Master of Technology in Instrumentation and Electronics (Curriculum)

FIRST SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
Departmental/ Specialization Basket	Subject Code	Subject Name	Lecture	Sessional	Examination	Sessional	
Paper-I	PG/ IEE/ T/111A	Process Control System Design/ Synthesis	3		100		3
	PG/IEE/ T/111B	Embedded Systems					
Paper-II	PG/IEE/T/112A	Signals and Systems	3		100		3
	PG/ IEE/T/112B	Digital Communication System					
Paper-III	PG/IEE/T/113A	Advanced Electronic Instrumentation	3		100		3
	PG/IEE/T/113B	Digital Systems Design with FPGAs					
	PG/IEE/T/113C	Medical Instrumentation					
Note:The students have to select 3 subjects from the departmental/ specialization basket, i.e. one subject each from the list given in the baskets of Paper-I, Paper-II and Paper-III							
Inter-Disciplinary Basket	SubjectCode	SubjectName	Lecture	Sessional	Examination	Sessional	
Paper-IV	PG/IEE/T/114A	Soft Computing- Theory and Application	3		100		3
	PG/IEE/T/114B	Advanced Microprocessors and Microcontrollers					
		From the inter-disciplinary basket of ETCE Dept					
Paper-V	PG/IEE/T/115A	Instrumentation and Measurement Techniques	3		100		3
	PG/IEE/T/115B	Aerospace Instrumentation					
Paper-VI	PG/IEE/T/116A	Mathematical Methods in Instrumentation	3		100		3
	PG/IEE/T/116B	Optimization Techniques					
Note: The students have to select 3 subjects from the interdisciplinary basket, i.e. one subject each from the list given in the baskets of Paper-IV, Paper-V and Paper-VI							
Sessional Courses							
Sessional1	PG/IEE/S/111	Laboratory		4		100	3
Sessional2	PG/IEE/S/112	Assignment		4		100	3
			18	**8**	**600**	**200**	**24**

TotalPeriods/Week=26 **TotalMarks=800**

SECOND SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
Departmental/ Specialization Basket	Subject Code	Subject Name	Lecture	Sessional	Examination	Sessional	
Paper-VII	PG/IEE/T/127A	Instrumental Analysis	3		100		3
	PG/IEE/T/127B	Sensors-Science and Technology					
	PG/IEE/T/127C	Control of Industrial Process					
Paper-VIII	PG/IEE/T/128A	Speech Processing	3		100		3
	PG/IEE/T/128B	Digital Filtering and Control					
	PG/IEE/T/128C	Pattern Recognition					
Paper-IX	PG/IEE/T/129A	Electronic System Design	3		100		3
	PG/IEE/T/129B	Electronic Olfaction					
Note: The students have to select 3 subjects from the departmental/ specialization basket, i.e. one subject each from the list given in the baskets of Paper-VII, Paper-VIII and Paper-IX							
Inter-Disciplinary Basket	SubjectCode	SubjectName	Lecture	Sessional	Examination	Sessional	
Paper-X	PG/IEE/T/1210A	Dynamic System Control and Optimization	3		100		3
	PG/IEE/T/1210B	Control SystemSynthesis					
	PG/IEE/T/1210C	Environmental Instrumentation					
Note: The students have to select one subject from the list given in the inter-disciplinary basket of Paper-X.							
Sessional Courses							
Sessional1	PG/IEE/S/121	Term Paper Leading to Thesis		4		100	3
Sessional2	PG/IEE/S/122	Seminar		4		100	3
			12	**8**	**400**	**200**	**18**

TotalPeriods/Week=20 **TotalMarks=600**

THIRD and FOURTH SEMESTER

Courses							
1	PG/IEE/TH/21	ThesisWork		16		300	12
2	PG/IEE/VV/22	Viva-VoceonThesis				100	
				16		**400**	**12**

TotalPeriods/Week=26 **TotalMarks=800**

Master of Technology in Instrumentation and Electronics (Syllabus)

Course code: PG / IEE / T / 111A	Process Control System Design/ Synthesis	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Basic concepts of Process Control systems • Real time applications of various control mechanisms • Present control strategies used in plant and process instrumentation • Several associated instruments other than controllers and their operations	
Course Outcomes:	On completion of the course, the students will be able to CO1: Define and explain basic aspects of process Modelling (K1, A1) CO2: Describe the different process parameters (K2, A1) and discuss process dynamics (K3-apply,A2) CO3: Describe about several process controllers(K2,A2) and explain dynamic models of chemical processes(K3,A2)	
Unit I	**Basic aspects of Process Modeling: CO1** Process Modeling: Reasons for modeling, Lumped parameter system models, Analytical approximation, Effect of parameter variation, The parameter estimation technique— Linear regression, least square regression technique.	
Unit II	**Process dynamics and process parameters: CO2** Process Dynamics: Different process control parameters, Characteristic parameters of process plant (Self Regulation, Potential value, Process reaction rate, Process resistance, Process Capacitance, Process time lag).	
Unit III	**Process Controllers: CO3** Design of process control system following various approaches: Self operating Controller, Pneumatic controller, Electronic Controller, Supervisory controller, Adaptive Controller, Direct Digital Controller, Programmable Logic Controller, Distributed Control Systems	
Unit IV	**Dynamic model of chemical processes: CO3** Dynamic model of chemical processes: Balance Equations, Material balance,material and energy balance, Form of Dynamic models—Linear models and deviation variables. Case Study: Gas surge Drum, Isothermal chemical reactor, Jacketed stirred-tank heater.	
Text Books	1 Process Dynamics & Control by D. E. Seborg, T. F. Edgar & D. A. Mellichamp, 2nd eds., John Wiley & Sons.	
Reference Books	**1.** B. G. Liptak, Instrument Engineers Handbook, Chilton Book Co., Philadelphia. **2.** Principles of Process Control - D Patrnabis, TMH	
Mode of Evaluation	Assignments, Semester Exam	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 127C: Control of Industrial Process		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: PG / IEE / T / 111B	Embedded Systems	L T P C 3 0 0 3
Course Prerequisites	Typical Processor Architecture, Design of Microprocessors / Microcontroller Based Systems, Introductory level knowledge in Operating System	
Objectives:	The course aims to provide adequate knowledge about • The basics of Embedded Systems. • The basics of Memory organization, Device Networks, Device Drivers • The basic concepts of RTOS	
Course Outcome:	On completion of the course, the students will be able to CO1: Explain the basics of embedded system development tools CO2: Understand Memory organization, Devices, and Buses for Device Networks CO3: Describe concepts of RTOS and its Case Studies.	
Unit I	CO1: 12 hrs Introduction to Embedded Systems - definitions and constraints, Processors.	
Unit II	CO2: 15 hrs Memory organization, Devices, and Buses for Device Networks, Device Drivers, Interrupt Servicing Mechanism.	
Unit III	CO2: 13hrs Review of typical Software Architectures, Introduction to RealTime Operating Systems. Hardware-Software co-design approach. Case Studies on hardware-software co-design approach.	
Text Books	1) Qing Li with Caroline Yao “Real-Time Concepts for Embedded Systems ” CMP books 2011 2. Craig Hollabaugh, “Embedded Linux: Hardware, software and Interfacing”, Pearson Education, 2002.	
Reference Books	1. KarimYaghmour, Jon Masters, Gillad Ben Yossef, Philippe Gerum, “Building embedded linux systems”, O'Reilly, 2008. 2. Christopher Hallinan, “Embedded Linux Primer: A practical real world approach”, Prentice Hall, 2007. 3. Doug Abbott, “Linux for embedded and real time applications”, Elsevier Science, 2003. . Programming andcustomizing the multicore propeller microcontroller, Shane Avery , Chip Gracey, Vern Graner, Martin Hebel and Joshua HintzeMcGraw-Hill	
Mode of Evaluation	Final-Written Term End Examination	
Course delivery format	Power point teaching and assignments	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 111C Embedded Systems		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
	CO1	3	2	1		1							
	CO2	1	3	2		2							
	CO3	1	3	2									

