THIRD YEAR UG: B. TECH

ELECTRONICS AND COMPUTER SCIENCE

REVISION: FRCRCE-3-26

Board of Studies Approval: 05/03/2026
Academic Council Approval: 27/03/2026

Dr. DEEPAK BHOIR
Dean Academics

Dr. Swapnali Makdey
HOD (ECS)

Dr. Sapana Prabhu
Principal

INSTITUTE VISION

To be a leading institution in education, transforming students into globally competent professionals with strong ethical values, innovation capabilities, and a commitment to sustainable societal development.

INSTITUTE MISSION

M1: Develop industry-ready engineers with strong academic foundations, practical skills, and an entrepreneurial mind-set capable of addressing industry and societal needs.

M2: Cultivate a culture of innovation and research to address real-world challenges through interdisciplinary approaches and sustainable practices.

M3: Foster a vibrant industry–academia ecosystem by actively engaging faculty and students in knowledge exchange, collaborative learning and professional skill development.

DEPARTMENT VISION

Creating globally competent engineers with strong fundamentals and good learning ability to empower Digitalization and Innovation.

DEPARTMENT MISSION

M1: To enrich the competence in Electronics and Computer Science through knowledge, skills, and commitment to lifelong learning.

M2: To nurture effective solution providers having a practical knowledge base equipped with a multi-disciplinary approach.

M3: To cultivate an ambience to encourage innovation, research and entrepreneurship skills.

M4: To improve employability by creating competitive engineers, with an ethical and professional attitude.

PROGRAM EDUCATIONAL OBJECTIVES

PEO1: Graduates will have the ability to utilize their technical knowledge and professional skills for building successful careers while maintaining ethical standards.

PEO2: Graduates will have the ability to pursue higher studies and research activities in Electronics and Computer Science.

PEO3: Graduates will have the ability to become entrepreneurs and professionals in multi-disciplinary roles and take up leadership positions in global organizations.

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PROGRAM SPECIFIC OUTCOMES

Engineering Graduates will be able to

PSO1: Design and implement cost-effective hardware/software systems for real-life applications.

PSO2: Adapt to new generation technologies in Electronics & Computer Science domains with an innovative approach.

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Curriculum Structure for UG Programs at Fr CRCE w.e.f. A.Y. 2026-27

SEM-V

Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks (1 Credit=50 Marks)					Credits	
						ISE	MSE	ESE		Total	Points	Total
								Min	Max			
25PCC13EC12	PCPEC	PCC	Control Systems	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PCC13EC13	PCPEC	PCC	VLSI Design	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PCC13EC14	PCPEC	PCC	Artificial Intelligence	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PCC13EC15	PCPEC	PCC	Analysis of Algorithms	PR	2	50	-	-	-	50	1	1
25PCC13EC16	PCPEC	PCC	Software Engineering	TH	2	20	30	20	50	100	2	2
				SS/SL	2	-	-	-	-	-	-	
25PCC13EC17	PCPEC	PCC	Embedded systems and RTOS	TH	1	10	15	10	15	50	1	2
				PR	2	50	-	-	-	50	1	
				SS/SL	1	-	-	-	-	-	-	
25PEC13ECXX	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PEC13ECXX	PCPEC	PEC	Program Elective Lab	PR	2	50	-	-	-	50	1	1
25OE13EC3X	MDC	OE	1. Health, Wellness and Psychology 2. Emotional and Spiritual Intelligence	TH	2	100	-	-	-	100	2	2
				SS/SL	2	-	-	-	-	-	-	
25MDM4X	MDC	MDM	MDM Course-4	TH	2	20	30	20	50	100	2	2
				SS/SL	2	-	-	-	-	-	-	
25DMX3	DM	DM	Double Minor Course	TH	2	20	30	20	50	100	2	4*
				TU	2	50	-	-	-	50	2	
				SS/SL	2	-	-	-	-	-	-	
25HR04	HR	HR	Honors with Research	SS/SL	6	-	-	-	-	-	4	4*
Total					**TH:TU:PR 15:0:13=28**					**1100**		**22**

SEM-VI

Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks (1 Credit=50 Marks)					Credits	
						ISE	MSE	ESE		Total	Points	Total
								Min	Max			
25PCC13EC18	PCPEC	PCC	Communication and Computer network	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PCC13EC19	PCPEC	PCC	Machine Learning	TH	2	20	30	20	30	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PCC13EC20	PCPEC	PCC	Cloud Computing Lab	PR	2	50	-	-	-	50	1	1
25PCC13EC21	PCPEC	PCC	CAD for VLSI	PR	2	50	-	-	-	50	1	1
25PCC13EC22	PCPEC	PCC	System Security	PR	2	50	-	-	-	50	1	1
25PEC13ECXX	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PEC13ECXX	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2	-	-	-	-	-	-	
25PEC13ECXX	PCPEC	PEC	Program Elective Lab	PR	2	50	-	-	-	50	1	1
25PEC13ECXX	PCPEC	PEC	Program Elective Lab	PR	2	50	-	-	-	50	1	1
25OE13EC4X	MDC	OE	Public Relations and Corporate Communication	TH	2	100	-	-	-	100	2	2
				SS/SL	2	-	-	-	-	-	-	
25MDM5X	MDC	MDM	MDM Course-5	TH	2	20	30	20	50	100	2	2
				SS/SL	2	-	-	-	-	-	-	
25VSE13EC04	SC	VSEC	Data acquisition and processing Lab	PR	2	50	-	-	-	50	1	1
25DM4X	DM	DM	Double Minor Course	TH	2	20	30	20	30	100	2	4*
				TU	2	20	-	30	-	50	2	
				SS/SL	2	-	-	-	-	-	-	
25HR05	HR	HR	Honors with Research								4	4*
Total					**TH:TU:PR 12:0:18=30**			-	-	**1100**	-	**22**

List of Program Elective Courses:

Track-A:

SEM-V:	SEM-VI:
PEC13EC11: Automation PEC13EC12: Biomedical Instrumentation Lab	**Any two Theory:** PEC13EC13: Power Electronics PEC13EC14: Digital Signal Processing PEC13EC15: Analog VLSI Design **Laboratory:** PEC13EC16: IoT Laboratory PEC13EC17: Image Processing Lab

Track-B:

SEM-V	SEM-VI
PEC13EC21: Cryptography PEC13EC22: Block chain Lab	**Any two Theory:** PEC13EC23: Natural Language Processing PEC13EC24: Big Data Analytics PEC13EC25: Advanced Algorithms. **Laboratory:** PEC13EC26: Deep Learning Laboratory PEC13EC27: Software Testing & Quality Assurance Lab

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FINAL YEAR Electronics and Computer Science Program

Proposed Scheme for BE Electronics and Computer Science 2027-28

EM-VII/VIII													
Course Code	Course Vertical	Sub-Vertical	Course Name		Notional hours	Examination Marks (1 Credit=50 Marks)					Credits	
						ISE	MSE	ESE		Total	Points	Total
								Min	Max			
25PEC14ECXX	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL								
25PEC14ECXX	PCPEC	PCC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL								
25PEC14ECXX	PCPEC	PCC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL		-	-	-	-	-	-	
25PEC14ECXX	PCPEC	PCC	Program Elective Course	TH	2	20	30	20	30	100	2	3
				PR	2	20	-	30	-	50	1	
				SS/SL								
25MDM6X	MDC	MDM	MDM Course-1	TH	2	20	30	20	50	100	2	2
				SS/SL								
25MDM7X	MDC	MDM	MDM Course-2	TH	2	20	30	20	50	100	2	2
				SS/SL								
25RMC14EC01	EL	RM	Essentials of Research Methodology	TH	2	20	30	20	50	100	2	2
				SS/SL								
25RMC14EC02	EL	RM	Intellectual Property Rights	TH	2	20	30	20	50	100	2	2
				SS/SL								
25PRJ14EC01	EL	PR	Major Project	PR	12	100	-	100	-	200	6	6
25SEM14EC01	PCPEC	PEC	Course Seminar		Online	As per Rubrics for Seminar					2	2
25INT14CE01	EL	INT	Semester long Internship	PR	36-40 hrs	As Per Internship Manual					12	12
HXXXCXXX	HMM/DM	HMM/DM	Honors/Minor Degree Course	TH	Online	As Per SWAYAM					8	8*
HXXXCXXX	HMM/DM	HMM/DM	Honors/Minor Degree Lab (Project)	PR							**2**	**2***
Total					**TH:TU:PR 16:0:8+ 12=36**					**1200**		**40+*10**

Students must mandatorily select two subjects from Track A and two subjects from Track B. Track A:

Course Code	Name of the Course
25PEC14EC18	MEMS
25PEC14EC19	Robotics
25PEC14EC30	ASIC Verification
25PEC14EC31	High Performance Computing

Track B:

Course Code	Name of the Course
25PEC14EC28	Quantum Computing
25PEC14EC29	Blockchain Technology
25PEC14EC40	Soft Computing and Optimization Algorithm
25PEC14EC41	Product, services and IT service management

Details of MDM

Course Code	Course Name
25MDM61	Disaster Management
25MDM62	Environment Management
25MDM71	Management Information System
25MDM72	Finance Management

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Course Code	Course Name	Teaching Scheme (Hours / Week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC12	Control Systems	2	--	2	2	2	--	1	3
		Examination Scheme							
		Head	ISE	MSE		ESE		Total	
						Min	Max		
		Theory	20	30		20	50	100	
		Lab	50	--		--	--	50	

Pre-requisite Course Codes		Signals & Systems
After the successful completion, students should be able to:		
Course Outcomes (CO)	CO1	Describe elements of control systems with their types
	CO2	Obtain transfer functions of given physical systems
	CO3	Derive mathematical models using various modeling approaches
	CO4	Analyze performance of control systems based on time response
	CO5	Evaluate the stability of a given control system

