SEMESTER 5

APPLIED ELECTRONICS AND INSTRUMENTATION

SEMESTER S5

CONTROL SYSTEM THEORY

Course Code	**PCAET501**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	GYMAT101- Mathematics for Electrical Science and Physical Science - 1	**Course Type**	Theory

Course Objectives:

1. To study the elements of control system, modelling and perform stability analysis of systems.
2. To understand the state variable analysis method.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**System modelling -** Introduction to control systems, Classification of control systems. Open loop and closed loop control systems, Transfer function, Poles and Zeros, Mathematical modelling of electrical, mechanical and electromechanical system, Block diagram reduction techniques, Signal flow graph, Mason's gain formula.	11
2	**Time domain analysis -** Standard test signals, Response of first and second order systems to impulse and step inputs. **Time domain specifications -** Delay time, rise time, peak time, maximum percentage overshoot and settling time. **Steady state response -** Steady state error- Static & Dynamic error coefficients. **Concept of stability:** Routh-Hurwitz method for stability analysis.	11

3	**Stability analysis in time domain** Root locus - Construction of root locus, Effect of addition of poles and zeros. **Frequency domain analysis -** Frequency response, Frequency domain specifications, Stability in the frequency domain, Nyquist stability criterion, Stability analysis using Polar and Bode plots, relative stability, Gain margin and phase margin.	**11**
4	**State variable analysis:** State space representation of Continuous Time systems. Transfer function from State Variable Representation, Solution of state equations, state transition matrix, Controllability and Observability - Kalman's Test.	**11**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyze the systems using transfer function approach	**K3**
CO2	Conduct time domain analysis and steady state analysis of systems	**K3**
CO3	Conduct stability analysis of systems using time domain and frequency domain methods	**K3**
CO4	Analyze control systems using state space techniques	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3			2							3
CO2	3	3			2							3
CO3	3	3	2		2							3
CO4	3	3	2		2							3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Control Engineering	Katsuhiko Ogata	Pearson Education	5/e, 2009
2	Control Systems: Principles and design	M. Gopal	McGraw Hill Education India Education	4/e, 2012
3	Automatic Control systems	Benjamin C. Kuo, Farid Golnaraghi	Wiley	9/e, 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Automatic Control Systems (with MATLAB programs)	S. Hassan Saeed	KATSON Educational series	2013
2	Control System Engineering	Norman S Nise	Wiley	5/e, 2009
3	Modern Control Systems	Richard C Dorf and Robert H. Bishop	Pearson Education	13/e, 2016
4	Control System Engineering	I. J. Nagrath and Madan Gopal	New Age International	7/e, 2021

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/107106081
2	https://nptel.ac.in/courses/107106081
3	https://nptel.ac.in/courses/107106081
4	https://nptel.ac.in/courses/107106081

SEMESTER S5

PROCESS DYNAMICS AND CONTROL

Course Code	PCAET502	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. Understand the fundamental principles of process control and automation.
2. Design, implementation and optimize control strategies for various types of processes.
3. Discuss advanced control techniques and their application in industrial settings.
4. Discuss emerging technologies such as Industry 4.0 and their impact on smart manufacturing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Process characteristics** - Incentives for process control, Process Variables types and selection criteria, Process degree of freedom, The period of Oscillation and Damping, Characteristics of physical System: Resistance, Capacitive and Combination of both. Elements of Process Dynamics, Types of processes- Dead time, Single /multi capacity, self-Regulating /non-self-regulating, Interacting /non interacting, Linear/non-linear, and Selection of control action for them. Study of Liquid, Gas, Flow and Thermal Processes.	11
2	**Elements of Process Control Loop** - Pneumatic and electric actuators, control valves - characteristics of control valves, valve positioner - I/P and P/I converters- Electronic Controllers. Analysis of Control Loop: Steady state gain, Process gain, Valve gain, Process time constant, Variable time Constant, Transmitter gain, linearizing an equal percentage valve, Variable pressure drop. Analysis of Liquid level Control, Temperature control.	11
3	**Feedback Control** - Block Diagram, Control Performance Measures for standard Input Changes. Different Controllers (P, PI, PD and PID) and	11

	tuning parameters. Tuning of feedback controllers: Open loop and closed loop tuning techniques. Quarter Decay ratio response, minimal error integral criteria. Advanced Control Techniques: Cascade control, Feed forward control, feedback-feed forward control, Ratio control, Selective Control.	
4	**Model Based controllers** - Internal Model control, Model Predictive controller, Adaptive and Self-Tuning Controller. Computer Control of Process Plants - Centralised Control System, Distributed Control Systems- Fieldbus System-Fieldbus Types, Hierarchical Control Systems, Supervisory Control and Data Acquisition (SCADA) system- Basic concept Industry 4.0 and Smart Manufacturing - Integration of cyber-physical systems (CPS), IoT, and AI to optimize manufacturing processes.	**11**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand and apply the dynamics and characteristics of industrial processes for effective control.	**K3**
CO2	Analysis and design effective control loops using different components for industrial processes	**K3**
CO3	Design, analyze, and implement effective feedback control systems.	**K3**
CO4	Understand advanced control systems and applications of computer control systems	**K2**
CO5	Summarize advanced model-based controllers and Industry 4.0	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3	2								2
CO2	3	3	3	2								2
CO3	3	3	3	2								2
CO4	3	2	3	2								2
CO5	3	2	3	3								2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Process Control: Modeling, Design and Simulation, 1/e	B.WayneBequette	PHI	2002
2	Automatic Process Control	Donald Eckman	Wiley Eastern Limited	2009
3	Process control Systems	F.G.Shinskey	TMH	1996
4	Principles and practice of Automatic Process Control, 3rd edition	Carlos A. Smith, Armando B. Corripio	John Wiley & Sons,	2005
5	Process Control Instrumentation Technology, 8th Edition	Curtis D Johnson	Pearson; 8th edition	2005
6	Process Systems Analysis and Control, 3/e	Donald H Coughnowr	Mc Graw Hill	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Instrumentation - Process control	B.G.Liptak	Chilton Book Company, Pennsylvania	1995
2	Computer Based Industrial Control	Krishna Kant	PHI	2010
3	Fundamentals of Process Control Theory, 3rd Edition	Paul W. Murrill	ISA	1999
4	Chemical Process Control: An Introduction to Theory and Practice	George Stephanopoulos	Pearson	2015
5	Process Control- Designing processes and Control Systems for Dynamic performance, 2nd ed	Thomas E Marlin	McGraw-Hill International Editions	2000
6	Industry 4.0: The Industrial Internet of Things	Alasdair Gilchrist	Apress	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/103/103103037/
2	https://archive.nptel.ac.in/courses/103/103/103103037/
3	https://archive.nptel.ac.in/courses/103/103/103103037/
4	https://archive.nptel.ac.in/courses/103/103/103103037/

