ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 16
(Syllabi for Electronics and Instrumentation Engineering Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Contents (Volume - 16)

Syllabi for Higher Semester (3 - 8) EIE Courses

ACADEMIC CURRICULA

Engineering Science Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIS204T	Course Name	INDUSTRIAL DATA COMMUNICATION	Course Category	S	ENGINEERING SCIENCE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basics of inter-networking and serial communication*
CLR-2:	*know the operation of MODBUS and HART*
CLR-3:	*impart knowledge on Field bus and PROFIBUS*
CLR-4:	*introduce the concept of different communication protocol such as AS–INTERFACE, Device Net and industrial Ethernet*
CLR-5:	*provide insight into the wireless communication*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the various inter-networking parameters and serial communication*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*illustrate the different types of communication modes such as MODBUS and HART*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the various types of network devices for Fieldbus and PROFIBUS*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*identify the different communication protocol such as AS–INTERFACE, DeviceNet and industrial Ethernet*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*explain the concept of wireless communication*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Communication Concepts	***9 Hour***
Introduction to analog communication and digital communication - Introduction to serial and parallel transmission, data organization - Communications codes, error coding, protocol concepts, ISO OSI model, internet model, IEEE 802 model - Universal serial bus - LAN model, topologies, 802 and industrial LANs, wireless LANS, IEEE 802 Medium Access Control, industrial token passing, logical link control, TCP/IP protocol - Electrical devices interfaces protocol- IEC61850	
Unit-2 - Modbus and Hart	***9 Hour***
Evolution of industrial data communication standards - MODBUS - Protocol structure, function codes - HART communication protocol, communication modes - HART networks, HART commands, HART applications and troubleshooting	
Unit-3 - Field Bus and Profibus	***9 Hour***
Fieldbus introduction, architecture, basic requirements of fieldbus standard, fieldbus topology, interoperability and interchangeability – Introduction – Profibus protocol stack – Profibus communication model - Communication objects - Foundation fieldbus, versus profibus	
Unit-4 - AS–Interface (AS-I), Devicenet and Industrial Ethernet	***9 Hour***
AS interface- Introduction – Physical layer – Data link layer – Operating characteristics – DeviceNet – Introduction – Physical layer - Data link layer and application layer - Industrial Ethernet-Introduction - 10Mbps ethernet - 100Mbps ethernet - Gigabit ethernet	
Unit-5 - Wireless Communication	***9 Hour***
Wireless sensor networks: Hardware components – Energy consumption of sensor nodes – Network architecture – Sensor network scenario - Wireless MAC standards – IEEE 802.11 - IEEE 802.15.4 – Zigbee wireless HART – Wireless standard for process industry – ISA100 –Introduction to industrial IoT	

Learning Resources	1. *Lawrence Larry, M., "Thompson, Industrial Data Communications",ISA books, 4th ed., 2008.* 2. *William Buchanan, "Computer Buses", CRC Press, 2000.* 3. *William Stallings, "Wireless Communication & Networks", Prentice Hall of India, 2nd ed., 2005.*	4. *Andrew S. Tanenbaum, David J. Wetherall, "Computer Networks, Prentice Hall of India Pvt. Ltd., 5th ed., 2011* 5. *Steve Mackay, Edwin Wrijut, Deon Reynders, John Park, "Networks Design, Installation and Troubleshooting" Newnes Publication, Elsevier 1st ed., 2004*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K. Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. Vibha K, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIC201J	Course Name	DIGITAL PRINCIPLES AND SYSTEM DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart the basics of digital systems*
CLR-2:	*understand the process of design in combinational logic circuits*
CLR-3:	*gain the skills to design synchronous and asynchronous sequential logic circuits*
CLR-4:	*explore the different logic functions using transistor and MOSFET*
CLR-5:	*introduce the digital application with logical circuits*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply fundamentals of number systems to simplify and realize logical expression*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*design combinational logic digital circuits*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*compare synchronous and asynchronous circuit using logic circuits*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*design digital circuits for various applications*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*develop digital circuit using PLA, PAL, PROM*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Introduction to Digital Design ***15 Hour***

Identify digital IC and some common packages- Timing diagram and its purpose - Review of number systems - Boolean algebra and rules –simplification of boolean functions-Minterm, canonical SOP form, Maxterms, Canonical POS form -Simplification of switching function using K maps-Quine-McCluskey

Practice:

1. Simplification of switching function using K maps and implementation using logic gates. 2. Realization of combinational circuits: Half adder, Full adder, Half subtractor, Full subtractor

3. Realization of BCD adder and 2-bit Magnitude Comparator

Unit-2 - Combinational Circuit Design ***15 Hour***

Introduction to combinational circuits- Arithmetic operation circuits-Adder, subtractor, multiplier, divider, magnitude comparator -Multiplexer- Demultiplexer -Decoders and encoders - Priority encoder-Parity generator and Parity checker -Code converter.

Practice:

1. Realization of MUX, Realization of Boolean expression using MUX. 2. Design of BCD to 7-segment decoder. 3. Realization of Code Converters

Unit-3 - Synchronous and Asynchronous Sequential Circuit ***15 Hour***

Sequential circuits – Flip flops -Triggering, types, conversions, excitation tables – Analysis and design procedures – State reduction and state assignment – Shift registers – Counters- MOD counters, up-down counter, ring counters – Sequence detectors

Practice:

1. Realization of one flip flop using another flip flop 2. Design and implementation of synchronous sequential circuits. 3. Design and implementation of asynchronous sequential circuits

Unit-4 - Digital Application	***15 Hour***
Introduction to game control circuits- Combinational circuit design for applications (State diagram, state table, state input-state machine and output signals, Input latches)- Odd prime number detector-Elevator control system- Traffic signal control system- Event detector circuit -Seven segment display decoder -Fireplace control circuits	
Practice:	
1. Design and implementation of Hazard free circuit. 2. Design of asynchronous Counters. 3. Mini Project Presentation: Realization of digital control circuits	
Unit-5 - Programable and Memory Devices	***15 Hour***
Basic memory structure – ROM -PROM – EPROM – EEPROM –EEPROM, RAM – Static and dynamic RAM – Programmable Logic Devices – Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA) – Implementation of combinational logic circuits using ROM, PLA, PAL-Complex programmable logic device (CPLD)-Introduction to VHDL programming.	
Practice:	
1. Realization of Boolean algebra using PLA. 2. Verification of gates using Lab View. 3. Verification of Combinational logic circuits VHDL	

Learning Resources	1. *M. Morris Mano, Michael D. Ciletti, " Digital Design: With an Introduction to Verilog HDL, VHDL and System Verilog", 6th ed., Pearson, 2018* 2. *Thomas L.Floyd, "Digital Fundamentals", 11th ed., Pearson India, 2014*	3. *Charles H. Roth, Lizy K. John, "Digital System Design Using VHDL", 2nd ed., Cengage learning, 2012* 4. *NPTEL video Lecture series on,"Digital circuits and Systems", by Prof. S.Srinivisan, IIT Madras.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.N.Deepa, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC202T	Course Name	ELECTRICAL AND ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand working of galvanometer, electro dynamometer as ammeter and voltmeter*
CLR-2:	*know various techniques that measure power*
CLR-3:	*learn various techniques that measures resistance, capacitance, inductance and frequency*
CLR-4:	*introduce different measuring devices*
CLR-5:	*gain knowledge on various display devices and calibration techniques*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the working of instruments for measuring current and voltage*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*apply different methods to measure power*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*use different techniques for measuring resistance, capacitance and inductance*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*select the appropriate measuring instruments based on the application and range*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-5:	*outline the working of various display devices and calibration procedure*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - Electrical Measurements	***9 Hour***
Introduction to measurement and instruments – Classification of electromechanical instruments – Principles of moving coil, moving iron, dynamometer type, rectifier type, thermal instruments –Extension of instrument range shunt and multipliers – Transformers current and potential.	
Unit-2 - Measurement of Power	***9 Hour***
Introduction to measurement of power – Electrodynamic wattmeter – Low power factor (LPF) wattmeter – Errors – Single phase and three phase power measurement – Hall effect wattmeter – Thermal type wattmeter.	
Unit-3 - Measurement of Resistance, Capacitance, Inductance and Frequency	***9 Hour***
Measurement of low, medium, high resistances – Megger – Ohmmeters – AC bridges general form – Capacitance measurements – Inductance measurements – Frequency measurements – Detector in bridge measurement – Bridge screening – Wagner earth – Transformer ratio bridges.	
Unit-4 - Electronic and Digital Measurements	***9 Hour***
Electronic voltmeter – Current measurement with electronic instruments – Digital voltmeter – Analog and digital multi-meters – Digital frequency meters – Digital LCR meter – Q-meter – Digital wattmeter, energy meters.	
Unit-5 - Digital Display Devices and Calibration	***9 Hour***
CRO – DSO – MSO – Function generators – Signal generators – Analyzers waveform, spectrum and distortion – LED – LCD - Organic LED displays – Calibration of ammeter, voltmeter, wattmeter, oscilloscope and energy meters.	

Learning Resources	1. *A.K Sawhney. Puneet Sawhney, A course in electrical and electronic measurements and instrumentation, Shree Hari Publications, Reprint ed., 2021.* 2. *H. S. Kalsi, Electronic Instrumentation, McGraw Hill Education; 3rd ed., 2017.* 3. *Ernst O.Doeblin and Dinesh Manik, Measurements systems, Mc Graw Hill series, 7th ed., 2019.*	4. *Prithwiraj Purkait,, Budhaditya Biswas,, Chiranjib Koley, Electrical and Electronics Measurements and Instrumentation, Mc Graw Hill series, 1st ed., 2017.* 5. *Albert Helfrick and William Cooper, Modern Electronic Instrumentation & Measurements Techniques, Pearson Education, 3rd ed., 2015.* 6. *Liptak B G, Process Measurement Analysis, Volume 1, Instrument Engineer's Handbook, Chilton, 4th ed., 2005.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. C.Likith Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC203J	Course Name	ELECTRONICS FOR ANALOG SIGNAL PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the operation of BJT amplifier circuits for a given specification*
CLR-2:	*know the operation of FET amplifier circuits*
CLR-3:	*impart knowledge on the effects of feedback on amplifier circuits*
CLR-4:	*understand the operation of oscillator circuits and power amplifier circuits*
CLR-5:	*gain knowledge on current sources used in IC amplifiers*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the BJT amplifier circuits and its frequency response*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*analyze the FET amplifier circuits and its frequency response*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*apply the characteristics of feedback amplifier circuits*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*illustrate the condition for oscillation and types of oscillator circuits*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*outline the basic circuit building blocks that are used in the IC amplifiers*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - BJT Amplifiers ***15 Hour***

Introduction to BJT circuits - Biasing types of BJT Models – Ebers model - Moll Model and Gummel model – Poon model of BJTs - Transistor α, current amplification β, bipolar transistor switch, SPICE BJT model, punch through and breakdown mechanisms - AC analysis of CE, CC amplifier configuration using hybrid-π model - Multi-stage amplifier configurations- Frequency response analysis of basic BJT CE amplifier
Practice:
1. Verification of the frequency response of CE amplifiers. 2. Design and verification of cascaded CE amplifier. 3. Determination of characteristics of FET amplifier

Unit-2 - FET Amplifiers ***15 Hour***

Introduction to voltage-controlled device - Overview of FET DC circuit analysis - Graphical analysis, load lines, and small-signal models - AC analysis of common-source MOSFET amplifier configurations - Low frequency response and high frequency response analysis of a basic FET CS Amplifier- Operational voltage levels - BiCMOS operation.
Practice:
1. Verification of voltage divider bias for BJT circuits for a given operating point. 2. Analyze MOSFET amplifier configurations

Unit-3 - Feedback Amplifiers ***15 Hour***

Feedback amplifier - Advantages of negative feedback - Mixing and sampling networks - Types and effects - Voltage-series amplifier- Voltage-shunt amplifier- Current-shunt amplifier- Current-series amplifier - Introduction to tuned amplifiers - Types of tuned amplifiers - Problem solving
Practice:
1. Efficiency determination of class C power amplifier. 2. Design of BJT Current Sources Frequency. 3. Determination of RC oscillators

Unit-4 - Oscillators and Power Amplifiers	***15 Hour***
Oscillators – Classification - Condition for oscillation - RC oscillators - RC phase shift - Wien bridge oscillators - Resonant frequency oscillators - Hartley, colpitts and crystal oscillators - Power amplifiers - Class A, class B, class AB Amplifiers - Efficiency derivation - Distortion in power amplifiers - Problem solving *Practice:* *1. Frequency determination of LC oscillators.*	
Unit-5 - IC Biasing and Amplifiers with Active Load	***15 Hour***
BJT current sources - Cascode current source - Widlar current source - Multi transistor current source - MOSFET current source, FET current sources - Cascade current mirror - Wilson current mirror - Analysis of CE BJT amplifier circuit with active load - Basic BJT differential Pairs - Analysis of BJT differential amplifier with active load *Practice:* *1. Design and analyze negative feedback amplifier configurations. 2. Design and analyze FET CS amplifier with active load. 3. Design and analyze differential amplifier with active load. 4. Mini Project*	

Learning Resources	1. *David A. Bell, "Electronic Devices and Circuits", 5th ed., Oxford University Press, 2015.* 2. *Donald Neamen, "Electronic Circuits: Analysis and Design", 3rd ed., McGraw-Hill Education, 2011.* 3. *Muhammad Rashid, "Microelectronic Circuits: Analysis & Design", 2nd ed., Cengage Learning, 2010.* 4. *Adel S. Sedra, Kenneth C. Smith, "Microelectronic Circuits: Theory and Applications", OUP, 2014.*	5. *Robert L. Boylestad, Louis Nashelsky, "Electronic Devices and Circuit Theory", 11th ed., Pearson Education, 2013* 6. *Albert P. Malvino, David J. Bates, "Electronic Principles", 8th ed.,Tata McGraw Hill, 2015* 7. *NPTEL video lecture series on "Analog Electronic Circuits", by Dr. Shouribrata Chatterjee, IIT Delhi.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. Vibha K SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC205J	Course Name	ANALOG INTEGRATED CIRCUITS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basics of operational amplifiers, their characteristics and configurations*
CLR-2:	*explore the various linear and non-linear applications of op-amp*
CLR-3:	*impart knowledge on applications of timer, PLL*
CLR-4:	*provide knowledge on data converter terminology and various circuit arrangements for A/D and D/A conversion*
CLR-5:	*gain knowledge on special function ICs*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the DC and AC characteristics of operational amplifiers with their effects on output and their compensation techniques*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-2:	*analyze the linear and non-linear applications of an Op-Amp*	*3*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-3:	*illustrate the working of multivibrators using special application IC 555*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-4:	*select analog to digital converter based on conversion time and accuracy*	*3*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*
CO-5:	*use special function integrated circuits*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*

Unit-1 - Introduction To OP-AMP ***15 Hour***

Basic information of the op-amp - Miller op-amp, ideal op-amp, inverting amplifier, non-inverting amplifier, differential amplifier, CMMR, op-amp internal blocks - DC characteristics of non-ideal op-amp - AC characteristics of non-ideal op-amp - Analysis of data sheets of an op-amp - Summing amplifier, subtractor, difference amplifier.

Practice:

1. Analyze differential amplifiers. 2. Design Inverting, Non-inverting amplifier

Unit-2 - Application of Operational Amplifier ***15 Hour***

Differentiator, integrator ideal circuits, practical circuits, V to I converter, I to V converter, instrumentation amplifier, instrumentation amplifier IC - Active filters, low pass filter, high pass filter, band pass filter, band reject filter – Comparator - Schmitt trigger, astable multivibrator, monostable multivibrator, triangular wave generator, function generator - Clipper and clamper.

Practice:

1. Testing of differentiator and integrator. 2. Design and Testing of active filter

Unit-3 - Timer and Phase Locked Loop ***15 Hour***

Timer, description of functional diagram, monostable operation, astable operation, schmitt trigger – PLL, basic principles, phase detector/comparator, voltage controlled oscillator, low pass filters, PLL application - Basic principle of sine wave oscillators, wien bridge oscillator, RC phase shift oscillator, quadrature and biphasic oscillator.

Practice:

1. Analyze multi vibrators using op-amp. 2. Testing of schmitt trigger using op-amp. 3. Design of phase shift oscillators using op-amp

Unit-4 - Analog to Digital and Digital to Analog Converters	***15 Hour***
DAC principle, weighted resistor DAC, R-2R ladder DAC, inverted R-2R ladder DAC, multiplying DACs, monolithic DAC - Sample and hold circuit - ADC principle, direct type, parallel comparator ADC, counter type ADC, servo tracking ADC, successive approximation ADC, charge balancing ADC, duel slope ADC- DAC/ADC specification	
Practice:	
1. Analyze wien bridge oscillators using op-amp. 2. Astable multi vibrator using NE555 timer. 3. D- A converter using Op-amp	
Unit-5 - Special Function IC's	***15 Hour***
Power amplifier, audio and video amplifiers - Linear voltage regulator, series op-amp regulator, IC voltage regulators, fixed regulator used as adjustable regulator, 723 general purpose regulator, current limit protection, switching regulator- Buck/boost regulators- Isolation amplifier, coupler.	
Practice:	
1. A-D converter using op-Amp. 2. Analyze monostable multivibrator using NE555. 3. Mini project	

Learning Resources	1. *Ramakant Gayakwad, "Op-amps and Linear Integrated Circuits", 4th ed., Pearson, 2021.* 2. *Robert, F., Coughlin, Frederick F., Driscoll, "Operational Amplifiers and Linear Integrated Circuits", 6th ed., Pearson, 2009* 3. *Sergio Franco, "Design with Operational Amplifiers and Linear Integrated Circuits", 4th ed., Sergio Franco, 2015.*	4. *Paul R. Gray, "Analysis and Design of Analog Integrated Circuits", 5th ed., Wiley India, 2010.* 5. *Roy Choudhry, D. and Shail B. Jain, "Linear Integrated Circuits", 5th ed, New Age International, 2018.* 6. *NPTEL video lectures series on "Electronics for Analog Signal Processing II" by Prof. K.R.K. Rao, IITM.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT,Trichy, srinikkn@nitt.edu*	1. *Dr.J Sam Jeba Kumar ,SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	2. *Dr. P.A.Sridhar , SRMIST*

Course Code	21EIC206J	Course Name	CONTROL SYSTEMS DESIGN AND ANALYSIS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the mathematical modeling of mechanical and electrical systems*
CLR-2:	*introduce the time domain analysis of first and second order systems*
CLR-3:	*impart the knowledge on stability analysis of linear systems*
CLR-4:	*explore the frequency domain methods and use it for analysis purpose*
CLR-5:	*provide the procedure for the design of controllers using conventional control methodologies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop mathematical models of systems using various modeling techniques*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*compare the time domain specifications*	*3*	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyze the stability of systems using time domain approach*	*2*	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*interpret the system for its stability using frequency domain specifications*	*3*	-	-	*2*	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*design different conventional controller*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Transfer Function ***15 Hour***

Introduction to systems with examples-Open loop and closed loop systems, feed forward and feedback system -Mathematical modeling of mechanical translational and rotational system - Conversions of mechanical system to electrical system -Transfer function using block diagram reduction techniques -Transfer function using signal flow graph- Case study for development of transfer function for real time system

Practice:

1 .Introduction to MATLAB. 2 .MATLAB commands for control sys programming. 3 .Development of transfer function for real time system

Unit-2 - Time Domain Analysis ***15 Hour***

Transfer function of first order system using step and ramp-Transfer function of second order system undamped, under damped, over damped and critically damped system using step input-Problems on first and second order system transfer functions-Transient response -Steady state response-Steady state error analysis

Practice:

1. Step, Ramp and Impulse response of first order and second order systems. 2. Identification of damping in second order systems. 3. Time domain analysis for second order systems

Unit-3 - Stability Analysis ***15 Hour***

Concepts of stability- Necessary conditions for stability- Routh stability criterion- Stability analysis using Routh's Hurwitz criterion- Relative stability analysis- Introduction to root- locus techniques- Root locus plots of typical systems -Stability analysis of linear systems using root locus.