<table>
<tr><td>Course code:
PG / IEE / T/ 112A</td><td>Signals and Systems</td><td>L T P C
3 0 0 3</td></tr>
<tr><td>Course Prerequisites</td><td colspan="2"></td></tr>
<tr><td>Objectives:</td><td colspan="2">The course aims to provide adequate knowledge about
• Apply efficient method for calculating the DFT & IDFT.
• Design & implement FIR & IIR filters.
• Perform Frequency transformations in Analog and Digital domains.
• Define the various structures for discrete-time systems.</td></tr>
<tr><td>Course Outcome:</td><td colspan="2">On completion of the course, the students will be able to
CO1: Examine the time domain and frequency domain representations of discrete-time signals. (K4)
CO2: Apply efficient method for calculating the DFT & IDFT. (K3)
CO3: Design & implement FIR & IIR filters, Perform Frequency transformations in Analog and Digital domains and Define the various structures for discrete-time systems. (K5)</td></tr>
<tr><td>Unit I</td><td colspan="2">CO1: 08 hrs
Discrete Fourier Transform: Discrete Fourier Transform (DFT), DFT as a linear Transformation and Relationship of DFT to other transform.
Properties of DFT: Periodicity, Linearity and Symmetry properties, Multiplication of two DFTs and circular convolution, additional DFT properties.
Linear filtering methods based on the DFT: Use of DFT in linear filtering, Filtering of long data sequences.</td></tr>
<tr><td>Unit II</td><td colspan="2">CO2: 08 hrs
Frequency Analysis of Signals using DFT.
Discrete Cosine Transform (DCT): Forward DCT, Inverse DCT, Relationships between DFT and DCT, Energy Compaction property of DCT.
Efficient computation of DFT: FFT Algorithms
Direct computation of DFT, Divide and conquer approach to computation of DFT, Radix-2 FFT Algorithms for the computation of DFT and Inverse DFT.</td></tr>
<tr><td>Unit III</td><td colspan="2">CO3: 18hrs
Design of Digital Filters:
Causality and its Implications, Characteristics of practical Frequency Selective Filters.
Design of FIR Filters: Symmetric and anti-symmetric FIR Filters, Design of Linear phase FIR Filters using Windows, Design of Linear phase FIR filters by frequency Sampling method, Design of FIR Differentiators and Hilbert Transformers – typical case studies.
Analog Filters: Characteristics of commonly used Analog Filters – Butterworth andChebyshev Type-1 filters.
Design of Digital IIR Filter from Analog Filters:
IIR Filter design by Impulse Invariance, IIR Filter Design by the Bilinear Transformation - typical case studies.
Frequency Transformations: Frequency transformation in the Analog Domain, Frequency transformation in the Digital Domain.
Structures for the realization of the discrete time systems:
Structures for FIR systems: Direct form structure, Cascade form structures, frequency Sampling structures, lattice Structure.
Structure for IIR systems: Direct form structures, Signal Flow Graphs and Transposed Structures, Cascade Form Structures, Parallel- Form and Lattice</td></tr>
<tr><td>Text Books</td><td colspan="2">1) Proakis G, Dimitris G. Manolakis; “Digital Signal Processing”; PHI; 4th Edition; 2007, ISBN: 81-317-1000-9.
2) Lonnie C. Ludeman; “Fundamentals of Digital Signal Processing” ; John Wiley & Sons; 2013; ISBN: 978-81-265-2222-4.</td></tr>
<tr><td>Reference Books</td><td colspan="2">1) Monson H.Hayes; “Digital Signal Processing”; Schaum’s Outline Series; 2nd Edition;</td></tr>
</table>

	2011; ISBN: 0071635092. 2) Alan .V. Oppemheim; "Discrete Time Signal Processing"; PHI; 2nd Edition; 2002; ISBN: 81-7808-244-6
Mode of Evaluation	Final-Written Term End Examination
Course delivery format	Power point teaching and assignments
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples
Supporting Laboratory course	
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
PG / IEE / T/ 112ASignals and Systems	**CO 1**	**3**	**2**	**1**		**1**							
	CO 2	**1**	**3**	**2**		**2**							
	CO 3	**1**	**3**	**2**									

Course code: PG / IEE / T / 112B	Digital Communication System	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Transmitter and receiver circuit of digital communication system. • Behavior of communication channel • Source coding and channel coding techniques • Spread spectrum communication	
Course Outcomes:	On completion of the course, the students will be able to • CO1: Understand and analyze the basic principles of digital communication transmitter and receiver (K2, A1-explain) • CO2: Explain the impact of source and channel coding in setting up reliable and efficient communication environment (K1-describe) • CO3: Apply new techniques for the development of next generation communication system (K3)	
Unit I	**Transmitter: CO1** Nyquist sampling theorem with detailed mathematical deliberation, signal, uniform quantization in connection to digital transmission, different types of pulse modulation: PAM, PCM, DPCM, ADPCM, DM- case studies	
Unit II	**Receiver: CO1** Basic elements of digital communication receiver, concept of matched filter receiver-illustration with case studies, BER calculation, source of ISI, Nyquist minimum bandwidth theorem	
Unit III	**Information theory: CO2** Definition of information and entropy, different types of source codes- prefix code (Huffman code: a case study), Lempel-ziv code: illustrative examples.	
Unit IV	**Channel codes: CO2** Necessity and use of channel code, desirable properties, linear block code as a case study: its construction, properties, error correction capability, convolutional code	
Unit V	**Spread spectrum modulation: CO3** Basic concept behind spread spectrum modulation, transmitter and receiver circuit of spread spectrum modulator, importance of spreading codes- PN sequence: a case study	
Text Books	1. Simon Haykin. “Communication Systems”. Wiley, 4th Edition, 2006.	
Reference Books	1. T. S. Rappaport. “Wireless Communications- Principles and Practice”, Pearson, 2003. 2. B. P. Lathi and Z. Ding. “Modern Digital and Analog Communication Systems”. Oxford University Press, Fourth Edition, 2011.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Video lectures on YouTube platform, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 112C: Digital Communication System		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: PG / IEE / T / 113A	**Advanced Electronic Instrumentation**	**L T P C** **3 0 0 3**
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Basic components of electronic instruments like analog to digital converters • Signal processing techniques for electronic instruments • Noise in electronic instruments and grounding and shielding techniques • Electronic measuring instruments like oscilloscope, function generator, spectrum analyzer	
Course Outcomes:	On completion of the course, the students will be able to CO1: Explainthe functioning of analog to digital converters and digital to analog converters (K1, A1) CO2: Analyze the measurement signals and noise (K2, A2) CO3: Explain and the principle of functioning of a few measuring instruments (K1, A1).	
Unit I	**Analog to digital converters and Digital to analog converters: CO1** Basic converter errors, D/A converter circuits, A/D conversion principles – integrating, sigma-delta, flash and successive approximation type.	
Unit II	**Basic signal processing techniques for electronic instruments: CO2** Averaging, integrating, basic filtering techniques, fast Fourier transforms. Typical case studies on selected techniques.	
Unit III	**Noise in electronic instruments and Grounding and shielding techniques : CO2** Noise Processes, Statistics and Error Analysis. Grounding and Shielding Techniques: Capacitive and Inductive crosstalk, EM coupling and interference, grounding considerations, shielding theory and techniques.	
Unit IV	**Digital Test & Measuring Instruments: CO3** Principle of operation, basic functional blocks and hardware software issues of the following: Digital Storage Oscilloscopes Arbitrary Waveform Generators Spectrum Analyzers	
Text Books	1. David Bell, "Electronic instrumentation and measurements", Oxford University Press, 3rd edition, 2014. 2. Cooper and Helfrick "Modern Electronic Instrumentation and Measuring Techniques", PHI, 1998.	
Reference Books	1. Wolf and Smith, "Student Reference Manual for Electronic Instrumentation Laboratories", PHI, 2nd edition, 2018. 2. D. Patranabis, "Priciples of Electronic Instrumentation", PHI, 2009.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 113A: Advanced Electronic Instrumentation		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	2	1	1		1							
	CO2	3	1			1							
	CO3	2	1	1		1							