SEMESTER S5

POWER ELECTRONICS

Course Code	**PCAET503**	**CIE Marks**	40
Teaching Hours/Week (L:T:P:R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCAET302 Electronic Devices and Circuits	**Course Type**	Theory

Course Objectives:

1. To introduce various power semiconductor devices
2. To acquire knowledge about rectifiers, inverters & converters used in industrial applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Power Semiconductor Devices -** Overview of power electronics applications, Power diodes and Bipolar power transistors – static and dynamic characteristics, Power MOSFET, IGBT, SCR and GTO. **Protection circuits and Rectifiers -** BJT and MOSFET driver circuits, Snubber circuits, Single phase and three phase diode bridge rectifiers, Single phase and three phase controlled rectifiers.	**10**
2	**DC – DC Switch Mode Converter -** Buck, Boost and Buck-Boost converters under Continuous conduction mode. Isolated Converters – Forward, Push-Pull, Half bridge, Full bridge and Flyback configurations. Switched Mode Power Supply.	**9**
3	**DC – AC Switch Mode Inverter** - Inverter topologies, Driven Inverters – Push-Pull, Half bridge and Full bridge configurations, Three phase Inverter, Basic concept of pulse width modulator.	**9**

4	**Applications (concepts only) -** DC Motor Drives, Induction Motor Drives, Residential and Industrial applications, Electric utility applications.	**8**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24 marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Illustrate the characteristics of important power semiconductor switches	**K2**
CO2	Apply the principle of drive circuits and rectifier circuits for power applications	**K3**
CO3	Design DC-DC converters and DC-AC inverters	**K4**
CO4	Apply the principle of power electronic drives for various applications	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										3
CO2	3	3										3
CO3	3	3	3									3
CO4	3	3	3									3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Power Electronics, 3ed (An Indian Adaptation): Converters, Applications and Design	Ned Mohan, Tore M. Undeland and William P. Robbins	Wiley	3rd Edition, 2022
2	Power Electronics Essentials and Applications	Umanand L	Wiley	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Power Electronics: Devices, Circuits, and Applications	M H Rashid	Pearson Education	4th Edition, 2017
2	Power Electronics	Daniel W. Hart	McGraw Hill	2010
3	Power Electronics	P S Bimbhra	KHANNA	7th Edition, 2022

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108105066 https://archive.nptel.ac.in/courses/108/102/108102145/
2	https://nptel.ac.in/courses/108105066 https://archive.nptel.ac.in/courses/108/102/108102145/
3	https://nptel.ac.in/courses/108105066 https://archive.nptel.ac.in/courses/108/102/108102145/
4	https://nptel.ac.in/courses/108105066 https://archive.nptel.ac.in/courses/108/102/108102145/

SEMESTER S5

DIGITAL SIGNAL PROCESSING

Course Code	PBECT504	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCECT402 Signals and Systems	Course Type	Theory

Course Objectives:

1. To describe signals mathematically and understand how to perform mathematical operations on signals
2. To gain knowledge of Digital filters

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Review of sampling, Z-Transform and DTFT** The Discrete Fourier Transform - DFT as a linear transformation (Matrix Relation), IDFT, Properties of DFT and examples (proof not necessary). Circular convolution, linear convolution using circular convolution, Filtering of long data sequences, overlap save and overlap add methods. Frequency Analysis of Signals using the DFT (concept only required)	9
2	Design of FIR Filters - Symmetric and Anti-symmetric FIR Filters, Design of linear phase FIR filters using Window methods (rectangular, Hamming and Hanning). Design of IIR Digital Filters from Analog Filters (Butterworth), IIR Filter Design by Impulse Invariance, and Bilinear Transformation, Frequency Transformations in the Analog Domain.	9
3	Structures for the realization of Discrete-Time Systems - Block diagram and signal flow graph representations of filters.	9

	FIR Filter Structures - Linear structures, Direct Form. IIR Filter Structures - Direct Form, Transposed Form, Cascade Form and Parallel Form. Multi-rate Digital Signal Processing - Decimation and Interpolation (Time domain and Frequency Domain Interpretation), Anti- aliasing and anti-imaging filter.	
4	Efficient Computation of DFT - Fast Fourier Transform and computational advantage over DFT, Radix-2 Decimation in Time FFT Algorithm. Computer architecture for signal processing - Harvard Architecture, pipelining, MAC, Introduction to TMS320C67xx digital signal processor, Functional Block Diagram. Finite word length effects in DSP systems - Introduction, fixed-point and floating-point DSP arithmetic, ADC quantization noise.	**9**