Practice:

1. Stability analysis of linear systems using pole – zero location of the system. 2. Stability analysis of linear systems using Routh Hurwitz criterion. 3. Stability analysis of linear systems using Root Locus

Unit-4 - Frequency Domain Analysis	***15 Hour***
Frequency domain specifications - Introduction to closed loop frequency response- Bode plot,-Polar plot -Nyquist plot: construction, interpretation and stability analysis. ***Practice:*** *1. Frequency response analysis using Bode Plot. 2. Frequency response analysis using Polar Plot. 3. Frequency response analysis using Nyquist Plot*	
Unit-5 - Design of Controllers	***15 Hour***
Introduction to conventional controllers-Design of PI, PD, PID controllers- Compensation techniques- Performance goals, specifications - Design of leadcompensators - Design of lag compensators -Case study of a controller design for real time applications ***Practice****:* *1. Design of PID Controller for first order and second order systems. 2. Design of compensator. 3. A mini project on controller design of real time application*	

Learning Resources	1. *Norman S. Nise, "Control Systems Engineering", 7th ed., Wiley, 2014.* 2. *D'azzo John J.; Houpis Constantine H.; Sheldon," Linear Control System Analysis and Design with MATLAB", 5th ed., Taylor & Francis, 2003.* 3. *Farid Golnaraghi, Kuo Benjamin C., "Automatic Control Systems", 10th ed., Wiley India Pvt. Ltd*	4. *Ogata.K, "Modern Control Engineering", 5th ed., Pearson, 2015* 5. *Nagrath I.G, Gopal M., "Control Systems Engineering", 6th ed. , New Age International Publishers, 2018* 6. *NPTEL Video Lecture Series on Control Engineering by Prof. Ramkrishna Pasumarthy, IIT, Madras.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India,Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. N.Deepa, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC301P	Course Name	EMBEDDED SYSTEM DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	4	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the architecture of microprocessor*
CLR-2:	*understand the fundamentals of peripheral interfacing*
CLR-3:	*impart microcontroller programming skills*
CLR-4:	*provide knowledge on ARM processor*
CLR-5:	*interpret on interfacing real world devices with processor.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*write basic assembly language program for 8086 processor*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*3*	-
CO-2:	*describe the various peripherals and its interfacing with processor*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	*3*	-
CO-3:	*construct assembly language program for microcontroller*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-
CO-4:	*analyze the various algorithms in ARM processor*	*2*	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	*3*	-
CO-5:	*develop a prototype and program for control application*	*2*	*2*	*3*	-	-	-	-	-	*3*	-	-	-	-	*3*	-

Unit-1 - 8086 Microprocessor	***18 Hour***
Introduction to computer architecture - Intel 8086 microprocessor architecture - Instruction set - Interrupts - Addressing modes - Programing.	
Unit-2 - Peripherals Interfacing	***18 Hour***
Interfacing RAM and EPROM - Programmable Peripheral Interface - Programmable Interval Timer - Programmable Communication Interface - Programmable Interrupt Controller	
Unit-3 - Microcontroller	***18 Hour***
8051/8031 architecture, I/O ports and memory organization - Instruction set - Addressing modes, assembly language programming - Interrupts - Timer/Counter	
Unit-4 - ARM Processor	***18 Hour***
ARM Processor, architecture, processor families - Instruction set, software development tools - Interfacing with external devices - ARM Cortex.	
Unit-5 - Applications	***18 Hour***
The practice hours will be utilized to develop small project prototype using - µP/µC like Design of traffic light control system – Design of PID control for temperature/level process - Robot arm control - Interfacing display - Design of multichannel data acquisition system - Design of smart transmitter - Counting the occurrence of events using IR proximity sensor - Remote monitoring of process using zigbee protocol.	

Learning Resources	
1. *Ray, A.K. and Bhurchandi, K.M., "Advanced Microprocessor and Peripherals", 3rd ed., Tata McGrawHill, 2017* 2. *N.SenthilKumar,"Microprocessors and Microcontrollers", Oxford University Press,2011* 3. *Muhammad Ali Mazidi, Janice GillispieMazidi and RolinD.MCKinlay, "The 8051 Microcontroller and Embedded Systems", 2nd ed., Pearson Education, 2010,*	4. *Johnathon M Valvano, "Embedded Systems: Introduction to ARM Cortex M Microcontrollers", 5th ed., 2017* 5. *NPTEL Video Lecture series on "Lecture Notes on Microprocessors and Microcontrollers ",by Prof. Krishna Kumar, IISc Bangalore*

Learning Assessment									
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		Formative CLA-1 Average of unit test (20%)		Project Based Learning CLA-2 (60%)		Report and Viva Voce (20%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	10%	-	10%	-	-
Level 2	Understand	20%	-	-	15%	-	15%	-	-
Level 3	Apply	30%	-	-	30%	-	30%	-	-
Level 4	Analyze	30%	-	-	20%	-	20%	-	-
Level 5	Evaluate	-	-	-	20%	-	20%	-	-
Level 6	Create	-	-	-	5%	-	5%	-	-
	Total	100%		100%		100%		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com	1. Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu	1. Dr J. Sam Jeba Kumar, SRMIST
2. Mr. Gautham, Schneider Electric,gautham.r@se.com	2. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com	

Course Code	21EIC302J	Course Name	PROCESS CONTROL	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the terminology and mathematical modeling of various processes*
CLR-2:	*understand the characteristics, selection and sizing of control valves*
CLR-3:	*impart knowledge in different control modes for the process used in industry*
CLR-4:	*provide various PID tuning methods for process applications*
CLR-5:	*explore advanced process control schemes to control process parameters for various processes*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop the mathematical model of various chemical process*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-2:	*explain the working and application of different type of actuators and control valves*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-3:	*apply the various control schemes and recommend the right control scheme for a given application*	*-*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-4:	*analyze the different methods of tuning of a controller for any process*	*2*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-5:	*design a mathematical model and implement using various advanced control schemes*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*

Unit-1 - Process Dynamics ***15 Hour***

Need for process control - Process control loop- Process Variables and dynamics- Objectives and requirements of process control- Hardware elements of process-Piping and Instrumentation diagram- Instrument terms and symbols- Servo and Regulatory operation- Continuous and batch processes- Mathematical model of level processes- Interacting and non-interacting systems- Mathematical model for Interacting and non-interacting systems - Laws and assumptions governing gas process and thermal process- Mathematical models of thermal processes- Self regulation -Degrees of freedom

Practice:

1. Identify the components of the process control loop. 2. Determine the characteristics of interacting system. 3. Determine the characteristics of non-interacting system

Unit-2 - Final Control Elements ***15 Hour***

Need for final control elements- I/P converter- P/I converter- Pneumatic actuators- Electric actuators- Control Valves - selection of control valves-Types of control valves- Characteristic of Control Valves - Inherent characteristics -Installed characteristics- Valve positioner and its importance -Electronic valve positioner- Control valve sizing -Guidelines for control valve sizing - Cavitation and flashing -cavitation / flashing impacts on valves

Practice:

1. Determine the characteristics of I/P and P/I converter. 2. Determine the characteristics of Pneumatically Actuated Control Valve.
3. Determine the characteristics of Pneumatically Actuated Control Valve (with and without Positioner

Unit-3 - Different Controller Modes ***15 Hour***

Need for controller - Basic control actions - Continuous and Discontinuous modes of controllers - Characteristics of ON- OFF controllers -Characteristics of Single speed floating controllers-Basic control schemes tuning – Proportional (P), Integral (I) and Derivative (D) modes - P+I, P+D and P+I+D control modes -Reset windup -Anti-reset windup -Auto/manual transfer -Direct/reverse action –Bumpless transfer- Practical forms of PID Controller - PID Implementation Issues.

Practice:*1. Design the on-off, P, PI and PID controller for the Pressure Process. 2. Design the on-off control, P, PI and PID controller for the flow Process. 3. Design on-off control, P,PI and PID controller for the level Process*

Unit-4 - Tuning of Controllers	***15 Hour***
PID controller Tuning - One quarter decay ratio, semi empirical rules - Time Integral performance -Selection of Time Integral performance Criteria-Tuning – Process reaction curve -Formulae and procedure - Z-N open loop tuning Formulae and procedure -Continuous cycling method -Formulae and procedure-Damped oscillation method -Stability analysis using tuning methods -Controller tuning with one quarter decay ratio. Selection of control modes for processes like level, pressure, temperature and flow. ***Practice**:1. Tune the PID Controller for mathematically described process using ZN method. 2. Tune the PID Controller for mathematically described process using ZN open loop method* *3. Compare the responses of simple and cascade control system using MATLAB*	
Unit-5 - Advanced Control Schemes	***15 Hour***
Cascade control, ratio control, Adaptive control, feed forward control. Over-ride, split range and selective control. Multivariable process control, interaction ofcontrol loops. Introduction to Dynamic Matrix Control. Case Studies: Distillation column, boiler drum level control and chemical reactor control ***Practice:**1. Modelling and simulation of any process using virtual instrumentation software. 2. IoT based water level control system. 3. Mini project on IoT based process applications*	

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, 4th ed., 2016* 2. *Stephanopoulos. G" Chemical Process Control - An Introduction to Theory and Practice", Prentice Hall ofIndia,2nd ed.,2015* 3. *D.R. Coughanour, 'Process Systems analysis and Control',McGraw- Hill, 3rd ed., 2013*	4. *Curtis D. Johnson Process Control Instrumentation Technology, 8th Edition, Pearson, 2006* 5. *NPTEL video lectures on "Chemical Process Control" by Prof. Sujit Jogwar, IITM.* 6. *P.W. Murrill , "Fundamentals of Process Control Theory", 3rd ed.,ISA Books* 7. *Bela.G.Liptak.,"Process Control and Optimization"., Instrument Engineers' Handbook., volume 2,CRC press and ISA, 2005*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Neelakandan Mani, Senior Director, CTS, pymani2010@yahoo.com*	1. *Dr.K.Srinivasan, NIT,Trichy, srinikkn@nitt.edu*	1. *Dr. A.Asuntha, SRMIST*
2. *Srinath, Design Engineer, instrumentation, VATECHWABAG,srinath.vigneshwar@gmail.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC303T	Course Name	DISCRETE TIME SIGNAL PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explore the knowledge on classification of signal, systems and mathematical representation of signals*
CLR-2:	*understand the various transform techniques applicable to discrete time signals*
CLR-3:	*introduce the design procedure for digital IIR filters using various methods*
CLR-4:	*impart the design procedure for digital FIR filters using various methods*
CLR-5:	*provide the exposure to the architectures of digital signal processor and applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*compare the different types of signals and systems to perform mathematical operations on signals*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*design the signals transform in both time and frequency domain*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-3:	*apply different techniques in digital IIR filter design for the given set of specifications*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-4:	*analyze the different techniques in digital FIR filter design for the given set of specifications*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*explain the selection of DSP processor for signal processing applications*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Signals and Systems	***9 Hour***
Classification of systems: Continuous, discrete, linear, causal, stability, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.	
Unit-2 - Discrete Fourier Transform	***9 Hour***
Z-transform and its properties, inverse z-transforms - Discrete Time Fourier transform (DTFT) - DTFT properties -Discrete Fourier Transform(DFT) - DFT properties - Direct computation of DFT - Circular convolution - Linear using circular convolution - Direct computation of IDFT - computational complexity - FFT:Radix2, Twiddle factor - Decimation in time FFT algorithm -Computation of DFT using DIT algorithm - Decimation in frequency FFT algorithm - Computation of DFT using DIF algorithm - IDFT using FFT algorithms- Computation of IDFT using FFT algorithm	
Unit-3 - Design of IIR Filters	***9 Hour***
Design procedures for digital IIR - frequency transformation techniques - Design of digital IIR filters using Butterworth Filter - Design of Low pass and high pass Butterworth filter -Design of band pass Butterworth filter - Design of band reject Butterworth - Design of digital IIR filters using Chebyshev approximations - Design examples -Design of digital IIR filters using Bilinear transformation method - Design of digital IIR filters using Impulse Invariant transformation method	
Unit-4 - Digital FIR Filters	***9 Hour***
Introduction - advantages of FIR over IIR filters - linear phase filters - Fourier series method - Design of digital FIR filters using Fourier series method - Low pass filter design -High pass filter design using Fourier series method - Band pass filter design using Fourier series method - - Windowing technique: Rectangular - Triangular window-Hamming window	
Unit-5 - Digital Signal Processor and Applications	***9 Hour***
FIR & IIR filter realization - TMS320C54X Architecture - Central Processing Unit - Arithmetic and logic unit - Barrel shifter-- Multiplier/Adder Unit-Accumulators -0n-chip Peripherals - Addressing Modes -Application of DSP in Signal processing - Application of DSP in Image - Application of DSP in Radar system	

Learning Resources	1. *John G Proakis and Manolakis, " Digital Signal Processing Principles, Algorithm and Applications", Pearson, 4th ed., 2014* 2. *Mithra, S.K., "Digital Signal Processing: A Computer Based Approach", 3rd ed., 2013*	3. *Darrell Williamson,"Discrete Time Signal Processing: An algebraic Approach", 2nd ed.,, 2012* 4. *Johnson, J.R.," Introduction to Digital Signal Processing", Prentice Hall of India,2009* 5. *NPTEL Video Lecture series on, "Digital Signal Processing" by Prof. S.C. Dutta Roy, IIT Delhi*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr A.Asuntha, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC304T	Course Name	INDUSTRIAL INSTRUMENTATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand about the temperature measurement techniques*
CLR-2:	*know the different techniques of pressure measurement techniques*
CLR-3:	*impart the knowledge on different techniques of measurement of flow and level*
CLR-4:	*acquire familiarity about measurements of speed, force, torque, acceleration*
CLR-5:	*impart knowledge on measurement techniques of density, viscosity, humidity*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize different techniques to measure temperature*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*analyze the construction and working of various industrial devices used to measure pressure*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*explain the different methods for flow and level measurement*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*illustrate the different methods for the measurement of speed, force, torque, acceleration*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*outline the parameters to measure density, viscosity, humidity*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Measurement of Temperature	***9 Hour***
Definitions and standards – Bimetallic thermometers – IC sensors –Thermocouples - Radiation methods of temperature measurement – Optical pyrometers – Two color radiation pyrometers – Fiber optic sensor for temperature measurement - Prototype of temperature control for any applications - Thermal imaging	
Unit-2 - Measurement of Pressure	***9 Hour***
Manometer types - Bourdon Tube - Bellows, diaphragms and capsules - Electrical methods - Elastic elements, strain gauges – Capacitive type pressure gauge - Piezo resistive pressure sensor - McLeod gauge, thermal conductivity gauge - Ionization gauges – Calibration - Dead weight tester - Level Measurement using differential pressure transmitter	
Unit-3 - Measurement of Flow, Level	***9 Hour***
Orifice, Venturi, pitot tube - Flow nozzle rotameter - Positive displacement meter - Turbine flowmeter - Electromagnetic flow meter - Ultrasonic flow meter - Open channel flow measurement - Sight glass, float gauge, displacer, bubbler tube - Differential pressure methods - Electrical methods - resistance type, capacitance type - Radar level transmitter	
Unit-4 - Measurement of Speed, Force, Torque, Acceleration	***9 Hour***
Measurement of speed - Revolution counter, drag cup tachometer, AC and DC tacho generators, photo electric pickup - Measurement of force - Load cell, pneumatic load cell, hydraulic load cell - Measurement of torque using strain gauges and magneto elastic principle - Elementary accelerometers, seismic accelerometers, practical accelerometers, calibration	
Unit-5 - Measurement of Density, Viscosity, Humidity	***9 Hour***
Hydrometer - Continuous weight measurement, liquid densitometer – Float principle, air pressure balanced method – Gas density measurements – Gas specific gravity measurements- Viscosity terms, rotameter type viscometer - Humidity terms - Dry & wet bulb Psychrometer – Hot wire electrode type hygrometer, electrolytic hygrometer, dew point hygrometer	

Learning Resources	1. *Donald P Eckman, "Industrial Instrumentation ǁ", CBS publishers and distributors, 2004.* 2. *Murthy, D.V.S., "Transducers and Instrumentation", 2nd ed., Prentice Hall of India Pvt. Ltd., New Delhi, 2011.* 3. *Ernest O Doebelin, "Measurement systems Application and Design ǁ", Tata McGraw- Hill Book Company, fifth ed., 2010* 4. *Patranabis D, "Principles of industrial Instrumentation", Tata McGraw Hill, 3rd ed., New Delhi, Reprint 2010*	5. *John P Bentley, "Principles of Measurement Systems ǁ", Pearson education, 3rd ed., 2009* 6. *Gregory K McMillan and Douglas M Considine, "Process/ Industrial Instruments and Controls Handbook ǁ", Tata Mc-Graw Hill, 5th ed., 2009* 7. *M.M.S. Anand, "Electronics Instruments and Instrumentation Technology", Prentice Hall of India Pvt. Ltd., New Delhi, 2004* 8. *NPTEL video lectures on "Industrial Instrumentation" by Prof. Alok Barua, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. Vibha.K, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr.J.Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC305J	Course Name	INDUSTRIAL PROCESS AUTOMATION SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the hardware components of programmable logic controller*
CLR-2:	*provide knowledge on PLC programming using various function blocks*
CLR-3:	*impart skills to troubleshooting PLC software and hardware*
CLR-4:	*understand the hardware components and communication in SCADA*
CLR-5:	*interpret on distributed control system in process automation*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the main parts of a PLC and describe their functions*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*write the ladder logic program for control application*	*3*	-	*2*	*1*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*examine various preventive maintenance and troubleshooting methods*	*3*	-	-	*1*	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*describe the various elements of SCADA system*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*analyze the various operator displays used in distributed control system*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - PLC Hardware Components ***15 Hour***

Evolution of PLC-Architecture of a PLC- -PLC size and application-Discrete I/O, analog I/O, special I/O modules- Developing logic circuit - Switches-Electromagnetic control relays -Sensors-Output control devices-Seal-in circuits, electrical interlocking circuits, program scan-PLC programming languages, ladder logic.