Course code: PG / IEE / T / 113B	Digital Systems Design with FPGAs	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Critical issues related to Digital System design • VHDL/Verilog language for designing digital systems. • FPGA architecture details • Implementing digital systems using FPGA	
Course Outcomes:	On completion of the course, the students will be able to CO1: Define and explain the critical issues faced during digital system design (K1, A1) CO2: Apply the VHDL/Verilog language to develop digital systems (K5, A4) CO3: Describe the FPGA architecture and implement the digital systems (K2, A1)	
Unit I	**Digital system design issues : CO1** Digital Systems Design with FPGAs, Hierarchy in Design, Controllers, Mealy and Moore Machines, metastability, synchronization, FSM issues, clock trees, clock skew, pipelining, multiple clock domains, case studies.	
Unit II	**Digital design using VHDL/Verilog : CO2** VHDL/Verilog : behavioral, data flow, structural models, simulation cycles, process, concurrent and sequential statements, loops, delay models, synthesis, FSM coding, library, packages, functions, procedures, resource sharing, test benches, hardware software co-simulation; case studies.	
Unit III	**System implementation using FPGAs : CO3** FPGA: logic block architecture, routing architecture, programmable interconnections, design flow, Xilinx Vertex and ActelProASIC architectures, device programming, debugging, applications, case studies, embedded system on programmable chips.	
Text Books	1. Bora Tar &CemUnsalan : "Digital System Design with FPGA: Implementation Using Verilog and VHDL", McGraw Hill Education, 2. Wayne Wolf : "FPGA Based System Design", Pearson India	
Reference Books	1. Ming-Bo Lin: "Degital System Designs and Practices"; John Wiley and Sons Ltd.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 113B: Digital Systems Design with FPGAs		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	1	3	2	1								
	CO2	1	3	1	1	2							
	CO3	1	2	1	3	2							

Course code: PG / IEE / T/ 113C	Medical Instrumentation	L T P C 3 0 0 3
Version No.		
Course Prerequisites	PG / IEE / T/ 112A, PG / IEE / T/ 113A	
Objectives:	The course aims to provide adequate knowledge about • Specifications and standards of medical equipment and patient safety • Transducers used in biomedical instruments • Principle of operation and working details of different diagnostic equipments, assistive devices and therapeutic devices	
Expected Outcome:	On completion of the course the students will be able to **CO1: Describe and explain the standards of Medical Instruments and specify the patient safety aspects (K1, A1)** **CO2: Understand and explain the application ofsensing devices in biomedical instruments (K2, A1)** **CO3:Understand the principle of diagnostic equipmentsand clinical instrumentation, assistive devices,therapeutic devices, and explain their applications (K2,A1)**	
Unit I	**Introduction of Medical Instrumentation: 13 hrs: CO1** General Description of medical instrumentation, its problems and specialty, Equipment standards and patient safety.	
Unit II	**Sensing devices for biomedical instruments: 19hrs: CO2** Modeling, design, fabrication, packaging and material characterization.	
Unit III	**Principles of Diagnostic equipment andClinical instrumentation;Application of various Assistive devices; Principles of Therapeutic devices: 28 hrs: CO1: CO2: CO3** Vector cardiograph, echocardiograph, comparison of ECG, VCG and ECHO, monitoring and transmission of ECG, IR imaging and its diagnostic criteria, Measurement of blood flow - electromagnetic flow meters and its specialty, plethysmography - impedance plethysmography, discussion of other blood flow meters, their advantages and disadvantages over these methods, Ultrasonography - principles, different scanning modes, its instrumentation. Hearing aid and its problems, contact lens and its problems, artificial heart and its viability and Chemotherapy. Case specific application of standard medical equipments.	
Text Books	Leslie Cromwell, Biomedical Instrumentation and Measurements,Prentice Hall Geddes,L.A. and L.E.Baker,Principles of Biomedical Instrumentation,JohnWiely& Sons	
Reference Books	John G Webster, Handbook of Biomedical Instrumentation and Sensors, CRC Press John G Webster,Medical Instrumentation Application and Design,Houghton Mifflin Company.	
Mode of Evaluation	Final-written term end examination.	
Course delivery format	Presentations and supporting, short duration technical videos.	
Supplementary academic support	Providing links to online courses and websites featuring tutorials, practical applications, case studies to supplement classroom presentations.	
Other learning activities	Class discussions, presentations by industry experts, participation in events organized by professional bodies on relevant topics.	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping :(3 – Strong, 2 – Moderate and 1 – Weak)

MTIEE33: Medical Instrumentation		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
	CO 1	2	1	1									
	CO 2	3	2	1	1								
	CO 3	1	1	3	2	1	1						

Course code: PG / IEE / T/ 114A	Soft Computing- Theory and Applications	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about - Various aspects of fuzzy rule based systems design. Neural networks and Genetic algorithms, their computational steps and applications.	
Course Outcomes:	On completion of the course, the students will be able to **CO1:** Explain the basic constituents of soft-computing and the various computational steps of fuzzy decision making systems with case studies. (K2, K3, A1). **CO2 :** Describe different Neural network structures and their learning methods. (K2, A1). **CO3 :** Discuss the basic operational steps of genetic algorithms. (K1,A1)	
Unit I (CO1)	Introduction to soft computing and its constituents: Fuzzy Logic, Artificial Neural Networks, and Evolutionary Computations. Introduction to fuzzy sets. Basic definitions and Terminology; Set/theoretic operators; Membership function formulation and parameterization. Fuzzy relation, implications, cylindrical extension, projection and composition. Approximate reasoning, compositional rule of inference, rule based system, term set, fuzzification, inferencing, defuzzification, Mamdani-Assilian (MA) and Takagi-Sugeno(TS) fuzzy models - some case studies on application of fuzzy rule based systems.	
Unit II (CO2)	Introduction to artificial neural networks, different architectures of neural networks. Single andMmultilayerfeedforward neural networks. Supervised and unsupervised learning neural networks, Back-propagation algorithm, Self-organizing feature maps. Hybrid Neuro-fuzzy systems.	
Unit III (CO3)	Introduction to Evolutionary Computations. Basics of Genetic Algorithms (GA) and its computational steps, Reproduction-Crossover-Mutation operators. Hybrid GA-fuzzy system.Case studies onapplication of optimal tuning of controller parameters.	
Text Books	1. Neuro-Fuzzy and Soft Computing, A Computational Approach to Learning and Machine Intelligence, J.-S.R Jang., C.-T Sun., & E. Mizutani, Prentice Hall, Upper Saddle River, NJ, 1997. 2. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003. 3. Genetic Algorithms in Search, Optimization, and Machine Learning, David E Goldberg, Addison Wesley, 1989.	
Reference Books	1. Intelligent Control: Aspects of Fuzzy Logic and Neural Nets, C.J. Harris, C.G. Moore& M. Brown, World Scientific , 1993. 2. An Introduction to Fuzzy Control, D. Driankov, H. Hellendroorn, M. Rainfrank, Springer-Verlag, Berlin Heidelberg, 1993. 3. Fuzzy Logic: with Engineering Applications, T. J. Ross, Wiley, 2007.	
Mode of Evaluation	Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	

Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 114A: Soft Computing- Theory and Applications		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	**3**	**2**	**1**	**1**								
	CO2	**3**	**2**	**1**	**1**								
	CO3	**3**	**2**	**1**	**1**								

Course code: PG / IEE / T/ 114B	Advanced Microprocessors and Microcontrollers	**L T P C** **3 0 0 3**
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • **Hardware and software features of a typical 16-bit microprocessor and its upgrades** • **Hardware and software features of a typical 8-bit microprocessor with RISC Architecture** • **Typical on-chip Peripheral devices of a microcontroller** • **Developing application software on a microcontroller platform using standard crosscompilers**	
Course Outcomes:	On completion of the course, the students will be able to CO1: Review of the basic architecture of Microprocessors and Microcontrollers (K2, A2-Study) CO2: Review of on-chip peripheral modules of typical processors (K2, A2-Study) CO3: Design and debug application programs using C cross-compilers (K3,A4)	
Unit I	**Introduction to Microprocessors: CO1** Intel 8086: Internal Architecture; Memory Address Space; Data organization; Segment Registers and Memory Segmentation; Dedicated, Reserved and General purpose memory; Pointer and Registers; Generation of a memory address; Stack handling. Hardware Organization of the Memory Address Space. Intel 80386 processor families: Internal Architecture; Real-address-mode and Protected-address-modes of operation. Memory Management, Virtual Addressing, Paging, Protection and Multitasking in Protected-address-mode of operation.	
Unit II	**Introduction to Microprocessors : CO1** PIC18-Q43 family: 8-bit CPU based on modified Harvard Architecture; Memory organization – Program Memory, Data RAM, Data EEPROM; Device I/O port features; Analog and Digital Interfaces, Clocking Structure, Program/Debug features.	
Unit III	**Microcontroller on-chip peripheral modules: CO2** PIC18-Q43 familyAnalog Interfaces: A/D converter, D/A converter, Comparators, Zero-cross detector, Voltage Reference; PIC18-Q43 family Digital Interfaces: Programmable timers, PWM modules, Configurable Logic Cell (CLC), Compare/Capture modules, Complementary Waveform Generators (CWG), Numerically controlled oscillators (NCO) , Signal Measurement Timer (SMT), UART, SPI, I^2C modules.	
Unit IV	**Design and debug application programs using C cross-compilers : CO3** Introduction to MPLAB X Integrated Development Environment (IDE), MPLAB XC8 C-compiler and MPLAB PICkit 4 device programmer Case studies – code examples on timers, A/D and D/A converters, PWM outputs, data transmission and reception through UART and SPI modules.	
Text Books	1. Walter.A. Tribal, Avtar Sing and N.K. Srinath, "The 8088 and 8086 Microprocessors: Programming, Interfacing, Software, Hardware, and Application", Pearson India. 2. Microchip PIC18F27/47/57Q43 - 28/40/44/48-Pin, Low-Power, High-Performance Microcontroller with XLP Technology, PIC18F27/47/57Q43 Data Sheet (microchip.com)	
Reference Books	1. Brey B. Barry "The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium pro Processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64-bir Extensions - Architecture, Programming, and Interfacing", Pearson India 2. Muhammad Ali Mazidi, Rolin D. McKinlay, Danny Causey "PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18", Pearson Prentice Hall	