Course Assessment Method

(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	**30**	**12.5**	**12.5**	**60**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To learn fundamental properties and relations relevant to DFT and solve basic problems involving DFT-based filtering methods.	**K1**
CO2	To design linear phase FIR filters and IIR filters of different specifications.	**K3**
CO3	To realise the various FIR and IIR filter structures for a given system function.	**K3**
CO4	To compute DFT efficiently using FFT method and to understand the architecture of a DSP processor.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2		2							2
CO2	3	3	3		3							2
CO3	3	3	3		3							2
CO4	3	3	2		3							2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal Processing using Matlab	Vinay K. Ingle, John G. Proakis	Cengage Learning	3rd Ed., 2011
2	Think DSP: Digital Signal Processing using Python	Allen B. Downey	Green Tea Press	2012
3	Discrete-Time Signal Processing	Alan V Oppenheim, Ronald W. Schafer	Pearson Education	3rd Ed., 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal Processing	Shaila D. Apte	Wiley	2nd Ed, 2019
2	Digital Signal Processing: A Computer based Approach	Mitra S. K.	McGraw Hill	4th Ed., 2014
3	Digital Signal Processing: A Practical Approach	Ifeachor E. C., Jervis B. W.	Pearson Education	2nd Ed., 2009
4	Digital Signal Processing	Salivahanan S.	McGraw Hill	4th Ed., 2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/117102060 https://nptel.ac.in/courses/108105055
2	https://nptel.ac.in/courses/117102060 https://nptel.ac.in/courses/108105055
3	https://nptel.ac.in/courses/117102060 https://nptel.ac.in/courses/108105055
4	https://nptel.ac.in/courses/117102060 https://nptel.ac.in/courses/108105055

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**

    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Creativity in solutions and approaches

SEMESTER S5

DATA COMMUNICATION

Course Code	PEAET521	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	-	Course Type	Theory

Course Objectives:

1. Equip students with basic knowledge in data communication networks
2. Get acquainted with the design constraints of different types of data networks
3. Familiarize with packet routing methodologies in modern communication networks
4. Acquire knowledge about various application-level interfaces to data networks

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Layered Tasks in Communication, OSI model, Digital signals, Transmission impairments, Performance measures, Transmission modes.	7
2	Physical Layer - Guided and unguided media, different switched networks. Data Link Layer: Framing, Flow and Error Control, HDLC, PPP, random and controlled access, IEEE standards for wired and wireless LAN.	11
3	Network Layer - Logical addressing, Internet Protocol, unicast and multicast routing protocols, ICMP. Transport Layer: UDP, TCP, SCTP, Congestion control	11
4	Application Layer - Name space, DNS, remote logging, SMTP, POP, FTP, HTTP, SNMP, RTP, Security in Internet	7

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. • Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the different data communication aspects and analyze communication networks using well defined performance metrices	**K4**
CO2	Explain the various physical layer and media access control standards in the data communication	**K2**
CO3	Identify various packet routing and congestion control techniques in large communication networks.	**K2**
CO4	Recognize the methodologies developed to interact with the present communication technologies	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2									3
CO2	3		2									3
CO3	3		2									3
CO4	3		2									3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Data Communications and Networking	Behrouz A. Forouzan	McGraw Hill Education	5th, 2017
2	TCP/IP Protocol Suite	Behrouz A. Forouzan	McGraw Hill Education	4th , 2017
3	Computer Networks	Tanenbaum	Pearson Education	6th, 2022
4	Data and Computer Communication	William Stallings	Pearson Education	10th, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Data Networks	D. P. Bertsekas & R. Gallager	Prentice Hall	2nd, 1992
2	High Performance Communication Networks	J. Walrand & P. Araiya	Morgan Kaufmann	2nd,2004
3	Computer Networking: A Top Down Approach Featuring Internet	J. K. Kurose & K. W. Ross	Pearson Education	8th, 2022
4	Communication Networking:	Anurag Kumar, D.	Morgan Kaufmann	1st, 2004

	An Analytical Approach	Manjunath, Joy Kur		

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105082
2	https://nptel.ac.in/courses/106105082
3	https://nptel.ac.in/courses/106105082
4	https://nptel.ac.in/courses/106105082

SEMESTER S5

MODERN PROCESSOR ARCHITECTURE

Course Code	PEAET522	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PBECT404 Microcontrollers	Course Type	Theory

Course Objectives:

1. To understand the various aspects of processor architecture
2. To illustrate the memory hierarchy in processors
3. To analyze thread level parallelism and multiprocessor architectures

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to computer architecture** Classes of computers, defining computer architecture, Introduction to RISC and CISC architectures, Classification of instruction set architectures, basics of performance measurements. Basic parallel processing techniques – instruction level, thread level and process level. Classification of parallel architectures. Introduction to Graphical Processing Unit (GPU).	9
2	**Pipelined Processors and Super Scalar Organization** Pipelining fundamentals – Pipelined design, concept of Arithmetic pipelining and Instruction pipelining. Basic concept of Deeply pipelined processors. **Super Scalar Organization** – Limitations of Scalar pipelines, Basics concepts of parallel, diversified and dynamic pipelines. Superscalar pipeline overview – instruction fetch, decode, dispatch, execute, completion and retiring.	9