Practice:

1. Automatic level control in a tank. 2. Material handling system

Unit-2 - PLC Programming ***15 Hour***

Timer instructions- On-delay timer -Off-delay timer -Retentive timer -Cascading timer -Up counter - Down counter -Cascading counter- Combining counter and timer functions-RS/SR function block-FBD programming -Data manipulation -Data compare instructions- Math instructions- IL programming

Practice

1. Speed control of DC motor. 2. Development of control logic for Automatic Bottle filling process

Unit-3 - Trouble Shooting ***15 Hour***

PLC enclosures, PLC mounting- Electrical noise -Leaky inputs and outputs – Grounding - Voltage variations surge control -Program editing -Commissioning -Preventive maintenance -Troubleshooting PLC software, hardware -Trouble shooting guide -Processor module -Input malfunctions

Practice

1. Automatic temperature control. 2. Automatic flow control. 3. Development of control logic for Lift Control

Unit-4 - Scada Elements and Communication	***15 Hour***
Functionality of SCADA -History of SCADA - Elements of SCADA -Analog/discrete signals measurement-Control techniques- RTU -Analog and discrete control -MTU -Communication system components -Field/RTU communication -Communication topology -RTU/MTU communication, system components -Monitoring alarms, status points -Control interfacing. ***Practice:*** *1. Development of control logic for Car parking. 2. Stamping machine control. 3. SCADA program for traffic light control system*	
Unit-5 - Distributed Control System	***15 Hour***
Evolution of DCS -DCS architecture -LCU -Operator interface, requirements -Operator input output devices - Operator displays - Engineering interface- Low-level/high level engineering interface -DCS Application case study ***Practice:*** *1. Development of SCADA program for level Process. 2. On line monitoring and control of level process using DCS. 3. Mini Project*	

Learning Resources	1. *Frank D. Petruzella, "Programmable Logic Controller",Tata McGraw Hill 5thed., 2017.* 2. *Bolton. W, "Programmable Logic Controllers", 6th ed., Elsevier Newnes, 2016.* 3. *Krishna Kant, "Computer-based Industrial Control", Prentice Hall, NewDelhi, 2nd ed., 2011.* 4. *Lukcas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 19861.*	5. *Stuart Boyer A, "SCADA : Supervisory control and data Acquisition", ISA-The Instrumentation, Systems, and Automation Society, 4th ed. 2016* 6. *Dobrivojie Poppovik, Vijay P Bhatkar, "Distributed Computer Control Systems in Industrial Automation" CRC Press, 1990* 7. *NPTEL Video Lecture series on "Industrial Automation and Control", by Prof. S. Mukhapadhyay, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr J. Sam Jeba Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC306J	Course Name	INSTRUMENTATION SYSTEM DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*gain knowledge on the designing aspects of signal conditioning circuits for the measurement of level, temperature and PH*
CLR-2:	*explore the designing concepts of transmitters*
CLR-3:	*impart the designing skills needed to test analog/ digital PID controller, data loggers and alarm circuits*
CLR-4:	*familiarize with the design of orifice and control valve sizing*
CLR-5:	*explore various control panel design and control room design details*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design signal conditioning circuits for different applications*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*design transmitters for key process variables*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*design data loggers and conventional controllers*	*2*	*1*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*calculate control valve sizing parameters*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*design control panel for an industrial application requirement*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Design of Signal Conditioning Circuits ***12 Hour***

Introduction to process control system - Design of V to I and I to V converter, analog filter design - Signal conditioning circuit for temperature measurement, RTD, thermocouple, thermistor- Design of instrumentation amplifier

Practice:

1. Design of regulated power supply. 2. Design of I to V and V to I convertor. 3. Design of ON/OFF controller for thermal process

Unit-2 - Design of Transmitters ***12 Hour***

Study of transmitter and its design features, design of 2-wire and 4-wire analog transmitters, design of RTD based temperature transmitter, design of capacitance based level transmitter, air purge level measurement system design – Design of smart flow transmitter, orifice plate, venturi meter.

Practice*:*

1. Design and testing of 2-wire analog transmitter. 2. Design and testing of 2-wire smart transmitter. 3. Design and testing of analog PID controller

Unit-3 - Design of Data Logger and PID Controller ***12 Hour***

Review Of Continuous And Non-Continuous Controllers, Design Of ON / OFF Controller, Electronic PID Controller - Microcontroller Based Data Logger, Data Acquisition, Design Of PC Based Data Acquisition, Model Design For Level And Flow Control System With Data Acquisition - Various Wireless Control Techniques Of The Process Control Parameters

Practice:

1. Design And Testing Of Data Logger. 2. Design And Testing Of Digital PID Controller. 3. Design And Testing Of Alarm Circuits

Unit-4 - Orifice and Control Valve Sizing	***12 Hour***
Orifice Sizing, Liquid, Gas And Steam Services, Valve Parameter And Sizing, Sizing Steam Valves With Examples, Gases Other Than Steam, 3-Way Valves, Valve Bodies, Valve Characteristics, Actuator Sizing - Rotameter Design And Considerations	
Practice:	
1. Design And Testing Of Annunciation Circuits. 2. Development Of Software Program For Sizing Control Valve	
Unit-5 - Control Panel Design	***12 Hour***
Control Panel Design, Panel Selection, Size, Type, Construction And IP Classification - Power Wiring And Distribution, Typical Wiring Diagrams For AI, DI, AO, DO, RTD, And T/C Modules - Earthing Scheme, Panel Ventilation, Cooling And Illumination - Operating Consoles- Ergonomics - Wiring Accessories, Wire Size And Color Coding, Packing - Control Room Design Layout – Case Study On Panel Design Software	
Practice:	
1. Design and Implementation of IoT Enabled Transmitter. 2. Mini Project	

Learning Resources	1. *Bela G. Liptak, "Instrument Engineers Handbook - Process Control and Optimization", 4th ed., Vol.2, CRC Press,2005* 2. *C. D. Johnson, "Process Control Instrumentation Technology", 8th ed., Prentice Hall, 2006*	3. *J.P. Bentley, "Principles of Measurement Systems", Pearson Education, 2015.* 4. *Considine D.M., Process Instruments and Controls Handbook, McGraw-Hill., 5th ed., 2009.* 5. *Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd (2011)*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. ManojGupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mrs. S.Sharanya, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC401J	Course Name	IMAGE PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the concepts of digital images*
CLR-2:	*impart skills to enhance the image*
CLR-3:	*understand the restoration of image and reconstruction*
CLR-4:	*outline the various image segmentation techniques*
CLR-5:	*provide knowledge of techniques for image compression and recognition*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the characteristics of digital image*	*2*	*-*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*
CO-2:	*implement the techniques for enhancing the images*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*
CO-3:	*evaluate the restoration and reconstruction of the digital images*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*
CO-4:	*analyze the techniques for segmenting the images*	*-*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*
CO-5:	*examine the various algorithms for image compression and recognition*	*-*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*

Unit-1 - Fundamentals of Digital Image ***12 Hour***

Steps in Digital Image Processing, components - Elements of visual perception - Image sensing and acquisition – Image sampling and quantization – Relationships between pixels - Color image fundamentals, RGB, HSI models, light and electromagnetic spectrum - Mathematical tools used in image processing.

Practice:

1. Simulation and Display of an Image, Negative of an Image (Binary & Gray Scale). 2.Implementation of Relationships between Pixels

Unit-2 - Image Enhancement ***12 Hour***

Basics intensity transformation functions- Histogram processing - Fundamentals of spatial filtering, smoothing and sharpening spatial filtering - Frequency Domain: Introduction to Fourier Transform, smoothing and sharpening frequency domain filters, ideal, Butterworth and gaussian filters - Homomorphic filtering -Color image enhancement

Practice:

1. Implementation of Transformations of an Image. 2. Contrast stretching of a low-contrast image, Histogram, and Histogram Equalization. 3. Display of FFT (1-D & 2-D) of an image

Unit-3 - Image Restoration and Reconstruction ***12 Hour***

Image Restoration, degradation model, properties - Noise models, periodic noise reduction by frequency domain filtering - Estimating the degradation functions, inverse filtering Image reconstruction from projections

Practice:

1. Implementation of Image Smoothening Filters (Mean and Median filtering of an Image). 2. Implementation of Edge Detection using Gradient Filters. 3.Implementation of image sharpening filters

Unit-4 - Image Segmentation ***12 Hour***

Edge linking, boundary detection – Thresholding - Region oriented segmentation - Region growing – Region splitting and merging - Morphological processing, erosion and dilation - Segmentation by morphological watersheds, watershed segmentation

Practice:

1. Implementation of Image Intensity slicing technique for image enhancement. 2. Implementation of image-restoring techniques. 3. Image Segmentation using watershed transform

Unit-5 - Image Compression and Recognition	***12 Hour***
Lossless compression - Variable length coding - LZW coding - Bit plane coding - Predictive coding- DPCM - Lossy Compression: transform coding - JPEG standard – MPEG - Regional Descriptors, topological feature, texture - Patterns and pattern classes, recognition based on matching ***Practice:*** *1. Image Compression by DCT, DPCM. 2.Mini Project*	

Learning Resources	*1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson, 4th edn, 2018.* *2. Anil K. Jain, Fundamentals of Digital Image Processing, Pearson, 2004.* *3. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, Digital Image Processing using MATLAB ', Pearson Education, Inc., 4th edn, 2020.*	*4. William K. Pratt, Digital Image Processing, John Wiley, New York, 2002* *5. NPTEL Video lectures on "Digital image processing". https://nptel.ac.in/courses/117105135*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*20%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com	*1. Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	*1. Dr. P A Sridhar, SRMIST*
2. Mr. Gautham, Schneider Electric, gautham.r@se.com	*2. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIC402J	Course Name	POWER ELECTRONICS AND ITS APPLICATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the operation of power semiconductor devices*
CLR-2:	*understand the triggering and commutation techniques used in thyristor*
CLR-3:	*gain knowledge on different controlled rectifier method*
CLR-4:	*provide the operation of different type of inverter and chopper*
CLR-5:	*impart knowledge on power electronics applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the different types of power semiconductor devices and their switching characteristics*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*analyse the triggering and commutation circuits used in thyristor*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-3:	*illustrate the operation, switching techniques and basics topologies of converters*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-4:	*explain the different types of inverters circuit and choppers circuits*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*outline the power electronics applications used in various field*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Power Semiconductor Devices ***12 Hour***

Introduction to power electronics devices, types of power electronics converters - Power diodes - Power transistor - Power MOSFET - IGBT - Thyristor - Two transistor model of thyristor, thyristor ratings, thyristor protection, series and parallel operation of thyristor - Selection of device based on its specifications.

Practice:

1. Static characteristics of thyristor. 2. Static characteristics of IGBT and MOSFET

Unit-2 - Triggering & Commutation Circuits ***12 Hour***

Firing circuits for thyristor - Thyristor triggering circuits with R, RL and RC circuits - Triggering the circuits with micro controller - Triggering the circuits with Aurdino controller - Commutation techniques - Natural commutation, forced commutation, types of commutation.

Practice:

1. Controlled half wave rectifier using RC triggering circuit. 2. Controlled full wave rectifier using RC triggering circuit

Unit-3 - Converters ***12 Hour***

Single phase half controlled and fully controlled rectifiers with R, RL, RLE load - Three phase fully controlled rectifiers with R, RL, RLE load - Effect of source inductance - Dual converters - Cyclo-converter - Single phase step up and step down cyclo-converter with RL load - Introduction of matrix converter - Design of matrix converter with R load

Practice:

1. Single phase half-controlled rectifier with R load, R–L load with and without freewheeling diode. 2. Single phase fully controlled full wave rectifier with R load, R–L load with and without freewheeling diode
3. Single phase MOSFET/IGBT based PWM inverter

Unit-4 - Inverters and Choppers	**12 Hour**
Introduction to Voltage Source Inverters (VSI) - Types, series, parallel and bridge - 180 mode VSI, 120 mode VSI - PWM inverters - Single pulse modulation, multiple pulse modulation, sinusoidal pulse modulation - Chopper - Buck chopper - Boost chopper - Buck-boost converter	
Practice:	
1. Design of buck converter. 2. Design of boost converter. 3. Design of buck-boost converter	
Unit-5 - Applications	**12 Hour**
Solid state switching circuits - Light dimmer circuits - Electronic timer - Power supply - Types - Battery charger - Battery charging regulator, emergency lighting system - Industrial process control - Temperature control, liquid level control, Design of PV for home appliances - Design of induction heating	
Practice:	
1. AC voltage regulator. 2. Speed control of stepper motor. 3. Mini Project	

Learning Resources	1. *Ned Mohan, Tore M. Undeland and William P. Robb and Design, John Wiley and Sons, "Power Electronics Converter and Applications design", 3rd ed., 2002.* 2. *Bimbhra P. S, "Power Electronics", Khanna Publishers, 5th ed., 2012* 3. *G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K. Sinha, "Thyristorised Power controllers", New Age International Publishers, 1st ed., Reprint 2005*	4. *Rashid, M.H., "Power Electronics – Circuits, Devices and Applications", PHI, 3rd ed., 2004* 5. *NPTEL video Lecture series on, "Power Electronics", by Prof B.G. Fernandes, IIT Bombay.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. Vibha.K, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIE201T	Course Name	RELIABILITY AND SAFETY 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	*EIE*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore reliability failure models*
CLR-2:	*impart knowledge about the concepts of redundancy and maintenance*
CLR-3:	*gain the concepts of maintainability*
CLR-4:	*provide the various concepts of reliability tests*
CLR-5:	*understand the concepts of safety engineering*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the fundamental concepts of reliability*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*interpret the concepts of redundancy and maintenance*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*compare the various concepts of maintainability*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*identify the techniques used for of reliability test*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*explain the techniques of safety engineering*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Reliability	***9 Hour***
Introduction to reliability failure modes, failure density function - Design of Hazard models - 'Bath-tub' curve - Applicability of Weibull distribution, failure data -Reliability calculation for series, parallel series and K-out of M systems, a priori and a posteriori concept - Mortality curve- System effectiveness, ranking of dataprobability plotting techniques, hazard plotting	
Unit-2 - Concepts of Redundancy and Maintenance	***9 Hour***
Use of redundancy and system reliability - Maintenance - Preventive measures - Total productive maintenance (TPM), proactive/reactive maintenance, imperfect Maintenance - Maintenance policies - PM versus b/d maintenance - PM schedule and product characteristics – Inspection models - Case study.	
Unit-3 - Maintainability	***9 Hour***
Maintainability, relationship between reliability, maintainability and availability - Corrective maintenance time distributions and maintainability demonstration – Design considerations for maintainability - Maintenance staffing - Maintenance resource requirements - Optimal repair effort - Maintenance planning and scheduling - Optimal size of service facility - Optimizing profit/downtime - Replacement decisions - Case study.	
Unit-4 - Reliability Tests	***9 Hour***
Introduction to life - destructive tests, non-destructive tests, Estimation of parameters for exponential - Indian boiler act 1923 - Static and mobile pressure vessel rules (SMPV) - Component reliability and MIL standards - Reliability prediction models - RBD approach - Standby systems -Application of Bayes' theorem - Markov analysis - Fault tree analysis - Case study.	
Unit-5 – Safety	***9 Hour***
Safety - Causes of failure and unreliability - Reliability and safety - Safety margins in critical devices - Origins of consumerism and importance of product knowledge- Product safety, product liability - Definition and measurement of risk - Risk analysis techniques- Industrial safety and risk assessment - Principles of accident prevention – Accident investigation and analysis - Safety "t" score - Case studies.	

Learning Resources	1. *Andrew K.S.Jardine & Albert H.C.Tsang, "Maintenance, Replacementand Reliability", Taylor and Francis, 2006.* 2. *Bikas Badhury & S.K.Basu, "Tero Technology: Reliability Engineeringand Maintenance Management", Asian Books, 2003.*	3. *Charles E. Ebeling, Reliability and Maintainability Engineering, Tata McGraw Hill, 2000* 4. *R. K. Gupta, "Reliability, maintenance and safety engineering", University Science Press, Bangalore, 2009* 5. *L M Deshmukh, "Industrial safety management", TATA McGraw Hill, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India,Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mrs. A. Brindha, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE202T	Course Name	RENEWABLE ENERGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the need of energy conversion and the various techniques of energy storage*
CLR-2:	*introduce the field applications of solar energy*
CLR-3:	*gain knowledge about wind energy conversion system*
CLR-4:	*impart the concepts of Geothermal and tidal energy system*
CLR-5:	*provide knowledge of various direct energy conservation systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the fundamental concepts in energy conservation*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*interpret the working of solar energy system and its applications*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*compare the various of concepts and applications of wind energy*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*explain geothermal and tidal energy production and its applications*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*select the applications of direct energy conversion systems*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to Energy Scenario	***9 Hour***
Importance of renewable sources of energy - Sustainable design and development - Types of RE sources- Present Indian and international energy scenario of conventional - Indian energy scenario in various streams - Present renewable energy status - Global energy status- Per capita energy consumption - Future energy plans - Case study.	
Unit-2 - Solar Energy	***9 Hour***
Introduction to Solar radiation - Measurements of solar radiation and sunshine - Flat plate and concentrating collectors - Solar thermal applications - Solar thermal energy storage techniques - Fundamentals of solar photo voltaic conversion - Study of solar PV systems - Summer and winter greenhouse solar PV applications - Case study	
Unit-3 - Wind Energy	***9 Hour***
Wind data and energy estimation - Wind resource assessment - Study of horizontal axis wind turbine - Wind turbine generators and its performance - Study of hybrid systems - Wind turbines (Wind mill) - Site Selection considerations - Basic components of a wind energy conversion system (WECS) - Advantages & Limitations of WECS - Environmental issues - Case studies.	
Unit-4 - Geothermal and Tidal Energy	***9 Hour***
Introduction to Bio resources - Biomass direct combustion - Study of thermochemical conversion - Study of Biomass gasifier - Types of biomass gasifiers – Cogeneration – Carbonization – Pyrolysis - Biogas plants – Digesters - Biodiesel production - Ethanol production - Urban waste to energy conversion - MSW incineration plant-Case study	
Unit-5 - Direct Energy Conservation System	***9 Hour***
Small hydro - Tidal energy - Wave energy - Open and closed OTEC Cycles, limitations - Geothermal energy sources and types of geothermal power plants - Environmental impact - Tidal energy - Basic Principles and components of tidal Power – Introduction to thermionic emission & work function - Case studies.	