Mode of Evaluation	Assignments, Final-Written Term End Examination
Course delivery format	Class room lecture, Tutorial and Discussion
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 128D Advanced Microprocessors and Microcontrollers		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	**3**	**2**	**1**									
	CO2	**3**	**2**		**1**								
	CO3	**2**	**3**		**1**	**2**							

Course code: PG / IEE / T/ 115A	Instrumentation and Measurement Techniques	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Architecture of a generalized measurement system • Transduction principle of various sensors and transducers • P, PI, PD and PID controllers • Signal conditioning circuits for sensors, transmitters, and other measuring systems.	
Course Outcomes:	On completion of the course, the students will be able to CO1: Organize various functional parts of a measurement system in block diagram level (K5). CO2: Choose best suited sensors/transducers for measurement of various physical parameters like displacement, pressure, force, temperature, flowetc (K6). CO3: Identify the controller modes and analyze the close loop response of the 1st and 2nd order process in presence of P, PI, PD, PID controllers (K4). CO4: Design necessary signal conditioning circuit for measurement systems (K5)	
Unit I	**Architecture of a generalized measurement system: CO1** General measurement systems: Specifications of instruments, functional block diagram of measurement system, creating functional block diagram for a given measurement system, static and dynamic characteristics.	
Unit II	**Transduction principle of various sensors and transducers: CO2** Sensors/Transducers: Resistance type - potentiometer, strain gauge; Inductive type – LVDT Temperature sensing elements – RTD, thermistor, thermocouple, semiconductor IC sensors; Pressure sensing elements – manometers, elastic elements, Bourdon tube, diaphragm, bellows, electrical type, McLeod gauge, Pirani gauge; Flow sensing elements – head meters (orifice, venturi), area meters, rotameters, electromagnetic flowmeter, Coriolis flow meter, Ultrasonic flowmeter; Analytical sensors – pH measurement.	
Unit III	**P, PI, PD and PID controllers: CO3** Principles of process control: process control and automation, Process transfer function, basic process control loop block diagram, terms and objectives, servo and regulatory control, stability criteria. Theory of controllers: Proportional, Proportional- Integral (PI), Proportional-Derivative (PD), PID, Complex control strategies, case study: Boiler drum level control, Combustion control. Control elements: controller, final control elements. Introduction to PLC and DCS.	
Unit IV	**Signal conditioning circuits for sensors, transmitters, and other measuring systems: CO3** Deflection bridge, Instrumentation amplifier, Switching devices – relays (electromagnetic), contactor, transistor switches, Opamp – inverting, non-inverting, differential configurations Power amplification, active filters (LP, HP, BP and Notch), constant current and voltage sources. Wired signal transmission in industry (voltage 1-5V, current 4-20mA loop), F-V, V-F converters, V-I, I-V converters, A/D and D/A converters.	
Text Books	William C. Dunn, Fundamentals ofIndustrial Instrumentationand Process Control, McGraw-Hill, New York.	
Reference Books	1. E. A. Doebelin, Measurement Systems: Application and Design, McGraw Hill,	

	New York 2. J. P. Bentley, Principles of Measurement Systems. Publisher, John Wiley & Sons, Incorporated, 1986. 3. G. Stephanopoulos, Chemical Process Control-An Introduction to Theory and Practice, Prentice Hall of India, New Delhi, 2nd Edition, 2005. 4. Béla G. Lipták, Process Control: Instrument Engineers' Handbook, Butterworth-Heinemann 5. Schilling&Belove—Electronic Circuit: Discrete & Integrated , 3/e , McGraw Hill.
Mode of Evaluation	Assignments, Final-Written Term End Examination
Course delivery format	Class room lecture, Tutorial and Discussion
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 115B: Instrumentation and Measurement Techniques		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	**2**	**3**	**3**	**1**								
	CO2	**1**	**3**	**3**	**3**	**1**							
	CO3	**3**	**3**	**3**	**3**	**1**							
	CO4	**2**	**3**	**3**	**2**	**2**							

Course Code PG / IEE / T/ 115B	Aerospace Instrumentation	**L T P C** **3 0 0 3**
Course Prerequisites:	Sensors , transducers, Process Instrumentation and Control,	
Objective	The course aims to provide adequate knowledge about a. Brief concept on Atmospheric Measurement; b. Detailed description of Measurement of atmospheric flow , temperature, density and conductivity c. Description of Payload, Rockets & Satellites d. Understanding of Aircraft instrumentation & measurement	
Course Outcome:	On completion of the course, the students will be able to CO1: Describe Measurement of atmospheric parameters (K2, A1). CO2: Describe measurements procedures of upper atmospheric parameters (K2, A1). CO3: Describe Payload, Rockets & Satellites , Aircraft Instrumentation & Control (K2, A1)	
Unit I	**Measurement of Atmospheric Flow, Pressure, Temperature: CO1** Measurement Of Pressure Static, Average, Dynamic, Impact Pressure And Total Pressure. Measurement Of Flow Direction - Probes, Impact Plate, Angle of Attack Sensors, Measurement Of Temperature - Total Temperature Of Flowing Gas, Temperature Of Oxygen, Temperature Of Solid Objects. Measurement Of Atmospheric Density And Conductivity,	12 L
Unit II	**Atmospheric Instruments: CO2** Balloons And Payloads, Electrostatic Flux Meter. Measurement of Pollutants By Laser Optical Method, Measurement Of NO And Ozone, Ion Density Measurement, Measurement of Stratospheric Aerosols, Instruments In Upper Atmosphere Studies	12 L
Unit III	**Some Special Measurements : CO3** Measurement Using Rockets & Satellites, Measurement Of X-Ray & X-Ray Fluxes, Optical Remote Sensing. Aircraft Instrumentation, Measurement Of Aircraft Speed, Measurement Of Fluid Velocity, Local Linear Velocity & Bulk Velocity Strain And Thrust Measurement, Acceleration. Case studies on selected areas.	14 L
Unit IV	**Aircraft Instrumentation and Control: CO3** Aircraft Rocket-Study Instrumentation, Missile Control Instrumentation	8 L
Reference books	1. Aircraft Instrumentation and Systems Hardcover – 30 December 2013 by S. Nagabhushana (Author), L. K. Sudha (Author), IK International Pvt. Ltd. 2.Aerospace Engineering: Design, Development and Applications, Stephen Baggins,	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 115C Aerospace Instrumentation		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1		3	1									
	CO2		3	1									
	CO3		3	1									