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Feedback Control Systems**		04
	1.1	Mathematical preliminaries – Revision of Laplace transform, Inverse Laplace transform, Laplace transforms & inverse Laplace transforms of standard functions, revision of partial fraction expansion, solutions of differential equations using Laplace transforms	1	
	1.2	Overview of open loop system & closed loop system, block diagram, types, practical examples, comparison with advantages & disadvantages	1	
2		**Mathematical Modeling of Physical Systems**		05
	2.1	The transfer function – definition, advantages, disadvantages, poles & zeros in s-plane, characteristic equation, transfer function derivations of simple physical systems (electrical networks)	2,3	
	2.2	Block diagram algebra – elements of block diagram representation, block diagram reduction rules, numerical examples of the same	2,3	
3		**System Response to Transient & Steady State Conditions**		05
	3.1	Standard test signals, definition of first order systems & second order systems, time domain specifications, analysis of transient response by second order model, numerical examples	1,2,3	
	3.2	Types of systems – type 0, type 1 & type 2, steady state errors, static error constants, analysis of different system types using impulse, step, ramp & parabolic signals	2,3	
4		**Stability Analysis of Control Systems**		06
	4.1	Concept of stability, necessary conditions for stability, Routh-Hurwitz stability criterion, relative stability analysis	1,2	
	4.3	Root Locus technique for stability analysis, numerical examples	1,2	
5		**Frequency Response Analysis of Control Systems**		06

	5.1	Frequency domain specifications, importance of gain margin (GM) & phase margin (PM), correlation between the time domain response & frequency domain response	1,2,3	
	5.2	Bode plots for stability analysis, numerical examples on Bode plots	1,2,3	
	5.3	Polar & Nyquist Plots – introduction & stability criterion	1,2,3	
			Total (Hours)	**26**

Sr. No.	Title of Experiment	Ref.
1	Obtain time response characteristics of first order system	1, 2
2	Obtain time response characteristics of second order system	1, 2
3	Determine step & impulse response for type 0, type 1 & type 2 systems	1, 2
4	Frequency response characteristics of first order & second order systems	1, 2
5	Obtain root locus plot for given LTI system	1, 2
6	Obtain Bode plot for given LTI system	1, 2
7	Simulation of block diagram reduction techniques	1, 2, 3
8	Simulation of LTI system transfer functions	1, 2, 3

Course Assessment:

Self-learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Theory:

ISE:

ISE activities carry 20 Marks. These activities will be conducted throughout the semester.

MSE:

The written summative examination of 30 Marks based on 50% syllabus for 90 minutes.

ESE:

The written summative examination will be conducted for 50 Marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

Laboratory Learning:

ISE: Laboratory ISE is divided into two components: 25 Marks for submission of experiments and 25 Marks for oral/practical evaluation.

Recommended Books:

1. I.J. Nagrath & M. Gopal, "Control Systems Engineering", New Age International Publishers, 5th edition.
2. Norman S. Nise, "Control Systems Engineering", John Wiley & Sons, 2nd edition.
3. Benjamin C. Kuo, "Automatic Control Systems", Prentice Hall India (PHI), 4th edition.
4. Katsuhiko Ogata, "Modern Control Engineering", Pearson Education, 4th edition.

SUGGESTED CO – PO Articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	2	-	-	-	-	-	2	3
CO2	2	3	3	2	-	-	-	-	-	-	-	2	3
CO3	2	3	3	2	-	-	-	-	-	-	-	2	3
CO4	2	2	2	3	3	-	-	-	-	-	-	2	3
CO5	2	2	2	3	3	2	-	-	-	-	-	2	3

Legends:- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember	Understand	Apply ✓	Analyze ✓	Evaluate ✓	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC13	VLSI Design	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Digital Electronics Electronic Devices and Applications
After the successful completion students should be able to:		
Course Outcomes	CO1	Demonstrate a clear understanding of choice of technology and technology scaling
	CO2	Analyze CMOS based circuits
	CO3	Realize logic circuits with different MOS circuit design styles
	CO4	Demonstrate the understanding of system level design issues in VLSI design such as protection, timing, and power dissipation
	CO5	Compare different approaches for memory implementation
	CO6	Simulate MOS based circuits

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Technology Trends**		**4**
	1.1	Technology Comparison: Comparison of BJT, NMOS and CMOS technology	1,2	
	1.2	MOSFET Scaling**:** Types of scaling, Level 1 and Level 2 MOSFET Models.	1,2	
	1.3	MOSFET capacitances		
2		**Direct realization methods**		**7**
	2.1	Circuit Analysis**:** Static and dynamic analysis (Noise, propagation delay, and power dissipation) of resistive load and CMOS inverter	1,2	
	2.2	Comparison of all types of MOS inverters, design of CMOS inverters, CMOS Latch-up	1,2	
	2.3	Logic Circuit Design**:** Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter. Implementation of any complex function.	1,2	
3		**MOS Circuit Design Styles**		**5**

	3.1	Design Styles: Static CMOS, pass logic, transmission gate, Pseudo NMOS, Domino, NORA, Zipper, C2MOS, sizing using logical effort	1,2,3	
	3.2	Circuit Realization**:** SR Latch, JK FF, D FF, 1 Bit Shift Register, MUX, decoder using above design styles	1,2,3	
	3.3	Data Path Design**:** Adder: Bit adder circuits, ripple carry adder, CLA adder. Multipliers and shifter: Partial-product generation, partial-product accumulation, final addition, barrel shifter	1,2,3	
4		**Semiconductor Memories**		**5**
	4.1	SRAM: ROM Array, SRAM (operation, design strategy, leakage currents, read/write circuits)	2,3	
	4.2	DRAM (Operation 3T, 1T, operation modes, leakage currents, refresh operation, Input-Output circuits)	2,3	
	4.3	Flash (mechanism, NOR flash, NAND flash). Peripheral Circuits: Sense amplifier, decoder	2,3	
5		**VLSI Clocking and System Design**		**5**
	5.1	Clocking: CMOS clocking styles, Clock generation, stabilization, and distribution	2,4	
	5.2	Low Power CMOS Circuits**:** Various components of power dissipation in CMOS, Limits on low power design, low power design through voltage scaling	2,4	
	5.3	IO pads and Power Distribution and Interconnect: ESD protection, input circuits, output circuits, simultaneous switching noise, power distribution scheme: Interconnect delay model, interconnect scaling, and crosstalk.	2,4	
			Total	**26**

Self-learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment: -

Theory:

ISE: ISE activities carry 20 Marks. These activities will be conducted throughout the semester.

MSE:

The written summative examination of 30 Marks based on 50% syllabus for 90 minutes.

ESE:

The written summative examination will be conducted for 50 Marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

	List of Experiments	Ref
1	Output and Transfer Characteristics of NMOS and PMOS transistors using SPICE simulation	3
2	Comparative Analysis of Various Load Inverter Circuits (Resistive Load, NMOS Load, PMOS Load, CMOS Inverter) from Transfer Characteristics	3
3	Design and Analysis of CMOS NAND and NOR Gates - Static and Dynamic Characteristics	3
4	Estimation of Power Dissipation in CMOS Circuits (Static, Dynamic, and Short Circuit Power)	3
5	Layout Design and Extraction for VLSI Circuits using Cadence/Magic - DRC and LVS Verification	1,4
6	Design and Implementation of 2:1 and 4:1 Multiplexer using Transmission Gate Logic	1,4
7	Pass Transistor Logic Implementation - XOR/XNOR Gates and Full Adder Design	1,4
8	Comparison of Different MOS Design Styles (Static CMOS, Pseudo-NMOS, Dynamic Logic - Domino/NORA)	1,4
9	Design and Analysis of 6-T SRAM Cell - Read/Write Operations and Stability Analysis	1,4
10	D Flip-Flop Implementation using Different Design Styles (Master-Slave, Transmission Gate based)	1,4
11	Study of Novel Devices - FinFET characteristics and comparison with planar MOSFET	1,4

Course Assessment:-

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. S.-M. Kang and Y. Leblebici, CMOS Digital Integrated Circuits: Analysis and Design, 3rd ed. New York, NY, USA: McGraw-Hill, 2003.
2. CMOS VLSI Design: A Circuits and Systems Perspective – Neil H. E. Weste & David Harris
3. Digital Integrated Circuits: A Design Perspective – Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic
4. Circuit Design for CMOS VLSI – Ken Martin / Uyemura

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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	2	-	-	-	-	-	2	3	2
CO2	3	3	2	2	2	-	-	-	-	-	2	3	3
CO3	3	2	3	2	2	-	-	-	-	-	2	3	3
CO4	2	3	2	3	3	2	-	-	-	-	2	2	3
CO5	2	3	2	2	2	-	-	-	-	-	2	3	2
CO6	2	2	3	2	3	-	-	-	-	-	2	3	3

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms Level

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
PCC13EC14	Artificial Intelligence	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE		ESE		Total	
						Min	Max		
		Theory	20	30		20	50	100	
		Lab	50	--		--	--	50	

Pre-requisite Course Codes		Data structures and algorithms, Discrete mathematics, Basic Mathematics
After the successful completion students should be able to:		
Course Outcomes	CO1	Identify and select suitable architectures for real-world AI problems in different environment.
	CO2	Apply appropriate search strategies to design and implement problem-solving agents
	CO3	Apply inference rules to develop intelligent agents.
	CO4	Construct Bayesian Belief Networks for decision-making.
	CO5	Develop AI applications by implementing expert system components and Prolog-based programs.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Intelligent Agents**		
	1.1	Artificial Intelligence (AI), AI Perspectives: Acting and Thinking humanly, Acting and Thinking rationally History of AI, Applications of AI, The present state of AI, Ethics in AI	T1	4
	1.2	Introduction of agents, Structure of Intelligent Agent, Characteristics of Intelligent Agents, Types of Agents, Simple Reflex, Model Based, Goal Based, Utility Based Agents.		
	1.3	Environment Types, Deterministic, Stochastic, Static, Dynamic, Observable, Semi-observable, Single Agent, Multi Agent		
2		**Solving Problems by Searching**		
	2.1	Definition, State space representation, Problem as a state space search, Problem formulation, Well-defined problems	T1	10
	2.2	Solving Problems by Searching, Performance evaluation of search strategies, Time Complexity, Space Complexity, Completeness, Optimality		
	2.3	Uninformed Search, Depth First Search, Breadth First Search, Depth Limited Search, Iterative Deepening Search, Uniform Cost Search. Bidirectional Search		

	2.4	Informed Search, Heuristic Function, Admissible Heuristic, Informed Search Technique, Greedy Best First Search, A* Search, Local Search, Hill Climbing Search, Simulated Annealing Search, Optimization, Genetic Algorithm		
	2.5	Game Playing, Adversarial Search Techniques, Mini-max Search, Alpha-Beta Pruning		
3	**3.1**	Definition and importance of Knowledge, Issues in Knowledge Representation, Knowledge Representation Systems, Properties of Knowledge Representation Systems	T1	**6**
	3.2	Propositional Logic (PL), Syntax, Semantics, Formal logic-connectives, truth tables, tautology, validity, well-formed-formula,		
	3.3	Predicate Logic, FOPL, Syntax, Semantics, Quantification, Inference rules in FOPL, Forward Chaining, Backward Chaining and Resolution in FOPL		
4		**Reasoning Under Uncertainty**		
	4.1	Handling Uncertain Knowledge, Random Variables, Prior and Posterior Probability, Inference using Full Joint Distribution	T1 R1	**2**
	4.2	Bayes' Rule and its use, Bayesian Belief Networks, Reasoning in Belief		
5		**Planning and Learning**		
	5.1	The planning problem, Partial order planning, total order planning.	T1 R1	**4**
	5.2	Learning in AI, Learning Agent, Concepts of Supervised, Unsupervised, Semi Supervised Learning, Reinforcement Learning, Ensemble Learning.		
	5.3	- Expert Systems, Components of Expert System: Knowledge base, Inference engine, user interface, working memory, Development of Expert Systems		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:

ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.

MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.

ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

List of Experiments:

1	Design of Intelligent System Using PEAS. Design the state space problem for given Problem statement	T1
2	Implement any one of the Informed search techniques E.g. A-Star algorithm for 8 puzzle problem	T1
3	Implement any one of the Uninformed search techniques	T1
4	Implement adversarial search using min-max algorithm.	T1
5	Write a program in prolog to implement simple facts and Queries	T1
6	Prove the goal sentence from the following set of statements in FOPL by applying forward, backward and resolution inference algorithms.	T1
7	Create a Bayesian Network for the given Problem Statement and draw inferences from it. (You can use any Belief and Decision Networks Tool for modeling Bayesian Networks)	T1, R1
8	Implement a Planning Agent	T1 R1
9	Case study of any existing successful AI system	T1 R1
10	Mini project/presentation/Group activity/ Simulation using modern tools	T1 R1

Course Assessment: -

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Suggested list of activities:

1. Quiz/ crossword
2. Open book test
3. Case Studies
4. Model making
5. Presentation

Recommended Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach —Second Edition" Pearson Education.
2. Elaine Rich and Kevin Knight —Artificial Intelligence‖ Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.
3. George F Luger "Artificial Intelligence" Low Price Edition, Pearson Education., Fourth edition.

Text Books:

1. Ivan Bratko "PROLOG Programming for Artificial Intelligence", Pearson Education, Third Edition.
2. D. W. Patterson, Artificial Intelligence and Expert Systems, Prentice Hall.
3. Saroj Kaushik "Artificial Intelligence", Cengage Learning.
4. Davis E. Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.

Online Resources:

1. NPTEL: *An Introduction to Artificial Intelligence*
   https://onlinecourses.nptel.ac.in/noc22_cs56/
2. Fundamentals of AI:

   https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_ge20

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	-	-	-	-	-	-	2	2	2	2	-	-
CO2	2	2	-	-	2	-	-	2	2	2	2	-	2
CO3	3	2	-	-	2	-	-	2	2	2	2	-	2
CO4	3	-	-	-	3	-	-	2	2	2	2	-	2
CO5	2	2	2	2	3	2	2	2	2	2	2	2	3

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: - 0

Blooms level

Remember ✓	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC15	Analysis of Algorithms	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Data Structure
After the successful completion students should be able to:		
Learning Outcomes	LO1	Compare the efficiency of algorithms belonging to different complexity classes (linear, quadratic, cubic, etc.).
	LO2	Apply divide and conquer strategy to design and implement algorithms.
	LO3	Apply greedy strategy to design and implement algorithms.
	LO4	Apply dynamic programming strategy to design and implement algorithms.
	LO5	Apply backtracking and branch-&-bound strategy to design and implement algorithms.
	LO6	Explore and implement string matching algorithms.

	List of Experiments	Ref.	LOs
1	Analysis of Complexity Classes & Sorting: Compare algorithms based on different time complexity classes (linear, quadratic, cubic). Understanding Asymptotic Notations. Implementation of Bubble sort, Selection sort, Insertion sort, Shell sort, Linear search, Binary search	2	CO1
2	Divide and Conquer Strategy: Binary search, Finding minimum and maximum, Merge sort, Quick sort, Randomized Quick sort, Tennis tournament construction.	1, 2	CO2
3	**Greedy Method:** Knapsack problem, Job sequencing with deadlines, Minimum cost spanning trees (Kruskal and Prim's), Optimal storage on tapes, Single source shortest path.	1, 2	CO3
4	**Dynamic Programming:** Multistage graphs, All pair shortest path, Single source shortest path, Optimal binary search tree, 0/1 knapsack, Travelling salesman problem, Flow shop scheduling.	1, 3	CO4
5	**Backtracking:**	1, 4	CO5

	8 queen problem (N-queen problem), Sum of subsets, Graph colouring, Knapsack problem.		
6	**Branch & Bound:** Travelling salesperson problem, 15 puzzle problem, Flow Shop Scheduling.	1, 3, 5	CO5
7	**String Matching Algorithms:** The Naïve string-matching Algorithms, Rabin Karp algorithm, Boyer-Moore Algorithm, Knuth-Morris-Pratt algorithm, Longest common subsequence.	1, 5	CO6
	Total	26	

Course Assessment: -

Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", PHI Publication, 2nd Edition, 2005.
2. Ellis Horowitz, Sartaj Sahni, S. Rajsekaran. "Fundamentals of computer Algorithms", 2nd Edition, University Press, 2007.
3. Steven S. Skiena, "Algorithm Design Manual", Springer Publication, 2nd Edition, 2008.
4. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", Tata McGraw Hill, 1st Edition, 2006.
5. S. K. Basu, "Design Methods and Analysis of Algorithm", PHI, 2nd Edition, 2013.

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SUGGESTED CO - PO articulation Matrix

Laboratory Outcmes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	-	2	-	-	-	-	-	-	-	2	-
CO2	3	2	3	-	2	-	-	-	-	-	-	3	2
CO3	3	2	3	-	2	-	-	-	-	-	-	3	2
CO4	3	3	3	-	2	-	-	-	-	-	-	3	2
CO5	3	3	3	2	2	-	-	-	-	-	-	3	2
CO6	3	2	2	-	3	-	-	-	-	-	2	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC16	Software Engineering	2	--	--	2	2	--	--	2
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	--	--	--	--	--		

Pre-requisite Course Codes		Programming Fundamentals
After the successful completion, students should be able to:		
Course Outcomes	CO1	Compare various software process models and utilize version control systems (Git/GitHub) to manage collaborative development workflows.
	CO2	Analyze complex user requirements to develop structured Software Requirement Specifications (SRS) using both traditional and Agile-based techniques.
	CO3	Design system architectures using UML modeling while applying SOLID principles and Design Patterns to ensure code maintainability.
	CO4	Formulate testing strategies and implement Continuous Integration (CI/CD) pipelines to automate software quality assurance.
	CO5	Apply software metrics and estimation models (COCOMO) to plan schedules, manage risks, and assess project feasibility.
	CO6	Evaluate modern System Design principles including microservices, load balancing, and cloud-native architectures for scalable software solutions.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Software Engineering & Process Models**	1	**5**
	1.1	**Software Characteristics:** Software vs. Hardware evolution, Software myths, and the "Software Crisis."		
	1.2	**SDLC Fundamentals:** Core phases of the Software Development Life Cycle (Planning, Analysis, Design, Implementation, Testing, Maintenance).		
	1.3	**Traditional Models:** Waterfall Model, Incremental Model, and the V-Model.		
	1.4	**Evolutionary Models:** Prototyping and the Spiral Model (Risk-driven approach).		
	1.5	**Agile Methodology**: The Agile Manifesto, Scrum framework (Roles, Events, Artifacts), and Kanban.		
2		**Requirements Engineering**	1	**5**

	2.1	**Requirement Elicitation:** Functional vs. Non-functional requirements; Techniques: Interviews, Surveys, and JAD (Joint Application Development).		
	2.2	**Requirement Analysis:** Data flow diagrams (DFD), Data Dictionary, and Entity-Relationship modelling for requirements.		
	2.3	**The SRS Document:** Structure of the Software Requirement Specification (SRS) based on IEEE 830 standards; Characteristics of a good SRS.		
	2.4	**Requirement Validation:** Review, Inspection, and Traceability matrix.		
3		**Software Design & Architectural Modelling**	2	**4**
	3.1	**Design Concepts:** Abstraction, Modularity, Information Hiding, and Functional Independence.		
	3.2	**Coupling & Cohesion:** Measurement of module strength and interaction; aiming for "High Cohesion, Low Coupling."		
	3.3	**Architectural Styles:** Layered architecture, Client-Server, and Microservices overview.		
	3.4	**UML Modelling:** Structural modelling (Class Diagrams) and Behavioural modelling (Use Case Diagrams, Sequence Diagrams).		
4		**Software Testing Strategies**	3	**4**
	4.1	**Testing Fundamentals:** Verification vs. Validation; White-box vs. Black-box testing concepts.		
	4.2	**Black-Box Techniques:** Boundary Value Analysis (BVA) and Equivalence Class Partitioning.		
	4.3	**White-Box Techniques:** Control flow testing, Basis Path testing, and Cyclomatic Complexity.		
	4.4	**Levels of Testing:** Unit Testing, Integration Testing (Top-down, Bottom-up), and System Testing.		
	4.5	**Regression & Acceptance**: Impact of changes; Alpha and Beta testing.		
5		**Project Management & Metrics**	4	**4**
	5.1	**Software Metrics:** Size-oriented (LOC) vs. Function-oriented (Function Point) metrics.		
	5.2	**Estimation Models:** COCOMO (Constructive Cost Model) — Basic, Intermediate, and Detailed.		
	5.3	**Project Scheduling:** Work Breakdown Structure (WBS), Gantt Charts, and PERT/CPM charts.		
	5.4	**Risk Management:** Reactive vs. Proactive risk strategies; Risk identification, Projection, and RMMM (Risk Mitigation, Monitoring, and Management).		
6		**Maintenance & Modern Trends**	5	**4**

