M*	*M*									*H*	*M*	*H*
H	-	-	*H*									*H*	*M*	*M*
H	*M*	*H*	*H*	*H*								*H*	*H*	*M*

Duration (hour)		Basics of Acoustic Engineering	Auditory System and Hearing	Acoustic Echo and Noise control	Transducers for Acoustic Measurements	Applications of Acoustics
		9	9	9	9	9
S-1	SLO-1	*Introduction to acoustic*	*Anatomy of the auditory systems*	*Human Perception of Echoes*	*Fundamental properties of Transducers*	*Architectural acoustics – Sound in enclosures*
	SLO-2	*Introduction to acoustic*	*Anatomy of the auditory systems*	*Human Perception of Echoes*	*Fundamental properties of Transducers*	*Reverberation time*
S-2	SLO-1	*Harmonic Plane Waves*	*Physiology of the auditory systems*	*Echo Problem*	*Condenser Microphones*	*Sound absorption materials*
	SLO-2	*Harmonic Plane Waves*	*Physiology of the auditory systems*	*Echo Problem*	*Condenser Microphones*	*Measurements of acoustic output in living rooms*
S-3	SLO-1	*Energy Density*	*Function of the auditory systems*	*Adaptive Filters for Echo Cancellation*	*Dynamic Pressure Microphones*	*Acoustic Factors in architectural design*
	SLO-2	*Energy Density*	*Function of the auditory systems*	*Adaptive Filters for Echo Cancellation*	*Dynamic Pressure Microphones*	*Environmental acoustics – Introduction*
S-4	SLO-1	*Acoustic Intensity*	*Physiological measures*	*LMS algorithm*	*Dynamic Pressure Microphones*	*Weighted sound level*
	SLO-2	*Specific Acoustic Impedance*	*Physiological measures*	*NLMS algorithm*	*Dynamic Pressure difference Microphone*	*Speech interference*
S-5	SLO-1	*Spherical Waves*	*Physiological measures*	*Least Squares Algorithms*	*Dynamic Pressure difference Microphone*	*Highway noise*
	SLO-2	*Spherical Waves*	*Auditory processing models*	*Least Squares Algorithms*	*Piezo ceramic accelerometer*	*Aircraft noise rating*
S-6	SLO-1	*Decibel Scales*	*Auditory processing models*	*Recursive Least Squares Algorithms*	*Piezo ceramic accelerometer*	*Virtual Sound--*
	SLO-2	*Rays and Waves*	*Auditory processing models*	*Recursive Least Squares Algorithms*	*Piezo ceramic accelerometer*	*Sound localization cues*
S-70	SLO-1	*Transmission-Incidence*	*Auditory processing models*	*Affine Projection algorithm*	*Laser Doppler velocimeter*	*Synthetic 3D Audio*
	SLO-2	*Transmission-Incidence*	*Auditory processing models*	*Affine Projection algorithm*	*Laser Doppler velocimeter*	*Synthetic 3D Audio*
S-8	SLO-1	*Reflection*	*Speech Intelligibility*	*Noise cancellation using Affine Projection algorithm*	*Laser Doppler velocimeter*	*Seismology- Signal Model in seismic processing*

	SLO-2	*Absorption*	*Speech Intelligibility*	*Noise cancellation using Affine Projection algorithm*	*Capacitive sensors*	*Optical sensor Signal Model in seismic processings*
S-9	SLO-1	*Viscosity*	*Signal processing in hearing aids*	*Fast Affine Projection Algorithm (FAP).*	*Capacitive sensors*	*Underwater and Oceanographic acoustics*
	SLO-2	*Thermal conduction*	*Signal processing in hearing aids*	*Fast Affine Projection Algorithm (FAP)*	*Capacitive sensors*	*Inverse Problems in underwater acoustics*

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

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

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

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Course Code	18ECE343T	Course Name	AUTOMATIC SPEECH RECOGNITION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Express the basic techniques in speech signal processing broadly used in the area of speech recognition*	2	75	60
CLO-2 :	*Outline the use of hidden Markov models can be used as generative models for speech and how they can be trained*	2	75	60
CLO-3 :	*Describe commercial as well as research-oriented applications within speech recognition*	2	75	60
CLO-4 :	*Summarize the essentials of dialogue system design and evaluation*	2	75	60
CLO-5 :	*Implement simple dialogue systems and Stochastic Approaches*	2	75	60
CLO-6 :	*Apply the speech recognition techniques in real time applications.*	2	75	60

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

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

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

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

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

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

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

Course Code	18ECE360T	Course Name	REHABILITATION ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning
CLR-1 :	*Learn concepts and terminologies in Rehabilitation Engineering*	1
CLR-2 :	*Understand different types of wheel chair design and mobility aids*	2
CLR-3 :	*Study the components of orthotic and prosthetic devices and their fabrication*	3
CLR-4 :	*Become aware of Engineering concepts in sensory substitution and augmentation*	
CLR-5 :	*Understand the legal concepts in Rehabilitation Engineering*	
CLR-6 :	*Study the contemporary topics in Rehabilitation Engineering*	

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the need for rehabilitation Engineering and proficiently use terminologies related to it.*	*1,2*	*80*	*70*
CLO-2 :	*Know the various wheel chair design and mobility aid design aspects*	*1,2*	*75*	*65*
CLO-3 :	*Learn about orthotic and prosthetic devices, their design and types.*	*2*	*70*	*65*
CLO-4 :	*List the various possibilities to augment or substitute visual and auditory capabilities*	*2,3*	*70*	*65*
CLO-5 :	*Describe the legal concepts in Rehabilitation Engineering*	*3*	*80*	*65*
CLO-6 :	*Gain exposure to the latest topics in Rehabilitation Engineering*	*3*	*80*	*65*

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

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduce to Rehabilitation Engineering and Assistive technologies*	*Interventions in seating system*	*Amputation: Definition, need, situations where it can be avoided*	*Basic structure of eye, How it functions, problems that can be faced*	*Application of robots in rehabilitation*
	SLO-2	*Learn Concepts of Rehabilitation Engineering*	*Wheel Chairs-Introduction*	*Classification of amputation*	*Categories of visual impairment, identification of level of intervention needed*	*Types of robots used*
S-2	SLO-1	*Learn Terminologies Rehabilitation Engineering*	*Types of Wheelchairs*	*Prosthetics: Definition, Need for prosthesis*	*Artificial Eye-Complete replacement*	*Challenges in robot design for differently abled people*
	SLO-2	*Considerations for Rehabilitation Engineering*	*Describe on Manual wheelchairs*	*Use of prosthesis, Where prosthesis can't be used*	*Retinal implant*	*Differences in material used*
S-3	SLO-1	*Various approaches for Rehabilitation engineering*	*Component Design*	*Basic types of prosthesis, Prosthesis Prescription*	*Sensory augmentation for blind*	*Functional electrical stimulation definition,*
	SLO-2	*PAD process*	*Electrical Power wheel chairs*	*Prosthesis for shoulder, neck, torso*	*Cortical prosthesis*	*Circuit for stimulations*
S-4	SLO-1	*PHAATE model*	*Power assisted wheelchair-Design*	*Prosthesis for elbow, arm*	*Assist devices for visual rehabilitation*	*Significance of myoelecticl signal*
	SLO-2	*Universal design- Introduction*	*Design types*	*Fabrication and issues involved*	*Auditory devices*	*Acquisition of myoelecticl signal, challenges*
S-5	SLO-1	*Seven Principles of Universal design*	*Wheelchair transportation*	*Parts of Lower extremity*	*Devices for navigation, Design of navigation device*	*Activities of daily living*
	SLO-2	*Benefits of Universal design*	*Lift Mechanism*	*Significance of each part, Different movements involved*	*Tactual sensory substitution, Applications and examples of tactual substitution in real life*	*Low tech and hi tech aids in daily living*

S-6	SLO-1	*Universal design Matrix*	*Wheelchair safety*	*Prosthesis for knee, hip*	*Main part of ear, Measurement of hearing*	*Neural engineering*
	SLO-2	*Design based on human ability*	*Wheelchair standards and tests*	*Material used for fabrication, examples of available prosthesis*	*Problems that can arise, Range of hearing*	*Implementation in rehabilitation*
S-7	SLO-1	*Standards for assistive technology- National and International*	*Intelligent Mobility aids*	*Orthosis: Definition, Difference between orthosis and prosthesis*	*Surgical hearing aids*	*Behavioural disorders and its types*
	SLO-2	*Role of Rehabilitation Engineering in standards development*	*Smart wheeled walkers*	*Orthosis for shoulder, neck*	*Cochlear and eardrum interventions*	*Rehabilitation methods involves*
S-8	SLO-1	*Rehabilitation Engineering and its research opportunities*	*All terrain wheelchair*	*Orthosis for foot, Material used: the problems faced with the material*	*Non surgical hearing aids*	*Sports rehabilitation*
	SLO-2	*Future of Engineering in Rehabilitation*	*Current directions in wheelchair research*	*Components of lower limp prosthesis*	*Design of a simple external hearing aid*	*Measurement technology for sports mechanics*
S-9	SLO-1	*Seating and common pathologies*	*Parts of Upper extremity*	*External circuitry design and support system*	*Sign language*	*Legal aspect in rehabilitation*
	SLO-2	*Seating assessment*	*Significance of each part, Different movements involved*	*Indentifying the orthosis and prosthesis which can be used Practice session: student to indentify the area of amputation and what to use in that location*	*Devices for sign language translation*	*Provision for rehabilitation*

Learning Resources	1. *Rory A Cooper, Hisaichi Ohnabe, Duglas A Hodson, "An Introduction to Rehabilitation Engineering", CRC Press, First edition, 2006* 2. *Rory A Cooper, "Rehabilitation Engineering Applied to Mobility and Manipulation", CRC Press, First edition, 2010* 3. *Horia-Nicolai.L. Teodorescu, Lakhsmi.C. Jain, "Intelligent Systems and Technologies in Rehabilitaion Engineering", CRC Press, First Edition, 2010.*	4. *Marion A Hersh, Michale A Johnson, "Assistive Technology fo Visually impaired and blind people", Springers Publications, First edition 2008.* 5. *Suzanne Robitaille, "The illustrated guide to Assistive technology and devices-Tools and gadgets for living independently", Demos Health Newyork, First edition, 2010.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Dr. Varshini karthik, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Mrs. A. Bhargavi haripriya, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE361T	Course Name	BIOMEDICAL NANOTECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Learn the different synthesis method and its application*			
CLR-2 :	*Apply the various characterization techniques in nano materials*			
CLR-3 :	*Comprehend the principles behind nanomedicine*			
CLR-4 :	*Gain a broad understanding of concepts and applications of nanomedicine*			
CLR-5 :	*Apply concepts of nanomedicine to a focused clinical area of their choice*			
CLR-6 :	*Acquire knowledge to apply these nanosystems for the diagnosis and therapy.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Analyze the suitable method in biomedical application*	*3*	*80*	*75*
CLO-2 :	*Identify the various characterization techniques in nano materials*	*3*	*80*	*70*
CLO-3 :	*Describe the properties and techniques in nano biomaterials*	*3*	*75*	*70*
CLO-4 :	*Analyze the concept of nano therapeutics and application in biomedical*	*3*	*80*	*75*
CLO-5 :	*Identify the principle behind modern bio nano imaging techniques*	*3*	*80*	*70*
CLO-6 :	*Apply the nano materials in 3D printing techniques*	*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	PSO - 2	PSO – 3
M	-	-	*L*	-	-	-	-	-	-	-	-	*L*	-	*L*
L	-	-	*L*	-	-	-	-	-	-	-	-	*L*	-	*L*
L	-	-	*L*	-	-	-	-	-	-	-	-	*L*	-	*L*
M	-	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
M	-	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*
M	-	-	*M*	-	-	-	-	-	-	-	-	*L*	-	*L*