Course code: PG / IEE / T / 116A	Mathematical Methods in Instrumentation	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • State space representation of dynamic systems. • Matrix algebra and matrix calculus • Vectors and linear vector spaces • Solving simultaneous linear equations	
Course Outcomes:	On completion of the course, the students will be able to CO1: Define and explain basic concepts of state space representation and modelling of systems (K1, A1) CO2: Describe the linear vector spaces (K2, A1) and discuss its applications in different practical problems (K3-apply,A2) CO3: Solve problems related to matrix algebra, matrix calculus, eigenvalues, eigenvectors and functions of matrices (K3)	
Unit I	**State space representation: CO1** Analytical and experimental modeling of systems, mathematical representation of systems-specific case studies. State space representation of dynamic systems, obtaining system equations from differential and difference equations, transfer functions and linear graphs, interconnection of subsystems. Typical case studies on state-space representation of systems.	
Unit II	**Linear Vector Spaces: CO2** Vectors and linear vector spaces, basis, reciprocal basis, mappings, domain, range, spanning a vector space, linear manifolds, subspaces, projections, adjoint transformations.	
Unit III	**Matrix Algebra and calculus: CO3** Matrix algebra, rank and trace of matrices, matrix inversion, partitioned matrices, differentiation and integration of matrices, matrix calculus.	
Unit IV	**Solving Simultaneous Linear Equations: CO3** Row reduced echelon form, Gram Schmidt expansion, QR decomposition, Singular Value decomposition (SVD), eigenvalues, eigenvectors, generalized eigenvectors, Jordan form, spectral decomposition, bilinear and quadratic forms, functions of square matrices, Cayley Hamilton Theorem.	
Text Books	1. W.L. Brogan. "Modern Control Theory". 3rd Edition, Prentice Hall.	
Reference Books	1. S. H. Zak. "Systems and Control". Oxford University Press. 2003. 2. Gilbert Strang. "Linear Algebra and its applications". Cengage Learning. 2018. 3. M. Gopal. "Modern control system theory". New Age International Publishers. 2005.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 116A: Mathematical Methods in Instrumentation		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course Code: PG / IEE / T / 116B	Optimization Techniques	**L T P C** **3 0 0 3**
Course Prerequisites:	Linear algebra, Matrix Operation, probability, Basic Programing knowledge , Signal Processing & Genetic Algorithm	
Objective	The Course Aims To Provide Adequate Knowledge About A. Brief Concept on Classical Optimization Techniques; B. Linear and Non-Linear Programming C Comparative Study Of NLP Algorithms D. Understanding Of Decomposition Techniques	
Course Outcome:	On Completion Of The Course, The Students Will Be Able To CO1: Describe Classical Optimization Techniques (K2, A1). CO2: Describe Linear & Non-Linear Programming, NLP Study & Algorithms (K2, A1). CO3: Describe Decomposition Techniques & Optimization Algorithms (K2, A1)	
Unit I	**Classical Optimization Techniques: CO1** Inadequacy Of Classical Optimization Techniques. Linear Programming Problem, Simplex Method And Extensions.	10 L
Unit II	**Non-Linear Programming: CO2** Non-Linear Programming: Quasi-Newton Reduced Gradient And Gradient Projection Method. Penalty Function Methods.	10L
Unit III	**NLP Algorithms:CO2 , CO3** Benchmark Problems, Case Studies And Computer Programs For Comparative Study of NLP Algorithms, Decomposition Techniques For Large Problems.	12L
Unit IV	**Dynamic Optimization & Nature Inspired Optimization: CO3** Introduction To Dynamic Optimization And Nature Inspired Optimization Algorithm.	10L
Reference Books	1. Optimization Techniques And Applications With Examples By Yang, Wiley 2. Optimization Techniques ,Pawan Kumar Oberoi 3.Optimization Methods For Engineers By R. V. S. Raju , Prentice-Hall Of India Pvt.Ltd	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 116B Optimization Techniques		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
	CO1		3	1									
	CO2		3	1									
	CO3		3	1									

Course code: PG / IEE / S / 111- Laboratory	Laboratory	L T P C 0 0 4 3
Course Prerequisites		
Course Outcomes:	On completion of the course, the students will be able to CO1: Design and execute programs with different case studies in MATLAB toward solving problems in project activities. CO2: Design case studies and simulate electronic circuits using PSpice toward project activities. CO3: Design and develop case studies with LABVIEW toward project activities.	
Syllabus :	Usage of software tools like MATLAB, PSpice, LABVIEW, etc. for use in system modeling, testing, and specific instrumentation applications. Typical case studies using MATLAB, PSpice & LABVIEW. Project assignments that require usage of the tools for their implementations,	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

IEE/PC/B/S/ 321: Digital Signal Processing Laboratory		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
	CO 1	3	1	1		1							
	CO 2	3	1			1							
	CO 3	2	3	1		1							

Course code: PG / IEE / S / 112	Assignment	L T P C 0 0 4 3
Course Prerequisites		
Course Outcomes:	On completion of the course, the students will be able to CO1: Organize the planning and execution of a mini engineering project as a team (S2, A4-customize) CO2: Create/collect an engineering data base and/or develop solution for a specific engineering problem of topical interest (K5, S5) CO3: Present a scientific report on the mini project / problem. (K5, A5-represent)	
Syllabus :	Design, implementation and testing of MATLAB/ Labview or other software based student mini projects. Design, implementation and testing of some Instrumentation system based student mini projects. Compile scientific report of work done.	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12
ASSIGNMENT PG / IEE / S / 112	CO 1	2	2	3	2	2	2			1	1		
	CO 2	1	2	2	2	3							
	CO 3		1	1		3							

Course code: PG / IEE / T/ 127A	Instrumental Analysis	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Spectroscopic methods • Chromatography • Electron Microscopy	
Course Outcome:	On completion of the course, the students will be able to CO1: Understand Spectroscopic methods and group discussion with its different case studies. CO2: Understand, Explain the Chromatography analysis group discussion with its different case studies. CO3: Describe the basic principlesofElectron Microscopy.	
Unit I	**Absorption Spectroscopy: 10 hrs: CO1** **Absorption Spectroscopy**: Quantitative aspects, photometer and spectrophotometer designs. Molecular UV and V absorption Spectroscopy, Absorbing Species, Application in qualitative and quantitative analysis, Photo acoustic spectroscopy. Molecular fluorescence, phosphorescence and chemiluminescence spectroscopy. Atomic spectroscopy, Atomic absorption types, Atomic fluorescence types. Emission spectroscopy with Plasma, Arc, Spark, Flame emission type. IR absorption spectroscopyqualitative and quantitative analysis, IR emission spectroscopy. Raman spectroscopy - various types of the spectroscopy and their applications, NMR - application to Proton and other isotopes, environmental effects, ESR. X-ray spectroscopy, fluorescence, absorption, diffraction. The electron microscope. Electron spectroscopy and its applications. Mass spectroscopy - identification of pure compounds, Molecular secondary ion mass spectrometry. Typical case studies on selected topics.	
Unit II	**Chromatography: 12 hrs : CO2** Chromatography : Plate theory, qualitative and quantitative analysis, Computerized system; Gas-liquid chromatography, Gas solid type, HPLC, Partition Chromatography, Absorption chromatography, Ion-exchange chromatography, Size exclusion chromatography, Superficial type. Plate theory, qualitative and quantitative analysis, Computerized system; Gas-liquid chromatography, Gas solid type, HPLC, Partition Chromatography, Absorption chromatography, Ion-exchange chromatography, Size exclusion chromatography, Superficial type, and Electro chromatography. Typical case studies on selected topics.	
Unit III	**Spectroscopic Techniques in UV Visible and X-ray ranges: 12 hrs : CO2** Absorption in Visible and UV-range, monochromators and detectors, Sources and their λ - ranges, Colorimetry, Atomic Spectral Methods: Emission and Absorption: Visible, UV and X-rays; sources, principles, detectors, sample preparation etc., XRD.	
Unit IV	**Electron Microscopy: 12 hrs : CO3** Electron Microscopy - SEM with auxiliary equipment like AUGER. Electrochemical cells, cell potentials, electrode potentials, Reference electrodes, Metallic electrodes, Membrane electrodes, Potentiometric methods.	
Text Books	1) Principles of Instrumental Analysis- Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Thomson Brooks/Cole, 2007	
Reference Books	1) Liptak BG. Instrument Engineers' Handbook, Volume One: Process Measurement and Analysis. CRC press; 2003 2) Patranabis,D., Principles of Industrial Instrumentation, 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010.	
Mode of Evaluation	Written CT-I & II and Assignments Final-Written Term End Examination	
Course delivery	Primarily black board teaching.	

format	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples
Supporting Laboratory course	
Recommended by the Board of Studies on	
Date of Approval by the Academic Council	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

IEE/PC/B/T/311: Analytical Instrumentation		**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
	CO1	**3**	**1**	**1**									
	CO2	**3**	**2**	**1**									
	CO3	**3**	**2**	**1**									