	6.1	**Software Maintenance:** Corrective, Adaptive, Perfective, and Preventive maintenance; Re-engineering.		
	6.2	**Configuration Management:** SCM process, Version Control (Git), and Change Control.		
	6.3	**DevOps & CI/CD:** The DevOps lifecycle; Continuous Integration and Continuous Deployment pipelines.		
	6.4	**Ethics & Professionalism:** Software Engineering Code of Ethics; Case studies on software failures.		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:
ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE: The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

Recommended Books / Online Resources:

1. "Software Engineering: A Practitioner's Approach" Roger S. Presman, 9th Edition, TMH
2. UML Distilled: A Brief Guide to the Standard Object Modelling Language by Martin Fowler.
3. Software Testing: A Craftsman's Approach by Paul C. Jorgensen.
4. Software Project Management by Bob Hughes and Mike Cotterell.
5. https://www.atlassian.com/continuous-delivery/principles/continuous-integration-vs-delivery-vs-deployment
6. https://microservices.io/
7. https://refactoring.guru/design-patterns
8. https://www.google.com/search?q=https://www.browserstack.com/guide/test-driven-development
9. https://snyk.io/learn/devsecops/
10. https://docs.github.com/en/copilot

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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	2	-	-	-	2	2	-	-
CO2	3	3	2	2	2	2	2	2	3	2	2	2	2
CO3	3	3	3	2	3	2	-	-	2	-	2	2	2
CO4	2	3	2	3	2	2	-	-	2	-	2	-	-
CO5	3	2	-	-	2	-	-	2	2	3	2	-	-
CO6	2	2	2	2	3	2	2	2	2	2	3	3	3

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember ✓	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC17	Embedded Systems and RTOS	1	--	2	2	2	--	1	2
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	10	15	10	25	50		
		Lab	50	-	-	-	50		

Pre-requisite Course		25PCC11CS03: Digital Electronics 25PCC12EC06: Computer Organization & Architecture
After the successful completion students should be able to:		
Course Outcomes	CO1	Identify the characteristics and hardware components for any given embedded system.
	CO2	Apply suitable communication protocols for embedded applications and integrate sensors and actuators for real-time control operations.
	CO3	Compare GPOS and RTOS, and apply RTOS concepts to develop multitasking embedded applications.
	CO4	Design embedded system applications using different embedded core based on system life-cycle requirements, considering ethical and environmental issues.
	CO5	Use tools and techniques for testing, debugging, and developed embedded applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1.		**Introduction to Embedded Systems**		2
	1.1	Definition, Characteristics, Classification, Applications	3,4,9	
	1.2	Design metrics of Embedded system and Challenges in optimization of metrics	3,4,9	
2		**Embedded Hardware Elements**		8
	2.1	Features of Embedded cores- μC, ASIC, ASSP, SoC, FPGA, RISC and CISC cores. Types of memories	1,5,7	
	2.2	Case Study: ARM Cortex-M3 Features, Architecture, Programr's model, Special Registers, Operating Modes and States, MPU, Memory map and NVIC, Watch-Dog timer	5,7	
	2.3	Low power: Need and techniques, Case study of Low Power modes in ARM Cortex-M3.	5,7	

	2.4	Communication Interfaces: Comparative study of Serial Communication Interfaces (RS-232, RS-485), SPI, I2C, CAN, USB (v2.0), Bluetooth, Zig-Bee (Frame formats of above protocols are not expected)	3	
3.		**Embedded Software**		**8**
	3.1	Program Modelling concepts: DFG, CDFG, FSM.	4,	
	3.2	Real-time Operating system: Need of RTOS in Embedded system software, Comparison with GPOS, Concept of a Task, Task states, Multi-tasking,	4,6	
	3.3	Task scheduling -Pre-emptive Shortest Job First (SJF), Round-Robin, Priority, Rate Monotonic Scheduling, Earliest Deadline First (EDF), Inter-Process communication: Message queues, Mailbox, Event timers,		
	3.4	Task synchronization: Need, Issues - Deadlock, Race condition, live Lock, Solutions using Mutex, Semaphores. Shared Data problem, Priority Inversion.		
		Introduction to FreeRTOS		**3**
4.	**4.1**	FreeRTOS Task Management features, Resource Management features, Task Synchronization features, Event Management features, Calculation of the CPU Utilization of an RTOS, Interrupt Management features, Time Management features.	10	
		Testing and Debugging Methodology		**2**
5.	**5.1**	Testing & Debugging: Hardware testing tools, Boundary scan /JTAG interface concepts, Emulator.	3,4	
	5.2	Software Testing tools, simulator, debugger. White-Box and Black-Box testing.	3,4	
6.		**System Integration**		**5**
	6.1	Embedded Product Design Life-Cycle (EDLC)- Waterfall Model	3,4	
	6.2	Hardware-Software Co-design	3,4	
	6.3	Case studies for Automatic Chocolate Vending Machine, Washing Machine, Smart Card, highlighting i) Specification requirements (choice of components), ii) Hardware architecture iii) Software architecture.	3,4,8	
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:

ISE: ISE activities carry 10 marks. These activities will be conducted throughout the semester
MSE: The written summative examination of 15 marks based on 50% syllabus for 60 minutes.
ESE: The written summative examination will be conducted for 25 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 90 minutes.

	Laboratory learning		
	Suggested List of experiments	**Module**	**Ref.**
1.	Interfacing of LEDs /switches with any embedded core. (8051/ARM/STM32, etc)	1	1
2.	Interfacing of LCD/ Seven segment display with any embedded core. (8051/ARM/STM32,etc)	1	1
3.	Interfacing of a DC motor (speed and Direction control) with any embedded core.(8051/ARM/STM32,etc)	1	1
4.	Implement power management in any embedded core of your choice	2	2
5.	Implement the I2C communication to connect to DS1307 RTC	2	2
6.	Porting of FreeRTOS to Arduino/STM32.	3	2,4,9
7.	Write a Program to Create Multiple Tasks and understand the Multitasking capabilities of RTOS (FreeRTOS).	3	2,4,9
8.	Write a Program to illustrate the Queue Management Features of Free RTOS.	3	2,4,9
9.	Write a Program to illustrate the Event Management Features of Free RTOS.	3	2,4,9
10.	Design a embedded system application and perform the testing and debugging	4,5	2,4,9

Course Assessment

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Reference Books:

1. M.A.Mazidi, J.C.Mazidi, Rolin D. McKinlay,"The 8051 Microcontroller and Embedded Systems Using Assembly and C", Pearson Education, Second Edition, 2007.
2. Kenneth J. Ayala, "The 8051 Microcontroller", Cengage Learning India Pvt. Ltd, Third Edition, 2005.
3. Rajkamal, "Embedded Systems: Architecture, Programming and Design", McGraw Hill Education (India) Private Limited, New Delhi, 2015, Edition 3rd.
4. Sriram Iyer, Pankaj Gupta, " Embedded Real Time Systems Programming", Tata McGraw Hill Publishing

Company ltd., 2003.
5. Joseph Yiu, "The Definitive guide to ARM CORTEX-M3 & CORTEX-M4 Processors", Elsevier, 2014, 3rd Edition.
6. Jonathan W. Valvano, "Embedded Microcomputer Systems – Real Time Interfacing", Publisher - Cengage Learning, 2012 Edition 3rd.
7. AndrewSloss, Domnic Symes, Chris Wright, "ARM System Developers Guide Designing and Optimizing System Software", Elsevier, 2004
8. FrankVahid, Tony Givargis, "Embedded System Design – A Unified Hardware/Software Introduction", John Wiley & Sons Inc., 2002.
9. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, New Delhi, 2009.
10. www.freertos.org
11. https://www.keil.com
12. https://www.arduino.cc
13. Situnayake, D., & Plunkett, J. AI at the Edge: Solving Real-World Problems with Ebedded Machine Learning O'Reilly Media.2023
14. Patterson, D. A., & Hennessy, J. L. Computer Organization and Design RISC-V Edition: The Hardware Software Interface (2nd ed.). Morgan Kaufmann.2021
15. Harris, S. L., & Harris, D. *Digital Design and Computer Architecture: RISC-V Edition*. Morgan Kaufmann.2022.
16. Harris, D., Stine, J., Harris, S., & Thompson, R. *RISC-V System-on-Chip Design* (1st ed.). Morgan Kaufmann. ISBN-13: 978-0323994989.2025
17. Kleidermacher, D., & Kleidermacher, M. *Embedded systems security: Practical methods for safe and secure software and systems development*. Elsevier/Morgan Kaufmann 2012.
18. Merli*, D.Engineering secure devices: A practical guide for embedded system architects and developers 2024.*

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2
CO2	3	2	2	-	2	-	-	-	-	2	-	2	-
CO3	2	2	-	-	2	-	-	-	-	-	2		1
CO4	3	2	3	2	2	2	2	2	-	2	2	2	-
CO5	2	-	2	-	3	-	-	-	-	-	2	-	2

Legends :- High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms level

Remember✓	Understand✓	Apply✓	Analyze✓	Evaluate	Create

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total

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25PEC13EC11	**Automation**	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	**MSE**	**ESE**		**Total**		
					Min	**Max**			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Control Systems
After the successful completion students should be able to:		
Course Outcomes	CO1	Demonstrate the need of automation in a process control system
	CO2	Select proper components for pneumatic & hydraulic systems
	CO3	Choose the transmitter / controller for the given process application
	CO4	Analyze the controller parameters for discrete or continuous type
	CO5	Design the (electronic) controller for given process or application