3	**Memory Hierarchy** Computer system overview, Concept of latency and bandwidth. Memory Hierarchy – Introduction, levels in modern Memory hierarchy, concept of temporal and spatial locality, DRAM Technology. Cache memories – cache hit, cache miss and hit ratio, types of cache mapping – direct, associative and set associative. Virtual Memory systems – Demand paging, memory protection. Overview of memory hierarchy implementations.	**9**
4	**Thread-Level Parallelism** Introduction to thread level parallelism and Multiprocessor Systems, Basic architecture of Centralised Shared Memory multiprocessor and distributed memory multiprocessor, concept of Cache coherence problem, basic schemes for enforcing coherence – Snooping coherence protocol. Introduction to Distributed Shared Memory and Directory-Based Coherence, directory-Based cache Coherence protocol	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic of computer architecture and parallel processing techniques	**K2**
CO2	Apply concepts of parallel processing to develop pipelined and superscalar architectures	**K3**
CO3	Demonstrate the different memory systems in modern processors	**K2**
CO4	Analyse thread level parallelism and multi-processor architectures	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3									3
CO2	3	2	3	2								3
CO3	3	2	3									3
CO4	3	2	3	2								3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Architecture: A Quantitative Approach	John L. Hennessy, David A. Patterson	Morgan Kaufmann	6th Edition, 2018
2	Modern Processor Design: Fundamentals of Superscalar Processors	John Paul Shen, Mikko H. Lipasti	Waveland Press	2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Organization & Architecture: Design for performance	William Stallings	Pearson	11th Edition, 2022
2	Computer Organization and Embedded Systems	Carl Hamacher, Zvonko Vranesic, Safwat Zaky and Naraig Manjikian	McGraw Hill	6th Edition, 2023
3	Computer Architecture	Behrooz Parhami	Oxford University Press	2012
4	Parallel Computer Organization and Design	Michel Dubois, Murali Annavaram and Per Stenstroem	Cambridge University Press	2012
5	Computer Architecture: Complexity and Correctness	Silvia M. Mueller and Wolfgang J. Paul	Springer	2010
6	Computer Architecture and Implementation	Harvey G. Cragon	Cambridge University Press	2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105033
2	https://nptel.ac.in/courses/106105033
3	https://nptel.ac.in/courses/106105033
4	https://nptel.ac.in/courses/106105033

SEMESTER S5

SOFT COMPUTING

Course Code	PEAET523	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To understand the fundamentals of Genetic Algorithms and hybrid systems.
2. To familiarize various techniques of soft computing like fuzzy logic, neural networks and genetic algorithm.
3. To give an overview of the concepts and terminologies in fuzzy logic systems.
4. To acquire knowledge on artificial neural networks with its advantages and applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Soft Computing. Difference between Hard Computing & Soft Computing. Applications of Soft Computing. Artificial Neurons vs Biological Neurons. Basic models of artificial neural networks – Connections, Learning, Types of activation functions. McCulloch and Pitts Neuron. Realization of logic gates using McCulloch-Pitts neuron model.	9
2	Perceptron Networks– Learning rule, Supervised and Unsupervised learning, Training and testing algorithm. Adaptive Linear Neuron– Architecture, Training and testing algorithm. Back propagation Network – Architecture, Training and testing algorithm. Fuzzy sets – properties, operations on fuzzy set. Fuzzy membership functions.	9

3	Methods of membership value assignments – intuition, inference, Rank Ordering. Fuzzy relations– operations on fuzzy relation. Fuzzy Propositions. Fuzzy implications. Defuzzification– Lamda cuts, Defuzzification methods. Fuzzy Inference Systems - Mamdani and Sugeno types. Fuzzy Logic Control systems. Applications of Neural Networks -Neural Networks in Control Systems.	**9**
4	Concepts of genetic algorithm. Operators in genetic algorithm - coding, selection, cross over, mutation. Stopping condition for genetic algorithm. Rank method–Rank space method AI search algorithm. Neuro-fuzzy hybrid systems. Genetic – neuro hybrid systems. Integration of neural networks, fuzzy logic and genetic algorithms.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe soft computing techniques and the basic models of Artificial Neural Network	**K2**
CO2	Solve practical problems using neural networks	**K3**
CO3	Illustrate the operations, model and applications of fuzzy logic	**K3**
CO4	Illustrate the concepts of Genetic Algorithm	**K3**
CO5	Describe the concepts and the need for using hybrid soft computing approaches	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3											3
CO2	3	2	3	2								3
CO3	3	2	3	2								3
CO4	3	2	3	2								3
CO5	3											3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Soft Computing	S.N.Sivanandam and S.N. Deepa	John Wiley & Sons.	3rd Edition, 2018
2	Multi-objective Optimization using Evolutionary Algorithms	Kalyanmoy Deb,	John Wiley & Sons.	1st Edition, 2008
3	Fundamentals of Neural Networks: Architecture, Algorithms and Applications	Laurene Fausett	Pearson	1st Edition, 2004

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fuzzy Logic with Engineering Applications	Timothy J Ross	John Wiley & Sons	3rd Edition, 2011
2	Neural Networks, Fuzzy Logic & Genetic Algorithms Synthesis and Applications	T.S.Rajasekaran, G.A.Vijaylakshmi Pai	Prentice-Hall India	2nd Edition, 2017
3	Neural Networks- A Comprehensive Foundation	Simon Haykin	Pearson Education	2nd Edition, 2003
4	Fuzzy Set Theory & Its Applications	Zimmermann H. J	Springer	3rd Edition, 1996
5	*Neural Fuzzy Systems* – A neuro fuzzy synergism to intelligent systems	Chin –Teng Lin and C.S. George Lee	Prentice Hall International	1st Edition, 1996