Course code: PG / IEE / T / 127B	Sensors - Science and Technology	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • the principles of sensing and measurement • how sensor systems can be modeled, designed, calibrated, characterised, and analysed • sensor fabrication technologies • various applications of sensors	
Course Outcomes:	On completion of the course, the students will be able to CO1: Explain the principles of physical and chemical sensors (K1, A1) CO2: Apply the sensor model and design different sensors (K2, A2) CO3: Understand the sensor fabrication and packaging technologies, interfacing techniques and applications of sensors (K1, A1).	
Unit I	**Principles of Physical and Chemical Sensors: CO1** Sensor classification, Sensing mechanism of Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological Sensors. Sensor Characterisation and Calibration: Study of Static and Dynamic Characteristics, Sensor reliability, aging test, failure mechanisms and their evaluation and stability study. Case study on sensor characterization and calibration.	
Unit II	**Sensor Modeling and Design: CO2** Numerical modeling techniques, Model equations, Different effects on modeling (Mechanical, Electrical, Thermal, Magnetic, Optical, Chemical and Biological) and examples of modeling. Sensor Design and Packaging: Partitioning, Layout, technology constraints, scaling, compatibility study.	
Unit III	**Sensor Fabrication and Packaging Technologies: CO3** Thick and thin films fabrication process, Micro machining, IOC (Integrated Optical circuit) fabrication process, Ceramic material fabrication process, Wire bonding, and Packaging.	
Unit IV	**Sensor Interfaces and Applications: CO3** Sensor Signal processing, Multi sensor signal processing, Smart Sensors, Interface Systems. Typical case studies. Sensor Applications: Process Engineering, Medical Diagnostic and Patient monitoring, Environmental monitoring.	
Text Books	1. Jon. S. Wilson, “Sensor Technology Hand Book”, Elsevier, 2011.	
Reference Books	1. Ramon Pallas-Areny and John G Webster, Sensors and Signal Conditioning, Wiley India Pvt. Ltd 2012. 2. Peter Grundler, "Chemical Sensors: Introduction for Scientists and Engineers", Springer, 2011. 3. Patranabis.D, “Sensors and Transducers”, Wheeler publisher, 1994.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 127B:Sensors - Science and Technology		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: PG / IEE / T/ 127C	Control of Industrial Process	**L T P C** **3 0 0 3**
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Basic concepts of Process Control systems • Real time applications of various control mechanisms • Present control strategies used in plant and process instrumentation • Several associated instruments other than controllers and their operations	
Course Outcomes:	On completion of the course, the students will be able to CO1: Define and explain basic concepts of process control systems (K1, K2, A1) CO2: Describe the different control schemes (K2, A1) and discuss its applications in different practical problems (K3-apply, A2) CO3: Describe about several process plant instrumentation and discuss about various devices associated with control systems (K2,A2)	
Unit I	**Basic concepts of Process Control systems: CO1** Basics of process control systems, process instrumentation diagram for different process control loops.	
Unit II	**Real-time applications of different control schemes: CO2** Instrumentation system design for different units. Case study:- Deaerator of power plant Safety Interlock instrumentation system of a turbine driven boiler feed water pump. Control of Distillation Column, Control of Furnace	
Unit III	**Process Plant Instrumentation: CO3** Process Plant Instrumentation; Case sudy: Ammonia Production in a Fertilizer, Instrumentation System Design for Carbon, Sulphur and Hydrogen Sulphide gas removal process.	
Unit IV	**Associated devices: CO3** Studies of different Units related to process plant: Annunciator, Transmitter Comparative study of PLC, DCS and SCADA.	
Text Books	1 Process Dynamics & Control by D. E. Seborg, T. F. Edgar & D. A. Mellichamp, 2nd eds., John Wiley & Sons.	
Reference Books	**3.** B. G. Liptak, Instrument Engineers Handbook, Chilton Book Co., Philadelphia. **4.** Principles of Process Control - D Patrnabis, TMH	
Mode of Evaluation	Assignments, Semester Exam	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 127C: Control of Industrial Process		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: **PG / IEE / T/ 128A**	**Speech Processing**	**L T P C** **3 0 0 3**
Course Prerequisites	PG / IEE / T/ 112A - Signals and Systems	
Objectives:	The course aims to provide adequate knowledge about • digital representation of speech waveforms • techniques of speech analysis • speech recognition and enhancement methods	
Course Outcomes:	On completion of the course, the students will be able to CO1: Explain the digital conversion methods of speech signals (K2, A2) CO2: Describe the speech analysis techniques (K1, A1) CO3: Apply speech recognition and enhancement methods (K3, A1)	
Unit I	Digital representation of speech: CO1 Introduction to speech processing - its necessity. Digital models for speech signals: process of speech production, acoustic theory of speech production, and models of speech production, auditory knowledge. Digital representation of speech waveform: sampling speech signals, quantization, delta modulation, differential PCM, code conversion, and other new methods of coding. Typical case studies on digitization and coding of speech signal.	
Unit II	Speech Analysis: CO2 Fundamentals of speech analysis: background of speech processing tools, spectrographic analysis, short time analysis, time frequency analysis, homomorphic analysis. Linear predictive coding of speech: basic principles, solutions of LPC equations, prediction error, application of LPC parameters.	
Unit III	Speech recognition and enhancement : CO3 Fundamentals of speech recognition: current state of speech recognition systems, techniques and problems for noisy speech recognition, statistical and speech model based methods. Speech enhancement: spectral subtraction, noise masking, and comb filtering, statistical modeling.	
Text Books	1. Thomas F. Quatieri, “Discrete-Time Speech Signal Processing”, Prentice Hall, 2001. 2. Ben Gold and Nelson Morgan, “Speech and Audio Signal Processing”, John Wiley and Sons, 2nd edition, 2011. 3. L.R.Rabiner and R.W.Schaffer, “Digital Processing of Speech signals”, Prentice Hall	
Reference Books	3. J.R. Deller, J.H.L. Hansen and J.G. Proakis, “Discrete Time Processing of SpeechSignals”, John Wiley, IEEE Press. 4. J.L Flanagan, “Speech Analysis Synthesis and Perception”,Springer, Verlag	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 128A: Speech Processing		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	**3**	**1**	**1**									
	CO2	**3**	**1**	**1**									
	CO3	**3**	**1**	**1**									

Course code: PG/IEE/T/128B	Paper VIII Digital Filtering and Control	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Review of random signals and systems • Estimation problems • Viewpoints of controls and filtering.	
Course Outcome:	On completion of the course the students will be able to • CO1: Analyze and examine the characteristics of random process (K4) • CO2: Understand the notion of signal estimation (K2, A1-describe) • CO3: Explain the behavior of adaptive filters (K2)	
Unit I	**Introduction : Control and filtering duality: 6hrs** Classical Random Signal analysis: Estimation concept. Duality in control and filtering	
Unit II	**Introduction : Estimation: 10hrs** Maximum likelihood estimation, covariance estimation, nonparametric methods of spectral estimation, coherence analysis.	
Unit III	**Random signal analysis: 12hrs** Modern Random Signal analysis: All pole estimation, All zero estimation, Pole-zero estimation- case studies with illustrative examples.	
Unit IV	**Spectral Analysis : 4hrs** Spectral estimation, Parametric signal processing: optimal estimation, filters.	
Unit V	**Adaptive signal processing: 4hrs** Adaptive signal processing: Adaptation algorithms, All zero adaptive filters, Pole-zero adaptive filters. Adaptive estimation	
Unit VI	**Kalman filter : 12hrs** Model based signal processing: State space filters, Kalman filter identifier, Kalman filter deconvolver. Estimation for nonlinear dynamic systems- case studies with illustrations	
Text Books	Introduction to Applied Statistical Signal Analysis: R.Shiavi, Elsevier,2007. Estimation with application to tracking and navigation :Y.Bar-Shalom, X.Li&T.Kirubarajan.	
Mode of Evaluation	Final-Written Term End Examination	
Course delivery format	Primarily black board teaching and tutorial assignments	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications, research papers.	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 128B: Digital Filtering and Control		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: PG / IEE / T/ 128C	**Pattern Recognition**	**L T P C** **3 1 0 4**
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about - • The fundamentals of Pattern Recognition techniques • The various Pattern recognition techniques and their applications.	
Course Outcome:	On completion of the course the students will be able to **CO1:** Understand the various aspects ofpattern recognition systems (K1,A1) **CO2 :** Discuss the major approaches of pattern recognition techniques (K1, A1).. **CO3:** Describe the neural networks and fuzzy modelsforpatteren recognition (K2, A1)	
Unit I (CO1)	Introduction to three facets of pattern recognition: clustering, classification and feature analysis with case studies.	
Unit II (CO2)	Supervised learning, unsupervised learning. Bayesian classification, nearest neighbour classification, linear and quadratic discriminant functions, support vector machines. Linkage, k-means, Hierarchical, and ISODATA clustering techniques. Dimensionality reduction: Fisher discriminant analysis, Principal component analysis. Introduction to feature extraction, selection and ranking.	
Unit III (CO3)	Fuzzy sets, its relevance to pattern recognition. Fuzzy c-means clustering algorithms and fuzzy rule based classification. Motivation for neuro-computing, discussions on Hopfield networks, multilayer perceptron, Feedforward networks, training by Back Propagation and Self-organizing map in Neural Pattern Recognition. Learning vector quantization networks in relation to pattern recognition	
Text Books	• Duda, R.O., Hart, P.E., and Stork, D.G. Pattern Classification. Wiley-Interscience. 2nd Edition. 2001. • Bishop, C. M. Pattern Recognition and Machine Learning. Springer. 2007. • Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Academic Press, 2009.	
Reference Books	• Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995. • Robert J. Schalkoff, "Pattern Recognition : Statistical, Structural and Neural Approaches," John Wiley & Sons Inc., New York, 2007 • **Bezdek, J. C., Keller, J., Krisnapuram, R., Pal, N.Fuzzy Models and Algorithms for Pattern Recognition and Image Processing. Springer. 2005**	
Mode of Evaluation	Sessional – Written CT-I & II Final-Written Term End Examination	
Course delivery format	Primarily black board teaching and tutorial assignments	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T/ 128C: Pattern Recognition		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	**3**	**2**	**1**	**1**								
	CO2	**3**	**2**	**1**	**1**								
	CO3	**3**	**2**	**1**	**1**								