Module No.	**Unit No.**	**Topics**	**Ref.**	**Hrs.**
1.		**Introduction to Pneumatic & Hydraulic Systems**	3	**2**
	1.1	Basic pneumatic system block diagram, pneumatic compressors (piston, vane, screw), flapper nozzle, single & double acting cylinder, rotary actuators, filter-regulator-lubricator (FRL)		
	1.2	Basic hydraulic system block diagram, hydraulic pumps, hydraulic valves (globe, ball, needle, butterfly, gate & diaphragm), parameters of control valves, selecting control valves for particular application		
2		**Design of Signal Conditioning Circuits**	1	**6**
	2.1	Principles of analog & digital signal conditioning – signal level changes & biasing changes, linearization, conversion, filtering & impedance matching, loading, comparators & converters		
	2.2	Design of operational amplifier-based circuits viz. voltage divider circuits, bridge circuits, R-C filters, inverting & non-inverting amplifier, instrumentation amplifier, voltage to current (V to I) converters & current to voltage (I to V) converters, integrators, differentiators		
	2.3	Transmitters – Introduction to telemetry & its basic block diagram, 2 wire, 3 wire & 4 wire transmitters, 4 mA to 20 mA current transmitter, electronic transmitters for temperature, level, pressure & flow, current to pressure (I to P) & pressure to current (P to I) converters		

3		**Principles of Process Controllers**	1,2,4	**6**
	3.1	Continuous controller – single mode (P, I & D) & composite mode (PD, PI & PID), split range, auto select, ratio & cascaded controllers, selection criterion of controller for a process model		
	3.2	Tuning of PID controller – process loop tuning, open loop transient response method, Ziegler – Nichols tuning method, frequency response methods (numerical examples on PID tuning)		
4		**Programmable Logic Controllers (PLC)**	1,2,4	**6**
	4.1	Discrete state process controllers – the discrete state process variables, process specifications & event sequence descriptions		
	4.2	Relay controllers & ladder diagrams – introduction to relay logic ladder diagram, ladder diagram elements & programming examples		
	4.3	PLC – relay sequencers, programmable logic controller design, PLC operation, programming the PLC, PLC software functions (application examples on relay ladder logic programming)		
5		**Digital Process Control Systems**	2,4	**4**
	5.1	Data acquisition system (DAS) – objectives, signal conditioning of inputs, single channel DAS, multi-channel DAS, computer based DAS, data logger, difference between DAS & data loggers		
	5.2	Computer aided process control – architecture, the human machine interface (HMI), the supervisory control & data acquisition (SCADA), standard industrial interfaces (RS-232C, RS-422A & RS-485)		
	5.3	Supervisory control system (SCS), introduction to Fieldbus & Profibus process controlled networks, overview of distributed control system (DCS), highway addressable remote transducer (HART) protocol		
6		**Advances in Automation Systems**	4	**2**
	6.1	PC & microcomputer-based instrumentation, virtual instrumentation & LabVIEW introduction		
	6.2	Brief overview of advanced automation – additive manufacturing, digital twins, 3D printing, concept of Industry 4.0 & Society 5.0		
			Total (Hours)	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(b) Theory:

ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

List of Experiments:

Sr. No.	Title of Experiment	Ref.
1	Study of pneumatic single acting & double acting cylinder	3
2	Study of hydraulic process control valves	3
3	Design of instrumentation amplifier for variable voltage gain	1, 2
4	Design of signal conditioning circuits for LDR / thermistor / RTD / strain gauge	1, 2
5	Design of linearization circuits for transducers	1, 2
6	Tuning of P+I+D controller using MATLAB / Simulink	1, 2
7	Implementation of PLC ladder diagram for given application	1, 2
8	Simulating a simple process using LabVIEW	1, 2

Course Assessment: -

(c) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Curtis D. Johnson, "Process Control Instrumentation Technology", 7th edition, Prentice-Hall India (PHI)
2. William C. Dunn, "Fundamentals of Industrial Instrumentation & Process Control", 1st edition, McGraw Hill
3. Andrew Parr, "Pneumatics & Hydraulics", 2nd edition, Jaico Publishing Co.
4. B. G. Liptak, "Handbook of Process Control & Instrumentation", 4th edition, CRC Press

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SUGGESTED CO - PO Articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	–	–	2	2	–	–	–	–	2	2	–
CO2	3	3	2	–	2	2	–	–	–	–	2	2	–
CO3	3	3	2	2	2	2	–	–	–	–	2	2	2
CO4	3	3	–	3	2	–	–	–	–	–	2	2	2
CO5	3	2	3	2	3	2	–	2	2	2	2	3	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms level

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC12	Biomedical Instrumentation Laboratory	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Electronic Devices Measurements and Instrumentation
After the successful completion students should be able to:		
Learning Outcomes	LO1	Explain the principles used in measurement of physiological parameters like blood pressure, Oxygen Saturation and Respiration rate
	LO2	Perform measurement of ECG, EEG, EMG using diagnostic equipment
	LO3	Design Instrumentation amplifiers for Biomedical applications given the specifications
	LO4	Design filters to remove power line interference in physiological measurement

	List of Experiments	Ref.	LOs
1	Blood Pressure Measurement To measure the Systolic and diastolic blood pressure using: i. Sphygmomanometer (Manual method) ii. Automatic method	1,2,3	LO1
2	ECG measurement To plot the ECG acquired from the subject by using the 12 Lead system	1,2,3	LO2
3	EEG Measurement To plot and analyze the EEG acquired from the subject using plate electrodes	1,2,3	LO2
4	Measurement of Oxygen saturation (Spo2) To measure SpO2 using Pulse Oximeter	1,2,3	LO1
5	Instrumentation Amplifier	1,2,3	LO3
6	To design and implement an Instrumentation amplifier for the given specifications	1,2,3	LO3
7	Audiometer	1,2,3	LO4
8	To measure and plot the hearing capacity (both ears) using Audiometry [with and without masking]	1,2,3	LO4

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Handbook of Biomedical Instrumentation: R S. Khandpur. 2004 (TMH Pub).
2. Biomedical Instrumentation and Measurements‖: Leslie Cromwell, Pearson Education, 1980.
3. Medical Instrumentation, Application and Design: J G. Webster. (John Wiley).
4. "Introduction to Biomedical Equipment Technology", Carr –Brown. (PHI Publication)

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
LO1	3	2	2	2	2	3	2	2	2	–	2	3	-
LO2	3	2	2	3	3	2	2	2	2	–	2	3	–
LO3	3	2	3	2	3	2	2	2	2	2	2	2	3
LO4	3	2	3	2	3	2	2	2	2	2	2	2	3

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms level

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
PEC13EC21	Cryptography	2	--	2	2	2	--	1	3

Examination Scheme					
	ISE	MSE	ESE		Total
			Min	Max	
Theory	20	30	20	50	100
Lab	50	--	--	--	50

Pre-requisite Course Codes		Computer Networks
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply modular arithmetic technique in cryptographic operations.
	CO2	Implement symmetric and asymmetric cryptographic algorithms
	CO3	Demonstrate authentication mechanisms using cryptographic hash functions, digital signatures, and authentication protocols
	CO4	Analyze various attacks on network security, and different security protocols.
	CO5	Apply web security measures for protection against web-based attacks.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction: Number Theory and Classical Cryptography**		4
	1.1	Security Goals, Attacks, Services and Mechanisms, Techniques. Modular Arithmetic: Euclidean Algorithm, Fermat's and Euler's theorem	T1 T5	
	1.2	Classical Encryption techniques, Symmetric cipher model, monoalphabetic and polyalphabetic substitution techniques: Vigenere cipher, playfair cipher, Hill cipher, transposition techniques: keyed and keyless transposition ciphers		
2		**Symmetric and Asymmetric key Cryptography**	T1 T5	6
	2.1	Block cipher principles, block cipher modes of operation, DES, Double DES, Triple DES, Advanced Encryption Standard (AES),		
	2.2	Public key cryptography: Principles of public key cryptosystems- The RSA Cryptosystem, The knapsack cryptosystem		
	2.3	Symmetric Key Distribution: KDC, Needham-Schroeder protocol. Kerberos: Kerberos Authentication protocol, Symmetric key agreement: Diffie Hellman, Public key Distribution: Digital Certificate: X.509, PKI		
3		**Authentication using Cryptographic Hash Functions and Digital Signature**		6

	3.1	Cryptographic hash functions, Properties of secure hash function, MD5, SHA-1, MAC, HMAC, CMAC	T1 T5 T3	
	3.2	Digital signature and authentication protocols : Needham Schroeder Authentication protocol, Digital Signature Schemes – RSA, EI Gamal and Schnorr, DSS.		
4		**Network Security and System Security**		**6**
	4.1	Network security basics: TCP/IP vulnerabilities (Layer wise), Network Attacks: Packet Sniffing, ARP spoofing, port scanning, IP spoofing	T1 T5	
	4.2	Denial of Service: DOS attacks, ICMP flood, SYN flood, UDP flood, Distributed Denial of Service		
	4.3	Internet Security Protocols: PGP, SSL, IPSEC. Network security: IDS, Firewalls, IDS		
	4.4	Buffer Overflow, malicious Programs: Worms and Viruses, SQL injection		
5		**Web Security**		**4**
	5.1	Web Security Considerations, User Authentication and Session Management, Cookies, SSL, HTTPS, SSH,	T1 T3 T5	
	5.2	Web Browser Attacks, Web Bugs, Clickjacking, Cross Site Request Forgery, Session Hijacking and Management, Phishing Technique, DNS Attack, Secure Electronic Transaction, Email Attacks, Penetration Testing		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:
(a) Theory:

ISE:ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

List of Experiments		
1	Design and Implementation of a product cipher using Substitution and Transposition ciphers	T1 T5
2	Implementation and analysis of RSA crypto system and knapsack cryptosystem	T1 ,T2,T5
3	Implementation of Diffie Hellman Key exchange algorithm	T1 T5
4	For varying message sizes, test integrity of message using MD-5, SHA-1, and analyze the performance of the two protocols. Use crypt APIs.	T1 T5

5	Study the use of network reconnaissance tools like WHOIS, dig, traceroute, ns lookup to gather information about networks and domain registrars.	T1 T5
6	Study of packet sniffer tools: Wireshark, 1. Download and install Wireshark and capture ICMP, TCP and HTTP packets in promiscuous mode. 2. Explore how the packets can be traced based on different filters	T1 T5
7	Download and install NMAP. Use it with different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, xmas scan etc.	T1 T5
8	Detect ARP spoofing using NMAP and/or open-source tool ARPWATCH and Wireshark. Use ARPING tool to generate gratuitous ARPs and monitor using Wireshark	T1 T5
9	Simulate DOS attack using Hping, hping3 and other tools Explore the GPG tool of Linux to implement email security	T1 T5
10	Simulate buffer overflow attack using Ollydbg, Splint, Cpp check etc Setting up personal Firewall using IPTABLES.	T1 T5