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/105/106105173/
2	https://archive.nptel.ac.in/courses/106/105/106105173/
3	https://archive.nptel.ac.in/courses/106/105/106105173/
4	https://archive.nptel.ac.in/courses/106/105/106105173/

SEMESTER S5

OPTIMIZATION TECHNIQUES

Course Code	PEAET524	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	GYMAT101 Mathematics for Electrical Science and Physical Science-1	Course Type	Theory

Course Objectives:

1. To understand and formulate various optimization problems.
2. To solve linear and non-linear optimization problems.
3. To understand the modern optimization techniques

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Optimization** Engineering applications of optimization, mathematical formulation of an optimization problem, Transport problem as an example, Concept of convexity. Classification of optimization techniques - Constrained and Unconstrained Optimization, Global and Local Optimization, Stochastic and Deterministic Optimization. Classical Optimization - Single variable optimization, unconstrained multivariable optimisation, Multivariable optimization with Constraints (basic concept only), Karush-Kuhn-Tucker conditions.	9
2	**Linear Programming Problems and Game Theory** Mathematical formulation of Linear Programming Problems, Solving using Simplex method and Graphical method, Linear Programming Applications. Introduction to Game Theory, optimal solution of two person zero sum	9

	games. Basic concept of Graphical solution to games with mixed strategy	
3	**Network Optimization Models and Nonlinear optimization** Minimum Spanning Tree – Prim's Algorithm. Shortest Path Problem – Dijkstra's Algorithm Single Variable Optimization Methods - Fibonacci search method and Newton Raphson method. Multi-variable Methods - Hook-Jeeves pattern search method, Cauchy's (steepest descent) method.	**9**
4	**Modern Methods of Optimization** Introduction to Genetic Algorithm, GA operators – Reproduction, Crossover, Mutation. Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Optimization of Fuzzy Systems. Basics of Neural network based optimization.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand and formulate various optimization problems	**K2**
CO2	Apply various techniques for linear and non-linear optimization problems	**K3**
CO3	Understand the concepts of game theory and develop solutions	**K2**
CO4	Use modern techniques for optimization problems	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2		2						3
CO2	3	3	3	2		2						3
CO3	3	3	3	3		2						3
CO4	3	3	3	3	3	2						3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Optimization: Theory and Practice	Singiresu S. Rao	Wiley	5th Edition, 2023
2	Operations Research: An Introduction	Hamdy A. Taha	Pearson	10th Edition, 2019
3	Introduction to Operations Research	Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag, Preetam Basu	McGraw Hill	10th Edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Optimization	Edwin K. P. Chong and Stanislaw H. Zak	Wiley	4th Edition, 2017
2	Numerical Optimization	Jorge Nocedal and Stephen J. Wright	Springer	2nd Edition, 2006
3	Optimization for Engineering Design: Algorithms and Examples	Kalyanmoy Deb	PHI	2nd Edition, 2012
4	Optimization in Operations Research	Ronald L. Rardin	Pearson	2nd Edition, 2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/111105039
2	https://nptel.ac.in/courses/111105039
3	https://nptel.ac.in/courses/111105039
4	https://nptel.ac.in/courses/108104112

SEMESTER S5

BIOMEDICAL INSTRUMENTATION

Course Code	PEAET526	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCAET303 Transducers and Measurements	Course Type	Theory

Course Objective:

1. To give a brief introduction to human physiology and various instrumentation systems for the measurement and analysis of various physiological parameters

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Biomedical Instrumentation** - Block diagram, Problems encountered in biomedical measurements. Brief introduction on physiological systems of the body-Nervous, cardio-vascular and respiratory systems. Sources of bioelectric potentials- resting potential, action potential. Electrode theory, Nernst equation and various types of electrodes. Bio electric signals - ECG, EEG, EMG and ERG.	9
2	**ECG Measurements –** Electro conduction system of the heart. Electrocardiography, electrodes and leads – Einthoven triangle, ECG machine – block diagram. Measurement of blood pressure – direct and indirect measurement – oscillometric measurement – ultrasonic method. Blood flow cardiac output, plethysmography, cardiac arrhythmia. Pace makers, defibrillators. Respiratory parameters – Spiro meter, pneumograph.	9
3	**EEG and EMG Measurements –** EEG instrumentation, electrode placement, EEG patterns. Muscle response – Electromyogram (EMG) – Nerve Conduction velocity measurements.	9

	Patient monitoring systems – Intensive cardiac care, bedside and central monitoring systems. Sources of electrical hazards and safety techniques.	
4	**Biomedical Imaging Techniques** X-rays, laser applications. Basic principle of computed tomography. Magnetic resonance imaging system and nuclear medicine system. Ultrasonic imaging system - introduction and basic principle. Color doppler systems, Holter monitoring, Endoscopy.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the basic principles of physiological systems of human body	**K2**
CO2	Illustrate the design principles and development of various biomedical instruments	**K3**
CO3	Explain the principle of patient monitoring systems and identify safety issues related to biomedical instrumentation.	**K2**
CO4	Describe the applications of medical imaging techniques in biomedical instrumentation.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2			3	3					3
CO2	3		2			3	3					3
CO3	3		2		3	3	3					3
CO4	3		2		3	3	3					3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Medical Instrumentation Application and Design	John G. Webster, Amit J. Nimunkar	Wiley	5th edition, 2021
2	Biomedical Instrumentation And Measurements	Leslie Cromwell	Pearson Education India;	2nd edition, 2015
3	Handbook of Biomedical Instrumentation	Khandpur R.S	Tata McGraw-Hill, New Delhi, 2 Edition	2003