Duration (hour)		Synthesis of nano material	Nano materials characterization techniques	Nano biomaterials	Nano therapeutic	Nano biomedical imaging and 3D Bio printing techniques
		9	9	9	9	9
S-1	SLO-1	*Introduction About Nano technology*	*Introduction to Scanning electron microscope(SEM)*	*Introduction to nano biomaterials*	*Drug to delivery to central nervous system*	*Introduction to biomedical imaging*
	SLO-2	*Bulk synthesis:*	*Application of scanning electron microscope*	*Surface and bulk properties of biomaterials*	*Drug delivery across blood brain barrier*	*The emergence of nanoparticle as imaging platform in medicine*
S-2	SLO-1	*Top down and bottom approaches*	*Energy dispersive spectroscopy (EDS)*	*Nano biomaterials, Nano bio ceramics*	*Nano wire monitoring the brain activity*	*Magnetic resonance imaging basics*
	SLO-2	*Physical vapour deposition methods*	*Basics principle of atomic microscopy*	*Hydroxyapatite ant its properties*	*Introduction to Nano robot medical device*	*MRI working ,paramagnetic contrast agents*
S-3	SLO-1	*Electron beam evaporation techniques*	*Construction, working and application of atomic microscopy*	*Hydroxyapatite ant its applications*	*Application of Nano robot medical device*	*Magnetic Nano sensor*
	SLO-2	*Pulsed laser deposition*	*Introduction to transmission electron microscopy*	*Alumina and its properties ,application*	*Introduction to nano drug carrier*	*Radio labeled nano particles.*
S-4	SLO-1	*Sputtering techniques*	*Application of transmission electron microscopy*	*Zirconia and Titania and its properties*	*Nano carrier for ocular drug delivery*	*Sound waves nano particle*
	SLO-2	*Evaporation techniques*	*Scanning probe microscope*	*Zirconia and Titania ant its applications*	*Cell therapy for myocardial infection*	*Application in ultra sound imaging*
S-5	SLO-1	*Cathodic arc deposition*	*Nano indentation techniques*	*Nano diamond carbon nano materials*	*Types of cell therapy for myocardial infection*	*Biological imaging*
	SLO-2	*Spin coating unit, spray pyrolysis*	*Cantilever array sensor*	*Nano diamond carbon materials and its applications.*	*Nano neurosurgery,*	*Quantum dot in optical imaging*

S-6	SLO-1	*Chemical vapor deposition(CVD)*	*Basics principle of scanning tunneling microscopy*	*Introduction to surface modification*	*Nanolipoblockers*	*3D printing*
	SLO-2	*Types of chemical vapour deposition*	*Constriction and application of scanning tunneling microscope(STM)*	*Types of surface modification method*	*Antirestenosis drugs*	*Introduction and principle*
S-7	SLO-1	*Plasma method: Plasma enhanced CVD*	*Introduction about X-ray diffraction*	*Textured and porous materials*	*Introduction to nano particle drug formulations*	*3D printing technology :ink let based*
	SLO-2	*Hot filament CVD*	*Measurement and application of XRD*	*Cell biomaterials interactions*	*Nano particle drug formulations for spray inhalations*	*Pressure assisted, laser assisted*
S-8	SLO-1	*Chemical synthesis: Sol gel processing*	*X-ray photon spectroscopy(XPS)*	*Immune response*	*Introduction to nano bone implants*	*Solenoid valve based, acoustic jet based*
	SLO-2	*Hydrothermal,co precipitation,*	*Application XPS*	*Bone Scaffold preparations*	*Nano bone implants and scaffolds*	*3D bio printing in ceramics ,polymers*
S-9	SLO-1	*Wet chemical method*	*Electrochemical work station*	*Scaffold properties and its applications*	*Introduction to nano technology in cardio vascular system*	*3D bio printing in organs*
	SLO-2	*Hydrolysis ,Electrophoretic deposition*	*Application of electrochemical work station*	*In vitro and in vivo tissue biocompatibility*	*Regeneration of cardiovascular system*	*Challenge and future development of 3D bio printing*

Learning Resources	1. *Khandpur R.S, Hand-book of Biomedical Instrumentation, 2nd ed., Tata McGraw Hill, 2003* 2. *Michael Giersig, Gennady B. Khomutov,"Nanomaterials for Application in Medicine and Biology", Springer, 2008* 3. *Jeff W.M., Bulte and Michel M.J. Modo "Nanoparticles in Biomedical Imaging Emerging Technologies and Applications", Springer, 2010*	4. *Guozhong Cao, "Nanostructures and Nanomaterials, synthesis, properties and applications", Imperial College Press, 2004* 5. *C. N. Rao, A. Muller, A. K. Cheetham "The Chemistry of Nanomaterials: Synthesis, Properties and Applications", Wiley, 2004*

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

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

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

Course Code	18ECE362T	Course Name	PHYSIOLOGICAL MODELING AND SIMULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Build an engineering model based on physiological subsystems*			
CLR-2 :	*Implement static analysis for physiological systems*			
CLR-3 :	*Understand time domain and stability analysis of physiological systems*			
CLR-4 :	*Implement frequency response analysis for physiological systems*			
CLR-5 :	*Identify and estimate unknown parameters in system modeling*			
CLR-6 :	*Represent the working of physiological systems using different modeling techniques*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Develop a more in-depth level of understanding engineering analysis for modeling physiological systems*	*1,2*	*80*	*70*
CLO-2 :	*Perform static analysis of a system*	*1,2*	*80*	*70*
CLO-3 :	*Perform transient and stability analysis of a system.*	*1,2*	*80*	*70*
CLO-4 :	*Able to do frequency analysis of the system*	*1,2*	*80*	*70*
CLO-5 :	*Understand and implement system identification techniques*	*1,2*	*80*	*70*
CLO-6 :	*Implement the various mathematical modeling techniques to physiological systems*	*1,2*	*80*	*70*

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

Duration (hour)		Linear Model	Static Analysis	Time Domain Analysis	Frequency Domain Analysis	System Identification
		9	9	9	9	9
S-1	SLO-1	*Introduction to modeling methodology, need for models, approaches to modeling*	*Static analysis: Open loop versus closed loop*	*Introduction to time domain analysis*	*Frequency response: Open loop frequency response*	*Identification of physiological control system*
	SLO-2	*Model identification, model validation and Simulation*	*Loop gain calculation: Room temperature control*	*Linearized respiratory mechanics transient response*	*Closed loop frequency response*	*Basic problems in Physiological system analysis*
S-2	SLO-1	*System analysis, fundamental concepts*	*Steady state characteristics*	*Linearized respiratory mechanics first order model – impulse response for open loop*	*Relation between transient and frequency response*	*Nonparametric and parametric identification methods*
	SLO-2	*Physiological control system an example*	*Determination of steady state operating point for simple model of muscle stretch reflex*	*Linearized respiratory mechanics first order model – impulse response for closed loop*	*Frequency domain specifications*	*Numerical Deconvolution, Least square estimation*
S-3	SLO-1	*Engineering control system versus physiological control system*	*Human body Glucose – Insulin regulatory system*	*Transient response descriptors : Impulse response*	*Graphical representation of frequency response: Bode plot*	*Estimation using correlation functions*
	SLO-2	*Science of modeling*	*Steady state analysis of glucose –insulin model*	*Transient response descriptors : Step response*	*Bode plot :Linearized lung mechanics*	*Estimation in frequency domain, optimization techniques*
S-4	SLO-1	*Generalized system properties*	*Human body chemical regulation of ventilatory system*	*Concept of sliding theory*	*Graphical representation of frequency response: Nicholas chart*	*Problems in parameter estimation*
	SLO-2	*Models with combinations of system elements*	*Mechanism of respiration*	*Neuromuscular reflex action*	*Nicholas chart : Linearized lung mechanics*	*Input design*
S-5	SLO-1	*Linear model of respiratory mechanics*	*Gas exchanger mathematical modeling*	*Mathematical model of neuromuscular*	*Graphical representation of frequency*	*Identification of closed loop systems –*

				reflex motion	response : Nyquist plot	"opening the loop"
	SLO-2	Linear model of respiratory mechanics: Derivation of transfer function	Respiratory controller mathematical modeling	Calculation of transfer function	Nyquist plot: Linearized lung mechanics	Starling heart- lung preparation
S-6	SLO-1	Linear model of muscle mechanics	Closed loop analysis : lung and controller	Stability and transient response	Introduction : Circulatory system	Kao's cross – circulation experiment
	SLO-2	Linear model of muscle mechanics: Derivation of transfer function	Calculation of transfer function	Root locus and Routh-Hurwitz stability criterion	Mathematical model of circulatory system	Artificial brain perfusion for partitioning central and chemo reflexes
S-7	SLO-1	Distributed versus lumped parameter model	Heart and systemic circulation	Stability analysis: root locus method	Frequency response of circulatory system	Voltage clamp
	SLO-2	Distributed versus lumped parameter model: Derivation of transfer function	Mathematical modeling of cardiac output	Introduction to Nyquist plot	Graphical representation for frequency response of circulatory system	Opening the Pupillary reflex loop, Read rebreathing technique
S-8	SLO-1	Linear system and superposition principle	Calculation of transfer function for simplified model of cardiac output regulation	Nyquist criterion for stability	Frequency response of glucose – insulin model	Identification under closed loop condition
	SLO-2	Laplace transform and transfer function	Cardiac characteristics curve analysis	Relative stability theory	Mathematical model and simulation of glucose – insulin model	Minimal model of blood glucose regulation
S-9	SLO-1	Impulse function analysis	Venous return curve	Physiology: Pupillary reflex control	Frequency response approach to pupil control	Optimization : Introduction
	SLO-2	Basics of Linear convolution	Closed loop analysis of heart and systemic circulation	Mathematical modeling and stability analysis of pupillary reflex control	Frequency response characteristics curve for pupillary control	Optimization in systems with negative feedback

Learning Resources	1. Michael C.K. Khoo, "Physiological Control Systems - Analysis, Simulation and Estimation", Prentice Hall of India Private Ltd., 2nd edition, New Delhi, 2001. 2. V.Z. Marmarelis, "Advanced Methods of Physiological System Modeling", Vol.3, Springer Science and Business Media, 2013.	3. Claudio Cobelli Ewart Carson,, "Introduction to Modeling in Physiology and Medicine", Academic press series, 1st edition, 2008. 4. Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, "Applied Mathematical Models in Human Physiology", Vol.9, SIAM, 2004. 5. Dorf, "Modern Control Systems",Pearson Education India, 1st edition, 2008

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

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

Course Designers											
Experts from Industry				Experts from Higher Technical Institutions				Internal Experts			
1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com				1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu				1. Dr. T.Jayanthi, SRMIST			
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com				2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu				2. Mrs.G.Anitha, SRMIST			
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com				3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in							
Course Code	15EC363J	Course Name	MEDICAL IMAGE PROCESSING			Course Category	E	Professional Elective	L	T	P	C