Course Assessment: -

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books

1. William Stallings, "Cryptography and Network Security, Principles and Practice", 6th Edition, Pearson Education, March 2013.
2. Behrouz A. Ferouzan, "Cryptography & Network Security", Tata McGraw Hill
3. Behrouz A. Forouzan& Debdeep Mukhopadhyay, "Cryptography and Network Security" 3rd Edition, McGraw Hill
4. Bruce Schneier, "Applied Cryptography, Protocols Algorithms and Source Code in C", Second EBruceSchneier, "Applied Cryptography, Protocols Algorithms and Source Code in C", Second Edition, Wiley.
5. Atul Kahate, "Cryptography and Network Security", Tata McGraw-Hill Education, 2003.
6. Eric Cole, "Network Security Bible", Second Edition, Wiley, 2011edition, Wiley

Online Resources:

1. https://www.vlab.co.in/participating-institute-iiit-hyderabad
2. https://cse29-iiith.vlabs.ac.in/
3. https://github.com/cmin764/cmiN/blob/master/FII/L3/SI/book/W.Stallings%20-%20Cryptography%20and%20Network%20Security%206th%20ed.pdf
   https://docs.google.com/file/d/0B5F6yMKYDUbrYXE4X1ZCUHpLNnc/view

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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	2	2	2	2	2	-	-
CO2	3	2	-	-	2	-	2	2	2	2	2	-	2
CO3	2	2	-	-	3	2	2	2	2	2	2	-	2
CO4	-	2	2	2	3	2	3	2	2	2	2	-	2
CO5	-	2	2	2	3	2	3	2	2	2	2	-	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: - 0

Blooms level

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
PEC13EC22	Blockchain Lab	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE	MSE	ESE		Total	
					Min	Max		
		Theory	-	-	-	-	-	
		Lab	50	--	--	--	50	

Pre-requisite Course Codes	Python, Data structure	
Course Outcomes	CO1	Implement basic blockchain structure and hashing.
	CO2	Demonstrate consensus mechanisms in blockchain.
	CO3	Perform cryptocurrency transactions using blockchain tools.
	CO4	Configure and use public or private blockchain platforms.
	CO5	Develop and deploy smart contracts using Solidity.

Sr. No.	Suggested List of Experiments
1	**1. SHA-256 Hashing and Immutability** **Objective:** To understand cryptographic hashing, block integrity, and immutability in blockchain. **Experiments:** • Implement a SHA-256 hashing program from scratch. • Demonstrate how small changes in input affect the hash output. • Show immutability in a simple blockchain model when a block is altered.
2	**Basic Blockchain Implementation** **Objective:** To build and understand core components of a blockchain. **Experiments:** • Create a basic blockchain using Python/Java with genesis block, proof of work, and data blocks. • Construct a Merkle tree and compute root hashes for transactions. • Validate blockchain integrity after adding multiple blocks.
3	**Installation and Setup of Blockchain Tools** **Objective:** To explore essential blockchain development tools. **Experiments:** • Install MetaMask wallet and connect to test networks. • Setup Ganache local blockchain. • Explore Remix IDE for smart contract development.
4	**Wallet Creation and Testnet Transactions** **Objective:** To perform real cryptocurrency transactions in a controlled environment.

	Experiments: • Create a blockchain wallet (e.g., MetaMask). • Connect MetaMask to an Ethereum test network. • Execute multiple testnet transactions and verify them using explorers.
5	**Smart Contract Development using Remix** **Objective:** To learn fundamentals of smart contract programming and deployment. **Experiments:** • Write a smart contract in Solidity using Remix IDE. • Compile and deploy the contract to a test network. • Interact with the deployed contract functions.
6	**Smart Contract Integration with Web Interface** **Objective:** To connect smart contracts with user interfaces through Web3 libraries. **Experiments:** • Use Web3.js / Ethers.js to connect a frontend application to a smart contract. • Implement contract function calls from a simple web page. • Perform transactions from the UI and observe state changes.
7	**Development of a Simple DApp** **Objective:** To design and develop a decentralized application combining frontend and blockchain backend. **Experiments:** • Build a basic DApp with frontend UI and smart contract backend. • Implement user interactions (e.g., token transfer, data storage). • Test the DApp on a local or test blockchain network.
8	**Decentralized Storage Using IPFS** **Objective:** To understand decentralized file storage and retrieval. **Experiments:** • Upload files to IPFS (InterPlanetary File System). • Retrieve files using IPFS content identifiers (CIDs). • Integrate IPFS storage with smart contracts and DApp front end.
9	**Hyperledger Fabric Setup and Chaincode** **Deployment Objective:** To explore permissioned blockchain frameworks used in enterprise systems. **Experiments:** • Install and configure Hyperledger Fabric network. • Write and deploy simple Chaincode (smart contract) in Fabric. • Invoke transactions and query ledger state.

10	**Mini Project: Blockchain Application Development** **Objective:** To design, implement, and present a complete blockchain application for real-world use cases. **Experiments:** • Select a use case (e.g., Supply Chain, Medical Records, Land Records). • Design system architecture combining blockchain, smart contracts, and UI. • Implement solution, test end-to-end, and prepare a project report. • Present demo and submit documentation as per guidelines.

Course Assessment:

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.
2. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos
3. Dr. Gavin Wood, O'reilly.
4. Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing.
5. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing
6. Blockchin enabled Applications, Vikram Dhillon, DevidMetcalf, Max Hooper, Apress

Online Resources:

1. https://ethereum.org/en/
2. https://hyperledger-fabric.readthedocs.io/en/release-2.2/whatis.html
3. https://www.blockchain.com/
4. https://docs.soliditylang.org/en/v0.7.4

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	-	-	-	2	-	2	2	2	2	-	-	2
CO2	2	-	-	-	2	-	2	2	2	2	-	-	2
CO3	2	-	-	-	3	-	2	2	2	2	2	-	2
CO4	2	-	-	-	2	-	2	2	2	2	2	-	2
CO5	2	2	2	-	3	2	2	2	2	2	2	-	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: -0

Blooms level

Remember✓	Understand✓	Apply✓	Analyze	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25OE13EC3X	Emotional and Spiritual Intelligence	2	--	--	2	--	--	--	2

Examination Scheme					
	ISE	MSE	ESE		Total
			Min	Max	
Theory	--	--	--	--	--
Lab	100	--	--	--	100

Pre-requisite		
After the successful completion students should be able to:		
Course Outcomes	CO1	Introduce the concept of emotional intelligence, its models, components and measures of emotional intelligence
	CO2	Understand the significance of emotional intelligence in self-growth and building effective relationships, Understand the professional impact of emotional intelligence
	CO3	Develop a wide range of work and life skills.
	CO4	Display spiritual intelligence in different roles.
	CO5	Apply the spiritual quotient for corporate benefits.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Fundamentals of Emotional Intelligence**		
	1.1	Emotion- Meaning, characteristics of emotion, components of emotion- cognitive component, physiological component, Behavioural component. Types of emotions, exposing the myths about emotion, physiological or bodily changes accompanying emotions, how emotions affect our thinking and actions	R1	3
	1.2	Nature and Significance of EI, Models of emotional intelligence: Ability, Trait and Mixed, Building blocks of emotional intelligence: self-awareness, self- management, social awareness, and relationship management	R2	3
2		**Personal and Social Competence**		
	2.1	Self-Awareness: Observing and recognizing one's own feelings, Knowing one's strengths and areas of development Self-Management: Managing emotions, anxiety, fear, and anger	R2	3

	2.2	Social Awareness: Others' Perspectives, Empathy and Compassion Relationship Management: Effective communication, Collaboration, Teamwork, and Conflict management (professional impact)	R2	**3**
	2.3	Strategies to develop and enhance emotional intelligence and using them effectively in professional life	R1	**2**
3	**3.1**	• Spiritual Intelligence- Definition, need, state of presence, psychological element, Intuitive intelligence. • Foundation of Spiritual Intelligence • Types of spiritual actions • Models- SQ and SI-Growth model • Yoga of Action and Spirituality: Professionalism	R6,R8	**3**
	3.2	• Types of spiritual actions • Models- SQ and SI-Growth model • Readiness for spiritual intelligence: self-leadership, synthesize high performance, spiritual awareness, neuropsychology, and state of conscious identity.	R5, R7	**3**
4		**Opposite Polarity in SI and Overall Impact on Personality**		**4**
	4.1	• Twin poles of attention- subject and the object pole • Benefits of Spiritual Intelligence- personal, social and corporate • Dimensions of Spiritual Intelligence- SI and Self Esteem, SI and Restoration of confidence SI and clarity of thoughts and speech, Personality moulding and SI.	R8	
5	**5.1**	**Spiritual Ecology and Environmental Grassroots Activism**		
		• Spiritual Stewardship and Ecology: Case studies based on making a difference in ecology through environmental grassroots activism.	R4	**2**
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

ISE

Activities, Quiz, Assignments= 50 marks
Emotional Intelligence: Identifying emotions and applying it to personal and professional situations 20 marks
Spiritual Intelligence: Performing solutions based on given problems 30 Marks

Recommended Books:

1. Bar-On, R., & Parker, J.D.A.(Eds.) (2000). The handbook of emotional intelligence, San Francisco, California: Jossey Bros.
2. Goleman, D. (2005). Emotional Intelligence. New York: Bantam Book.
3. Sternberg, R. J. (Ed.). (2000). Handbook of intelligence. Cambridge University Press.
4. Thich Nhat Hanh, V. S. (2016). Spiritual Ecology: The Cry of the Earth. Golden Sufi Center.