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomedical Instrumentation	M. Arumugam	Anuradha Publications	1994
2	Introduction to Biomedical Equipment Technology	Joseph J. Carr and John M. Brown	Wiley and sons, New York	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105101/
2	https://archive.nptel.ac.in/courses/108/105/108105101/
3	https://archive.nptel.ac.in/courses/108/105/108105101/
4	https://archive.nptel.ac.in/courses/102/105/102105090/

SEMESTER - S5

VLSI SYSTEM DESIGN

Course Code	PEAET525	CIE Marks	40
Teaching Hours/Week (L:T:P:R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PBECT304 Logic Circuit Design	Course Type	Theory

Course Objectives:

1. To understand the static and dynamic characteristics of CMOS circuits.
2. To design combinational and sequential logic circuits for VLSI design.
3. To understand the VLSI design flow, validation and testing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Overview of PMOS and NMOS devices (pre-requisite). **CMOS inverter** – Working, Voltage transfer characteristics. Static characteristics – switching threshold and noise margin. Dynamic characteristics – Device capacitance, RC delay model, Propagation delay and power consumption.	8
2	**Combinational Logic Circuits** Static CMOS Design – Complimentary CMOS, Design techniques for large fan-in, Ratioed logic, basics of pass transistor logic and transmission gate logic. Dynamic CMOS Design – Basic principles, concept of Domino logic, speed and power dissipation, signal integrity issues in dynamic logic.	9
3	**Sequential Logic Circuits and Arithmetic Building blocks** Sequential Logic Circuits – Timing metrics for sequential circuits, static SR flip-flop, Static Multiplexer based D flip-flop and master slave configuration. Dynamic Clocked CMOS (C^2MOS) Register. Arithmetic Building blocks – Static CMOS Full Adder, 4-bit carry bypass	10

	adder, Array multiplier, carry-save multiplier, barrel shifter.	
4	**VLSI Design Methodologies** ASIC Design flow and FPGA design flow, Introduction to SoC Design, Challenges in VLSI Design. Basics of semi-custom and full custom design methodologies. Validation and testing – Fault Modelling, struck at faults, Test procedure, logic testing vs memory testing, Built-in-self-test (BIST), Automatic test pattern generation (ATPG)	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

- The students should conduct all the 4 experiments mentioned below using EDA tools/ASIC Design tools like Electric, Alliance, Microwind, Glade, Cadence Synopsis, Mentor Graphics and Xilinx Vivado.
- The experiment 4 can also be carried out using FPGA design flow tools. It is required to set appropriate constraints in FPGA advanced synthesis options
- Use library files and technology files below 180 nm to carry out the experiments.

Experiment 1: Capture the schematic of CMOS inverter with load capacitance of 0.1pF and set the widths of inverter with Wn = Wp, Wn = 2Wp, Wn = Wp/2 and length at selected technology. Carry out the following analysis:

a) Set the input signal to a pulse with rise time, fall time of 1ns and pulse width of 10ns and time period of 20ns and plot the input voltage and output voltage of designed inverter.
b) From the simulation results compute tpHL, tpLH and td for all three geometrical settings of width.
c) Tabulate the results of delay and find the best geometry for minimum delay CMOS inverter.

Experiment 2: Draw layout of CMOS inverter with Wp/Wn =40/20, use optimum layout methods. Verify for DRC and LVS.
Also familiarise the tools available for floor planning, placement, routing and Generation of GDS II reports.

Experiment 3: Design a 2-input CMOS NAND gate having similar delay as that of CMOS inverter computed in experiment 1. Draw the schematic and analyse the delay. Also, verify the functionality of NAND gate and also find out the delay td for all four possible combinations of input vectors. Table the results.

Experiment 4: Write verilog code for 4-bit adder and verity its functionality using test bench. Synthesize the design by setting proper constraints and obtain the net list. From the report generated identify critical path, maximum delay, total number of cells, power requirement and total area required. Change the constraints and obtain optimum synthesis results.

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyse CMOS inverter	**K3**
CO2	Design and analyze combinational and sequential logic circuits	**K3**
CO3	Describe arithmetic building blocks in VLSI.	**K3**
CO4	Explain the VLSI design flow and testing methodologies.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3									3
CO2	3	3	3									3
CO3	3	3	3	2								3
CO4	3	3	3	2	3							3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Integrated Circuits: A Design perspective	Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic	Pearson Education	2nd Edition, 2016
2	CMOS Digital Integrated Circuits, Analysis and Design	Sung-Mo Kang, Yusuf Leblebici, Chulwoo Kim	Tata McGraw Hill	4th Edition, 2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	CMOS: Circuit Design, Layout, and Simulation	R Jacob Baker	Wiley	4th Edition, 2019
2	CMOS VLSI Design: A Circuits and Systems Perspective	Neil Weste, David Harris	Pearson Education	3rd Edition, 2010
3	Basic VLSI Design	Douglas A. Pucknell, Kamran Eshragian	PHI	3rd Edition, 1995
4	CMOS Logic Circuit Design	John P Uyemura	Springer	2005

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108107129
2	https://nptel.ac.in/courses/117106092 https://nptel.ac.in/courses/108107129
3	https://nptel.ac.in/courses/117106092 https://nptel.ac.in/courses/108107129
4	https://onlinecourses.nptel.ac.in/noc23_ee137/preview

SEMESTER S5

ROBOTICS AND AUTOMATION

Course Code	**PEAET595**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCAET303 Transducers and Measurements	**Course Type**	Theory

Course Objectives:

1. To introduce the fundamental concepts and terminology in Robotics and automation
2. To familiarize the various industrial applications of robotics