							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the fundamental image operations and image transforms*
CLR-2 :	*Apply various image enhancement techniques in enhancing the medial images*
CLR-3 :	*Analyze the various types of image segmentation algorithms*
CLR-4 :	*Gain knowledge in Image compression and image registration methods*
CLR-5 :	*Understand the image reconstruction techniques used in reconstruction of medical images*
CLR-6 :	*The learner gains knowledge in Image retrieval and digital image watermarking*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)
CLO-1 :	*Describe the 2D Sampling theory and different types of image transforms*	*1, 2*	*80*	*70*
CLO-2 :	*Implement the image enhancement techniques for improving the quality of medical images*	*2*	*80*	*70*
CLO-3 :	*Apply the different image segmentation algorithms for various medical applications*	*2*	*80*	*70*
CLO-4 :	*Differentiate and analyze the various image compression and registration algorithms*	*3*	*80*	*70*
CLO-5 :	*Analyze the various image reconstruction methods used for medical images*	*3*	*80*	*70*
CLO-6 :	*Illustrate the concepts of wavelet transform and digital image water marking*	*3*	*80*	*70*

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

Duration (hour)		Fundamental Image Operations and Transforms	Image Enhancement methods	Image Segmentation Algorithms	Image compression and image registration methods	Image Reconstruction Methods
		12	12	12	12	12
S-1	SLO-1	*Elements of Visual Perception- structure of human eye and image formation*	*Basic gray level transformation- image negative, intensity slicing techniques*	*Morphological operations-Erosion*	*Image compression-Introduction*	*Image reconstruction from projections- Radon transform- derivation*
	SLO-2	*Brightness range adaptation and discrimination*	*Contrast stretching, dynamic range compression and bit plane slicing*	*Dilation*	*Types of redundancies*	*Properties*
S-2	SLO-1	*Image sampling-2D sampling Theory*	*Histogram equalization*	*Image opening*	*Huffman coding technique*	*Inverse radon transform- convolution back projection*
	SLO-2	*Reconstruction from its samples*	*Histogram specification*	*Image closing*	*Procedure*	*Filter back projection*
S 3-4	SLO-1	*Lab1: Basic operations on images*	*Lab4: Gray transformation and histogram equalization*	*Lab 7: Morphological operations*	*Lab 10: Image compression*	*Lab 13: Image reconstruction from projection data*
	SLO-2					
S-5	SLO-1	*Quantization- optimal mean square quantizer*	*Image smoothening in spatial domain – Low pass filter*	*Edge detection- Marr hildreth edge detector*	*Image registration- Introduction*	*Digital implementation of filter back projection- Block diagram*
	SLO-2	*Uniform quantizer*	*Median filter*	*Algorithm*	*Dimensionality transformation*	*Algorithm*
S-6	SLO-1	*Neighborhood pixel relationships- adjacencies*	*Image sharpening in spatial domain –High pass filter, high boost filter*	*Canny edge detection- smoothing*	*Rigid registration algorithm*	*Wavelet transform-Introduction*
	SLO-2	*Distance measures*	*Derivative filters*	*Non maxima suppression and thresholding*	*Rigid registration algorithm*	*Algorithm*
S 7-8	SLO-1	*Lab2: Image transforms in spatial domain*	*Lab 5: Image smoothening using suitable filters*	*Lab 8: Edge detection techniques*	*Lab 11: Image registration*	*Lab 14: Wavelet transform*
	SLO-2					
S-9	SLO-1	*Image transform –DFT, DCT*	*Image smoothening in frequency domain*	*Thresholding –basics*	*Registration of MRI and PET images*	*Digital image watermarking-Introduction*

	SLO-2	*Properties*	*Image sharpening in frequency domain*	*Global thresholding algorithm*	*Clinical applications*	*Applications*
S-10	SLO-1	*Haar Transform*	*Color image processing-Introduction*	*Region based segmentation-region growing algorithm*	*Registration of MRI and CT images*	*Image retrieval-Introduction*
	SLO-2	*Properties*	*Color models*	*Region splitting and merging algorithm*	*Clinical applications*	*Content based image retrieval*
S 11-12	SLO-1 SLO-2	*Lab3: Image transforms in frequency domain*	*Lab 6: Image sharpening using suitable filters*	*Lab9: Image segmentation using Thresholding*	*Lab 12: Fusion of MRI and CT images*	*Lab 15: Digital image watermarking*

Learning Resources	1. *Rafael C., Gonzalez and Richard E. Woods,"Digital Image Processing", Pearson Education Asia, Third Edition, 2007* 2. *Anil.k.Jain, "Fundamentals of Digital image processing", Prentice Hall of India, 2nd edition 1997.*	3. *Joseph V.Hajnal, Derek L.G.Hill, David J Hawkes, "Medical image registration", Biomedical Engineering series, CRC press,2001.*

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

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

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

Course Code	18ECE364T	Course Name	BODY AREA NETWORK AND MOBILE HEALTHCARE	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Comprehend technical information and challenges in WBAN.*			
CLR-2 :	*Describe the hardware requirements of BAN*			
CLR-3 :	*Review the wearable sensors and standards for BAN*			
CLR-4 :	*Describe the mobile devices that is available for health care*			
CLR-5 :	*Summarize the possible and latest applications of mobile healthcare*			
CLR-6 :	*Learn about context-aware health care applications*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*List out the BAN challenges*	*1*	*80*	*75*
CLO-2 :	*Identify the hardware necessary for BAN*	*1*	*80*	*75*
CLO-3 :	*List and describe the various wearable sensors*	*1,2*	*80*	*75*
CLO-4 :	*Appreciate the mobile devices available for healthcare*	*1.2*	*80*	*75*
CLO-5 :	*List the latest applications and research opportunities with mobile healthcare.*	*2*	*80*	*75*
CLO-6 :	*Think about context-aware health care solutions*	*3*	*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	PSO - 2	PSO – 3
CLO-1 :		*L*													
CLO-2 :	*L*														
CLO-3 :		*L*											*L*		
CLO-4 :	*L*														
CLO-5 :														*L*	
CLO-6 :															*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*BAN-Definition*	*Processor in BAN*	*RF Communication*	*Sensors for wearable system*	*Mobile health technologies*
	SLO-2	*Terminologies used with BAN*	*Low Power MCUs*	*RF Communication in and around the body*	*Wearable system design for specific applications*	*Mobile nutrition tracking*
S-2	SLO-1	*Technical Challenges*	*Mobile Computing MCU*	*Antennal Design*	*Wearable system for ECG monitoring,*	*Accessing existing virtual electronic patient record*
	SLO-2	*Sensor design concepts*	*Integrated processor*	*Antenna testing*	*Wearable system for EEG monitoring,*	*Mobile personal health records,*
S-3	SLO-1	*Types of sensors*	*Radio transceiver along with the processor*	*Propagation issues*	*Wearable system for Gait analysis*	*Monitoring hospital patients,*
	SLO-2	*Biocompatibility issues*	*Integrated processor with Memory*	*Base Station considerations*	*Evaluation of general performance*	*Sensing vital signs*
S-4	SLO-1	*Energy Requirements*	*Antenna for BAN*	*Network topology*	*Evaluation of night time performance*	*Transmission using wireless networks*
	SLO-2	*Energy supply*	*Antenna Requirements*	*Stand – Alone BAN*	*Evaluation parameters*	*Continuous monitoring*
S-5	SLO-1	*Nodes, number of node*	*Antenna Considerations*	*Wireless personal Area Network*	*Latest health monitoring methods*	*Patient Monitoring and wearable devices*
	SLO-2	*Optimal node placement in BAN*	*Types of antenna*	*Wireless personal Area Network Technologies*	*Smart phone based health care monitoring system*	*Patient Monitoring in Diverse Environments*
S-6	SLO-1	*System security*	*Wire antenna*	*IEEE 802.15.1*	*Phone based fall risk prediction*	*A framework for Capturing Patient Consent in Pervasive Healthcare Applications*
	SLO-2	*System Reliability*	*Ceramic antenna*	*IEEE P802.15.13*	*Emergency alerts*	*M-health application*
S-7	SLO-1	*BAN Standards*	*External antenna*	*IEEE 702.15.14*	*RFID based personal mobile medical assistance*	*Context aware sensing*

	SLO-2	*BAN with other standards*	*Sensor Interface*	*Zigbee*	*Other similar technologies*	*Technology Enablers for context-Aware healthcare Applications*
S-8	SLO-1	*BAN Architecture*	*Considerations on the interface*	*BAN and WBAN technologies*	*Infusing image processing capabilities*	*Case study I*
	SLO-2	*BAN and other technologies*	*Power sources- Batteries*	*Limitations in use*	*Secure medical sensor network with HIP*	*Case study I*
S-9	SLO-1	*BAN and Healthcare*	*Fuel cells for sensor nodes.*	*Coexistence issues with BAN*	*Diagnostic applications*	*Case study II*
	SLO-2	*Medical Applications of BAN*	*Other novel power sources*	*Other practical considerations*	*Therapeutic applications*	*Case study II*

Learning Resources	1. *Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2011.* 2. *Philip Olla, Josep Tan, "Mobile Health solutions for Biomedical applications", Medical Information science reference, Hershey New York, IGI Global 2009.* 3. *Zhang, Yuan-Ting, Wearable Medical Sensors and systems, Sringers, 2013.* 4. *Guang-Zhogn Yang(ED), " Body Sensor Networks", Springers, 2013* 5. *Mehmet R. Yuce Jamil Y.Khan, "Wireless Body Area Networks Technology, Implementation and applications", Pan Standford Pte. Ltd., Singapore, 2012*	6. *Konstantina, James C. Lin, Dimitrios, Maria Teresa, "Wireless mobile Communication and healthcare", Secon International ICST conference, Mobihealth 2011, Springers 2011.* 7. *Ullah, Sana, Et at, " A review of wireless body area networks for medical applications", arXiv: 1001.083, 2010* 8. *Patel, Shyamal, Et al, "A review of wearable sensors and systems with application in rehabilitation", Neuroeng Rehabil 9.12, 2012, 1-17.*

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

Course Code	18ECE365T	Course Name	BIO-INSPIRED HUMAN MACHINE INTERFACE	Course Category	E	Professional Electives	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Study the HMI design, principles and standards*			
CLR-2 :	*Attain knowledge in optic and acoustic based HMI design*			
CLR-3 :	*Acquire knowledge in Bioelectric interfaces*			
CLR-4 :	*Study the brain signal based HMI design*			
CLR-5 :	*Have an insight knowledge in advanced HMI design*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Explain the basics, rules and generic design flow of HMI systems*	*3*	*80*	*75*	*M*	*M*			*L*										
CLO-2 :	*Explain and analyze the optic and Acoustic based HMI systems*	*3*	*80*	*70*	*M*	*M*			*L*										
CLO-3 :	*Analyze and discuss the bioelectric based HMI design*	*3*	*75*	*70*	*M*	*M*			*L*										
CLO-4 :	*Explain and analyze brain signal based HMI design*	*3*	*80*	*75*	*M*	*M*			*L*										
CLO-5 :	*Analyze and discuss the advances and challenges in HMI design*	*3*	*80*	*70*	*M*	*M*			*L*										
CLO-6 :	*Design a biomimetic system for neural prosthesis*	*3*	*80*	*75*	*M*	*M*			*L*										