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	–	–	–	2	–	2	–	2	–	3	2
CO2	–	2	2	–	–	2	–	2	3	2	2	2	3
CO3	–	3	2	2	–	3	3	3	2	2	2	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25OE13EC3X	Health, Wellness and Psychology	2	--	--	2	--	--	--	2
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	100	--	--	--	100		

Pre-requisite		
After the successful completion students should be able to:		
Course Outcomes	CO1	Introduce the concept of health, wellness and psychology, and understand its effectiveness in handling stress.
	CO2	Develop human strength and life-enhancement skills through recovery and goal setting.
	CO3	Apply the holistic well-being quotient for personal and professional benefits.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Psychology, Health and Wellness**		
	1.1	Understanding holistic health- Meaning, components of holistic health- components of wellbeing, Psychology of overall health enhancing behaviors component, Types of health compromising behaviors, Illness Management and wellness enhancement.	R1	**4**
	1.2	Nature and source of stress, personal and professional triggers of stress, Effects of stress, coping with stress (minimalistic yet effective exercise habits)	R2	**4**
2		**Promoting Personal and Professional Wellness: Human Strengths & Life- Enhancement**		
	2.1	Strength: Definition, meaning; Realizing strength; Maximizing Unrealized strength Weakness: Definition, meaning; Identifying and overcoming weakness; Developing hope and optimistic approach.	R2 & R3	**4**

	2.2	Recovery and Goal Setting: analyzing trends in personality, Approaching Individual differences; Meaning of Goal setting, Types and effectiveness of Goal Setting. Motivation: Meaning, Theory of Needs, 4A's of coping with stress during or after goal setting.	R2	**4**
	2.3	Eudaimonic Wellness: Meaning and characteristics; concept of defensive coping.	R1, & R4	**2**
3		Positive Approach and The Psychology of Living in The Present		
	3.1	The Psychology of Living in the Present: meaning, self registering to the flow of positive thoughts and actions; addressing positive and negative emotions; Eliminating daily hassles, creating happiness. Responding to overthinking: Sociocultural factors and self-realization.	R1,R2, &R4	**4**
	3.2	Resilience: Meaning and Nature; How to build resilience; Self communication	R3 R4	**4**
		and self-care, reframe thoughts; channelize gratitude; practice resilience building: physical and mental exercises.		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

ISE:

Activity, quizzes, Assignments: 50 marks

Health and Wellness: Introduce Group Happiness Project. Group work: Meet, exchange, contact, collect info, talk about why you chose this topic, brainstorm ideas, and present people's opinions in your designed PPT: 30 marks

Psychology of wellness or happiness: Case Study or movie review presentation: Example: Chris Gardener in the Pursuit of Happiness (Group-specific interpretation): 20 Marks

Recommended Books:

1. Emmons, R.A., & McCullough, M.E. (2003). Counting blessings versus burdens: An experimental investigation of gratitude and subjective well-being in daily life. Journal of Personality & Social Psychology, 88, 377-389
2. Carpenter, S. (2012). Awakening to sleep. Monitor on Psychology, 44 (1), 40.
3. Emmons, R. A., & Mishra, A. (2012). Why gratitude enhances well-being: What we know, What We Need to Know.
4. Carr, A. (2004). Positive Psychology: The science of happiness and human strength UK Routledge.

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	-	-	-	2	-	2	-	2	-	2	2
CO2	-	2	2	-	-	2	-	2	3	2	2	3	2
CO3	-	3	2	2	-	3	2	2	3	2	2	3	3

Legends: - High: 03, Medium: 02, Low: 01, No Mapping

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze ✓	Evaluate	Create

Society of St. Francis Xavier, Pilar's
Fr. Conceicao Rodrigues College of Engineering
Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC18	Communication and Computer Networks	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		--
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply communication concepts to analyze physical and data link layers.
	CO2	Understand the fundamental concepts of data communication and the OSI/TCP-IP models.
	CO3	Evaluate Data Link Layer protocols, error control, and medium access methods.
	CO4	Design and implement network layer addressing (IPv4/IPv6) and routing strategies.
	CO5	Explain Transport and Application layer protocols for end-to-end communication and security.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Analog and Digital Communication**	1,2	3
	1.1	**Sampling & Digital Signal Representation:** Sampling Theorem (Nyquist rate), Quantization basics, PCM (Pulse Code Modulation), Bit rate vs Baud rate, Baseband vs Broadband transmission		
	1.2	**Digital Modulation & Wireless Transmission:** ASK, FSK, PSK, QPSK, QAM (concept + constellation diagram), Comparison of modulation techniques		
2		**Introduction to Data Communication:**	1,2	3
	2.1	Networks, Topologies, OSI & TCP/IP Reference Models.		
	2.2	**Data Communication:** Components, Data Flow, Performance (Latency, Bandwidth).		
3		**Data Link Layer**	1,2	4
	3.1	Error Detection and correction: Types of Errors, Detection, Error Correction, Framing, Flow Control (Stop-and-wait ARQ. Go-Back-N ARQ, Selective Repeat ARQ).		
	3.2	**Medium Access:** CSMA/CD, CSMA/CA, Ethernet Standards, ARP, RARP		
4		**Network Layer**	1,2	5
	4.1	Introduction to Network Layer, Design issues of Network layer.		
	4.2	Addressing: Physical Address, Logical Address, Port Address, And Application Specific Address. Introduction to Interface &		

		Services, Introduction to IPV4 Address: Classful Address, Classless Addressing, Special Address, NAT: Address Translation & translation table.		
	4.3	Routing Algorithm: Shortest Path Routing, Dijkstra Algorithm, Flooding, Link State Routing, Count to Infinity problem, Congestion Control Algorithm, Quality of Services: Leaky Bucket Algorithm, Token Bucket Algorithm.		
5		**Transport Layer**	1,2	**5**
	5.1	Process to Process Delivery: UDP; TCP congestion control and Quality of service.		
	5.2	TCP vs UDP, Connection Management,		
6		**Application Layer & Security**	1,2	**3**
		DNS, HTTP, SMTP, Firewalls, Introduction to Cryptography.		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:

ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

Laboratory Experiments		
		Ref.
1	Case Study-Classify various types of cabling used in networking	1,2
2	Illustrate various networking devices using Packet Tracer	1,2
3	Use CRC/ Hamming code for error detection and correction	1,2
4	Analyze various Networking Operations and Troubleshooting using command.	1,2
5	Use IP addressing, Subnet and Subnet Mask for given problem statement	2,3
6	Create a local area network using Static & Dynamic Routing Protocols in network infrastructure.	1,2
7	Illustrate Socket programming using TCP and Remote Login using Telnet/SSH	1,2
8	Build DHCP Functionality in network infrastructure	2,3
9	Mini project-Build Network Architecture for a given problem Statement.	2,3

Course Assessment: -

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Data Communications and Networking: Behrouz A. Forouzan, Tata McGraw-Hill, 4th Ed.
2. Computer Networks: A. S. Tannenbum, D. Wetherall, Prentice Hall, Imprint of Pearson 5th d.
3. Data and Computer Communications: William Stallings, Prentice Hall, Imprint of Pearson, 9th Ed.

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	2	-	-	-	-	-	2	2	2
CO2	3	3	2	2	2	-	-	-	-	-	2	2	2
CO3	3	3	2	2	2	-	-	-	-	-	2	2	2
CO4	3	3	3	2	3	-	-	-	-	-	2	2	3
CO5	3	2	2	2	2	-	-	-	-	-	2	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC19	Machine Learning	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	30	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Linear algebra
After the successful completion students should be able to:		
Course Outcomes	CO1	Synthesize a machine-learning-ready dataset by integrating statistical analysis, feature engineering, and dimensionality reduction techniques.
	CO2	Evaluate supervised learning models, including multiple regressions and decision trees, by applying standardized performance metrics to validate predictive accuracy and classification effectiveness.
	CO3	Design robust ensemble learning systems by integrating Bagging, Boosting, and Random Forest techniques with K-fold cross-validation to minimize model variance and bias.
	CO4	Implement linear and nonlinear Support Vector Machines to determine optimal decision boundaries for classification tasks.
	CO5	Apply graph-based, model-based, and density-based clustering algorithms to identify hidden patterns in unlabelled data using appropriate distance metrics and the Expectation-Maximization (EM) framework.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Machine Learning:** Need for Machine Learning, Machine Learning Explained, Machine Learning in Relation to Other Fields, Types of Machine Learning, Challenges of Machine Learning, Machine Learning Process, Machine Learning Application.	1,4	8
	1.2	Understanding Data: Introduction, Big Data Analytics and Types of Analytics, Big Data Analysis Framework, Descriptive Statistics, Univariate Data Analysis and Visualization, Bivariate Data and Multivariate Data. Feature Engineering and Dimensionality Reduction Techniques.	1,4	
2		**Learning with Regression and Trees**	1,4	6
	2.1	Learning with Regression: Linear Regression, Multivariate Linear Regression, Logistic Regression.	1,4	

	2.2	Learning with Trees: Decision Trees, Constructing Decision Trees using Gini Index (Regression), Classification and Regression Trees (CART)	1,4	
	2.3	Performance Metrics: Confusion Matrix, [Kappa Statistics], Sensitivity, Specificity, Precision, Recall, F-measure, ROC curve	1,4	
3		**Ensemble Learning**	1,4	**4**
	3.1	Understanding Ensembles, K-fold cross validation, Boosting, Stumping, XGBoost	2,4	
	3.2	Bagging, Subagging, Random Forest, Comparison with Boosting, Different ways to combine classifiers	1,2,4	
4		**Learning with Classification**	1,2,4	**4**
	4.1	Support Vector Machine Constrained Optimization, Optimal decision boundary, Margins and support vectors, SVM as constrained optimization problem, Quadratic Programming, SVM for linear and nonlinear classification, Basics of Kernel trick.		
5		**Learning with Clustering**	1,4	**4**
	5.1	Introduction to clustering with overview of distance metrics and major clustering approaches		
	5.2	Graph Based Clustering: Clustering with minimal spanning tree Model based Clustering: Expectation Maximization Algorithm, Density Based Clustering: DBSCAN		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

Theory:

ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE :
The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

Laboratory Experiments		
		Ref.
1	Set up Python environment with libraries (NumPy, pandas, scikit-learn, matplotlib, seaborn, TensorFlow, keras,) and perform exploratory Data Analysis (EDA) on a sample dataset.	1,2
2	Data preprocessing (handling missing values, data discretization, data normalization and standardization) on a real-world dataset	1,2
3	Implement Naïve Bayes Classification Algorithm.	2,3
4	Implement decision tree classifier	1,3
5	Implement Support vector machine	4
6	Implementation of k-Means clustering algorithm	5
7	Implementation of Hebbian Learning rule, Expectation - Maximization algorithm for clustering.	5
8	Implement Dimensionality Reduction using attribute selection measure.	5
9	Mini Project	