Learning Resources	1. *B H Khan, "Non-Conventional Energy Resources", Tata Mc Graw Hill Education Pvt Ltd, 2011* 2. *S. Hasan Saeed and D.K. Sharma, "Non-Conventional Energy Resources", S.K. Kataria & Sons, 2012* 3. *G. D. Rai, "Non-Conventional Energy Sources", 4th ed., Khanna Publishers, 2000.*	4. *Godfrey Boyle, "Renewable energy", Open University, Oxford University Press in association with the Open University, 2004.* 5. *S.P. Sukhatme, "Solar Energy", Tata Mc Graw Hill Education Pvt Ltd, 2008.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mrs. A. Brindha, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE203T	Course Name	FUNDAMENTAL OF MEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the importance and working of various micro sensors and actuator in micro devices*
CLR-2:	*know the process flow and sequence in micro fabrication of MEMS devices*
CLR-3:	*impart the knowledge on various micro machining techniques and design tools*
CLR-4:	*understand the significance involved in various levels of MEMS packaging and bonding*
CLR-5:	*introduce characterization techniques used for MEMS devices*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the operating principle of micro sensors and actuators used in micro devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*analyze the various fabrication techniques used in mems devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*apply the implication of micromachining techniques to fabricate 2D and 3D micro devices and structures*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*outline the importance of bonding and sealing at various levels of mems packaging*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*illustrate different characterization techniques*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction	***9 Hour***
Introduction To MEMS – Microelectronics Vs Micro systems – Scaling laws – Silicon as ideal material – Si wafer production – Chemical and mechanical properties of Si, polymer, quartz, GaAs - Micro sensors – Actuators – Micro devices – Micro gears – Micro motors – Micro valves – Micro pumps	
Unit-2 - Fabrication Overview	***9 Hour***
Introduction To fabrication process – Photo lithography – CVD – PVD – Ion implantation – Oxidation – Diffusion – Wet etching – Dry etching – Etchants properties – Etch stop method	
Unit-3 - Micromachining	***9 Hour***
Introduction to micromachining – Bulk micromachining – Isotropic etching – Anisotropic etching – Surface process – Interfacial and residual stress – LIGA process – Electromechanical design – Thermoelectric design – CAD.	
Unit-4 - Micromachining Packaging, Bonding and Sealing	***9 Hour***
Introduction To MEMS packaging – Challenges in selection of packing materials – Levels of packaging – Plastic encapsulation – Die preparation – Wire bonding – Surface bonding – Adhesive – SOI type – Sealing	
Unit-5 - Characterization	***9 Hour***
Structural characterization XRD, SEM, AFM, EDS, XPS – Optical characterization UV, Raman, FTIR – Electrical characterization VI.	

Learning Resources	1. *Mohamed Gad-El-Hak, "MEMS Design and Fabrication", CRC Press,2019* 2. *M. Madou, "Fundamentals of Micro fabrication", Taylor and Francisgroup, 2017* 3. *Tai-Ran Hsu, "MEMS and MICROSYSTEMS", 22nd reprint ed.,Wiley & Sons, 2015*	4. *Thomas M. Adams, Richard A. Layton, "Introductory MEMS Fabrication and Applications", Springer US, 2014* 5. *Vardhan Gardener, "Micro sensors and smart devices", John Wiley & Sons,Reprint ed., 2002* 6. *NPTEL video lecture series on Sensors & Actuators, by Prof. HardikPandya, IISc, Bangalore*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. C. Likith Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE204J	Course Name	FUNDAMENTALS OF DATA STRUCTURES AND ALGORITHM	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	*EIE*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of different data types and data structures*
CLR-2:	*impart skills to process data using stack and queues*
CLR-3:	*understand the tree data storage structure and their applications*
CLR-4:	*outline the various sorting and searching algorithms and their implementation*
CLR-5:	*provide knowledge of algorithms to find the shortest data search in graphs for real-time applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the various data types and algorithms*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*construct stack and queue data structures along with its operations*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*evaluate the tree data structures, its types and operations*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the various algorithms for sorting and searching*	*2*	-	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*use the various algorithms in data structures*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction ***12 Hour***

Variables, data types, data structures, abstract data types (ADTs)- Algorithm, analysis of algorithms, running time analysis, comparison of algorithms - Rate of growth - Asymptotic notation, Big-O notation [Upper Bounding Function], Omega-Q notation [Lower Bounding Function] - Theta-Θ notation [Order Function] – Linked lists and array

Practice:

1. Implementation of Data Types and Structures. 2. Implementation of Array – Insertion, Deletion

Unit-2 - Stacks and Queues ***12 Hour***

Format of a recursive function - Recursion and memory (Visualization), recursion versus iteration – Backtracking - Linked list - Stack, stack ADT, applications & implementation - Queue, queue ADT - Exceptions, applications & implementation

Practice:

1. Implementation of Doubly Linked List. 2.Implementation of Stack using array and Linked List

Unit-3 - Trees ***12 Hour***

Trees, binary trees, binary tree traversals, generic trees (N-ary Trees), threaded binary tree traversals (stack or queue-less Traversals) - Expression trees - XOR trees - Binary search trees (BSTs) - AVL (Adelson-Velskii and Landis) trees.

Practice:

1. Implementation of Queue using Array and linked list. 2 Implementation of Tree using array. 3. Implementation of sorting Techniques

Unit-4 - Sorting and Searching ***12 Hour***

Sorting, classification of sorting algorithms, types of sorts - Searching, need for searching, types of searching, comparing basic searching algorithms - Symbol tables and hashing-String searching algorithms

Practice:

1. Implement hashing with linear Probing. 2. Implementation of Search Techniques. 3. Implementation of Graphs using the array

Unit-5 - Algorithms	***12 Hour***
Graph algorithms - Applications of graphs - Shortest path algorithms - Minimal spanning tree - Greedy algorithms - Divide and conquer algorithms - Algorithms design techniques	
Practice:	
1. Implementation of Shortest path Algorithm. 2. Implementation of Minimal Spanning Tree. 3. Mini Project	

Learning Resources	1. *Narasimha Karumanchi, 'Data Structures and Algorithms Made Easy', CareerMonk Publications, 5th ed., 2017* 2. *Thomas H. Cormen, Introduction to Algorithms, The MIT Press, 4th ed., 2022*	3. *Mark Allen Weiss, Data Structures and Algorithm Analysis in C, 2nd ed., Pearson Education, 2015.* 4. *Reema Thareja, Data Structures Using C, 1st ed., Oxford Higher Education, 2011.* 5. *NPTEL Video lectures on "Programming, Data structures and Algorithms", Prof. Shankar Balachandran, IIT Madras.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. P A Sridhar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE205T	Course Name	TRANSDUCERS FOR BIOMEDICAL APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	understand the transduction principles and the various electrodes used in medical field.
CLR-2:	impart the knowledge on various temperature transducers
CLR-3:	explore various biomedical Instruments used for pressure measurements
CLR-4:	gain knowledge on the various flow and displacement transducers.
CLR-5:	introduce the fundamental concept of bio analytical sensors

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	interpret the transduction principles used in biomedical applications	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-2:	compare the temperature transducers which are used for measuring various biological parameters	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	explain the different instruments used for measuring pressure and their principle	2	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	select suitable flow and displacement transducers for diagnosis and therapeutic applications	3	2	-	-	-	-	-	-	-	-	-	-	-	3	-
CO-5:	analyze the recent transducers for various applications	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-

Unit-1 - Transduction Principles	**9 Hour**
Overview of Transducers-Man instrument system -Problems encountered in measuring a living system - Static and dynamic characteristics -Factors influencing the choice and design of the transducer in measuring the physiological parameters -Study of biological sensors in the human body -Human cell -Generation of action potentials -Bio-potential electrodes -Selection of electrodes-Survey of recent electrodes used in clinical applications	
Unit-2 - Temperature Transducers	**9 Hour**
Overview of temperature transducers for biomedical applications -Principle and applications -Thermometry -Thermo resistive transducer –Resistive Temperature Detector -Thermistor - Thermo emf transducer-thermo couples -Thermography -Non contact type infrared thermometry -Optical pyrometer -Nasal air flow measurement	
Unit-3 - Pressure Transducers	**9 Hour**
Overview of pressure transducers -Principle and applications -Diaphragm displacement pressure transducers - Catheter tip transducer -Implantable pressure transducer -Micro pressure transducer -Vascular pressure sensors- Strain gauge and diaphragm type capacitive pressure transducer -Piezo electric pressure transducer - Fiber optic pressure transducer for intracranial pressure measurement in new born -Stethoscopes -Tonometry -Phonocardiograph sensor	
Unit-4 - Flow and Displacement Transducers	**9 Hour**
Overview of flow and displacement transducers-Principle and applications - Blood flow in a single vessel -Tissue blood flow -Electromagnetic blood flow transducer -Ultrasonic flow transducer -Implantable flow sensors - Contact and noncontact displacement sensors - Fleish pneumotachometer -Capacitive and displacement transducer for respiration sensing	
Unit-5 - Analytical Sensors	**9 Hour**
Biosensors -Principle, types and applications -Biologically active material and analyte -Bio affinity based biosensors -Microorganisms based biosensors -Biocatalysts based biosensors -Sensors for smell, sound, vision -Microbial biosensor for ammonia and nitrogen dioxide -Optical biosensor for antibody-antigen detection -Enzyme based glucose sensor	

Learning Resources	1. *John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, 4th ed., New York, 2009.* 2. *Leslie Cromwell," Biomedical Instrumentation and Measurement", Prentice Hall of India, New Delhi, 2007*	3. *Carr, J.J., Elements of Electronic Instrumentation and Measurement, Pearson Education India, 2011* 4. *Standard Handbook of Biomedical Engineering & Design – Myer Kutz, McGraw Hill Publisher, 2003.* 5. *James E. MooreJr, Duncan J. Maitland, "Biomedical Technology and Devices", CRC press, 2nd ed., 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.N.Deepa, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE301T	Course Name	BUILDING AUTOMATION SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*provide basic knowledge in building automation systems*
CLR-2:	*understand the basic concepts of HVAC and air handling unit*
CLR-3:	*impart knowledge in the design of various sub systems of terminal unit*
CLR-4:	*provide insight into some of the safety mechanisms*
CLR-5:	*explore the various components of access control system*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the need of intelligent buildings and develop automation systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-2:	*design air handling units for different specifications*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*design terminal units for different specifications*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*identify the components of fire alarm system*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	*3*
CO-5:	*familiarize with the components of access control system and protocols for communication*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	*3*

Unit-1 - Introduction to Building Automation Systems	***9 Hour***
Introduction to intelligent building - Intelligent architecture structure - Facility management vs. Intelligent buildings - Lifecycle of building - Evolution of intelligent buildings - Introduction to BAS - Different systems of BAS - Comfort parameters - temperature, humidity, pressure - Heat Transfer - conduction, convection, radiation - Working principle - Sensors	
Unit-2 - HVAC - Air Handling	***9 Hour***
Concept of air handling unit - Components in AHU - Different types of dampers – working, configuration - Different types of AHU - Design and working - Operation of different modes in AHU – Humidification – Dehumidification - Static Pressure Control - Volume Matching – Cooling – Heating - Economizer mode, Heat recovery techniques -Plate heat exchanger - Heat recovery wheel - AHU for different applications	
Unit-3 - HVAC - Terminal Unit	***9 Hour***
Concept of Variable Air Volume (VAV) system - Different types of VAV – Design - Working, series fan powered, parallel fan powered, pressure dependent, supply- exhaust VAV, dual duct VAV, Design, working, use of radiation coil, chilled beam, CRAC unit, VRV systems unit heater, Fan coil unit and unit ventilator, Chilled water system, Concept of refrigeration cycle, components used in refrigeration cycle, different types of chilled water system, Working and design of different types of boilers, Working and design of different types of heat exchanger	
Unit-4 - Fire and Alarm System	***9 Hour***
Fire triangle, Fire stages, Components of fire alarm system, Different fire sensors, smoke detectors and their types, CO and CO2 sensors, Fire control panels, design Considerations for the FA system, concept of IP enabled fire & alarm system, design aspects and components of FA system.	
Unit-5 - CCTV & Access Control System, Communication Protocols	***9 Hour***
Field Devices, Peripheral Devices, User Devices, System Architecture, Different types of Access Cards & Card Readers, Components of CCTV system, Types of camera, Transmission Methods, Open Protocols -BACnet, LON, PROFIBUS, MODBUS, M-bus, Proprietary Protocols- N2, CBUS, Wireless filed devices,controllers, routers, coordinators, Benefits of a Wireless BAS, Wireless field bus, Basic Reference Model (BRM)	

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

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.G.Joselin Retna Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	2. *Dr. Sam Jeba Kumar, SRMIST*

Course Code	21EIE302T	Course Name	ELECTRICAL ENERGY MANAGEMENT AND CONVERSION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the different types of energy resources*
CLR-2:	*learn the different types of energy conversion techniques from the available energy resources*
CLR-3:	*understand the methods of energy audit and energy management*
CLR-4:	*explore the methods of energy conservation*
CLR-5:	*know the impact of energy systems to the environment*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the different types of energy resources*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*analyze the different types of energy conversion techniques from the available energy resources*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*select the methods of energy audit and energy management*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*identify the methods of energy conservation*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*infer the impact of energy systems to the environment*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Energy Resources	***9 Hour***
Commercial energy – Coal, oil - Natural gas, Nuclear power – Hydro - Solar energy - Principle of photovoltaic conversion and applications -Types of solar cells - Wind energy - Bio-energy - Biomass conversion processes - Ocean energy, tidal, geothermal – Fuel cell and its applications	
Unit-2 - Energy Conversion Techniques	***9 Hour***
Conventional energy conversion - Reversible and irreversible cycles - Thermodynamics analysis - Carnot, stirling - Otto, diesel, atkinson, brayton, rankine - Direct conversion of thermal to electrical energy - Thermoelectric converters – Thermo-ionic converters – MHD - Chemical to electrical energy – Batteries - Hydrogen energy - Solar photovoltaic cells - Energy storage systems - Fuel cells	
Unit-3 - Energy Audit and Management	***9 Hour***
General philosophy and need of energy audit and management - Definition and objective of energy management - Energy management skills - Energy management strategy - Energy audit: Need, types, methodology and approach - Energy management approach - Understanding energy costs - Energy performance - Plant energy study report	
Unit-4 - Energy Conservation	***9 Hour***
Introduction to ENCON - Approach and modern techniques - Benefits, trends - Energy conservation technology (Thermal energy) - Energy intensive industries - Techno-economic evaluation - Thermal utilities – Furnaces - Refractories - Energy storage - Techno commercial analysis - Practical energy conservation measures in government and non-government organizations	
Unit-5 - Environmental Impact of Energy Systems	***9 Hour***
Environmental degradation due to energy production and utilization - Primary and secondary pollutants - Global warming - Sociological and economic problems - Methods of energy impact assessment - Environmental pollution limits guidelines - Waste as a source of energy - Pollution control - International standards - United nation framework convention on climate change	

Learning Resources	1. *Christen Thomas, Efficiency and Power in Energy Conversion and Storage: Basic Physical Concepts, CRC Press, 2019* 2. *Frank Kreith, Energy Management and Conservation Handbook, 2nd ed, CRC Press, 2016.* 3. *Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012*	4. *Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill,2007* 5. *NPTEL Video Lecture series on "Energy Resources and Technology" by Prof. Banerjee, IIT Kharagpur* 6. *NPTEL Video Lecture series on "Energy Conservation and Waste Heat Recovery" by Prof. P.K.Das, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *T.A.Balaji, Robert Bosch, Coimbatore, Balaji.TAnanthanpillai@in.bosch.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.G.Y. Rajaa Vikhram, SRMIST.*
2. *G.Vijayakumar, Assistant Engineer, TANGEDCO, vickywhy10@gmail.com*	2. *Dr.S.Latha, TCE, Madurai, sleee@tce.edu*	

Course Code	21EIE303T	Course Name	AUTOMOTIVE SENSORS AND SMART SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the basics of automotive system*
CLR-2:	*understand the principles behind various powertrain sensors and its application across a vehicle*
CLR-3:	*impart the principles and applications behind various body sensors and actuator technologies used in a vehicle*
CLR-4:	*know and understand the need of different safety and security systems*
CLR-5:	*gain the knowledge on different electronic systems and smart interactive systems in the car*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the basics of automotive system*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*describe the principles of powertrain sensors used in a vehicle*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*examine the body sensors and actuator technologies involved in a car*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*analyze the various safety and security systems involved in a car*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*apply the knowledge in designing new electronic supportive systems for a car*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Automobile Fundamentals ***9 Hour***

Introduction - Electronics in automotive and its evolution, automotive physical configuration, engine block, cylinder head, piton - Crankshaft, camshaft, connecting rod, valve, 4-stroke cycle - Engine control - Ignition system - Spark plug, high voltage circuit and distribution - Spark pulse generation - Ignition timing – Drivetrain – Transmission – Driveshaft - Differential - Suspension, brakes, steering system - Requirements in automotive sensor.

Unit-2 - Power Train Sensors ***9 Hour***

Introduction to IC powertrain and its operation - Intake Air Temperature (IAT) sensor engine coolant oil temperature sensor - Exhaust gas recirculation temperature sensor - Exhaust gas - Temperature sensor - Manifold Absolute Pressure (MAP) sensor - High-pressure fuel sensor - Engine oil pressure sensor - Crankshaft angular position sensor - Cam position sensor - Piston position sensor - Throttle plate angular position - Knock sensor - Oxygen concentration sensor - Mass Air Flow (MAF) rate sensor

Unit-3 - Body Sensor and Actuator Technology ***9 Hour***

Rain Sensor - Acceleration Sensor - Yaw Rate Sensor - Chassis Level Sensor - Fuel Level Sensor - Capacitive based Pressure Sensor - Steering wheel Sensor -Torque Sensor - Actuators – Electric, electromechanical, electromagnetic, hydraulic and pneumatic, stepper Motors, relays - Applications of Body Sensors -Applications of Actuators.