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to HMI*	*Vision based HMI design-Introduction-*	*Bioelectric Interfaces-Introduction*	*Brain Computer Interfaces-Introduction*	*Affective Computing based HMI-Introduction*
	SLO-2	*Need for HMI systems*	*Face Recognition-Signal Acquisition*	*Myoelectric interfaces-Introduction*	*Brain regions and responsibilities*	*Affective Computing based HMI-Data Acquisition*
S-2	SLO-1	*Types of HMI*	*Face Recognition-Data Analysis*	*Muscle regions and responsibilities*	*Active methods for measuring brain activity*	*Affective Computing based HMI-Data Classification*
	SLO-2	*Types of HMI*	*Vision based HMI design-Data Classification*	*Methods for measuring muscle activity*	*Active methods for measuring brain activity(Contd.)*	*Application of Affective Computing based HMI*
S-3	SLO-1	*HMI-guidelines*	*Gait Recognition-Signal Acquisition*	*Myoelectric Signal –Data Analysis*	*Invasive BCI*	*Wearable Computing-Introduction*
	SLO-2	*HMI-principles*	*Gait Recognition-Data Analysis & Classification*	*Myoelectric Signal –Data Analysis(Contd.)*	*Non-invasive BCI*	*Wearable Computing*
S-4	SLO-1	*HMI-standards*	*Gesture Recognition-Data Analysis &Classification*	*Myoelectric Signal –Data Classification*	*EEG based BCI*	*Tactile based HMI*
	SLO-2	*HMI-Ethical Issues*	*People tracking*	*Application of Myoelectric HMI*	*P300 based BCI*	*Tactile based HMI*
S-5	SLO-1	*Interaction design-basics*	*LED based HMI system*	*ECG based HMI design*	*VEP based BCI*	*Motion based HMI*
	SLO-2	*Interaction design-Design rules*	*LASER based HMI system*	*ECG based HMI design(Contd.)*	*NIRS based BCI*	*Motion based HMI*
S-6	SLO-1	*HMI Systems-Data Collection*	*Speech Communication*	*EOG based HMI design-Introduction*	*Application in Prosthetic Control*	*Biomimetic design of neural prosthesis*
	SLO-2	*HMI Systems-Data Analysis*	*Speech Communication (Contd.)*	*EOG based HMI design-Signal Acquisition*	*Application in Prosthetic Control*	*Biomimetic design of neural prosthesis*
S-7	SLO-1	*HMI Systems-Design*	*Fundamentals of Speech Recognition*	*EOG based HMI design-Signal Analysis*	*Neurorehabilitation*	*Intracranial human machine interfaces for Communication and control*

	SLO-2	*HMI Systems-Prototyping*	*Fundamentals of Speech Recognition(Contd.)*	*EOG based HMI design-Signal Analysis(Contd.)*	*Neurorehabilitation*	*Intracranial human machine interfaces for Communication and control*
S-8	SLO-1	*Evaluation of HMI Systems*	*Automatic Speech Recognition*	*EOG based HMI design-Signal Classification*	*Neuromarketing*	*Multimodal approaches for advanced HMI design*
	SLO-2	*Evaluation of HMI Systems*	*Automatic Speech Recognition(Contd.)*	*EOG based HMI design-Signal Classification(Contd.)*	*Neuromarketing*	*Multimodal approaches for advanced HMI design*
S-9	SLO-1	*Bio-inspired HMI Systems*	*Multimodal Interaction &Approaches*	*Applications of EOG based HMI*	*Brain controlled wheel chairs*	*Multimodal approaches for advanced HMI design*
	SLO-2	*Bio-inspired HMI Systems*	*Multimodal Interaction &Approaches (Contd.)*	*Applications of EOG based HMI (Contd.)*	*Brain controlled wheel chairs*	*Multimodal approaches for advanced HMI design*

Learning Resources	1. *Yvonne Rogers, Helen Sharp, Jenny Preece, "Interaction Design: Beyond Human Computer Interaction", 3rd Edition, Willey Publisher, 2012.* 2. *P C Yuen, Y Y Tang, P S P Wang, "Multimodal Interface For Human-Machine Communication", World Scientific, 2002.* 3. *Aboul-Ella Hassanien and Ahmad Taher Azar, "Brain-Computer Interfaces: Current Trends and Applications", Springer International Publishing AG, 2016.*	4. *Rajesh P. N. Rao, "Brain-Computer Interfacing : An Introduction", Cambridge University Press, 2013* 5. *Masaki Kurosu, Human-Computer Interaction. User Interface Design, Development and Multimodality, Springer International Publishing AG, 2017*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*1. Dr.Hariharan, 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*
. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE366T	Course Name	IMPLANTABLE BIOELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Comprehend technical information about miniaturized Implantable Biomedical devices*			
CLR-2 :	*Introduce to neural interfaces and cyborgs*			
CLR-3 :	*Know about implantable user interface and CMOS imaging systems*			
CLR-4 :	*Learn about implantable electronics biocompatibility criteria and telemetry*			
CLR-5 :	*Know the key design trends in implantable systems*			
CLR-6 :	*Know the future of Biomedical Implantable systems*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Describe the design of Implantable Biomedical Devices*	*1,2*	*80*	*75*
CLO-2 :	*Tell about neural interfaces and cyborgs*	*1*	*80*	*75*
CLO-3 :	*Describe about implantable user interface and CMOS imaging systems*	*1,2*	*80*	*75*
CLO-4 :	*Tell about implantable electronics biocompatibility criteria and telemetry*	*1*	*80*	*75*
CLO-5 :	*Consolidate on design trends in implantable systems*	*2,3*	*80*	*75*
CLO-6 :	*Summarize the future of Biomedical Implantable systems*	*2,3*	*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	PSO - 2	PSO – 3
M														
L														
M														
					L	*L*								
L													*L*	
													L	

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Bioelectronics-Introduction*	*Neural interfaces and cyborgs- introduction*	*Implantable user interfaces*	*Biotelemtry*	*Design trends in Biomedical Implantable systems*
	SLO-2	*Energy Harvesting as a Pathway to miniaturization,*	*Fusing Robotics with the Human Body*	*Design Considerations*	*Inductive Link for Forward Data*	*Design of Implant Systems-*
S-2	SLO-1	*Implantable Devices*	*Anatomy of Peripheral Nerves*	*Evaluating Basic Implanted User Interfaces*	*Wireless Power Link*	*Review-History*
	SLO-2	*Implementation of Implantable Devices*	*Interfacing with the periphery for recording and stimulation*	*Qualitative Evaluation,*	*Implantable device with external units*	*Basic Considerations and Characteristics of RF MEMS Implantable Systems-*
S-3	SLO-1	*RF Power Harvesting*	*Listening to the Brain*	*Medical Considerations*	*Implantable Telemetry Link*	*Legal Considerations of the Radio Frequency (RF)*
	SLO-2	*Matching network, rectifier,*	*Interfacing with the Central Nervous System*	*Limitations*	*Wideband telemetry links*	*Field Strength*
S-4	SLO-1	*Regulator and band gap reference*	*Eletrical Modulation of the Human Nervous System*	*CMOS Imaging Devices*	*Multichannel neural recording systems*	*Power Levels*
	SLO-2	*Implant functional block*	*Pain Modulation*	*Fundamentals of CMOS Imaging*	*Wireless endoscope*	*Biocompatibility*
S-5	SLO-1	*Wireless Communication Link,*	*Electrical Modulation of Inflammation*	*Photo sensors,*	*Microelectrode Arrays*	*Protection of the Biomedical Implant*
	SLO-2	*Forward and reserve data link*	*Cyborgs*	*Log sensors*	*Interface Electronics*	*Systems-Characteristics of Biological and Medical Signals*
S-6	SLO-1	*Payload*	*The Neuro-Tech Version*	*SPAD sensors*	*Electrode equivalent circuit*	*Design considerations of Implantable Systems, Micro power Electronic Design*
	SLO-2	*Applications*	*Biological Brains in a Robot Body*	*Artificial Retina*	*Stimulation Front Ends*	*Approaches*

S-7	SLO-1	*Locomotive Implant*	*Deep Brain Stimulation*	*Principle of Artificial Retina*	*Recording Front-Ends*	*Samples*
	SLO-2	*Implantable Cardiac Probe,*	*General Purpose Brain Implants*	*Artificial Retina Based on CMOS Imaging Device*	*Instrumentation amplifier*	*Power Supply design.*
S-8	SLO-1	*Communication power delivery*	*Brain-Computer Interfaces*	*Brain-Implantable CMOS Imaging Device*	*Improving the Biocompatibility of Implantable Bioelectronics Devices.*	*System integration*
	SLO-2	*System Overview of a Generic Bioelectronics Implant*	*Noninvasive Brain-Computer Interfaces*	*Measurement Methods for Brain Activities*	*Implantable Bioelectronics Devices Materials*	*Micro-Packages,*
S-9	SLO-1	*Circuit Design for Low-Power Signal Processing.*	*Sub dermal Magnetic Implants*	*Fiber Endoscope and Head-Mountable Device*	*Surface Composition*	*Present Challenges,*
	SLO-2	*Architecture-Level Optimization for Low-Power Data Processing*	*RF ID Implants.*	*Summary and future directions*	*Response to Implantation*	*Nano-Enabled Implantable Device for In Vivo Glucose Monitoring*

Learning Resources	1. *Evgeny Katz, "Implantable Biolectronics Devices materials and Applications", Wiley-VCH, 2014.* 2. *Vinod Kumar Khanna, "Implantable Medical Electronics Prosthetics, Drug Delivery and Health Monitoring", Springer, 2016*	3. *Swarup Bhunia, Steve Majerus, Mohamad Sawan, Implantable Biomedical Microsystems: Design Principles and Applications", Elsevier, 2015.*

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

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

Course Designers		
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1. Sathyanarayanan J, Mindray Medical India Pvt Ltd, sathyanarayananjayagopal@mindray.com	*1. Dr. S. Poonguzhali, Anna University, poongs@annauniv.edu*	*Dr. Varshini Karthik, SRMIST*
2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*Mr.Karthik Raj, SRMIST*
3. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*3. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	18ECE367T	Course Name	REGULATORY AFFAIRS IN MEDICAL INSTRUMENTS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ECC201J, 18ECE260J	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Communication Engineering		Data Book / Codes/Standards	Nil	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
		1	2	3
CLR-1 :	*Understand the fundamental troubleshooting procedures and testing of basic electronic components*			
CLR-2 :	*Get an idea about the fault diagnosis in analog circuits and digital ICs.*			
CLR-3 :	*Acquire an idea about the basic troubleshooting procedures for biomedical equipment*			
CLR-4 :	*Get an idea about the medical device classification globally and regulatory standards*			
CLR-5 :	*Get an idea about the Indian perspective medical device regulatory system*			
CLR-6 :	*Get an overall idea about the importance of troubleshooting and medical device classification in India*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO – 3
CLO-1 :	*Apply the common troubleshooting procedures in Electronic Equipment and Outline the testing procedures of active and passive components*	*1, 2*	*80*	*70*	*M*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	*Analyze the faults in analog circuits and digital ICs*	*1, 2*	*80*	*70*	*M*	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-
CLO-3 :	*Identify the problems in common biomedical equipment in hospitals when it is not working and provide a suitable solution*	*2*	*80*	*70*	-	*M*	-	-	-	-	-	-	-	-	-	-	*M*		-
CLO-4 :	*Outline the importance of medical device classification based on the application and ISO standards*	*1*	*80*	*70*	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*M*	-
CLO-5 :	*Describe the Indian medical device regulatory system*	*1*	*80*	*70*	-	-	-	-	-	-	-	-	-	-	-	*M*	-	-	-
CLO-6 :	*Outline the job opportunities in regulatory affairs in India*	*1,2*	*80*	*70*	-	-	-	-	-	-	-	-	-	-	-	*L*	-	-	-