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of Robotics** Robotics and Automation – Definition and history of robotics, Differences between robotics and automation, Applications of robotics in industry and service sectors. Robot Anatomy – Basic components - Links, joints, and end effectors, Degrees of Freedom (DOF) and their significance. Configurations of Robots – Cartesian, Cylindrical, Spherical, Articulated, SCARA. Work Volume and Workspace Analysis – Definition and importance, Factors affecting workspace. Manipulator Kinematics – Position representation, Introduction to forward and inverse kinematics, Homogeneous transformations and their application in robot kinematics. D-H Notations – Formulating and solving kinematic equations.	9
2	**Control Systems for Robots** Basic Control System Models – Open-loop and closed-loop control, Block diagrams and transfer functions. Robot Motions – Types of motions – Slew motion, joint-interpolated	9

	motion, and straight-line motion. Path planning and trajectory generation. Controllers – On/off control, Proportional (P) control, Integral (I) control, Proportional plus integral (PI) control, Proportional plus derivative (PD) control and Proportional plus integral plus derivative (PID) control.	
3	**Actuation and Feedback Mechanisms** Sensors – Types of sensors - Position and velocity sensors. Working principles of encoders and resolvers, Potentiometers and tachometers. Actuators - Electric actuators - DC motors, stepper motors, and servomotors. Hydraulic actuators, Pneumatic actuators. Power Transmission Devices - Gears, belts, chains, lead screws and ball screws. End Effectors – Types of grippers - Mechanical, vacuum and magnetic, Design considerations for grippers. Methods of Power and Control Signal Transmission - Electrical, hydraulic and pneumatic transmission.	**9**
4	**Industrial Applications and Work Cell Design** Material Handling - General considerations for material handling with robots, Material transfer applications. Pick and Place Operations - Techniques and applications, Integration with production lines. Palletizing and Related Operations - Methods and case studies. Manufacturing Processes - Die casting, plastic molding, forging, Machining operations, stamping press operations, Role of robots in automation of these processes. Robot Cell Layouts - Design considerations for multiple robots and machine interfaces, Examples of typical robot cell layouts. Work Cell Control - Interlocks and safety mechanisms, Error detection and recovery strategies. Work Cell Controllers - Types and functions of work cell controllers, Integration with other control systems. Cycle Time Analysis - Techniques for analyzing and optimizing robot cycle times, Factors affecting cycle time and productivity.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

- Each student should Design, simulate, and analyze a robotic arm with three or more degrees of freedom (DoF) for a pick and place system, operating within a defined work volume.
- Computational tools such as MATLAB or Octave can be utilized for for simulation and analysis.
- Find below the details of the project and the outcomes to be evaluated.

Project: Design, simulate, and analyze a robotic arm with three or more degrees of freedom (DoF) for a pick and place system, operating within a defined work volume.

Project Components:

1. Design Specifications and Simulation
    - Develop comprehensive arm specifications, including: a) Link dimensions b) Joint movement parameters c) Actuator specifications d) Sensor requirements
    - Ensure design enables full access to the specified work volume
    - Create a detailed 3D model for simulation purposes
2. Kinematic Analysis
    - Derive kinematic equations using Denavit-Hartenberg (DH) parameters
    - Construct homogeneous transformation matrices
    - Implement and validate forward as well as inverse kinematics
3. Path Planning and Motion Simulation
    - Define an efficient path for pick and place operations
    - Simulate arm movements along the planned path
    - Analyze motion profiles for optimization opportunities
4. Actuator Modeling and Dynamic Analysis
    - Develop an electric motor models for joint actuation
    - Simulate joint torques and forces during movement under a fixed load condition
5. Control System Implementation and Evaluation
    - Implement multiple control strategies: a) ON-OFF control b) Proportional (P) control c) Proportional-Integral (PI) control d) Proportional-Integral-Derivative (PID) control
    - Simulate arm movement along the predefined path under load for each control strategy
    - Evaluate and compare performance metrics for each control method

Project Deliverables:

1. Detailed design specifications and 3D model
2. Kinematic and dynamic analysis reports
3. Identify and address technical challenges encountered
4. Simulation results and performance comparisons
5. Comprehensive project report including methodology, results, challenges, and recommendations

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. • Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the basic components, structural configurations and degrees of freedom (DOF) of robots.	**K2**
CO2	Apply forward and inverse kinematics for different types of robotic manipulators.	**K3**
CO3	Implement various types of controllers and understand their impact on robot motion control	**K3**
CO4	Identify and compare different types of sensors and actuators used in robotic systems	**K2**
CO5	Understand the basics of robot cell layouts considering multiple robots and machine interfaces.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2										3
CO2	3	3		2								3
CO3	3	2	3	2	2							3
CO4	3	3	3	2	3							3
CO5	3	2	3	2	2	2	2			2	2	3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Robotics: Mechanics and Control	John J. Craig	Pearson	4th Edition, 2022
2	Robot Modeling and Control	Mark W. Spong, Seth Hutchinson, and M. Vidyasagar	Wiley	2nd Edition, 2020
3	Industrial Robotics - Technology, Programming and Applications	Mikell P Groover, Mitchell Weiss, Roger N Nagel, Nicholas Odrey, Ashish Dutta	Mc Graw Hill	2nd Edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Robotics: Mechanics, Planning, and Control	Kevin M. Lynch, Frank C. Park	Cambridge University Press	1st Edition, 2017
2	Robotics: Modelling, Planning and Control	Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo	Springer	1st Edition, 2009
3	Robotics, Vision and Control: Fundamental Algorithms In MATLAB	Peter Corke	Springer	2nd Edition, 2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/107106090
2	https://nptel.ac.in/courses/107106090
3	https://nptel.ac.in/courses/107106090
4	https://nptel.ac.in/courses/107106090