Unit-4 - Safety and Security System ***9 Hour***

Tire pressure monitoring systems, anti-lock braking systems - Traction Control Systems - Adaptive Cruise Control, types of Adaptive Cruise Control, parking guide systems, airbag system, and reversible seat belt pre-tensioner - Electronic Power Steering systems - Vehicle Stabilization Systems - Collision Avoidance Systems.

Unit-5 - Smart Supporting Systems ***9 Hour***

Power windows - Smart window lift control module - Central locking system - Door lock indicators - Automatic wiper systems - Electronic vehicle immobilizer -Oil pressure warning system - Engine overheat warning system - Speed warning system - Brake actuation warning system – Gear neutral indicator - Anti-Theft alarm system - Computer controlled air conditioning systems - Power & ventilated seats - Roof control module

Learning Resources	1. *Gregory T. Kovacs "micro machined Transducers Sourcebook", 1sted., 2010.* 2. *Johan H. Huijsing "Smart Sensor Interfaces (Analog IntegratedCircuits & Signal Processing) " Springer, 1997* 3. *G.B.S. Narang,"Automobile Engineering", KhannaPublishers,Twelfthreprint New Delhi, 2005.*	4. *Holman, J.P, Experimental methods for Engineers, McGraw Hill Book Co.,2000* 5. *NPTEL Lectures notes on "Fundamentals of Automotive systems "by Prof.Sankar Ram, IIT Madras*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India,Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. A.Vimala Juliet, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr.J.Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE304T	Course Name	MACHINE LEARNING ALGORITHMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basic knowledge about machine learning*
CLR-2:	*introduce the concept of data preprocessing and supervised learning*
CLR-3:	*provide knowledge on unsupervised learning and Bayesian network*
CLR-4:	*introduce the basic concepts of neural network and applications of machine learning in industrial sector*
CLR-5:	*impart adequate knowledge on industry using machine learning*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the fundamental concepts and methods of machine learning*	*3*	*2*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*analyze various machine learning application based on data pre-processing and supervised learning*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*design the architecture of unsupervised learning and Bayesian network*	-	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*develop the neural network architecture for industrial applications*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*apply various learning algorithms of Neural network and its application in machine learning*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Machine Learning	***9 Hour***
Machine -Types of Machine Learning Supervised Learning Unsupervised - Regression - Classification - The Machine Learning Process - Data Collection and - Feature Selection - Algorithm Choice-parameter and Model Selection – Training Evaluation -Bias-Variance Tradeoff – Under fitting and Over fitting Problems- Bias and - Problem Solving	
Unit-2 - Data Preprocessing and Supervised Learning	***9 Hour***
Data quality – Data preprocessing, Data Cleaning:– Handling missing data and noisy - Data integration:- Redundancy and correlation analysis -Factor - Independent Components Analysis - Supervised Learning: Linearly separable and nonlinearly separable populations- k-means algorithm-Logistic Regression Radial Basis Function Network -Support Vector Machines, Kernels – Risk and Loss Functions - Support Vector Machine Algorithm -Multi Class Classification - Support Vector Regression - Problem solving	
Unit-3 - Unsupervised Learning and Bayesian Networks	***9 Hour***
Classification problems- decision boundaries- nearest neighbor methods- Probability and classification- Bayes optimal decisions- Naive Bayes and Gaussian class-conditional distribution- Linear classifiers- Bayes' Rule and Naive Bayes Model- Decision tree- Ensemble methods: Bagging-random forests- boosting - Decision Tree and Boosting.	
Unit-4 - Network and Application in Industries	***9 Hour***
Multi-Layer -Back propagation Learning Algorithm - Neural Network -Activation functions- Types of Loss - Optimization: Gradient Descent Algorithm - Stochastic Gradient Descent-Batch Normalization and Dropouts - Applications of Neural Network-Relationship between machine learning and industry - Energy sector - Oil and gas -Industrial Sector -g Industrial goods and services	
Unit-5 - Case Studies	***9 Hour***
Machine level case study: Introduction - Fingerprint of industrial motors - Performance of industrial motor as a fingerprint -Clustering algorithm for fingerprint - Agglomerative Hierarchical Clustering - K-means clustering-Affinity propagation - Gaussian model mixture clustering - Implementation details -Production level case study -Laser surface heat treatment -s Image acquisition and response time requirement	

Learning Resources	1. *Pedro Larrañaga, David Atienza, Javier Diaz-Rozo, Alberto Ogbechie, Carlos Esteban PuertoSantana, Concha Bielza., "Industrial Applications of Machine Learning", CRC Press, 2019* 2. *Tom M. Mitchell, "Machine Learning", Indian ed., 2017* 3. *Thomas A. Runkler, Data Analytics: Models and Algorithms for Intelligent Data Analysis, Springer Vieweg, 2nd ed., 2016.*	4. *Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier, 2011* 5. *NPTEL video lectures on "Introduction to machine learning",Prof. Balaraman Ravindran, IIT Madras.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr A.Asuntha, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr.J.Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE305T	Course Name	BIOMEDICAL DEVICES AND INSTRUMENTATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the physical foundations of biological systems and the various electrodes used in the medical field*
CLR-2:	*introduce the various physiological signal measurements*
CLR-3:	*understanding various biomedical Instruments used for non-electrical parameter measurement provide an overview of electrical parameter acquisition and recording*
CLR-4:	*know the various medical imaging systems*
CLR-5:	*understand the fundamental concept of life-assisting and therapeutic devices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the operation of different medical devices.*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*determine the techniques to measure, detect and analyze the bio-signals*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*select the appropriate medical instruments for measurement*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*analyze the suitable medical imaging system for diagnosis*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*interpret the medical devices for diagnosis and therapeutic applications*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Medical Instrumentation	***9 Hour***
Medical Instrumentation systems, classification of biomedical instruments, problems encountered in measuring a living system - Review of human body systems, cell and their structure - The heart and cardiovascular system - electrophysiology of the cardiovascular system, physiology of the respiratory system - Nervous system - Bio-potentials, resting and action potential, propagation of action potentials - Bio-potential Electrodes, electrode behavior, and circuit models - Types of electrodes, survey of recent electrodes used in biosignal acquisition.	
Unit-2 - Biomedical Signal Acquisition	***9 Hour***
Types and Classification of biological signals, generation of biological signals – Filters – Amplifiers, preamplifiers, differential amplifiers, chopper amplifiers, isolation amplifiers -Lead systems and recording methods, ECG, EEG, EMG, ERG - Electrical safety in the medical environment, micro and macro shock hazards, electrical hazards, leakage current instruments.	
Unit-3 - Basic Instrumentation in Photonics	***9 Hour***
Measurement of blood pressure, direct and indirect method - Cardiac output measurement, Fick's method, indicator dilution method, thermo dilution method - Blood flow Measurement, blood flow meter, radiographic, thermal convection methods - Pulmonary function measurements – Spirometer – Plethysmography - BSR, and GSR measurements - Blood Gas analyzers - Measurement of blood pH, pCO2, pO2, fingertip oximeter.	
Unit-4 - Medical Applications	***9 Hour***
X-radiations, X-ray tube, X-ray machine – Radiography – Fluoroscopy - Computer tomography - Magnetic resonance imaging - Positron emission tomography - Single photo emission computer tomography – Ultrasonography – Endoscopy - Thermal Imaging and its types	
Unit-5 - Hazards and Safety	***9 Hour***
Pacemakers - Defibrillators - AC and DC defibrillators – Ventilators, methods of artificial respiration, types of ventilators - Nerve and muscle stimulators – Electrotherapy – Diathermy - Heart Lung machine - Audio meters – Dialyzers - Therapeutic and Prosthetic Devices - Infant Incubators - Drug Delivery Devices - Artificial limb and hands - Telemetry.	

Learning Resources	1. *Cromwell, "Biomedical Instrumentation and Measurements", 2nd ed., 2015* 2. *RS Khandpur, "Handbook of Biomedical Instrumentation", 3rd ed., 2014*	3. *NPTEL Course on "Mathematical Aspects of Biomedical Electronic System Design", by Prof. Chandramani Singh, IISC Bangalore*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. P A Sridhar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE306T	Course Name	INDUSTRIAL INTERNET OF THINGS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the internet principles and various components of IoT*
CLR-2:	*give an overview of the interconnection and integration of the physical world with cyber space*
CLR-3:	*impart knowledge on different protocols and clouds for IoT*
CLR-4:	*know the challenges in the deployment of IoT and security issues*
CLR-5:	*provide an insight into design and development of IoT application*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*familiarize about the architecture and specifications of a given network*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*design simple IoT applications using prototyping boards*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*select the appropriate protocol for a specific network implementation*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*identify the security level needed for a particular industrial IoT application*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*analyze and Interpret the process data using cloud based process data management tools*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - IoT Overview	***9 Hour***
Definition and characteristics - IoT enabling technologies - ISO/OSI model - MAC address and IP address - Overview of TCP/IP - Classes of IP addresses – Basics of DNS - Static and dynamic addressing - Salient features of IPV4, Specifications of IPV6 - 6LoPAN - Functional components of IoT - IoT gateways, challenges, service oriented architecture	
Unit-2 - Physical and Logical Design Methodologies	***9 Hour***
Requirements – Specifications - Device and component integration - Physical design using prototyping boards - Sensors, actuators, choice of processor, interfacing and networking - Logical design - Open source platforms - Techniques for writing embedded code - Case studies and examples using Python programming - Examples using Arduino/Raspberry Pi prototyping boards, IoT application development using wireless sensor networks - Single node architecture- Hardware components - Energy consumption of sensor nodes	
Unit-3 - Protocols and Clouds for IoT	***9 Hour***
MQTT protocol - Components of MQTT - Constrained Application Protocol (CoAP) - Types of messages, request response model features, Extensible Messaging and Presence Protocol (XMPP) - Advanced message queuing protocol - Features IEEE 802.15.4 - ZigBee protocol - Xbee modules - Wireless HART - Z-Wave - Field bus ISA 100 – Bluetooth - NFC and RFID - Introduction to cloud storage models communication – API's web application framework - Designing a web API Web services - Designing a web AP	
Unit-4 - Industrial IoT	***9 Hour***
Introduction to the industrial internet - Basis of industrial IoT - Challenges in the deployment of IIoT - Benefits of IIoT - Applications of the industrial internet - Advantages of the industrial internet networked control systems - Network delay modeling - IIoT architecture - Industrial IoT - Processing characteristics, challenges, architecture and design methodologies for developing IoT application for networked control systems - Security issues - Middleware IIoT platforms securing the industrial internet	
Unit-5 - IIoT Applications and Security	***9 Hour***
Introduction - IIoT for industrial processes - Industrial control systems - PLC, DCS, SCADA - Smart factory - Inventory management & quality control – IioT Applications - Understanding security in IoT Design - Design requirements of IoT - Security issues and challenges	

Learning Resources	1. *ArshdeepBahga and Vijay Madisetti, "Internet of Things A Hands- on Approach", Universities Press (India),2015* 2. *Alasdair Gilchrist," Industry 4.0:The Industrial Internet of Things",Apress,2016*	3. *Adrian Mc Ewenand Hakim Cassimally, "Designing the Internet of Things",John Wiley& Sons, 2014* 4. *Francis Dacosta, "Rethinking the Internet of Things", Apress Open, 2013*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. G.Joselin Retna Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	2. *Dr.Sam Jeba Kumar, SRMIST*

Course Code	21EIE307T	Course Name	MODERN CONTROL TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the fundamentals of digital controller*
CLR-2:	*impart knowledge in multi loop and multivariable control design*
CLR-3:	*provide knowledge in model predictive control*
CLR-4:	*introduce adaptive control for real time system*
CLR-5:	*understand the need and use of optimal control*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the digital controllers for various systems*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*determine the controller parameters for MIMO system*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*outline the various model predictive control for different systems*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the various challenges in the real time parameter estimation*	*2*	-	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*describe the various types of optimal control methods*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Digital Control	***9 Hour***
Digital PID, deadbeat's algorithm, deadbeat's controller design - Dahlin's algorithm, dahlia's controller design - Kalman's algorithm, kalman's controller design – Pole placement controller, position and velocity form of PID	
Unit-2 - Multi Loop Regulatory Control	***9 Hour***
Introduction multi loop control, process interaction, pairing of inputs and outputs - Relative Gain Array, construction of relative gain array - Multi loop PID controller, decoupler, multi variable control, applications of multi loop control in various process industries	
Unit-3 - Model Predictive Control	***9 Hour***
Introduction to model predictive control, time delay systems - Smith predictor method description on MPC elements, types of MPC algorithms - State space formulation dynamic matrix control, prediction, measurable disturbances, control algorithm - Model algorithmic control, process model, prediction, control law - Case study 1, water heater control using dynamic matrix control	
Unit-4 - Adaptive Control	***9 Hour***
Introduction to adaptive control linear feedback, effects of process variations, adaptive schemes and problem - Real time parameter estimation - Least squares and regression models, estimating parameters in dynamic systems, simulation of recursive estimation, deterministic self-tuning regulators - Pole placement design, direct and Indirect self-tuning regulators - Stochastic and predictive self-tuning regulators, unification of direct self-tuning regulators - Linear quadratic STR, adaptive predictive control	
Unit-5 - Optimal Control	***9 Hour***
Review of basic concepts –State space technique, approach and matrix theory, review of numerical methods - Static optimization, optimal control through calculus of variation - Classical numerical techniques for optimal control, discrete-time optimal control - State dependent riccati equation - LQ observer and Kalman filter design - Linear quadratic Gaussian design.	

Learning Resources	1. *Gopal, M., "Digital Control and State Variable Methods", Tata McGraw Hill, 3rd Edition, 2003* 2. *Wiley John Seborg, D.E., Edgar,T.F. and Mellichamp, D.A., "ProcessDynamics and Control, 3rd Edition , 2010* 3. *Sasa V. Rakovic, William S. Levine Handbook of Model Predictive Control,– 2018*	4. *Adaptive Control: Second Edition, Karl J. Åström, Bjorn Wittenmark - 2013* 5. *Donald E. Kirk Optimal Control Theory: An Introduction, doverpublications, 2012*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	
Level 5	*Evaluate*	-	-	-	-	-	
Level 6	*Create*	-	-	-	-	-	
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mr.P.Jekan, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE308T	Course Name	FAULT DIAGNOSIS AND TOLERANCE SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	know basic knowledge in fault diagnostics and tolerance system
CLR-2:	understand the methods of detection of Fault in process
CLR-3:	identify the process of diagnosis of fault using different methods
CLR-4:	impart knowledge in the steps to design the controller for fault tolerant system
CLR-5:	study adequate information about the application of fault in electrical systems

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	summarize the model for fault diagnostics and tolerance system	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	apply the different methods for fault detection	3	-	2	-	-	-	-	-	-	-	-	-	1	-	-
CO-3:	illustrate the methods of fault diagnostics	3	-	2	-	-	-	-	-	-	-	-	-	1	-	-
CO-4:	explain the fault tolerant control and identify its elements	3	-	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	analyze the applications of fault tolerant system in various process and systems	3	-	2	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Introduction to Fault Diagnostics Systems	**9 Hour**
Types of faults - Different tasks of fault diagnosis - Implementation of fault diagnosis - Different approaches to FDD - Model free approaches - Model based approaches - Mathematical representation of faults – Disturbances - Additive and multiplicative types - Design of residual generator - Residual specification and implementation.	
Unit-2 - Fault-Detection Methods	**9 Hour**
Process models - Fault modelling - Signal models - Fault detection with limit checking - Fault detection with signal models - Fault detection with process - Identification methods - Fault detection with parity equations - Fault detection with state observers - Fault detection with state estimation - Fault detection of control loops - Fault detection with principal component analysis.	
Unit-3 - Fault-Diagnosis Methods	**9 Hour**
Diagnosis procedures - Diagnosis knowledge representation -Typical statistical symptom - distributions fault diagnosis - Fault diagnosis with classification methods - Bayes classification – Examples - Polynomial classification - Neural networks for fault diagnosis - Fault diagnosis with inference methods - Hybrid neuro - fuzzy systems - Parity space approach - Optimization based approach - Kalman filter approach	
Unit-4 - Controller For Fault-Tolerant Systems	**9 Hour**
Fault tolerant control problem - Fault tolerant control architecture - Fault-tolerant linear quadratic design - Fault-tolerant model matching design - Control reconfiguration of actuator -Fault-tolerant H∞ design - Handling the fault recovery transients - Progressive fault accommodation	
Unit-5 - Application	**9 Hour**
Fault detection and diagnosis of DC motor drives - Electrical throttle valve actuator - Fault detection and diagnosis of a centrifugal pump, pipe system - Fault detection and diagnosis of an automotive suspension - Fault detection and diagnosis of an automotive pressures - Fault tolerant control of a three tank system	

Learning Resources	1. *Rolf Isermann, Fault-Diagnosis Systems, Springer-Verlag Berlin Heidelberg 2006* 2. *Janos Gertler, Fault Detection and Diagnosis in Engineering Systems, Routledge, 2017.* 3. *Adel Haghani Abandan Sari, Data-Driven Design of Fault Diagnosis Systems: Nonlinear Multimode Processes, Springer-Verlag 2014,*	4. *MogensBlanke, Michel Kinnaert, Jan Lunze Diagnosis and Fault-Tolerant Control, Springer-Verlag Berlin Heidelberg 2016* 5. *Sraelkorian, c. Mani Krishna, Fault tolerant system, Elsevier 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mr.P.Jekan, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE309T	Course Name	E-VEHICLE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the knowledge on controller area network protocol used in electric vehicles*
CLR-2:	*provide knowledge on batteries used in electric vehicles*
CLR-3:	*understand the charging system in e-vehicles*
CLR-4:	*impart basic information on electric power train system*
CLR-5:	*understand the need and use of accessories in vehicles*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the electrical system in electric vehicles*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO-2:	*describe the various batteries and its maintenance*	2	-	2	-	-	-	-	-	-	-	-	-	-	-	2
CO-3:	*outline the various charging circuits and diagnose system faults*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO-4:	*analyze the various challenges in the path of power transition system*	2	-	-	2	-	-	-	-	-	-	-	-	-	-	2
CO-5:	*describe the various supporting elements of electric vehicles*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2