Course code: PG / IEE / T / 129A	Electronic System Design	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Implementation of RC filter circuits • Evolution of logic families • Usage of various Op-amp circuits • Characteristics and behavior of digital filters	
Course Outcomes:	On completion of the course, the students will be able to • CO1: Construct and describe different electronic circuits using active and passive components (K2, A1) • CO2: Explain and analyze the performance of various systems in time and frequency domain (K4) • CO3: Design appropriate electronic systems for several applications (K5)	
Unit I	**RC Circuit: CO1, CO2, CO3** Construction and working principles of RC low pass and high pass filter circuits, frequency response analysis, design of integrator and differentiator using RC circuits, compensated attenuator: illustrative examples with case studies	
Unit II	**Logic Family: CO1, CO2, CO3** Resistor transistor logic (RTL), diode transistor logic (DTL), transistor transistor logic (TTL), direct coupled transistor logic (DCTL), complementary metal oxide semiconductor (CMOS) logic: design of boolean functions and calculation of fan-out with case studies	
Unit III	**Op-amp Circuits: CO1, CO2, CO3** Summing amplifier, difference amplifier, negative resistance converter, voltage to current converter, current to voltage converter: construction and working principles, instrumentation amplifier	
Unit IV	**Digital Filter: CO1, CO2, CO3** Properties and architecture of FIR & IIR filter, calculation of frequency response: few case studies, design of 1st order low-pass and high-pass FIR and IIR filter	
Text Books	1. J. Millman and C. C. Halkias. "Integrated Electronics", Tata McGraw Hill. 2. Donald A Neamen."Electronic Circuits: Analysis and Design", Tata McGraw Hill. 3. S. K. Mitra. "Digital Signal Processing: A Computer Based Approach", Tata McGraw Hill.	
Reference Books	1. A. Mottershead."Electronic Devices and Circuits: An Introduction", Prentice Hall of India. 2. A. Malvino and David J Bates."Electronic Principles", McGraw Hill.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Video lectures on YouTube platform, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 129B: Electronic System Design		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: PG / IEE / T / 129B	Electronic Olfaction	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Functioning of the Mammalian olfactory system • Various components of electronic olfactory systems • Sensors used in electronic olfaction • Pattern classification and clustering models for electronic olfaction	
Course Outcomes:	On completion of the course, the students will be able to CO1: Define and explain the functioning of mammalian and artificial olfactory systems (K1, A1) CO2: Describe the different hardware components and sensors used in electronic olfaction systems (K2, A1) CO3: Apply clustering and pattern recognition methods (K3, A2) and classify various odour signals (K4, A3)	
Unit I	**Introduction to the mammalian and electronic olfactory systems: CO1** Introduction to human olfaction: Nasal chemosensory detection, Thresholds for odour and nasal pungency, Psychometric functions for odour and nasal pungency, The linear salvation model and its application to odour and nasal pungency. Electronic olfaction systems – introduction and their comparison to the mammalian system.	
Unit II	**Components of electronic olfaction systems: CO2** Olfactometry – Static and dynamic, Environmental Chambers, Instruments for chemical sensing. Odour handling and delivery system: Physics of evaporation, Sample flow system, Headspace sampling, Diffusion method, Permeation method, Bubbler, Sampling Bag method, Preconcentrator. Sensors for olfaction: Survey and classification of chemosensors, Chemoresistors, MOS, Organic conducting polymers, Chemocapacitors, QCM, SAW, Optical odour sensors. Signal conditioning and pre-processing: Bridge circuits, amplifiers, Filters, linearizers, Baseline manipulation, Normalization techniques, Noise in sensors, and circuits.	
Unit III	**Pattern analysis methods for electronic olfaction: CO3** Clustering, Classification and Regression techniques: Statistical pattern analysis methods – Linear discriminant analysis, principal component analysis, partial least square regression. Intelligent pattern analysis methods – Multilayer feedforward networks, Competitive feature mapping networks, Fuzzy based pattern analysis, Neuro fuzzy systems. Typical case studies on selected methods.	
Text Books	**1.** Susan S. Schiffman, Tim C. Pearce, H. Troy Nagle, Julian W. Gardner, “Handbook of Machine Olfaction: Electronic Nose Technology”, Wiley, 2002.	
Reference Books	4. Julian W. Gardnerand P.N. Bartlett, “Electronic Noses. Principles and Applications”, Measurement Science and Technology, 2002. 5. YousifAbdullatifAlbastaki and FatemaAlbalooshi, “Electronic Nose Technologies and Advances in Machine Olfaction”, IGI Global, 2018. 6. H. K. Patel, “The Electronic Nose: Artificial Olfaction Technology”, Springer, 2014.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 129C: Electronic Olfaction		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	1	1								
	CO2	3	2	1	1								
	CO3	3	2	1	1								

Course code: PG / IEE / T / 1210A	Dynamic System Control and Optimization	L T P C 3 0 0 3
Course Prerequisites	**PG / IEE / T / 116A**	
Objectives:	The course aims to provide adequate knowledge about • Analysis of continuous and discrete-time linear state equations. • System stability, controllability and observability, irreducible realizations • State and output feedback controllers and observers, pole placement • Optimal control theory and nonlinear control systems	
Course Outcomes:	On completion of the course, the students will be able to CO1: Solve problems related to continuous time and discrete time system equations (K3) CO2: Analyze problems related to system stability, controllability and observability(K4, A3-adapt) CO3: Solve problems related to controller and observer design using various linear and nonlinear approaches. (K3)	
Unit I	**Analysis of continuous and discrete-time linear state equations: CO1** System modes and modal decomposition, Transition matrix, time-invariant and time-varying matrices, continuous-time linear system solutions, discrete-time models and solutions.	
Unit II	**System stability, controllability and observability: CO2** Equilibrium points, stability definitions, Lyapunov stability theory, direct method of Lyapunov, controllability, observability, Kalman canonical forms, stabilizability, detectability, relation between state-variable and transfer function descriptions, irreducible realizations.	
Unit III	**State and output feedback controllers and observers, pole placement: CO3** State feedback, output feedback, pole placement, full state and reduced order observers, separation principle, design of decoupled systems.	
Unit IV	**Optimal control theory and nonlinear control systems: CO3** Optimal control problem, dynamic programming, linear quadratic regulator-specific case studies. Riccati equation, Pontryagin's minimum principle, robustness issues, phase plane protraits, linearization, dynamic linearization, describing functions and applications of Lyapunov stability theory.	
Text Books	1. W.L. Brogan. "Modern Control Theory". 3^{rd} Edition, Prentice Hall.	
Reference Books	1. S. H. Zak. "Systems and Control". Oxford University Press. 2003. 2. M. Gopal. "Modern control system theory". New Age International Publishers. 2005.	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 1210A: Dynamic System Control and Optimization		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	2	2	1	1							
	CO2	3	2	2	1	1							
	CO3	3	2	2	1	1							