Duration (hour)		Basic Troubleshooting Techniques& Testing Procedures	Fault Diagnosis in Analog, Digital Integrated Circuits and Home care device	Biomedical Machine Troubleshooting in Hospitals	Medical Device Classification and Standards	Medical Device Regulatory System in India
		9	9	9	9	9
S-1	SLO-1	*Equipment failure and its types*	*Characteristics of ideal op-amps*	*Troubleshooting- ECG Machine*	*Global Harmonization Task Force (GHTF) definition for medical device*	*Importance of regulatory system*
	SLO-2	*Causes of Equipment failure*	*Typical op-amp based medical circuits*	*And its preventive maintenance*	*Medical Device Life Cycle: Identify, Characterize*	*Market Overview*
S-2	SLO-1	*Functional block diagram of a troubleshooting system*	*Typical op-amp based medical circuits*	*Troubleshooting- EEG Machine*	*Medical Device Life Cycle: Optimize, Verify/Validate*	*Overview of Regulatory Environment*
	SLO-2	*Functional block diagram of a troubleshooting system*	*Fault diagnosis in op-amp circuits*	*And its preventive maintenance*	*Global Perspective on medical device regulations: USA, European Union*	*Overview of Regulatory Environment*
S-3	SLO-1	*Troubleshooting process*	*Example: Inverting amplifier troubleshooting process*	*Troubleshooting- defibrillator, suction machine*	*Global Perspective on medical device regulations: Canada, Australia, Japan*	*Functions Undertaken by DCGI and Central Government*
	SLO-2	*Fault finding aids*	*Typical Faults in digital circuits*	*And its preventive maintenance*	*Medical device classification: USA*	*Functions Undertaken by the FDA and State Governments*
S-4	SLO-1	*Troubleshooting techniques: Preliminary Observations*	*Different testing methods in digital circuits: Functional Testing, DC Test*	*Troubleshooting- electrosurgical unit*	*Medical device classification: European Union, GHTF*	*Indian Pharmacopoeia Commission*
	SLO-2	*Troubleshooting techniques: Functional block diagram approach*	*AC Test*	*And its preventive maintenance*	*Premarket Notification 510(k), Premarket Approval*	*Details of Key Regulator*

S-5	SLO-1	*Troubleshooting techniques: Split half method*	*Digital IC Troubleshooter:, Logic clip, Logic probe*	*Troubleshooting- anesthesia machine*	*Standards and its need*	*Organization Chart — CDSCO*
	SLO-2	*Application of Split half method in circuit troubleshooting*	*Digital IC Troubleshooters: Logic pulser, Logic current tracer*	*And its preventive maintenance*	*ISO 9000 core standards: Basic overview*	*Role of Distributors or Local Subsidiaries*
S-6	SLO-1	*Troubleshooting techniques: Systematic Troubleshooting*	*Digital IC Troubleshooters: Logic comparator*	*Troubleshooting- autoclaves & sterilizers*	*ISO 13485: Basic overview*	*Product Registration*
	SLO-2	*Correction action*	*Circuit board Troubleshooting*	*And its preventive maintenance*	*ISO 14971: Basic overview*	*Manufacturing site and product registration: process flow chart*
S-7	SLO-1	*Testing of passive components: Resistors, Capacitors*	*Troubleshooting- oxygen concentrators*	*Troubleshooting- endoscope*	*ISO 10933: Basic overview*	*Quality System Regulation*
	SLO-2	*Testing of passive components: Inductors, Diodes, LDR*	*And its preventive maintenance*	*And its preventive maintenance*	*ISO 14155: Basic overview*	*Technical Material Requirement & Labelling Requirement of Medical Device*
S-8	SLO-1	*Testing of active components: BJT*	*Troubleshooting- sphygmomanometers, Analog Blood pressure apparatus*	*Troubleshooting- incubators*	*ISO 11607: Basic overview*	*Manufacturing-Related Regulation*
	SLO-2	*Testing of active components: JFET*	*And its preventive maintenance*	*And its preventive maintenance*	*ISO 11137: Basic overview*	*Clinical Trial-Related Regulation*
S-9	SLO-1	*Testing of active components: MOSFET*	*Troubleshooting- nebulizer*	*Troubleshooting- X-ray Machine*	*IEC 60601: Basic overview*	*Commercial Aspect*
	SLO-2	*Testing of variable resistors and its different types*	*And its preventive maintenance*	*And its preventive maintenance*	*IEC 62353: Basic overview*	*Related Agencies/Departments and Ministries*

Learning Resources	1. *Joseph D Bronzino& Donald R Peterson, "Medical Devices and Human Engineering", CRC Press, 4th Edition, 2015* 2. *Myer Kutz, "Biomedical Engineering and Design Handbook- Volume 2: Applications", McGraw-Hill, 2nd Edition, 2009* 3. *Richard Fries, "Reliable Design of Medical Devices", CRC Press, 2nd Edition, 2006* 4. *Basem S EL-Haik & Khalid S Mekki, "Medical Device Design for Six Sigma: A Road Map for Safety and Effectiveness", John Wiley & Sons, 1st Edition, 2008* 5. *John J Tobin & Gary Walsh, "Medical Product Regulatory Affairs- Pharmaceutical, Diagnostics, Medical Devices", Wiley-Blackwell, 1st Edition, 2008* 6. *Norbert Leitgeb, "Safety of Electromedical Devices Law – Risks – Opportunities", SpringerWienNewYork, 1st Edition, 2010* 7. *"Medical Device Regulations Global overview and guiding principles", World Health Organization Geneva, 2003* 8. *Jack Wong and Raymond K Y Tong, "Handbook of Medical device regulatory affairs in Asia", Pan Stanford Publishing Pte. Ltd., 2ndEdition, 2018* 9. *Khandpur R S, "Troubleshooting Electronic Equipment- Includes Repair & Maintenance", Tata McGraw-Hill, 2nd Edition, 2009* 10. *Nicholas Cram & Selby Holder, "Basic Electronic Troubleshooting for Biomedical Technicians", TSTC Publishing, 2nd edition, 2010* 11. *Dan Tomal& Neal Widmer, "Electronic Troubleshooting", McGraw Hill, 3rd edition, 2004* 12. *Ministry of Health &Family Welfare, "Medical Equipment Maintenance Manual- A first line maintenance guide for end users", New Delhi, 2010*

Learning Assessment											
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		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*40 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*20 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

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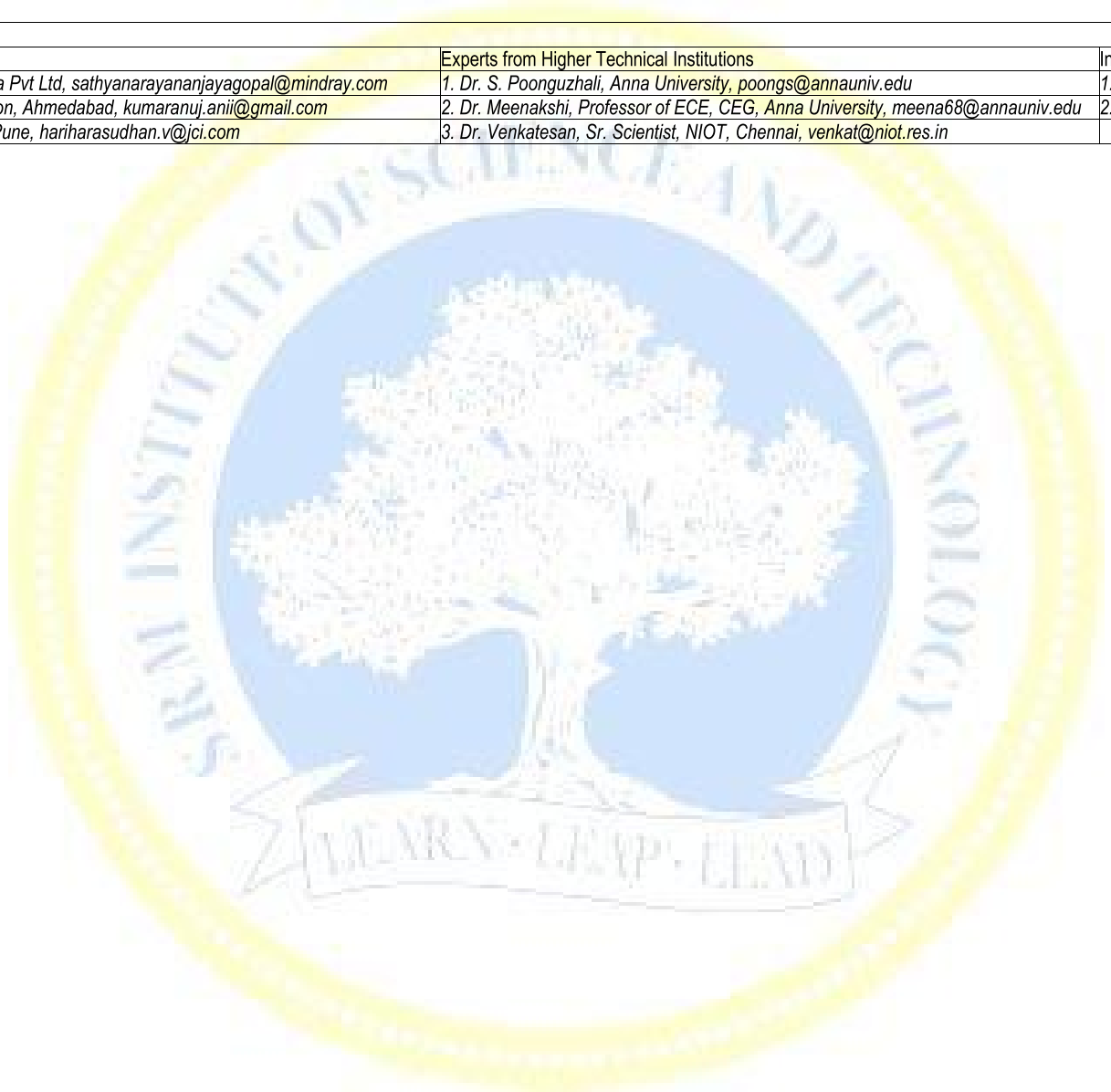

Course Code	18ECE368T	Course Name	Biomedical Laser Instruments	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Learn the optical characteristics of tissue			
CLR-2 :	Know the functioning of a laser system			
CLR-3 :	Familiarise the applications of laser in ophthalmology, Dermatology and cardiology			
CLR-4 :	Familiarise the applications of laser in Urology, Gynecology and dentistry			
CLR-5 :	Learn the non- thermal applications of laser in medicine			
CLR-6 :	Acquire knowledge on laser safety and management			