Unit-1 - Electrical Systems and Circuits	***9 Hour***
System approach, electrical wiring, terminals and switching, multiplexed wiring systems - Controller Area Network protocol, circuit diagrams and symbols requirements for two-wheeler, three-wheeler, heavy vehicles - Electromagnetic standards and interference - SAE automotive EMC standards, IEEE Standards related to EMC - Electromagnetic environment of an automobile electronic system - EMC between various vehicular systems - EMC between vehicle and surrounding –Ensuring interference suppression and immunity to interference - New developments in systems and circuits	
Unit-2 - Batteries	***9 Hour***
Overview of Battery - Battery parameters - Lead acid battery, battery charging, discharging, maintenance, diagnosing lead acid battery faults - Li-ion battery, types of Li-ion battery, charging, discharging - Hydrogen fuel cell - Fuel cell design, stack size, number of cells, stack configuration - Comparative analysis on all the batteries - New developments in electrical storage and batteries	
Unit-3 - Charging Systems	***9 Hour***
Charging systems, requirements, components and operation, testing procedures - Generation of electrical energy in motor vehicle, physical principles – Alternators, characteristic curves, charging circuits - Diagnosing charging system faults, alternative charging systems - Case study I	
Unit-4 - Electric Power Train Systems	***9 Hour***
Challenges in the path of transition from IC engines to electric engines, requirements, types of motors - Motors and circuits, operation of motors - Testing system and methodologies, diagnosing system faults - Updated research on E-power train system - Case study II	
Unit-5 - Supporting Systems and Accessories	***9 Hour***
Insulated and earth return systems, positive and negative earth systems, concealed headlights, lighting circuit types - Glare and preventive methods -Speedometer - Temperature gauges - Horns, defoggers - Power windows - Wipers, washers, blower motors – HVAC, climatic control systems - Power seats - Seat belt pretensioners - Case study III	

Learning Resources	1. *Behrooz Mashadi and David Crolla, "Vehicle Powertrain Systems", 1st edition, Wiley, 2012* 2. *Tom Denton, "Automotive Electricals / Electronics System and Components", 3rd Edition, 2004.*	3. *BOSCH, "Automotive Electrics, Automotive Electronics: Systems & Components, BOSCH", 4th Edition, 2005.* 4. *Jack Erjavec," A Systems Approach to Automotive Technology"Cengage Learning, 2009.* 5. *Edited by Ronald K.Jurgen, "Automotive Electronics Reliability", Vol 2, SAE International, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mr.P.Jekan, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE310T	Course Name	INTELLIGENT SYSTEMS AND CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*learn the concept of neural network system.*
CLR-2:	*understand the theoretical principles of fuzzy logic systems and control.*
CLR-3:	*know the process of modelling using neural control techniques.*
CLR-4:	*impart the skills to implement the neural network control algorithms.*
CLR-5:	*understand the different fuzzy control methodologies.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the principles and theory of neural network system.*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*apply the principles of fuzzy logic systems and control*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyze the models of any system using neural network-based control.*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*identify the various neural network control algorithms*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*explain the different fuzzy control methodologies.*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Neural Network System	***9 Hour***
Linear neural networks - Multi layered neural networks - Back propagation algorithm - Radial basis function – Networks - Adaptive learning Rate - Weight update rules - Recurrent networks back propagation through time - Recurrent networks - Real time recurrent learning - Self-organizing map - Multidimensional Networks	
Unit-2 - Fuzzy System	***9 Hour***
Review of conventional sets - Introduction to fuzzy sets - Membership functions -Fuzzy relations - Linguistic variables, fuzzy rule base - Reasoning for discrete and continuous fuzzy sets using graphical representation	
Unit-3 - Introduction to Neural Control	***9 Hour***
Adaptive Control Paradigms - Direct adaptive control- Indirect adaptive control - Non-Linear systems - Neural network models & neural control – Architecture - Network inversion in control system identification using feedforward network - Network inversion using gradient descent and Lyapunov function network inversion using extended Kalman filter & neural Model of a Robot Manipulator.	
Unit-4 - Neural Control System	***9 Hour***
Kohonen Self Organizing Map (KSOM) – Extended KSOM - Visual motor coordination with quantum – Clustering - Introduction to direct adaptive control of manipulators - Computed torque control - Adaptive control - Robust control - Neural network based adaptive control - Lyapunov based design, Back stepping - Rigid link electrically driven manipulator	
Unit-5 - Fuzzy Control System	***9 Hour***
Fuzzy Logic Controllers (FLC) – Mamdhani Type Takagi - Sugeno type basic architecture of an FLC, - Single link manipulator - Univariate Marginal Distribution Algorithm - Robot Arm Control - Fuzzy Control of a pH Reactor - Fuzzy Lyapunov Controller – Controller Design for T-S Fuzzy system.	

Learning Resources	1. *Passino, K.M. and S. Yurkovich. Fuzzy Control. Addison-Wesley Publishing Company, 1998,* 2. *Donald J.Norris, Beginning Artificial Intelligence with theRaspberry Pi, Apress, 2017* 3. *Abe, S., Neural Networks and Fuzzy Systems Theory andApplications, Kluwer Academic Publisher, 2012*	4. *Chennakesava R. Alavala, Fuzzy Logic and Neural Networks: Basic Concepts& Applications, New Age International Publishers, 2007* 5. *NPTEL Online Learning on Intelligent Systems and Control, by Prof.Laxmidhar Behera, IIT Kanpur*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mr.P.Jekan, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE311T	Course Name	STATE SPACE CONTROL 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	EIE	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	introduce the state space systems and the relevant techniques that can be applied to real time systems
CLR-2:	explore the mathematical techniques that are required to analyze and simulate the systems with state space model
CLR-3:	understand the structural properties of linear systems for the purpose of analysis
CLR-4:	impart the knowledge on the process of design of control schemes for state space systems using the computational and mathematical techniques
CLR-5:	provide the skills to implement the different control and observer design techniques

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	interpret the relevance of state space techniques as an underpinning methodology for the modelling, analysis, simulation and control of complex real-world systems	3	-	-	2	-	-	-	-	-	-	-	-	-	2	-
CO-2:	compare the mathematical techniques required to analyze, simulate, and control systems modelled in state-space form	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	analyze the structural properties of Linear Systems	3	-	-	2	-	-	-	-	-	-	-	-	-	1	-
CO-4:	explain the computational methods to design state space control techniques for systems modelled in state space form	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	design a controller with a reference input and observers	3	-	-	2	-	-	-	-	-	-	-	-	-	3	-

Unit-1 - Introduction to State Space	**9 Hour**
Introduction to state space systems - Concepts of state, state variable and state space model - State space representation of linear continuous time systems using physical, canonical and phase variables - Diagonalization, linearization and equilibrium points - State space representation of discrete time systems - Solution of state equations - Computation of state transition matrix	
Unit-2 - Analysis of Linear Systems	**9 Hour**
Dynamic response of the continuous time system - Modal decomposition - Introduction to phase portraits - Analysis by phase portraits - Relationship between state space representation and transfer function - Transfer functions of state space systems - Discretization of continuous time systems - Study through simulations - Eigen structure assignment	
Unit-3 - Structural Properties of Linear Systems	**9 Hour**
Stability - Linear system stability conditions - Controllability - Observability - Minimal realization, stabilizability - Detectability, duality - Problems on detectability and duality	
Unit-4 - Controller Design For Linear Systems	**9 Hour**
Pole placement using state feedback - Eigen value placement theorem, selection of desired poles - Controller design using simulation tools - Eigen structure assignment - Dead Beat control - Optimal control - Linear Quadratic Regulation - Infinite horizon regulator, receding horizon regulator	
Unit-5 - Controller and Observer Design for Linear Systems	**9 Hour**
Controller design using reference Input - Servo control using state feedback - Design of feed forward gain matrix - Integral control using state feedback - Internal model principle and disturbance rejection - Observer design for linear systems - State estimation, full state observers - Reduced order state observers - Observer design using simulation tools	

Learning Resources	1. *K.J. Astrom and R.M. Murray, "Feedback Systems – An Introduction for Scientists and Engineers",2nd ed., 2021* 2. *Dorf, R.C and Bishop, R.H, "Modern Control systems", 11th ed., Addison-Wesley, 2008.* 3. *Nise, N.S, "Control systems engineering", 6th ed., Wiley, 2011.*	4. *Kuo, B.C and F Golnaraghi.M, F, "Automatic control systems", 9th ed., Prentice Hall, 2009.* 5. *Lecture Series on "Control Engineering" by Prof. Ramkrishna Pasumarthy, IIT Madras and Dr. Viswanath Talasila, Ramaiah Institute of Technology, Bengaluru*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.N.Deepa, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE312T	Course Name	INDUSTRIAL PROCESSES AND CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the various equipment involved in the petrochemical industries*
CLR-2:	*understand the process of control of Distillation column, Heat exchangers, Reactors and Pump*
CLR-3:	*impart knowledge on various processes involved in iron and steel industries*
CLR-4:	*provide control of furnaces, milling, moldings, rolling and other process in process industries*
CLR-5:	*explore the applications of computer in controlling the learnt processes*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the process and instrumentation involved in petrochemical industries*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	*2*	-
CO-2:	*compare the control methodologies used for various process in petrochemical industries*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*analyze the different processes involved in iron and steel industries*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*interpret the control methodologies involved in iron and steel industrial processes*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*select the various computer applications used for industrial process control*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Oil and Gas Industry Processes	***9 Hour***
Importance of petrochemical industry; Growth in India-Petroleum exploration -Recovery Techniques-Constituents of petroleum-oil-gas separation-Processing wet gases-Refining of crude oil-Refinery gases- Evaporators -Types of Evaporators	
Unit-2 - Control Applications in Petroleum Industry	***9 Hour***
Temperature Control, Pressure control, Feed control of. distillation column - Reflux Control - Reboiler Control - Temperature Control of chemical reactors – Pressure Control of chemical reactors - Steam Heaters, Condensers, Reboilers and Vaporizers - Cascade Control-Steam Heaters, Condensers, Reboilers and Vaporizers – Feed forward Control -Centrifugal Pumps, Rotary Pumps and Reciprocating Pumps - Pumps: On-Off level control, Pressure control- Pumps: Flow control - Throttling control	
Unit-3 - Process Involved In Iron and Steel Industry	***9 Hour***
Introduction to Iron and Steel Industries - Description of the process I - Description of the process II - Raw material preparation - Iron making Blast furnaces-Raw Steelmaking - The basic oxygen - The Electric Furnace - Analyzers in the Iron and Steel Industry- Oxygen Analyzer	
Unit-4 - Control Applications in Iron & Steel Industry	***9 Hour***
Control system in the Iron and Steel Industry - Blast Furnace stove Combustion Control system - Gas Controls in Basic Oxygen Furnace (BOF) Furnaces – Water Controls in BOF Furnaces -Control system involved in level measurement-Strand Casting mold Level -Ingot Weight Measuring - Steel rolling -Annealing process control - Computer Controlled Batch Annealing	
Unit-5 - Computer Applications in Industrial Control	***9 Hour***
Evolution of computer applications in the industry -Review of data logging, SCADA, DDC and DCS - Case study: Water treatment control using SCADA - Analysis on the Water Treatment Control - Control of chemical reactor using SCADA-Analysis on the Control of chemical reactor using SCADA - Boiler control – Utilities management with computer system	

Learning Resources	1. *Liptak B.G.,Instrument and Automation Engineers' Handbook: Process Measurement and Analysis, Fifth ed., CRC Press, 2016.* 2. *Balchan.J.G, and Mumme K.I.,Process Control Structures and Applications, Van Nostrand Reinhold Company, New York, 1988.*	3. *Considine D. M., Process/Industrial Instruments and control Handbook, McGraw Hill, 4th ed., 1993* 4. *Waddams A.L, Chemical from petroleum, Butter and Janner Ltd., 1980* 5. *NPTEL video lectures on "Petroleum Refinery Engineering" by Dr.K.K.Pant, Prof. Deepak Kunzru, IIT, Delhi*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India,Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.A.Asuntha, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE313T	Course Name	DEEP LEARNING TECHNIQUES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the basic ideas and principles of neural networks*
CLR-2:	*impart the basic concepts of deep learning networks*
CLR-3:	*familiarize the student with image processing facilities like tensor flow and keras*
CLR-4:	*explore the use of deep learning architectures for various applications*
CLR-5:	*understand and implement deep learning architectures*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the ideas and principles of neural networks*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*interpret the use of tensor flow/keras in deep learning applications*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*explain the appropriate learning models in image related projects.*	*2*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*identify the application of various deep learning architectures.*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*classify various applications of deep learning in NLP and image processing*	*3*	-	-	*3*	*1*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to Neural Networks	***9 Hour***
Historical trends in deep learning – Optimization techniques - Learning algorithms, capacity, overfitting and underfitting – Supervised and unsupervised learning algorithms - Basic concept of neurons - Perceptron algorithm - Feed forward and backpropagation networks	
Unit-2 - Deep Learning Networks	***9 Hour***
Feed forward neural networks – Gradient descent – Back propagation algorithm – Vanishing gradient problem – Mitigation – RelU heuristics for avoiding bad local minima – Heuristics for faster training – Nestors accelerated gradient descent – Regularization – Dropout	
Unit-3 - Convolution Neural Networks	***9 Hour***
CNN architectures – Convolution – Pooling layers – Convolution and pooling as an infinitely strong prior - Random or unsupervised features- Transfer learning – Image classification using transfer learning	
Unit-4 - Deep Learning Architectures	***9 Hour***
LSTM, GRU, encoder/decoder architectures – Autoencoders – Standard- Sparse – Denoising – Contractive- Variational autoencoders – Adversarial generative networks – Autoencoder and DBM	
Unit-5 - Applications of Deep Learning	***9 Hour***
Image segmentation – Object detection – Automatic image captioning – Image generation with generative adversarial networks – Video to text with LSTM models – Attention models for computer vision – Case Study: Named entity recognition – Opinion mining using recurrent neural networks (RNN) – Parsing and sentiment analysis using RNN – Sentence classification using convolutional neural networks – Dialogue generation with LSTMs.	

Learning Resources	1. IanGoodfellow, YoshuaBengio, AaronCourville, "DeepLearning", MITPress, 2017. 2. Kevin P. Murphy, "Machine learning: A Probabilistic Perspective", MITPress, 2012. 3. Jason Brownlee, "Deep Learning with Python", ebook, 2016. 4. Francois Chollet, "Deep Learning with Python", Manning Publications, 2018. 5. Phil Kim, "Matlab Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence", Apress, 2017.	6. Ragav Venkatesan, Baoxin Li, "Convolutional Neural Networks in Visual Computing", CRC Press, 2018. 7. Navin Kumar Manaswi, "Deep Learning with Applications Using Python", Apress, 2018. 8. Joshua F. Wiley, "R Deep Learning Essentials", Packt Publications, 2016

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com	1. Dr.K.Srinivasan, NIT,Trichy, srinikkn@nitt.edu	1. Mrs.A.Brindha, SRMIST
2. Mr. Gautham, Schneider Electric,gautham.r@se.com	2. Dr. J. Prakash, MIT,Chennai, prakaiit@rediffmail.com	

Course Code	21EIE314T	Course Name	BIOMEDICAL SIGNAL AND IMAGE PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of processing in biomedical signals and images*
CLR-2:	*know about the generation and properties of human physiological signals*
CLR-3:	*study the generation and properties of biomedical images*
CLR-4:	*understand the fundamental feature extraction techniques of biomedical signals*
CLR-5:	*impart knowledge about the various techniques used for feature extraction from biomedical images*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the basics of the digital signals and images*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*demonstrate the properties of biomedical signals*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*determine the properties of biomedical images*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*interpret the features of biomedical signals*	-	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*illustrate the features of biomedical images*	-	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to Digital Signal and Image Processing	***9 Hour***
Signals - Analog, discrete, and digital signals – Signal processing, transformation and feature extraction - Examples, ECG and EMG – Characteristics of digital images, image capturing, representation and histogram - Sampling and Nyquist rate, filtering of signal, enhancement and restoration, edge detection and segmentation of images.	
Unit-2 - Properties of Biomedical Signals	***9 Hour***
ECG, cardiac electrophysiology, properties of ECG, clinical relevance, relation of ECG to cardiac events and disorders – EEG, properties of EEG signal, evoked potentials, EEG Clinical relevance, relation of EEG signal to neurological disorders – EMG, muscle activity, properties of EMG signal, EMG clinical relevance, relation of EMG signal to neuromuscular disorder.	
Unit-3 - Properties of Biomedical Images	***9 Hour***
Imaging modalities, ultrasound imaging, properties of ultrasound, X- Ray images – Physiological principles of MRI, properties of MRI and functional MRI, applications of fMRI and MRI - CT imaging, properties and features of CT images - Surgical applications, survey of surgical applications of medical image processing, real time Clinical examples.	
Unit-4 - Processing of Biomedical Signals	***9 Hour***
Cardiovascular diseases and the ECG signal, processing and feature extraction of ECG, QRS extraction methods, HRV and poincare plot analysis - EEG signal processing techniques, frequency transforms of EEG, extraction of evoked potentials - EMG signal analysis, time domain and frequency domain, extraction of parameters of EMG relevant to neuromuscular disorder - Blood pressure and blood flow, magneto encephalogram, respiratory signals.	
Unit-5 - Processing of Biomedical Images	***9 Hour***
Types of computed tomography, fourier slice theorem - X-ray imaging, X ray detection, image quality, image registration methods for biomedical images, edge detection techniques -Formulation of MRI reconstruction, registration with MR Images - Processing of ultrasound images, removal of speckle noise - Other biomedical image techniques, optical microscopy, electron microscopy, infrared imaging, biometrics.	