SEMESTER S5

PROCESS CONTROL LAB

Course Code	**PCAEL507**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCAEL307: Transducers and Measurements Lab., PCAET502: Process Dynamics and Control	**Course Type**	Lab

Course Objectives:

1. To study the responses of various controllers and valves
2. To simulate various types of controller using SIMULINK/MATLAB/Labview
3. To provide experience on control of various industrial processes using different control paradigms

Expt. No.	Experiments
PART A (Minimum 8 experiments are mandatory)	
1	Study of responses of P, PD, PI and PID controllers on Level/ Flow/ Thermal/ Pressure processes
2	Study of responses of ON-OFF controller and ON-OFF controller with dead zone.
3	Controller tuning using continuous cycling method
4	Controller tuning using Process Reaction curve method
5	Characteristics of Linear, Equal percentage and Quick opening valves
6	Control of Stepper motor/Water level/Bottle filling plant using PLC
7	Experiment to determine non-linearity if any, in a plant.
8	Data acquisition with ADC/DAC card and control applications using LabVIEW (Speed control / Temperature control)
9	Design and testing of a RTD based Temperature transmitter on a prototyping board.

10	Design and testing of an analog PID controller on a prototyping board.
	Part B (Minimum 2 experiments are mandatory)
	Experiments (1-4) shall be done using Arduino/Python/LabVIEW/MATLAB/SIMULINK
1.	PC based control of robotic arm
2.	Simulation study of feed-forward, cascade, and ratio control systems using MATLAB/SIMULINK
3.	PID controller design using MATLAB/SIMULINK
4.	Simulation of PID controller using MATLAB/SIMULINK/LabVIEW

Course Assessment Method

(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Make use of basic transducers for the measurement of physical variables like pressure, temperature etc.	**K4**
CO2	Familiarize various simulation tools -MATLAB, Labview, SIMULINK	**K3**
CO3	Tune controllers using Ziegler- Nichols & Cohen- Coon techniques	**K4**
CO4	Implement sensor-based measurement systems using modern tools	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2					3			3
CO2	3	2	3	2	3				3			3
CO3	3	2	3	3					3			3
CO4	3	2	3	3	3				3			3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Process Control: Modeling, Design and Simulation	B.Wayne Bequette	PHI	1st edition, 2002
2	Process Instrumentation and control Handbook	Considine	McGraw Hill	5th edition., 2009

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**
    - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
    - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.
2. **Conduct of Experiments (7 Marks)**
    - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
    - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
    - Teamwork: Collaboration and participation in group experiments.
3. **Lab Reports and Record Keeping (6 Marks)**
    - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
    - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.
4. **Viva Voce (5 Marks)**
    - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**
    - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
    - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.

- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted.

SEMESTER S5

LINEAR INTEGRATED CIRCUITS AND SIMULATION LAB

Course Code	**PCAEL508**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCECT403: Linear Integrated Circuits	**Course Type**	Lab

Course Objectives:

1. To study the design and implementation of various linear integrated circuits.
2. To familiarize the simulation of basic linear integrated circuits.

Expt. No.	Part A – List of Experiments using Op Amps (Minimum seven experiments mandatory)
1	Familiarization of Operational amplifiers - Inverting and Non inverting amplifiers, Integrator, Differentiator - frequency response, Adder, Comparators
2	Measurement of Op-Amp parameters
3	Difference Amplifier and Instrumentation amplifier
4	Schmitt trigger circuit
5	Astable and Monostable multivibrators
6	Waveform generators using Op Amps - Triangular and Sawtooth
7	Wien bridge oscillator - without & with amplitude stabilization
8	RC Phase shift Oscillator
9	Active first and second order filters (LPF, HPF, BPF and BRF)
10	Active Notch filter to eliminate the 50Hz power line frequency

	Part B – Application circuits using ICs **[Minimum three experiments are to be done]**
1	Astable and Monostable multivibrator using Timer IC NE555
2	DC power supply using IC 723: Low voltage and high voltage configurations, Short circuit and Fold-back protection.
3	A/D converters- counter ramp and flash type.
4	D/A Converters - R-2R ladder circuit
5	Study of PLL IC: free running, frequency lock range and capture range
	Part C – Simulation experiments **[**The experiments shall be conducted using open tools such as QUCS, KiCad or variants of SPICE]
1	Simulation of any three circuits from experiments 3, 5, 6, 7, 8, 9, 10 and 11 of section I
2	Simulation of experiments 3 or 4 from section II

Course Assessment Method

(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	**Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)**	**Internal Examination**	**Total**
5	**25**	**20**	**50**

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Design and implement basic linear integrated circuits using Op Amps.	**K4**
CO2	Design and implement basic linear integrated circuits using linear ICs.	**K4**
CO3	Design and simulate the functioning of basic linear integrated circuits and linear ICs using simulation tools.	**K4**
CO4	Effectively troubleshoot a given circuit and analyze it	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2						3			3
CO2	3	3	2						3			3
CO3	3	3	2		3				3			3
CO4	3	3	2						3			3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Linear Integrated Circuits	D. Roy Choudhary and Shail B Jain	New Age International	6th edition, 2021
2	Introduction to Pspice Using Orcad for Circuits and Electronics	M. H. Rashid	Pearson	3rd edition, 2015

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
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2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

   - Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

   - Accuracy of Results: Precision and correctness of the obtained results.
   - Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

   - Ability to explain the experiment, procedure results and answer related questions
   - Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

   - Completeness, clarity, and accuracy of the lab record submitted