Course code: PG / IEE / T / 1210B	Control System Synthesis	L T P C 3 0 0 3
Course Prerequisites		
Objectives:	The course aims to provide adequate knowledge about • Statistical Control Design for practical Nonlinear Systems. • State variable approach to Control System Design. • Digital Control. • Control of Large Scale Systems.	
Course Outcomes:	On completion of the course, the students will be able to CO1: Define and explain basic concepts of modelling nonlinear systems (K1, A1) CO2: Describe the state variable approach to control system design (K2, A1) and solve design problems related to controller design (K3) CO3: Define and explain the control of large scale systems and discuss its applications in different practical problems (K3-apply, A2)	
Unit I	Statistical Control Design for practical Nonlinear Systems: CO1 Power density spectra of system outputs, mean square error minimization, optimum system in time domain; optimization/minimization in servo problems, Saturation control. Nonlinear Systems: a. Describing Function: System design using describing function techniques, limitations and disadvantages, accuracy analysis. b. Phase plane technique: Construction, interpretation, limit cycles, types of non-linear elements, optimization methods. Student assignments on nonlinear system analysis using describing functions and phase-plane technique	
Unit II	State variable approach to Control System Design: CO2 Basics, Review of Controllability, Observability, Design of non-interacting controllers, Optimal Control, State estimation, Kalman algorithm and its variants. Student assignments on Controller and Estimator design	
Unit III	Digital Control: CO2 a. Discretization - requirement, principles and methods. b. Design Methods - Root locus, frequency response etc., their limitations; Different approaches of digital controller design - by transformation of continuous time model to z-domain, by direct digital modelling, by discrete approximation, by transformation to w-domain. Algorithm design - direct method, parallel method, factorization method; General Design considerations, Comparison of algorithms. Student assignments on digital controller design.	
Unit IV	Control of Large Scale Systems: CO3 System decomposition, Hierarchical, Multilevel Control and their co-ordination. Control designs using distributed computer network. Typical Case studies.	
Text Books	1. G. C. Goodwin, S. F. Graebe, M. E. Salgado. "Control System Design".Pearson. 2001. 2. B. Friedand. "Control System Design: An Introduction to State-Space Methods". Dover Publications. 2005. 3. S. H. Zak. "Systems and Control". Oxford University Press. 2003.	
Reference Books	1. Gilbert Strang. "Linear Algebra and its applications". Cengage Learning. 2018. 2. M. Gopal. "Modern control system theory". New Age International Publishers. 2005.	
Mode of Evaluation	Student Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Group discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the		

Board of Studies on	
Date of Approval by the Academic Council	

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 1210B: Control System Synthesis		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
	CO1	**3**	**2**	**1**	**1**								
	CO2	**3**	**2**	**1**	**1**								
	CO3	**3**	**2**	**1**	**1**								

Course code: PG / IEE / T / 1210C	Environmental Instrumentation	L T P C 3 0 0 3
Course Prerequisites	PG / IEE / T/ 115A - Instrumentation and Measurement Techniques PG / IEE / T/ 127A- Instrumental Analysis	
Objectives:	The course aims to provide adequate knowledge about • the different types of pollution • air pollution, water pollution and sound pollution • pollution monitoring instruments	
Course Outcomes:	On completion of the course, the students will be able to CO1: Analyze the effects of Water, solid waste and hazardous waste pollution and their treatment procedures (K2, A2) CO2: Explain the effect of air pollution and its mitigation (K1, A1) CO3: Describe sound pollution and its control	
Unit I	General introduction to pollution and its classification: CO1	
Unit II	Water, solid waste and hazardous waste pollution: CO1 Sources and classification, wastewater sampling and analysis, wastewater treatment. Solid waste management and Hazardous waste management.	
Unit III	Air pollution: CO2 Effect of air pollution on environment, its classification, meteorological factors responsible for pollution, method of sampling and measurement. Air pollution control methods and equipment: basics of fluid properties, cleaning of gaseous effluents, particulate emission equipments and control, particulate collector selection and gaseous emission control. Specific gaseous pollutants analysis and control. Typical case studies.	
Unit IV	Sound pollution: CO3 Basics of sound pollution, its effect to environment. Acoustic noise measurement, monitoring and control and related case studies	
Text Books	3. Bhatia, H.S., A Text Book in Environmental Pollution and control, Galgotia Publication (1998). 4. Rao, M.N. and Rao, H.V., Air Pollution, Tata McGraw Hill (2004). 5. Rao. C.S., Environmental Pollution Control, New Age International (P) Limited, Publishers, (2006) 2nd ed.	
Reference Books	5. Dhameja, S.K., Environmental Engineering and Management, S.K Kataria (2000).	
Mode of Evaluation	Assignments, Final-Written Term End Examination	
Course delivery format	Class room lecture, Tutorial and Discussion	
Supplementary academic support	Providing links to online courses/sites, providing additional learning materials from practical applications	
Other learning activities	Class discussions, Group problem solving sessions, Relate to other courses in the curriculum with examples	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

PG / IEE / T / 1210C: Environmental Instrumentation		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
	CO1	3	1	1									
	CO2	3	1	1									
	CO3	3	1	1									

Course code: PG / IEE / S / 121	Term Paper Leading to Thesis	L T P C 0 0 4 3
Course Prerequisites		
Course Outcomes:	On completion of the course, the students will be able to • **CO1:** Conduct literature survey for identification of appropriate field of research. • **CO2:** Design the work-plan for conducting the research work. • **CO3:** Develop and present a report based on the literature search and work-plan.	
Syllabus :	Identification of thesis project topic through literature survey. Defining the motivation, objective, existing research work in the area, research gap area and the scope of work. Formulation of the sub-modules for execution of the proposed work. Identification of the hardware/software support required for the study and availability of such resources. Compilationand presentation of a report on the above three modules.	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO1 2
ASSIGNMENT PG / IEE / S / 112	CO 1	2	3	1	1	2							
	CO 2	1	3	2	2	2							
	CO 3	1									3		

Course code: PG / IEE / S / 122	**Seminar**	**L T P C** **0 0 4 3**
Course Prerequisites		
Course Outcomes:	On completion of the course, the students will be able to CO1: Adapt themselves towards a given domain of engineering topics (A3) CO2: Compose technical report on given engineering topics (K5, S5) CO3: Defend their report before a technical forum (K6, A5) CO4: Practice interactive/group discussion on given engineering and associated topics (A4)	
Syllabus :	Each student will give a technical presentation on a seminar topic that relates to the course curricula, preferably on recent technological advances or current developments. Each student will participate in a group discussion on the topics presented.	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PG / IEE / S / 122: Seminar	CO1	1	2				2	2				2	3
	CO2	1	2				2	2	2		3	2	
	CO3		2			1	2	2			3	2	
	CO4		2				2	2		3		2	

Course code: **PG / IEE / TH / 21** **PG / IEE / VV / 22**	**THESIS WORK; VIVA VOCE ON THESIS**	**L T P C** **0 0 16 12**
Course Prerequisites		
Course Outcome:	On completion of the course, the students will be able to CO1: Organize the planning and execution of a proposed engineering project (S2, A4-customize) CO2: Create/collect an engineering data base and/or develop advanced knowledge (K5, S5) CO3: Compile a scientific report and give an oral presentation displaying grasp of chosen topic. (K5, A5-represent)	
Syllabus:	Design, implementation and testing of an Electronic / Instrumentation / Control or Software system based student project. The evaluation will be based on demonstration of the product, and oral as well as written presentation of the thesis report.	
Recommended by the Board of Studies on		
Date of Approval by the Academic Council		

CO-PO Mapping: (3 – Strong, 2 – Moderate and 1 – Weak)

THESIS WORK; VIVA VOCE PG / IEE / TH / 21 PG / IEE / VV / 22		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**
	CO 1	**2**	**2**	**3**	**2**	**2**	**2**			**1**	**1**		
	CO 2	**1**	**2**	**2**	**2**	**3**							
	CO 3	**3**	**2**	**2**	**1**	**3**					**3**		