Learning Resources	1. Rangaraj M. Rangayyan, "Biomedical Signal Analysis", Wiley-IEEE Press, 2nd ed., 2015. 2. Kayvan Najarian, Robert Splinter, Biomedical Signal and Image Processing, 2nd ed., 2012 3. N.Vyas, "Biomedical Signal Processing", 1st ed., University Science Press, New Delhi 2011.	4. NPTEL course 'Biomedical signal processing', Prof. Sudipta Mukhopadhyay, IIT Kharagpur 5. MIT Open Courseware, 'Biomedical Signal and Image Processing'

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com	1. Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu	1. Mrs. S.Sharanya, SRMIST
2. Mr. Gautham, Schneider Electric, gautham.r@se.com	2. Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com	

Course Code	21EIE401T	Course Name	CYBER SECURITY FOR INDUSTRIAL AUTOMATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the basic knowledge in industrial automation and control systems*
CLR-2:	*know the basic concepts of information system security for industrial control systems*
CLR-3:	*understand the difference between IACS and IT paradigms*
CLR-4:	*impart the adequate information about risk management for IACS*
CLR-5:	*explore the security methodologies and approaches for IACS*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the basic concepts of industrial automation and control systems*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*illustrate any application with add-on security features in industrial control systems*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*select the software with IT paradigms for IACS*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*evaluate the risk management approach for IACS*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*develop the security methodologies for industrial systems*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Fundamentals of Industrial Automation and Control Systems (IACS) — ***9 Hour***

IACS – Introduction - SCADA systems - Distributed control systems - Safety instrumented systems - IACS – Protocol - OSI model - TCP/IP model - OPC for process control - TCP, DNP3 protocol - Utility communication architecture – Profibus - Controller area network - Ethernet/IP - Open safety protocol - Issues in IACS security - Information security - Approaches of information security - Applications

Unit-2 - Information System Security Technology — ***9 Hour***

Information system security fundamentals -Terminologies - Threat matrix - Type and classes of attack - Additional system security - Policies, standards - Guidelines and procedures - Malicious codes and attacks – Firewalls – Cryptography - Digital signatures - Attacks against cryptosystems - Virtual private network – IPsec - Transport mode - Tunnel mode - Secure sockets layer - Physical and economic damage

Unit-3 - IACS Culture Versus it Paradigms — ***9 Hour***

Differences in culture, philosophy, and requirements - Comparison between IT and IACS issues - Considerations in adapting IT security methods to IACS – Threats and motivations for attackers - Threat sources - IT and IACS comparisons from a standards perspective - Technological trends - Smart grid and its trends - Smart grid protocols - Mapping of emerging technology - Example automation system - Bulk generation - Transmission domain - Distribution domain - Operations domain - Service provider domain - Markets domain - Customer domain

Unit-4 - Risk Management For IACS — ***9 Hour***

Risk management - Risk relationships - Cybersecurity management systems - Risk analysis - Addressing risk - Monitoring and improving the IACS - Integrated enterprise risk management - Guide for applying risk management framework - Insider threat -Threat example – Stuxnet - Defensive approaches – Electromagnetic pulse – HEMP – Solar – IEMI - Protection measures - Standards – IEC & IEEE

Unit-5 - Cyber Security Design and Implementation — ***9 Hour***

Cyber security lifecycle - Conceptual design process - Firewall design - Remote access design - Intrusion detection design - Security standards, Guidelines - NIST – Guide to ICS security, Management controls - ANSI/ISA security technologies, Blocking access control - Encryption technologies, Physical security controls - NERC – Critical infrastructure protection - Critical cyber asset identification - Security management controls -Personal and training - Electronic security – Physical security of critical cyber assets - Recovery plans

Learning Resources	1. *Ronald L. Krutz, "Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure", 2nd ed.,ISA, 2017* 2. *Perry S.Marshall. "Industrial Ethernet", ISA, 2017* 3. *Edward J,M.Colbert, "Cyber Security of SCADA and otherIndustrial Control Systems" , Springer, 2016*	4. *David J. Teumim, "Industrial Network Security", 2nd ed., ISA, 2010.* 5. *NPTEL Video Lecture series on "Introduction To Industry 4.0 AndIndustrial Internet Of Things" by Prof. Sudip Misra, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *T.A.Balaji, Robert Bosch, Coimbatore, Balaji.TAnanthanpillai@in.bosch.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.G.Y. Rajaa Vikhram, SRMIST.*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr.J.Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE402J	Course Name	ELECTRO-PNEUMATICS AND HYDRAULICS	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	*EIE*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basic working of electro pneumatic components*
CLR-2:	*provide knowledge on sequential and cascading pneumatic circuits*
CLR-3:	*impart knowledge on electro hydraulic components*
CLR-4:	*provide knowledge on time dependent control of hydraulic circuits*
CLR-5:	*gain knowledge on safety in pneumatic and hydraulic circuits*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the working of solenoid valve*	2	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*use sequential pneumatic circuits for process control*	-	2	2	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*outline the properties of electro hydraulics*	-	2	2	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*examine time dependent control circuits for hydraulic application*	-	2	2	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*illustrate the safety aspects of hydraulic and pneumatic circuits*	2	2	-	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Electro Pneumatic ***12 Hour***

Introduction to electro pneumatics and its components - Structure of pneumatic control system - Properties of electro pneumatics, principal, operation of solenoid valve - Directional control valves - Relay - Various types of electrical contacts, switching symbols

Practice:

1. Direction control of a single-acting cylinder (SAC)

2. Slow speed extension, rapid retraction of a SAC

Unit-2 - Sequential and Cascading Pneumatic Circuits ***12 Hour***

Logical building block, electrical latching circuits, dominant on and dominant off, electrical memory circuits- Stroke dependent control, pressure dependent control - Sequential circuits, cascading circuits

Practice:

1. Control of a double-acting cylinder (DAC) with memory valve

2.Demonstration of two-hand safety control

Unit-3 - Electro Hydraulics ***12 Hour***

Properties of electro hydraulics, principal - Operation of solenoid valve, various types of electrical contacts, switching symbols - Direct and indirect control of single, double acting cylinder

Practice:

1. Formulation of control for time dependent control of a SAC

2. Development of control for cascading DAC with impulse valve and reed switches

3. Formulation of control for time dependent control of a DAC

Unit-4 - Time Dependent Hydraulic Control	***12 Hour***
Signal storage by electrical self - locking - Mechanical locking by means of momentary switch contacts - Electrical locking by means of contacts - Stroke dependent control using sensors, momentary contact switches, pressure switches - Time dependent control ***Practice:*** *1. Development of control for sequential control of 2 DAC* *2. Demonstration of sequential control with signals overlapping* *3. Demonstration of hydraulically operated system*	
Unit-5 - Maintenance and Safety	***12 Hour***
Commissioning, inspection, repair - Manufacturing automation - Problem caused by gases in hydraulic fluids - Maintenance of fluid power circuits - Trouble shooting of fluid power circuits - Safety aspects involved in hydraulics, pneumatics. ***Practice*** *1.Demonstration of solenoid operated flow control valve* *2 Mini project*	

Learning Resources	1. *Zipfinger. L, "Electropneumatics Trainee's Manual", Bosch Rexroth AG, 2015* 2. *Elango Sivaraman, "Introduction to Hydraulics and Pneumatics", 3rd ed., PHI Learning, 2017* 3. *Anthony Esposito, "Fluid Power with Applications", 7th ed., Pearson education, 2014*	4. *Werner Gotz., "Electrohydraulics Trainee's Manual", Bosch Rexroth AG, 2015.* 5. *NPTEL Video Lecture series on "Fundamental of Industrial oil Hydraulics and Pneumatics" by Prof.R.Maiti,IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. J. Sam Jeba Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	2. *Dr. G. Joselin Retna Kumar, SRMIST*

Course Code	21EIE403T	Course Name	MULTISENSOR AND DECISION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart in depth knowledge of multisensor fusion concepts*
CLR-2:	*acquire the ability to use data and information from multiple sources and make informed decisions based on that data*
CLR-3:	*familiarize the importance of various algorithms in the field of multisensor fusion*
CLR-4:	*understand the concepts of Decision systems*
CLR-5:	*appreciate the skills to solve various complex problems requiring the application of multisensory and decision Techniques*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the importance and need for multisensor fusion and decision systems*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*interpret the main components, architectures and design issues in multisensor and decision systems*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*identify the appropriate architectures in the field of multisensor fusion*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*associate the solutions to complex multisensor and decision systems*	*3*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*develop appropriate design methodology to multisensor and decision systems*	*3*	-	-	*3*	*1*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to Multisensor Systems	***9 Hour***
Introduction, sensors and sensor data - Use of multiple sensors - Benefits of data fusion - Fusion applications - Network topologies - Parameter estimation- Robust statistics - Sequential bayesian interface - Bayesian decision theory.	
Unit-2 - Mutlisensor Data Compression and Multi Sensor Tracking	***9 Hour***
Signal tracking and multisensory data compression– Parameter estimation – Bayesian curve fitting– Maximum likelihood– Least gaussian model– Probabilistic subspace - Introduction and need of tracking - Bayesian multiple target tracking - Sensors for peace applications - Information fusion terminology – Multitarget / Multisensor tracking.	
Unit-3 - Kalman Filtering for Multisensor Data Fusion	***9 Hour***
Taxonomy of algorithms for multisensor data fusion - Decision level identify fusion - Knowledge based approaches - Data information filter – Decentralized estimation - Sensor fusion and approximate agreement - High performance data structures	
Unit-4 - Fault Diagnosis using State Estimators	***9 Hour***
State Observer, state estimators - Norms based residual evaluation - Statistical methods based residual evaluation - Generalized likelihood ratio approach – Fault diagnosis with classification networks - Simple pattern classification	
Unit-5 - Applications of Decision Systems	***9 Hour***
Introduction to decision systems for monitoring, Decision types - Decision trees - Design aspects - Logical decision framework - Decision systems for diagnosis -Fault diagnosis and detection using decision systems - Human and automation examples	

Learning Resources	1. *David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 2005.* 2. *RolfIsermann, Fault-Diagnosis Systems an Introduction from FaultDetection to Fault Tolerance, Springer Verlag, 2006.* 3. *Gregory S. Parnell, Patrick J. Driscoll, Dale L. Henderson, Decision Making in Systems Engineering and Management (Wiley Series in Systems Engineering and Management 2nd ed., Wiley Publishers.2010.*	4. *H.B. Mitchell, Multi-Sensor Data Fusion: An Introduction, SpringerPublications, 2007.* 5. *Rolf Isermann, Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance, Springer Verlag, 2006.* 6. *Yan, Liping, Lu Jiang, and Yuanqing Xia. Multisensor Fusion Estimation Theory and Application. Springer, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mrs.A.Brindha, SRMIST*
2. *Mr. Gautham, Schneider Electric,gautham.r@se.com*	2. *Dr. J. Prakash, MIT,Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE404T	Course Name	SYSTEM ON CHIP	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the hardware components and software involved in SoC*
CLR-2:	*introduce the basic elements in instruction handling and processor selection*
CLR-3:	*impart the basic principle of memory design used in SoC*
CLR-4:	*know the basic interconnectors and IP-based design and testing mechanism*
CLR-5:	*gain the knowledge for solutions to challenges and advanced SoC design*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the hardware components and software components for the design*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*classify the elements in instruction handling and processor for real time SoC design*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*use the different principles in memory design*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*outline the basic interconnect mechanism involved in SoC*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*apply the concepts to real-time challenges in SoC design*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - System Architecture — ***9 Hour***

Introduction to the components of the system - Processor architectures soft processors, Memory and addressing, system level interconnection - SoC design requirements and specifications, design integration, design complexity - Cycle time, die area and cost, ideal and practical scaling, area-time-power tradeoff in processor design - Configurability analysis system - Level methodologies and tools - SoC design methodologies and tools.

Unit-2 - Processor Selection For SOC — ***9 Hour***

Overview of SOC, processor core selection - Basic concepts – Instruction set, branches, interrupts and exceptions - Basic programming - Basic elements in instruction handling - Minimizing pipeline delays, reducing the cost of branches - Robust processors - Vector processors - Superscalar processors - VLIW processors.

Unit-3 - Memory — ***9 Hour***

SoC external memory - SoC internal memory - Scratchpads and cache memory, cache organization and write policies, strategies for line replacement at miss time, split I- and D caches, multilevel caches, SoC memory systems - Board-based memory systems, simple processor/memory interaction - HW/SW co-design: analysis, partitioning, real-time scheduling, hardware acceleration.

Unit-4 - Interconnect Architectures and SOC Customization — ***9 Hour***

Bus architectures - SoC internal memory - Processor customization approaches - Reconfigurable technologies, mapping designs onto reconfigurable devices - Architectural design exploration - Chip types and classification - FPGA-based design - Architecture of FPGA - FPGA interconnect technology - FPGA memory.

Unit-5 - FPGA Based Embedded Processor Case Studies and Application — ***9 Hour***

Hardware-software task partitioning - FPGA fabric immersed processor - Soft processors and hard processor - Tool flow for hardware/software co-design - Interfacing processor with memory and peripherals, types of on-chip interfaces, wishbone interface - Avalon switch matrix - OPB bus interface - Creating a customized microcontroller - Overview of CYCLONE V family architecture - Multiport memory controller architecture, CYCLONE V SOC FPGAs hard processor system.

Learning Resources	1. *Michael J. Flynn, Wayne Luk, "Computer system Design: System-on-Chip", Wiley-India, 2012.* 2. *Patrick Schaumont "A Practical Introduction to Hardware/Software Co-design", 2nd ed., Springer, 2012.* 3. *Sudeep Pasricha, Nikil Dutt, "On-Chip Communication Architectures: System on Chip Interconnect", Morgan Kaufmann Publishers, 2008.* 4. *W.H. Wolf, "Computers as Components: Principles of Embedded Computing System Design", Elsevier, 2008.*	5. *Lin, Y-L.S. (ed.), "Essential issues in SOC design: designing complex systems-on-chip. Springer, 2006.* 6. *Wayne Wolf, "Modern VLSI Design: IP Based Design", Prentice-Hall India, 4th ed., 2009.* 7. *Michael J Flynn, Wayne Luk "Computer System Design: System –on-chip" Wiley, October 2011, ISBN: 9780470643365* 8. *NPTEL Video Lectures notes on "System on Chip" by Prof. Santanu Choudary, IIT Delhi.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. A.Vimala Juliet, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE405T	Course Name	PROCESS DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the design dynamics of process data*
CLR-2:	*impart knowledge on different methods of linear regression analysis*
CLR-3:	*know the applications for various model selection and regularization methods*
CLR-4:	*outline the process for developing appropriate sensors using simulation tools*
CLR-5:	*introduce different software implementation techniques for data handling*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*recognize statistical terms related to data analytics*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*interpret the selection of right regression method for an application*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze and compare the performance of various model selection and regularization methods*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*select and design appropriate tool for sensor development*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*use appropriate software tools for data analysis*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Review of Data Relations, Data Pre Processing and Visualization — ***9 Hour***

Data mining and knowledge discovery – Data and relations, data scales, set and matrix representation, dissimilarity measures - Issues in data analytics, missing data, data outliers and false data - Data purification and handling – Sampling, quantization, filtering, transformation, integration, visualization – Principal component analysis - Histogram and spectral analysis

Unit-2 - Correlation and Regression — ***9 Hour***

Linear Correlation, correlation and causality, chi-square test, assessing model accuracy - Linear Regression, simple linear regression, multiple linear regression, estimating regression coefficient - Qualitative predictors in regression model, comparing linear regression with K-nearest neighbours - Logistic regression & models, estimating regression coefficient - Linear discriminant analysis - Quadratic discriminant analysis

Unit-3 - Resampling, Model Selection and Regularization — ***9 Hour***

Cross Validation, leave-one-out cross validation, k-fold cross validation - Subset selection, stepwise selection, choosing the optimal model, shrinkage methods - Ridge regression - Least absolute shrinkage and selection operator (LASSO) - Regression in high dimension data - Dimension reduction methods – Principal Component Regression, Partial Least Squares

Unit-4 - Classification, Clustering and Decision Trees — ***9 Hour***

Classification criteria- Naïve-bayes, nearest neighbor classifier- Learning vector quantization, decision trees - Clustering, sequential, prototype based, fuzzy - Cluster tendency assessment, cluster validity, self-organizing maps, bagging, random forest, boosting, support vector machine, relationship to logistic regression, ROC curve.

Unit-5 - Concept of Data Analytics — ***9 Hour***

Data analysis for representing functions, plotting data – rate information, scatter plots and their limitations, mean, median, mode and variance, covariance, multivariate distribution, curve fitting, weighted average, examining errors, least squares - Data Analysis with R programming, Commands, function, objects, basic computations, data visualization and graphics

Learning Resources	1. *Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, "An Introduction to Statistical Learning with Applications in R", Springer Texts in Statistics, 2014.* 2. *Thomas A. Runkler, "Data Analytics: Models and Algorithms for Intelligent Data Analysis", Springer Vieweg, 2nd ed.,2016*	3. *Ethem Alpaydin, "Introduction to Machine Learning", MIT Press,2013* 4. *William Menke and Joshua Menke, "Environmental Data Analytics with MATLAB", Elsevier, 2012.* 5. *John Chambers, "Software for Data Analysis: Programming with R", Springer, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Mrs. S.Sharanya, SRM IST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE406T	Course Name	SYSTEM IDENTIFICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify and represent the type of signals and systems*
CLR-2:	*provide the concept of estimating the parameter of input - output models using various parameter estimation models*
CLR-3:	*gain the knowledge of recursive plant model identification in open loop system*
CLR-4:	*understand the various methods of closed loop system identification*
CLR-5:	*introduce the applications of system identification in process industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*compare the signals and systems based on their properties and determine the response of LTI system*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*develop the linear representation of a dynamic system in discrete time systems*	2	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*design the recursive plant model identification and validation in open loop system*	2	-	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*explain the recursive plant model identification and validation in closed loop system*	2	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*apply the system identification methods to new model structure and identify the appropriate model for unknown system*	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to System Identification	***9 Hour***
Identification based on differential equations, Laplace transforms, frequency responses, difference equations. Auto-correlation, cross-correlation, power spectra. Random and deterministic signals for system identification: pulse, step, Pseudo Random Binary Sequence (PRBS), signal spectral properties, persistent excitation.	
Unit-2 - Parameter Estimation Methods	***9 Hour***
Introduction to discrete time system - Recursive and non-recursive system - ARX models - Design Example of ARX models - AR Model, MA -Design Example of AR Model, MA Model -ARMA Model - Design Example of ARMA Model - ARMAX model - Design Example of ARMAX Model - NARMAX model - Hammerstein model - Wiener model - bilinear parametric model - Problems using ARX, ARMAX Model - Linear model selection - Pseudo Random Binary Signal (PRBS) - Selection of PRBS	
Unit-3 - Plant Model Identification in Open Loop	***9 Hour***
Introduction to plant model - Identification methods - Least square method - Design using Least square method - Recursive Least Squares - Design using Recursive Least square - Extended Least Squares - Design using Extended Least Squares - Generalized Least Squares - Need for iteration - Choice of model structure - Model Structure Selection Based on Preliminary Data Analysis - Model Order Selection - Model Validation in open loop - Whiteness Test-correlation Test – Un correlation Test	
Unit-4 - Plant Model Identification in Closed Loop	***9 Hour***
Introduction - Approaches to closed loop identification - Direct approach - Indirect approach - Joint input output approach - Closed loop identification methods - Closed loop output error algorithm - Design of closed loop output error algorithm - Closed loop output error algorithm with adjustable predictor - Design of Closed loop output error algorithm with adjustable predictor - Filtered closed loop error algorithm - Design of filtered closed loop error algorithm - Filtered open loop error - Model validation in open loop - Model validation in closed loop - Whiteness test - correlation – Un correlation test	