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 :	Describe the optical properties of tissues	3	80	75
CLO-2 :	Have a deep understanding on technical aspects of a LASER system	3	80	70
CLO-3 :	Describe the applications of laser in ophthalmology, Dermatology and cardiology	3	75	70
CLO-4 :	Describe the applications of laser in Urology, Gynecology and dentistry	3	80	75
CLO-5 :	Explain the non- thermal applications of laser in medicine	3	80	70
CLO-6 :	Implement the aspects of laser safety	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	PSO - 2	PSO – 3
CLO-1 :	Describe the optical properties of tissues	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLO-2 :	Have a deep understanding on technical aspects of a LASER system	M	-	-	-	-	-	-	-	-	-	-	-	M	-	-
CLO-3 :	Describe the applications of laser in ophthalmology, Dermatology and cardiology	-	M	-	-	-	-	-	-	-	-	-	-		M	
CLO-4 :	Describe the applications of laser in Urology, Gynecology and dentistry	-	M	-	-	-	-	-	-	-	-	-	-	M		
CLO-5 :	Explain the non- thermal applications of laser in medicine	-	-M	-	-	-	-	-	-	-	-	-	-	M		
CLO-6 :	Implement the aspects of laser safety	-	-	-	-	-	-	-	M	-	-	-	-	L		

Duration (hour)		Optical properties of the tissues	Laser System	Laser Applications-I	Laser Applications-II	Non Thermal Applications of LASER and Laser safety management
		9	9	9	9	9
S-1	SLO-1	Fundamental Properties of light - Refraction, Reflection, Laws (Snell's law and Fresnel law)	Characteristics of Laser	Disorders in Eye	Lasers in urology- Lithotripsy	Optical coherence tomography-System description
	SLO-2					
S-2	SLO-1	Scattering, Absorption characteristics	Construction and working principle of laser system	Diagnostic Applications of laser in ophthalmology	Therapeutic applications of Lasers in urology	Applications of Optical coherence tomography
	SLO-2					
S-3	SLO-1	Light transport inside the tissue	Pumping Schemes	Therapeutic Applications of laser in ophthalmology	Laproscopy- System description	Elastography
	SLO-2					
S-4	SLO-1	Tissue properties	Classification of Laser	Dermatological disorders	Applications of laser in Gynecology	Laser Induced Fluorescence (LIF)-Imaging,
	SLO-2					
S-5	SLO-1	Laser Characteristics as applied to medicine and biology,	Solid state Laser - Construction and working principle	Applications of Lasers in dermatology	Applications of laser in Gynecology	FLIM Raman Spectroscopy and Imaging
	SLO-2					
S-6	SLO-1	Laser tissue Interactions – Photo chemical, Photo thermal and Photo mechanical interactions	Atomic laser- Construction and working principle	Diagnostic Applications of Lasers in cardiology	Applications of laser in laryngeal surgery	FLIM – Holographic and speckle application of lasers in biology and medicine
	SLO-2					
S-7	SLO-1	Fluorescence and Speckles	Molecular Laser- Construction and working principle	Therapeutic Applications of Lasers in cardiology	Applications of laser in Otology	Types of laser hazards
	SLO-2					
S-8	SLO-1	Alterations of bio tissue properties during hyper thermal and ablation reactions	Dye Laser - Construction and working principle	Lasers in Surgery	Applications of laser in neurology	Laser safety
	SLO-2					

S-9	SLO-1	*Photodynamic therapy - Principle and mechanism*	*Semiconductor Laser- Construction and working principle*	*Tissue welding and Soldering*	*Applications of Lasers in dentistry*	*Laser risk management,*
	SLO-2					

Learning Resources	1. *Leon Goldman, M.D., & R.James Rockwell, Jr., Lasers in Medicine, Gordon and Breach Science Publishers Inc., 1975.* 2. *Abraham Katzir, Lasers and Optical Fibers in Medicine, Academic Press Edition,1998.*	3. *Tuan Vo Dirh, Biomedical Photonics – Handbook, CRC Press, Bocaraton, 2003.* 4. *Glasser, O., Medical Physics -- Vol 1, 2, 3 Adam Hilgar Brustol Inc, 1987.* 5. *G.David Baxter, Therapeutic Lasers – Theory and practice, Churchill Livingstone 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.,

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

Course Code	18ECE369T	Course Name	HOME MEDICARE TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	Understanding the Home health Nursing practice			
CLR-2 :	Explaining the homecare care working with different clients			
CLR-3 :	Demonstrating the various medical devices used at home			
CLR-4 :	Highlighting the advancement in medical technologies			
CLR-5 :	Visualizing the use of wireless technology in health care			
CLR-6 :	Classifying the various mode of healthcare technology at home			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Applying Home health Nursing practice	3	80	75
CLO-2 :	Illustrate the homecare care working with different clients	3	80	70
CLO-3 :	Analyze the various medical devices used at home	3	75	70
CLO-4 :	Identify the advancement in medical health technologies	3	80	75
CLO-5 :	Analyze the use of wireless technology in health care	3	80	70
CLO-6 :	Describe the various type of healthcare technology at home	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	PSO - 2	PSO – 3
CLO-1 :	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-4 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-6 :	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		Introduction to Home health Nursing	Working With Clients	Medical Devices At Home	Advancement In Medical Technologies	Wireless Technology
		9	9	9	9	9
S-1	SLO-1	Home health care – purpose	Basic human needs	Medical devices at home	Advances and trends in health care technologies	Wireless communication basics
	SLO-2	Historical perspective	Communication and interpersonal skills	Medical devices at home	Advances and trends in health care technologies	Wireless communication basics
S-2	SLO-1	Understanding Home heathcare:Applying Theory to clinical practice	Caregiver observation	User centered design and Implementation	Driver impacting the growth of medical Technologies	Types of wireless network
	SLO-2	Role preparation and implementation	Caregiver observation	User centered design and Implementation	Driver impacting the growth of medical Technologies	Types of wireless network
S-3	SLO-1	Developing the plan of care and documentation	Recording and reporting, confidentiality	Co-design with old users	Impact of Moore"s law of medical imaging	Body area network
	SLO-2	Legal and ethical issues in home care	Recording and reporting, confidentiality	Co-design with old users	Impact of Moore"s law of medical imaging	Body area network
S-4	SLO-1	Case management and leadership strategies	Working with elderly – aging and body systems.	Device types – user issues.	E-health and personal healthcare	Emergency rescue
	SLO-2	Organisation of home care system	Working with elderly – aging and body systems.	Device types – user issues.	E-health and personal healthcare	Emergency rescue
S-5	SLO-1	Home care organisation	Working with children	Ethical and legal issues. Infant monitors	Defining the future of health Technology	Remote recovery
	SLO-2	Home care nursing practice	Working with children	Ethical and legal issues. Infant monitors	Defining the future of health Technology	Remote recovery
S-6	SLO-1	Home care nursing practice	Need for home care	Medical alert services	Inventing the future -tools for self-health	General health assessments Technology

						in medical information processing
	SLO-2	*Role of home care nurse and orientation strategies*	*Need for home care.*	*Medical alert services*	*Inventing the future -tools for self-health*	*General health assessments Technology in medical information processing*
S-7	SLO-1	*Environmental influences on home care*	*Mobility transfers and ambulation*	*Activity monitors*	*Future of Nano fabrication molecular scale devices*	*Future trends in healthcare technology*
	SLO-2	*Environmental influences on home care*	*Mobility transfers and ambulation*	*Activity monitors*	*Future of Nano fabrication molecular scale devices*	*Future trends in healthcare technology*
S-8	SLO-1	*Infection control in home*	*Range of motion exercises*	*The ventilator dependent patient*	*Future of telemedicine*	*Paradoxes of progress: Implications for home health care*
	SLO-2	*Infection control in home*	*Range of motion exercises*	*Device for patient with congestive heart failure*	*Future of telemedicine*	*Paradoxes of progress: Implications for home health care*
S-9	SLO-1	*Patient education in home*	*Skin care and comfort measures*	*Device for Patient with chronic Obstructive pulmonary disease*	*Future of medical computing*	*Cost of home healthcare*
	SLO-2	*Patient education in home*	*Skin care and comfort measures*	*Device for patient with Diabetic*	*Future of medical computing*	*Direction for emerging technology*

Learning Resources	1. *Robyn Rice, "Home care nursing practice: Concepts and Application", 4th edition, Elsevier, 2006.* 2. *LodewijkBos, "Handbook of Digital Homecare: Successes and Failures", Springer, 2011.*	3. Yadin David, Wolf W. von Maltzahn, Michael R. Neuman, Joseph. D, Bronzino,"Clinical Engineering", CRC Press, 2010. 4. Kenneth J. Turner, "Advances in Home Care Technologies: Results of the match Project", Springer, 2011.

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

Course Code	18ECE460T	Course Name	ACOUSTICS AND OPTICAL IMAGING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	To study in-depth the various optical properties of tissues and light interactions with tissues			
CLR-2 :	To study about various optical sources and instrumentation for various measurements			
CLR-3 :	To study about photonic detection and imaging techniques			
CLR-4 :	To understand the special techniques like optical holography			
CLR-5 :	To make them understand the working principles of optical imaging systems			
CLR-6 :	To Utilize the imaging techniques for various applications			

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	Analyze in-depth about the various optical properties of tissues and light interactions with tissues	3	80	75
CLO-2 :	Illustrate the hardware and techniques involved in acoustic imaging	3	80	70
CLO-3 :	Describe the optical properties of tissues	3	75	70
CLO-4 :	Analyze the physics behind optical holography	3	80	75
CLO-5 :	Identify the principle behind modern imaging techniques	3	80	70
CLO-6 :	Apply the imaging modality for interpretation	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	PSO - 2	PSO – 3
CLO-1 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-2 :	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-3 :	L	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-4 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-5 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L
CLO-6 :	M	-	-	-	-	-	-	-	-	-	-	-	L	-	L

Duration (hour)		PHYSICS OF ACOUSTICS	ACOUSTIC IMAGING	OPTICAL PROPERTIES OF TISSUES	OPTICAL HOLOGRAPHY	PHOTONIC DETECTION AND IMAGING TECHNIQUES
		9	9	9	9	9
S-1	SLO-1	The sine wave , sound in media-particle motion	Fundamentals of photo acoustic tomography	Fundamental Optical Properties	Fundamentals – Object wave	Life time based imaging
	SLO-2	Propagation of sound	Photo acoustic effect	Refraction, scattering, absorption	Photography	Techniques for Lifetime-Based Imaging
S-2	SLO-1	Speed of sound - wavelength and frequency	Image reconstruction methods	Light Transport in Tissue	Holography	Specifics of FLIM Data Analysis
	SLO-2	Complex waves- harmonics	Instrumentation	Numerical Approach: Monte Carlo Simulations	Interference during recording	Selected FLIM Applications
S-3	SLO-1	Phase, partials ,octaves, spectrum	Transducer array	Kubelka–Munk Model	Diffraction during reconstruction	Confocal microscopy
	SLO-2	Electrical, mechanical and acoustic analogs	Transducer array-based photoacoustic tomography	Tissue Properties	Imaging techniques –In line hologram	Image Formation in Scanning Microscopes
S-4	SLO-1	Wave phenomenon	Array-based PAT System	Refractive Indices	Off axis hologram, fourier hologram	Applications of Depth Discrimination
	SLO-2	Wavefronts, Interference,	2-D Imaging	Scattering Properties	Fraunhofer hologram, reflection hologram	Fluorescence Microscopy
S-5	SLO-1	Reflection, scattering	3-D Imaging	Absorption Properties	Optical properties of holographic imaging	Optical Architectures
	SLO-2	Diffraction, refraction	4-D Imaging	Light Interactions with a Strongly Scattering Tissue	Hologram of an object	Abberation Correction
S-6	SLO-1	Doppler effect , convection	Photoacoustic microscopy	Continuous Wave Light , Polarized Light,• Short Light Pulses, Diffuse Photon-Density Waves	Image equation, angular magnification	Near-Field Optical Microscopy