Unit-5 - Applications in Process Industries	***9 Hour***
Introduction to application in process - Case study: Modeling and identification of heat - Experimental ,identification of distillation - Experimental design , System identification modeling for flight control design - Experimental design , system identification based on selective sensitivity analysis - Experimental design -System identification tool box - Estimating transfer function models for a heat - Programming using system identification toolbox - Glass tube manufacturing process - Programming using system identification - Validating hammerstein-wiener models	

Learning Resources		
	1. *Arun K thangirila , Principles of System Identification: Theory and Practice, CRC Press,2018* 2. *Lennart Ljung, "System Identification", PTR Prentice Hall, Englewood Cliff, New Jersey, 1999* 3. *Karel J. Keesman, "System Identification, an introduction", Springer, 2011.*	4. *Y. Zhu,"Multivariable System Identification For Process Control", Elsevier Science,2001* 5. *NPTEL video lecture series on "System Identification" , by Prof. Dr.Arun K. Tangirala,, IIT Madras*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Deepak, ONGC, Mumbai, dsingh39@slb.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr.A.Asuntha, SRMIST*
2. *Dr.I.Thirunavukkarasu, MIanipal Institute of Technology, Karnataka, itarasu1881@gmail.com*	2. *M.Neelakandan, Cognizant Techno Solutions, Chennai., pymani2010@yahoo.com*	

Course Code	21EIE407T	Course Name	MACHINE VISION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the basic knowledge in Machine vision*
CLR-2:	*understand the concept of Image acquisition and conversion*
CLR-3:	*know the basic knowledge in image processing decision making*
CLR-4:	*introduce the three-dimensional machine vision techniques*
CLR-5:	*provide the adequate information in the implementation of machine vision in industry*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the fundamentals of machine vision*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*develop any application based on Image acquisition and conversion*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*outline the decision making process in image processing*	*2*	-	*3*	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*examine the three-dimensional machine vision techniques*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*illustrate the applications of machine vision concept in various industries*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Introduction	***9 Hour***
Data acquisition system relationships to other field, role of knowledge, image geometry, perspective projection, coordinate systems, sampling and quantization -Image processing -Level of computation point, local, global and object.	
Unit-2 - Image Acquisition and Conversion	***9 Hour***
Image Acquisition introduction, application features, contrast and resolution, light, wavelength, polarization, geometry of propagation, incandescent light bulb, discharge tube, illumination optics - Interactions of objects with light - Geometric Parameters shape or profile of object - Image formation by lensing, conventional imaging, image scanning, image conversion - Capturing techniques.	
Unit-3 - Decision Making in Image Processing	***9 Hour***
Image processing enhancement / preprocessing, segmentation, coding / feature extraction, image analysis / classification / interpretation – Pixel transformation - Scaling - Global and neighborhood transformation - Filters spatial and IIR - Localized thresholding - Edge segmentation - Thermal image in machine vision applications - Miscellaneous scalar features	
Unit-4 - 3D Machine Vision Techniques	***9 Hour***
Various approaches to obtain 3d data - Stereo – Stereopsis - Active learning - Simple triangulation range finding - Range from focusing - Time of flight range finders - Active triangulation range finder - Surface measurement using shading data - Depth from texture gradient.	
Unit-5 - Applications	***9 Hour***
Semiconductor industry - Electronic manufacturing - Bare board inspection system - Automated optical inspection - Automotive industry - Glassware inspection -Pharmaceuticals.	

Learning Resources	1. *Nellazuech, "Understanding & applying machine vision",Marceldekker Inc. 2000.* 2. *Alexander Hornberg, "Handbook of Machine and Computer Vision: The Guide for Developers and Users" Wiley Publisher, 2nded., 2017.* 3. *E. R. Davies, "Computer and Machine Vision", Academic Press,4th ed., 2012.* 4. *Beyererj, "Machine Vision Automated Visual Inspection Theory Practiceand Applications", Springer, 2015.*	5. *Snyder Wesley E., Qi Hairong, Wesley E. Snyder, "Machine Vision",Cambridge University Press, 2010.* 6. *NPTEL video lecture notes on, "Computer Vision" by Prof. JayantaMukhopadhyay, IIT Kharagpur.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. C. Likith Kumar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	

Course Code	21EIE408T	Course Name	NON-LINEAR CONTROL SYSTEM DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce basic concepts of phase plane analysis and limit cycles*
CLR-2:	*understand the describing functions in nonlinear systems*
CLR-3:	*explore the concepts of lyapunov theory for stability analysis of a non-linear system*
CLR-4:	*impart the knowledge of non-linear control system stability*
CLR-5:	*know the different types of control design techniques for non-linear systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the need of phase plane analysis in non-linear systems*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*develop the describing function for non-linear systems*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*identify the stability of non-linear system using lyapunov theory*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the different types of non-linear control system stability*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyze the different types of non-linear control system stability*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Phase Plane Method ***9 Hour***

Introduction - Need for non-linear control - Non-linear systems analysis - Phase plane analysis - Phase portraits - Constructing phase portraits - Analytical method - Method of isoclines - Phase plane analysis of linear system - Stable, unstable node, Saddle point - Phase plane analysis of Non- linear system - Existence of limit cycles - Stable, unstable, semi-stable limit cycles - Poincare theorem, Bendixon theorem

Unit-2 - Describing Function Method ***9 Hour***

Describing function fundamentals - Applications of describing functions - Basic assumptions - Describing function representation - Nonlinearities in control systems -Continuous and dis-continuous non-linearities - Saturation, on-off nonlinearity - Deadzone, backlash – Hysteresis - Describing functions of non-linearities - Describing function analysis of non-linear systems - Nyquist criterion - Existence of limit cycles - Detection of limit cycles - Stability of limit cycles - Reliability of describing function analysis

Unit-3 - Lyapunov Stability Theory ***9 Hour***

Nonlinear systems and equilibrium points - Autonomous and non-autonomous systems - Concepts of stability - Stability and instability - Asymptotic and exponential stability - Local and global stability - Linearization and local stability - Lyapunov's linearization method - Lyapunov's direct method - Positive definite functions and lyapunov's functions - Equilibrium points theorems - Lyapunov theorem for local stability - Lyapunov theorem for global stability - System analysis based on lyapunov's direct method - LTI system analysis -Krasovskii's method - Variable gradient method -Case study – Lyapunov control design

Unit-4 - Non-Linear Control System Stability ***9 Hour***

Non-linear control problems - Stabilization problems - Asymptotic stabilization problem - Tracking problems - Asymptotic tracking problems - Relationship between stabilization and tracking - Specifying desired behavior - Stability, accuracy - Speed of response, robustness – Cost - Issues in constructing nonlinear controllers - Procedure for control design - Modeling non-linear systems - Feedback and feedforward - Methods of non-linear control design - Feedback linearization - Robust control, Adaptive control - Case study – Non-linear control design applications

Unit-5 - Adaptive and Sliding Mode Control Design	***9 Hour***
Feedback linearization - Input-state linearization - Input-output linearization - Internal dynamics of linear systems - Mathematical tools - Lie derivatives - Lie brackets - Sliding control -Sliding surfaces - Switching control laws - Basic concepts of adaptive control - Design of adaptive controllers - Adaptive control of first order systems - Full state feedback - Output feedback - Adaptive control of non-linear systems - Robustness of adaptive control - On-line parameter estimation	

Learning Resources	1. *Michal Piorek, Analysis of Chaotic Behavior in Non-Linear Dynamical Systems, Springer., 2019* 2. *Mourad B, Nonlinear Control Systems using Matlabv, CRC Press, 2019.* 3. *Shuli Guo, Stability and Control of Nonlinear Time Varying Systems, Springer, 2018.*	4. *Martin Guay, Robust and Adaptive Model Predictive Control of Nonlinear Systems, IET Control Robotics and Sensors Series, 2015* 5. *NPTEL Video Lecture series on "Nonlinear system analysis" by Ramkrishna Pasumarthy and Dr. Arun D. Mahindrakar, IIT Madras*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *T.A.Balaji, Robert Bosch, Coimbatore, Balaji.TAnanthanpillai@in.bosch.com*	1. *Dr.J.Prakash, MIT, Chennai, prakaiit@rediffmail.com*	1. *Dr.G.Y. Rajaa Vikhram, SRMIST*
2. *Mr. Vijayarajeswaran, MD, Vi micro Pvt.Ltd, vijay@vimicrosystems.com*	2. *Dr.S.Latha, TCE, Madurai, sleee@tce.edu*	

Course Code	21EIE409T	Course Name	BIO-OPTICAL 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	*EIE*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart basic knowledge on optical properties of the Tissues*
CLR-2:	*understand the types of interaction between light and tissue*
CLR-3:	*introduce different types of Instruments for measurement, fibers, polarizers, detectors*
CLR-4:	*know various applications of laser in Surgical and Therapy in medicine field*
CLR-5:	*understand the Hazards in using Lasers*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the optical properties and its numerical approach*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*distinguish different types of Interactions between light and tissue and select appropriate for the application*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*select the appropriate source, fibers and detectors for experimental and practical applications*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*differentiate the use of lasers used for surgery or therapy*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*estimate the risks involved in handling the laser sources*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Optical Properties of Tissue	***9 Hour***
Fundamental Optical Properties, refraction, scattering and absorption - Light transport in tissues – Radiation transport therapy, approach & limiting cases - Numerical approach: Monte Carlo Simulation - Kubelka - Munk model - Effective index of refraction –Time-resolved propagation of light pulses - Tissue Properties, refractive index, scattering properties, absorption properties	
Unit-2 - Light – Tissue Interaction	***9 Hour***
Light interaction with tissue, Continuous wave light - short light pulses - Diffuse Photon – Density Waves, Polarized Light Interaction, Tissue structure and Anisotropy - Polarized light description - Single Scattering, and Quasi ordered tissue, Vector radiative transfer theory, Opto-Thermal Interaction, Temperature Rise and Tissue Damage Opto-Thermal and Optoacoustic Effects, Acousto-optical Interaction, - Refractive Index and Controlling of Light Interaction with Tissue, Fluorescence, Multiphoton Fluorescence	
Unit-3 - Basic Instrumentation in Photonics	***9 Hour***
Absorption Spectroscopy, quantitative aspects, photometer and spectrophotometer designs – Optical spectrum analyser, Instrumentation for Absorption, Scattering, and Emission Measurement, Excitation light sources, high-pressure ARC Lamps, low-pressure vapor lamps, incandescent lamps - Solid State Light Sources & Lasers - Industrial application of optical fibres, optical filters, tunable filters, polarizers – Detectors, single channel detectors, multichannel detectors - Detection methods – DC techniques, AC techniques, digital photon counting technique	
Unit-4 - Medical Applications	***9 Hour***
Medical applications of Laser - Lasers in Ophthalmology - Lasers in Dentistry - Lasers in Gynecology - Lasers in Urology - Lasers in Neurosurgery - Lasers in Angioplasty and Cardiology, Lasers in Orthopedics - Lasers in Dermatology and Cosmetics	
Unit-5 - Hazards and Safety	***9 Hour***
Laser Hazards, radiation, chemical, electrical - Eye hazards - Optical radiation - Skin Hazards - Associated Hazards from High Power Lasers - Laser Safety Standards - Hazard Classification - Viewing Laser Radiation, eye protection, laser beam calculations	

Learning Resources	1. *Tuan Vo-Dinh, "Biomedical Photonics Handbook" Volume – I, CRC Press, 2nd ed., 2015* 2. *Markolf H. Niemz, "Laser-Tissue Interactions: Fundamentals and Applications", Springer, 4th ed., 2019*	3. *R Splinter and B A Hooper, "An Introduction to Biomedical Optics", CRC Press –2007* 4. *NPTEL Course on "Mathematical Aspects of Biomedical Electronic System Design", by Prof. Chandramani Singh, IISc Bangalore*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric India, Manoj.Gupta@asia.meap.com*	1. *Dr.K.Srinivasan, NIT, Trichy, srinikkn@nitt.edu*	1. *Dr. P A Sridhar, SRMIST*
2. *Mr. Gautham, Schneider Electric, gautham.r@se.com*	2. *Dr. J. Prakash, MIT, Chennai, prakaiit@rediffmail.com*	2. *Dr. C. Likith Kumar, SRMIST*

Course Code	21EIE410T	Course Name	BIO-MECHATRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce the basic knowledge on Physiological System and Bio-Mechatronic System*
CLR-2:	*impart the skills to the need, working and design aspects of Hearing Implants*
CLR-3:	*outline the need for the design of Visual Implants*
CLR-4:	*provide the study and design of Heart and Respiratory Aiding System*
CLR-5:	*understand the need, working and design aspects of Prosthetic Limbs*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the concept for replacing the physiological system with Bio-mechatronic System*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*determine the techniques to design and develop Hearing Implants*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*explain the design and working of visual prosthesis*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*analyze the suitable design for Heart and respiratory aid*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*interpret the working of the arm and leg prosthetics*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction to Bio-Mechatronics — ***9 Hour***

Overview of Physiological Systems - Biochemical system - Nervous System - Cardiovascular System, respiratory system - Musculoskeletal System - Feedback Elements, Overview of Bio Mechatronics System, human subject, stimulus or actuation - Transducer and Sensors - Signal Processing Elements - Recording and Display

Unit-2 - Hearing Aids and Implants — ***9 Hour***

Sound, characteristics Impedance, sound pressure, sound intensity - Hearing works, outer ear, middle ear, inner ear and hearing statistics - Hearing aid, operation - Bone conduction Devices - Middle ear implants - PZT devices - electromagnetic hearing devices, issues with implantable middle ear devices, actuator design - Cochlear implants, working, installation of electrodes, processing, stimulation and strategies - Auditory brainstem implants

Unit-3 - Visual Prostheses — ***9 Hour***

Anatomy and physiology of the visual pathway, causes of blindness - Optical Prosthetics – Lasers - Thermal Images, night vision - Sonar Based System – Existing Systems, Issues with sonar laser-based System - Visual neuroprostheses, potential Sites for VN, components - Subretinal implants - Epi retinal implants - Optic nerve stimulation - Visual Cortex Implants

Unit-4 - Heart & Respiratory AID — ***9 Hour***

Introduction, heart as a pump - Heart valves, pump cycle - Cardiac output, pressure regulation - Heart disease, bio-mechatronics perspective - Artificial hearts - Ventricular assist devices, types of generations in VAD's - Engineering in heart assist devices - Fluid dynamics in Pulsatile LVADs, centrifugal & axial LVADs - Estimation and control of blood flow - Introduction to Respiratory Aids, mechanics of respiration, physical properties - Lung elasticity, frictional forces, inertia, energy - Lung characteristics - Mechanical Ventilation

Unit-5 - Active & Prosthetic Limbs — ***9 Hour***

Introduction to prosthetics, structure of the arm - Kinematic model of arm - Structure of the Leg, kinematic model of Leg - Kinematics of limb movements, center of mass and moment of inertia of limb segment, angular acceleration, center of mass and moment of inertia of complete limb segment - Passive prosthetics – actuation and control - Walking dynamics, knee prosthetics, foot prosthetics - Active prosthetics, arm & hand mechanism, control of prosthetic arm, hands and leg mechanism.

Learning Resources	1. *Jacob Segil, "Hand Book of Bio Mechatronics", Academic Press publications, 2019* 2. *Graham M. Brooker, "Introduction to Bio Mechatronics", SciTech publication, 2012.* 3. *Shane Xie · Wei Meng "Bio Mechanics in Medical Rehabilitation", Springer International Publishing AG, 2017.*	4. *Raymond Tong, "Bio Mechatronics in Medical and Health Care", Pan Stanford Publishing Pte. Ltd. 2011.* 5. *Jose L. Pons, "Wearable Robots - Bio mechatronic Exoskeletons", John Wiley & Sons Ltd, 2008.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

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Course Code	21EIE411T	Course Name	VIRTUAL AND AUGMENTED REALITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the need, benefits and implications of a virtual environment*
CLR-2:	*identify various input and output hardware devices for 3D interface*
CLR-3:	*introduce simple programming to create virtual environment*
CLR-4:	*impart knowledge on the design requirements for 3D manipulation and interaction*
CLR-5:	*provide the basic knowledge in designing immersive environment for different applications*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline the need, benefits and implications of immersive technologies*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*summarize input and output hardware devices for 3D interface*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*perform simple programming exercises using the virtual tools*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*categorize the design requirements of 3D manipulation and interaction*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*demonstrate an immersive environment using AR, VR and other gaming technologies*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Virtual Reality	***9 Hour***
Virtual reality and virtual environment - Historical development of VR – Scientific landmarks - Computer graphics - Real-time computer graphics – Virtual environments - Requirements of VR - Benefits of virtual reality	
Unit-2 - Hardware Technologies for 3D User Interfaces	***9 Hour***
Visual displays - Auditory displays - Haptic displays - Choosing output devices for 3D user interfaces - Input device characteristics - Desktop input devices – Tracking devices - 3D mice- Special purpose input devices - Direct human input - Home-brewed input devices - Selection of input devices for 3D interfaces	
Unit-3 - Software Technologies	***9 Hour***
Database – World space - World coordinate - World environment - Objects – Geometry - Position and orientation – Hierarchy - Bounding volume - Scripts and other attributes - VR environment – VR database - Tessellated data – LOD - Cullers and occluders - Lights and cameras – Scripts - Interaction – Simple feedback - Graphical user interface - Control panel - 2D controls - Hardware controls – Room, stage, area descriptions - World authoring and playback - VR toolkit	
Unit-4 - 3D Interaction Techniques	***9 Hour***
3D Manipulation tasks - Manipulation techniques and input devices - Interaction techniques for 3D manipulation - Design guidelines – 3D Travel tasks - Travel techniques - Design guidelines – Theoretical foundations of wayfinding - User centered wayfinding support - Environment centered wayfinding support - Evaluating wayfinding aids - Design guidelines –System control – Classification - Graphical menus - Voice commands -Gestural commands – Tools - Multimodal system control techniques	
Unit-5 - Designing and Developing 3D User Interfaces	***9 Hour***
Strategies for design and development of 3D interfaces - Virtual reality applications - Engineering, architecture, education, medicine, entertainment, science - Guidelines and evaluation	

Learning Resources	1. *Dieter Schmalstieg and Tobias Hollerer, "Augmented Reality:Principles and Practice", Pearson Education (US), 2016.* 2. *Steve Aukstakalnis, "Practical Augmented Reality: A Guide to theTechnologies, Applications, and Human Factors for AR and VR)", Addison-Wesley Professional; 1st ed., 2017.*	3. *C. Burdea and Philippe Coiffet, "Virtual Reality Technology", John Wileyand Sons, 2nd ed., 2008* 4. *Jason Jerald, "The VR Book: Human-Centered Design for VirtualReality", Morgan and Claypool, 2015* 5. *NPTEL foundation course on "Virtual and Augmented reality"*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India