	SLO-2	*Sound levels and decibel: ratios versus differences*	*Computed microscopy*	*Optothermal Interactions*	*Longitudinal magnification, image aberrations*	*Biological Applications of Near-Field Optical Microscopy*
S-7	SLO-1	*Logarithms , decibels, reference levels*	*Optical-resolution*	*Temperature Rise and Tissue Damage ,*	*Properties of light source -spectral bandwidth*	*Special Near-Field Techniques for Biological Applications*
	SLO-2	*Logarithmic and exponential forms compared*	*Acoustic-resolution*	*Optothermal and Optoacoustic Effects*	*Image plane holograms*	*Principles of Operation of Optical Coherence Tomography*
S-8	SLO-1	*Acoustic power*	*C-scan photoacoustic Microscopy*	*Fluorescence*	*Image luminance- without pupil*	*Applications of Optical Coherence Tomography*
	SLO-2	*Measuring sound pressure level*	*Photoacoustic computed microscopy*	*Formation of Speckles*	*With pupil, image plane holograms*	*Thermal imaging for biological and medical diagnosis*
S-9	SLO-1	*Sine wave measurement*	*Photoacoustic microscopy based on acoustic lens with variable focal length*	*Detectors: solid state detectors*	*Speckles- diffuser*	*Infrared Radiation and Thermal Imaging*
	SLO-2	*Examples*	*Confocal photoacoustic microscopy using a single multifunctional Lens*	*Time resolved and phase resolved detectors*	*Resolution, incoherent illumination*	*Applications of Infrared Thermal Imaging*

Learning Resources	1. *F. Alton Everest, Ken Pohlmann , "Master Handbook of Acoustics" McGraw-Hill, sixth edition, 2014* 2. *Huabei Jiang, "Photoacoustic Tomography" CRC press, Taylor & Francis Group,first edition, 2015.* 3. *Jose Luís del Cura, Pedro Seguí, Carlos Nicolau, "Learning Ultrasound Imaging"springer,first edition 2012.*	4. *Peter R. Hoskins, Kevin Martin, Abigail Thrush, "Diagnostic Ultrasound: Physics and Equipment", Cambridge university press,second edition, 2010* 5. *Gerhard K. Ackermann, Jürgen Eichler, "Holography: A Practical Approach", WILEY-VCH Verlag GmbH & Co, first edition, 2008.* 6. *Tuan Vo Dirh, "Biomedical photonics – Handbook", CRC Press, second 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	*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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Course Code	18ECE461T	Course Name	MACHINE VISION IN MEDICAL TECHNOLOGY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:	Learning
CLR-1 :	Utilize the types and concepts of machine vision	
CLR-2 :	Utilize the techniques involved in motion analysis	
CLR-3 :	Utilize the properties and techniques in 3D reconstruction	
CLR-4 :	Utilize the algorithm behind different methods of photogrammetry	
CLR-5 :	Applying the machine vision techniques to medical applications	
CLR-6 :	Utilize the numerical techniques for various medical applications	

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)
CLO-1 :	Familiarize with the machine vision and its problems	3	80	75
CLO-2 :	Explain the applications of differential vision and motion analysis	3	80	70
CLO-3 :	Describe and understand the concept of three dimensional reconstruction	3	75	70
CLO-4 :	Use stereo vision techniques and optical flow methods to study imaging techniques	3	80	75
CLO-5 :	Use contemporary numerical and simulation tools to implement methods and algorithms	3	80	70
CLO-6 :	Apply the machine vision in medical technology	3	80	70

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

Duration (hour)		Machine Learning For Machine Vision	Visualizing Of Objects In Motion	3D Reconstruction –Basics And Methods	Photogrammetry And Stereo Methods	Applying Computational Vision
		9	9	9	9	9
S-1	SLO-1	Learning and inference in vision	Two-frame structure	2D and 3D feature-based alignment	Photometric calibration	Automated Visual Inspection
	SLO-2	Human Vision	Two-frame structure from motion	Correlating 2D and 3D	Noise level estimation	Automated Visual Inspection with CT image
S-2	SLO-1	Geometric primitives	Perspective and projective factorization	Shape from texture	High dynamic range imaging	Computer Vision in Interventional Cardiology
	SLO-2	2D and 3D transformations	Constrained structure and motion	Shape from shading and photometric stereo	Optical blur (spatial response) estimation	Computer Vision using CT image
S-3	SLO-1	Photometric image formation	Dense motion estimation- Definition	Shape from focus	Super-resolution	Fusion of three dimensional quantitative coronary angiography and intracoronary imaging for coronary interventions
	SLO-2	Global optimization	Dense motion estimation	Active range finding	Blur removal	Merging Two image
S-4	SLO-1	Low level vision : Definition , example	Parametric motion	Surface representations	Image matting and compositing	Feature centric lesion detection and retrieval in thoracic images
	SLO-2	Classical filtering operations	Parametric motion- application in analysis	Interpolation, simplification	Optimization-based matting	Algorithm for retrieval
S-5	SLO-1	Edge detection: sobel	Motion models-Definitions	Point-based representation-Definition	Texture analysis and synthesis	Colorization of image after retrieval
	SLO-2	Geometric intrinsic calibration	Motion models-application	Point-based representations -Examples	Hole filling and inpainting	False coloring
S-6	SLO-1	Middle level: Definition , example	The Geometry of multiple views	Volumetric representations	Epipolar geometry	Medical image registration
	SLO-2	Segmentation by clustering	Affine structure from motion	Implicit surfaces and level sets	Rectification	For thermal image & digital image
S-7	SLO-1	Hough Transform	Elements of Affine Geometry	Model-based reconstruction	Sparse correspondence	Z-keying and background replacement

	SLO-2	*Case study: Human Iris location*	*Affine structure and motion from two images*	*Heads and faces*	*3D curves and profiles*	*In registered image*
S-8	SLO-1	*High level: Definition , example*	*Affine structure and motion from multiple images*	*Application: Facial animation*	*Dense correspondence*	*Volumetric and 3D surface reconstruction*
	SLO-2	*Model based vision*	*Application to Gait analysis*	*Whole body modeling and tracking*	*Sub-pixel estimation and uncertainty*	*Shape from silhouettes*
S-9	SLO-1	*Regression model- definition*	*Image Stitching - Concept*	*Rendering- Layered depth images*	*Multi-view stereo*	*Video denoising*
	SLO-2	*Graphical model*	*Image Stitching – Application*	*Light fields and Lumigraphs – 3D*	*Shape from silhouettes*	*Video denoising for live endoscopic images*

Learning Resources	1. *Richard Szeliski ,"Computer Vision: Algorithms and Applications", Springer, 2010* 2. *E R Davies , "Computer & Machine Vision : Theory , Algorithms, Practicalities" 4th Edition , Elsevier, 2012* 3. *Computer vision – A modern Approach, David A Forsyth & Jean ponce, Prentice Hall, 2002.*	4. *Milan Sonka ,Vaclav Hlavac, Roger Boyle, "Image processing, analysis and and machine vision" (3. ed.)., 2008* 5. *Chi Hau Chen , "Computer Vision in Medical Imaging"- Series in Computer Vision – Vol 2, World Scientific Publishing Co Ltd, 2014*

Learning Assessment											
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		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*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 %*	

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2. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*2. Dr. 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	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the need for 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*	*Radar, Radiation type*	*Electrical Type Flow meters-Principle*	*Three lead and four lead RTDs.*

			Gauge			
	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	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. 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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Analyze and mathematically model the process systems*	*3*	*80*	*75*
CLO-2 :	*Select and optimize the tuning of a controller*	*3*	*80*	*70*
CLO-3 :	*Demonstrate the working and application of different type of actuators and control valves*	*3*	*75*	*70*
CLO-4 :	*Understand and analyze the various advanced control schemes*	*3*	*80*	*75*
CLO-5 :	*Design suitable digital controllers for the process*	*3*	*80*	*70*
CLO-6 :	*Recommend the right choice of control schemes for the 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	PSO - 2	PSO – 3
H	*H*	*M*	*H*	*H*	-	-	*H*	*H*	-	*H*	*H*	*M*	*L*	*L*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	*H*	*H*	*H*	*L*	*L*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	*H*	*H*	*H*	*M*	*L*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	*H*	*H*	*H*	*M*	*H*
H	*H*	*H*	*M*	*H*	-	-	*H*	*H*	-	*H*	*H*	*H*	*H*	*H*
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*	*Lab14:Design the Deadbeat algorithm for the given system using MATLAB*
	SLO-2					

					ZN open loop method	
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	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
	SLO-2					

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	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. 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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Know and design various conventional compensators.*			
CLR-2 :	*Know and develop mathematical modeling using state space technique.*			
CLR-3 :	*Know and analyze the system using state space analysis techniques.*			
CLR-4 :	*Know the importance of structural properties and to analyze the stability of the system.*			
CLR-5 :	*Study the state space control methodologies for various systems.*			
CLR-6 :	*Know and design modern control techniques which are linear.*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Design cascade compensators in time domain and design PID controllers in time domain.*	*3*	*80*	*75*
CLO-2 :	*Understand and develop state space model for different systems*	*3*	*80*	*70*
CLO-3 :	*Analyze the controllability and observability of a system and to design controllers and observers.*	*3*	*75*	*70*
CLO-4 :	*Implement procedure to find the structural properties of any linear system*	*3*	*80*	*75*
CLO-5 :	*Understand the procedure of applying the control methodology on various linear systems*	*3*	*80*	*70*
CLO-6 :	*Design and apply linear based modeling and modern control methods for different linear systems.*	*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	PSO - 2	PSO – 3
H	*H*	*H*	-	*L*	-	-	*H*	-	-	-	*H*	*H*	-	*H*
H	*L*	*H*	-	*H*	-	-	*H*	-	-	-	-	*M*	-	*H*
H	*H*	-	*H*	*H*	-	-	*H*	-	-	-	-	*M*	-	*H*
H	*H*		*H*	*H*	-	-	*H*	-	-	-	-	*M*	-	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	-	-	-	*H*	*M*	-	*H*
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-*	*State space representation of discrete*			

		lag by using time domain	*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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	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	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	*L*	-	-	-	-	-	-	*L*	-	-	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	*M*	-	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	*M*	-	*H*	*H*	*H*	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	*M*	-	*H*	*H*	*H*	*H*
H	*H*	-	*H*	*H*	-	-	-	*H*	*H*	-	*H*	*M*	*H*	*H*
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	*Lab1: PLC Wiring*	*Lab 4: Traffic light control system*	*Lab 7: HMI Programming*	*Lab10: Lift control*	*Lab13: Electro pneumatic direction control*
	SLO-2					
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	*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*
	SLO-2					
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*	*Problems*	*Other Word-Level Math Instructions*	

			Ladder Programs			
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	*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. 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:*	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 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:*	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
					Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Identify the 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	*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*
	SLO-2					
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*	*Waveform Generator*

					Criteria,	
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	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. D. Nedumaran, Madras University, dnmaran@gmail.com	

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

			INDUSTRIES				3	0	0	3

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the basics of petrochemical industries.*	*3*	*80*	*75*
CLO-2 :	*Apply knowledge in working of various instruments that are used in iron and steel industries.*	*3*	*80*	*70*
CLO-3 :	*Acquire the knowledge of analyzers and measurement of density, level in paper industries.*	*3*	*75*	*70*
CLO-4 :	*Understand the operation of boiler in thermal industries.*	*3*	*80*	*75*
CLO-5 :	Understand the process safety in chemical industries.	*3*	*80*	*70*
CLO-6 :	*Apply the knowledge of process hazards in industries.*	*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	PSO - 2	PSO – 3
H	-	-	-	-	-	-	-	*H*	-	-	*H*	*H*	-	-
H	*H*	-	-	-	-	-	*H*	*H*	-	-	*H*	*H*	-	*H*
H	*H*	*M*	-	-	-	-	*H*	*H*	-	-	*H*	*H*	*H*	*H*
H	*H*	*M*	*H*	-	-	-	*H*	*H*	-	-	*H*	*H*	*H*	*H*
H	*H*	*M*	*H*	-	*H*	-	-	*H*	-	-	*H*	*M*	*M*	*H*
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*	*Dryer temperature control.*	*Use of feed forward and cascade control*	*Safety performance measurement tools*

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

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

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

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

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

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

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

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

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the elements of SCADA system*	*3*	*80*	*75*
CLO-2 :	*Develop any application based on SCADA along with GUI using SCADA software.*	*3*	*80*	*70*
CLO-3 :	*Understand evolution and architecture of DCS and hierarchical control in DCS*	*3*	*75*	*70*
CLO-4 :	*Demonstrate interfacing of hardware and software of computer based automation system.*	*3*	*80*	*75*
CLO-5 :	*Select and use the most appropriate automation technologies for a given application*	*3*	*80*	*70*
CLO-6 :	*Evaluate computer based automation system used in industries ranging from discrete, continuous process to hybrid processes.*	*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	PSO - 2	PSO – 3
H	-	-	-	-	*H*	-	-	-	-	-	*H*	*M*	*H*	-
H	-	-	-	-	*H*	-	-	-	-	*H*	*H*	-	*H*	-
H	*H*	*M*	*H*	*M*	*H*	-	*M*	*M*	-	*H*	*H*	*H*	*H*	*H*
H	*H*	*M*	*H*	*M*	-	-	*M*	*H*	-	*H*	*H*	*M*	*H*	*H*
H	-	*M*	-	*H*	-	-	*H*	*H*	-	*H*	*H*	*M*	*H*	*H*
H	-	-	-	-	*H*	-	*H*	*H*	-	*H*	*H*	*H*	*H*	*H*

Duration (hour)		SCADA Elements	Communication	DCS Architecture	Operator interface	DCS Application
		9	9	9	9	9
S-1	SLO-1	*SCADA basics introduction*	*SCADA Communication introduction*	*DCS - basics*	*DCS operator interfaces- introduction*	*DCS Application in Power plant*
	SLO-2	*Elements of SCADA*	*Communication system components*	*Evolution of Distributed Control System*	*Operator Interface Requirements*	*Automation strategy*
S-2	SLO-1	*Functionality of SCADA*	*Structure of a SCADA Communications Protocol*	*DCS Architecture*	*Low-level Operator Interface*	*Distributed system structure*
	SLO-2	*Process example*	*Field/RTU Communication*	*Local control unit*	*Continuous control station*	*Application functions*
S-3	SLO-1	*History of SCADA*	*Analog electronic controllers*	*I/O module(Analog & Digital)*	*Manual Loader Station*	*DCS Application in cement plant*
	SLO-2	*Development from Telemetry*	*Communication Topology*	*Basic elements*	*Indicator/Logic Station*	*System architecture*
S-4	SLO-1	*Key features*	*RTU/MTU Communication*	*Architectural parameters*	*Smart annunciators*	*DCS Application in iron plant*
	SLO-2	*Real time systems*	*System components*	*Types of architecture*	*High level Operator interface*	*System architecture*
S-5	SLO-1	*Analog signals measurement*	*Communication Protocols*	*CPU, Memory*	*Architectural Models*	*DCS Application in steel plant*
	SLO-2	*Control techniques*	*Operator interface*	*Local control unit languages*	*Hardware Elements*	*System architecture*
S-6	SLO-1	*Discrete signals measurement*	*Monitoring alarms*	*Language requirements*	*Operator displays*	*DCS Application in Paper and pulp industry*
	SLO-2	*Control techniques*	*Status points*	*Functional blocks*	*Engineering interface- Introduction*	*System architecture*
S-7	SLO-1	*Remote terminal unit*	*Control interfacing*	*Problem-oriented languages*	*System configuration requirements*	*DCS Application in petroleum-refining industry*
	SLO-2	*Analog and Discrete control*	*Parallel operator interface*	*High-level languages*	*Diagnosis of System Problems*	
S-8	SLO-1	*Monitoring signals*	*SCADA Development for any one typical application*	*Process interfacing issues*	*Low-level engineering interface*	*DCS Application in oil and gas processing industry.*
	SLO-2	*Master terminal unit*		*Security design issues*	*System configuration*	
S-9	SLO-1	*Process configuration*	*Programming for GUI development using SCADA software*	*Process input/output design issues*	*High-level engineering interface*	*DCS Application in water treatment plant*
	SLO-2	*Applications*		*Remote I/O and Communication*	*System configuration*	*System architecture*

				modules		

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

Learning Assessment

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

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

Course Designers		
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. 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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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:*			
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	PSO - 2	PSO – 3
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*	*Cordinators*
	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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Apply mathematical knowledge, science, engineering fundamentals to design circuits pertaining to various process measurements*	*3*	*80*	*75*
CLO-2 :	*Design signal conditioning circuits for various process parameters.*	*3*	*80*	*70*
CLO-3 :	*Optimize the performance of process output.*	*3*	*75*	*70*
CLO-4 :	*Select optimal sensor for process measurement.*	*3*	*80*	*75*
CLO-5 :	*Choose type of indication circuits for industry.*	*3*	*80*	*70*
CLO-6 :	*Analyze and select the suitable sensing and transduction unit.*	*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	PSO - 2	PSO – 3
CLO-1 :	*H*	*H*	*H*	*M*	-	-	-	-	-	-	-	*M*	*H*	-	-
CLO-2 :	*H*	*H*	-	*M*	*H*	-	-	-	*H*	-	*L*	-	*M*	*M*	*H*
CLO-3 :	*H*	-	*M*	*M*	*M*	-	*H*	*M*	-	-	-	-	-	-	*M*
CLO-4 :	*H*	*M*	-	*M*	-	*M*	*M*	-	-	-	-	-	-	*M*	-
CLO-5 :	*H*	-	*H*	-	-	-	*M*	-	*H*	*M*	-	-	*H*	-	*L*
CLO-6 :	*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*	*Lab 5: Design of V/I and I/V converter.*	*Lab 8: Development of Software Program*	*Lab11: Design of multi channel data*	*Lab 14: Functional constraints and*

	SLO-2	*Amplifier.*		*for sizing Rotameter.*	*acquisition system*	*specification in industry*
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 SLO-2	*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*

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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLR-1 :	*Educate on the basic concepts of data networks*			
CLR-2 :	*Introduce the basics of inter-networking and serial Communications*			
CLR-3 :	*Provide details on HART and Field buses*			
CLR-4 :	*Know different techniques on Modbus, PROFIBUS and other Communication protocols*			
CLR-5 :	*Present an overview of industrial Ethernet*			
CLR-6 :	*Study the working of computer busses and protocols*			

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Understand the basic concepts of data networks*	*3*	*80*	*75*
CLO-2 :	*Analyze the techniques of inter-networking and serial Communications*	*3*	*80*	*70*
CLO-3 :	*Understand the protocols and layers of HART and field bus*	*3*	*75*	*70*
CLO-4 :	*Analyze the techniques of MODBUS, PROFIBUS and other Communication protocol*	*3*	*80*	*75*
CLO-5 :	*Utilize the concept of industrial Ethernet*	*3*	*80*	*70*
CLO-6 :	*Analyze the working of computer busses and protocols*	*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	PSO - 2	PSO – 3
H	*H*	-	-	*M*	*H*	-	-	-	-	-	*H*	*H*	-	*H*
H	-	-	*H*	-	*H*	-	-	-	-	-	*H*	-	*M*	*H*
H	-	*M*	*H*	*M*	*H*	-	*H*	-	*H*	*M*	*H*	*M*	*H*	*H*
H	*H*	*M*	*H*	*M*	-	-	*H*	*H*	*H*	*H*	*H*	-	*H*	*H*
H	-	*M*	-	*H*	-	-	*H*	-	*H*	*H*	*H*	*H*	*H*	*H*
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	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. *Lan 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	*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.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:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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:*			
CLO-1 :	*Understand the basic concepts of IoT, Architecture and Its Applications*	*3*	*85*	*80*
CLO-2 :	*Analyze the techniques to apply IoT for Industry*	*3*	*85*	*75*
CLO-3 :	*Apply the knowledge of different techniques of IoT in industry with an advanced platform of Industry 4.0*	*3*	*80*	*80*
CLO-4 :	*Develop the knowledge of IoT in Automation.*	*3*	*85*	*80*
CLO-5 :	*Apply the knowledge of Engineering in IoT Automation System*	*3*	*80*	*75*
CLO-6 :	*Design the IoT based real-time projects*	*3*	*85*	*85*

Program Learning Outcomes (PLO)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
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*
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	*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. Y.RajaaVikhram, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. Joselin Retna Kumar, SRMIST*

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

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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	PSO - 2	PSO – 3
H	*H*	-	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*M*	-	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*M*	-	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*M*	-	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*M*	-	*H*
H	*H*	*H*	*H*	*H*	-	-	*H*	*H*	-	-	*H*	*M*	-	*H*
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*	*Types of converters*

					Microarray Concepts	
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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2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. D. Nedumaran, Madras University, dnmaran@gmail.com*	*2. Dr. A. Vimala Juliet, SRMIST*

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

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning		
		1	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
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	2	3
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)
CLO-1 :	*Appreciate the importance of sensors and actuators based on MEMS technology*	*3*	*80*	*75*
CLO-2 :	*Understand the fabrication and machining techniques of MEMS devices*	*3*	*80*	*70*
CLO-3 :	*Familiarize with the concepts of packaging and interfaces in MEMS devices*	*3*	*75*	*70*
CLO-4 :	*Appreciate the significance of general micro fabrication processes*	*3*	*80*	*75*
CLO-5 :	*Differentiate between the working principle of various micro sensors*	*3*	*80*	*70*
CLO-6 :	*Analyze recently developed smart devices employing MEMS technology*	*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	PSO - 2	PSO – 3
CLO-1 :	*Appreciate the importance of sensors and actuators based on MEMS technology*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	*H*	-	*H*
CLO-2 :	*Understand the fabrication and machining techniques of MEMS devices*	*H*	-	-	-	-	*H*	-	-	-	-	-	*H*	-	-	*H*
CLO-3 :	*Familiarize with the concepts of packaging and interfaces in MEMS devices*	*H*	*H*	*M*	*H*	*M*	*H*	-	-	-	-	-	*H*	*H*	-	*H*
CLO-4 :	*Appreciate the significance of general micro fabrication processes*	*H*	*H*	*M*	*H*	*M*	-	-	-	*H*	-	-	*H*	-	-	*H*
CLO-5 :	*Differentiate between the working principle of various micro sensors*	*H*	-	*M*	-	*H*	-	-	-	-	-	-	*H*	-	-	*H*
CLO-6 :	*Analyze recently developed smart devices employing MEMS technology*	*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*	*Significance & 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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