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Tom M. Mitchell, "Machine Learning", 1st edition, McGraw Hill.
2. Kevin P. Murphy, "Machine Learning — A Probabilistic Perspective", 1st edition, MIT Press
3. Stephen Marsland, "Machine Learning an Algorithmic Perspective,", 2nd edition, CRC Press
4. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning", 1 st edition, Cambridge University Press
5. Peter Harrington, "Machine Learning in Action", 1st edition, Dream Tech Press Drives

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	3	3	-	-	-	-	-	2	2	2
CO2	3	3	-	3	2	-	-	-	-	-	2	2	2
CO3	3	3	3	2	3	-	-	-	-	-	2	2	2
CO4	3	2	2	2	3	-	-	-	-	-	2	2	2
CO5	3	3	2	2	3	-	-	-	-	-	2	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember	Understand✓	Apply✓	Analyze✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC20	Cloud Computing Lab	--	--	2	--		--	1	1

Examination Scheme					
	ISE	MSE	ESE		Total
			Min	Max	
Theory	--	--	--	--	--
Lab	50	--	--	--	50

Pre-requisite Course Codes		Programming fundamentals
After the successful completion students should be able to:		
Course Outcomes	LO1	Analyze cloud computing service models and develop real-world web applications for deployment on commercial cloud platforms.
	LO2	Apply various virtualization techniques in practical scenarios.
	LO3	Create and deploy real-world web applications on commercial cloud platforms.
	LO4	Implement serverless solutions with messaging services like AWS Lambda, SQS, and SNS for event-driven architectures.
	LO5	Explore key security mechanisms in the cloud and propose solutions to mitigate associated challenges.
	LO6	Apply the principles of containerization to practical implementations.

Suggested list of Experiments			
		Ref.	LOs
	Cloud basics		
1	**Title: Introduction and overview of cloud computing.** Objective: To understand the origin of cloud computing, cloud cube model, NIST model, characteristics of cloud, different deployment models, service models, advantages and disadvantages	3	LO1
	Virtualization		
2	**Title: To study and implement Hosted Virtualization using VirtualBox& KVM.** Objective: To know the concept of Virtualization along with their types, structures and mechanisms. This experiment should have demonstration of creating and running Virtual machines inside hosted hypervisors like VirtualBox and KVM with their comparison based on various virtualization parameters.	3	LO2
3	**Title: To study and Implement Bare-metal Virtualization using Xen, HyperV or VMware Esxi.** Objective: To understand the functionality of Bare-metal hypervisors and their relevance in cloud computing platforms. This experiment	3	LO2

	should have demonstration of install, configure and manage Bare Metal hypervisor along with instructions to create and run virtual machines inside it. It should also emphasize on accessing VMs in different environments along with additional services provided by them like Load balancing, Auto-Scaling, Security etc.		
	Services		
4	**Title: To study and Implement Infrastructure as a Service using AWS/AZURE/GCP** Objective: To demonstrate the steps to create and run virtual machines inside Public cloud platform. This experiment should emphasize on creating and running Linux/Windows Virtual machine inside Amazon EC2 or Microsoft Azure Compute and accessing them using RDP or VNC tools.	1,2, 4	LO3
5	**Title: To study and Implement Storage as a Service using AWS S3, Glaciers.** Objective: To understand the concept of Cloud storage and to demonstrate the different types of storages like object storage, block level storages etc. supported by Cloud Platforms like Own Cloud/ AWS S3, Glaciers.	1,2, 4	LO3
6	**Title: To study and Implement Database as a Service on SQL/NOSQL databases like AWS RDS, AZURE SQL/ MongoDB Lab/ Firebase.** Objective: To know the concept of Database as a Service running on cloud and to demonstrate the CRUD operations on different SQL and NOSQL databases running on cloud like AWS RDS, AZURE SQL/ Mongo Lab/ Firebase.	1,2, 4	LO3
	SECURITY		
7	**Title: To study and Implement Security as a Service on AWS/AZURE/GCP** Objective: To understand the Security practices available in public cloud platforms and to demonstrate various Threat detection, Data protection and Infrastructure protection services in AWS and Azure.	1,4	LO5
8	**Title: To study and implement Identity and Access Management (IAM) practices on AWS/Azure/GCP** Objective: To understand the working of Identity and Access Management IAM in cloud computing and to demonstrate the case study based on Identity and Access Management (IAM) on AWS/Azure cloud platform.	1,2, 4	LO5
	Serverless and Messaging		
9	**Lab Title: Exploring AWS Lambda: Building Serverless Event-Driven Applications** Objective: To understand and implement serverless event handling using AWS Lambda, focusing on creating, deploying, and testing event-driven	1,4	LO4

	functions integrated with AWS services.		
10	**Lab Title: Implementing Scalable Messaging Systems with AWS SQS and SNS.** Lab Objective: To explore and implement cloud messaging services using Amazon SQS and SNS, focusing on building scalable, reliable, and event-driven communication systems.	1,4	LO4
	Containerization		
11	**Title: To study and Implement Containerization using Docker** Objective: To know the basic differences between Virtual machine and Container. It involves demonstration of creating, finding, building, installing, and running Linux/Windows application containers inside local machine or cloud platform.	6,7	LO6
12	**Title: To study and implement container orchestration using Kubernetes** Objective: To understand the steps to deploy Kubernetes Cluster on local systems, deploy applications on Kubernetes, creating a Service in Kubernetes, develop Kubernetes configuration files in YAML and creating a deployment in Kubernetes using YAML	6,7	LO6
	Mini Project		
13	**Design a Web Application hosted on public cloud platform (Suggested list of Mini Project Topics)** 1. Deployment of a scalable web application on AWS using EC2, S3, and RDS. 2. Implementing a CI/CD pipeline for a machine learning project using Jenkins and Docker. 3. Building a serverless application using AWS Lambda for real-time data processing. 4. Developing a microservices architecture application deployed on Kubernetes. 5. Setting up and managing a multi-tier application on a private cloud using OpenStack.	Online resources	LO1

Course Assessment: -

(a) <u>Laboratory:</u>

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Bernard Golden, "Amazon Web Services for Dummies", John Wiley & Sons, Inc.

2. Michael Collier, Robin Shahan, "Fundamentals of Azure, Microsoft Azure Essentials", Microsoft Press.

3. RajkumarBuyya, Christian Vecchiola, S ThamaraiSelvi, "Mastering Cloud Computing", Tata McGraw-Hill Education.

4. Barrie Sosinsky, "Cloud Computing Bible", Wiley publishing ,John Paul Mueller, "AWS for Admins for Developers", John Wiley & Sons, Inc.

6. Ken Cochrane, Jeeva S. Chelladhurai, NeependraKhare , "Docker Cookbook - Second . Edition", Packt publication

7. Jonathan Baier, "Getting Started with Kubernetes-Second Edition", Packt Publication

Online Resources:

1. Website link :

   Docker Containers and Kubernetes Fundamentals – Full Hands-On Course

   https://www.youtube.com/watch?v=kTp5xUtcalw

   Docker and Kubernetes Tutorials Playlist

   https://www.youtube.com/playlist?list=PLuZ-P8G2omalspeot9_F_qnJjeLNVADbw

   Docker and Kubernetes Tutorial for Beginners

   https://www.youtube.com/playlist?list=PLy7NrYWoggjwPggqtFsI_zMAwvG0SqYCb

   Complete Kubernetes Tutorial for Beginners

   https://www.youtube.com/playlist?list=PLy7NrYWoggjziYQIDorlXjTvvwweTYoNC

2. NPTEL link :

   https://onlinecourses-archive.nptel.ac.in/noc18_cs16/preview

   https://onlinecourses.nptel.ac.in/noc23_cs90/preview

   https://www.youtube.com/playlist?list=PLfiOAkfpIBRxwkGNQ25v_EY2HbU27luaN

3. Certification link :

   - AWS Cloud Solutions Architect Professional Certificate
   - Cloud Engineering with Google Cloud Professional Certificate
   - Preparing for Google Cloud Certification: Cloud Architect Professional Certificate

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SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
LO1	3	2	3	-	3	3	2	2	2	2	2	2	2
LO2	3	2	2	-	3	-	2	-	2	2	-	2	2
LO3	3	2	3	-	3	3	2	-	2	2	-	2	2
LO4	3	2	3	-	3	3	2	-	2	2	-	2	2
LO5	3	2	3	-	3	3	2	2	2	2	-	2	3
LO6	3	2	3	-	3	3	2	2	2	2	-	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC21	CAD for VLSI	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Digital electronics
After the successful completion students should be able to:		
Learning Outcomes	LO1	Understand and apply VLSI design principles using CAD tools
	LO2	Design and simulate digital circuits using HDL (Hardware Description Language)
	LO3	Perform layout design and verification using CAD tools
	LO4	Analyze timing, power, and area constraints in VLSI design
	LO5	Implement and verify complex digital systems on FPGA
	LO6	Use industry-standard EDA tools for VLSI design flow

	List of Experiments	Ref.	LOs
1	Introduction to CAD Tools for VLSI (e.g., Xilinx/Vivado, Cadence, Microwind): Interface, Directory Structure, and Basic Commands.	1	LO1 LO6
2	Design and Simulation of Basic Combinational Circuits (Adders, Multiplexers, Encoders) using VHDL/Verilog.	1, 2	LO2
3	Design and Simulation of Sequential Circuits (Flip-flops, Registers, Counters) using VHDL/Verilog.	1, 2	LO2
4	Design of Finite State Machines (FSM) (Mealy and Moore Machines) for sequence detection.	2	LO2 LO4
5	Synthesis of Digital Circuits: Analysis of Area, Power, and Timing Reports.	3	LO4 LO6
6	CMOS Layout Design of Basic Gates (Inverter, NAND, NOR) using Layout Editor (e.g., Microwind/Cadence Virtuoso).	3	LO3

7	Physical Verification: Performing Design Rule Check (DRC) and Layout vs. Schematic (LVS) checks.	3	LO3 LO6
8	Parametric Analysis of CMOS Inverter (DC Characteristics and Transient Analysis).	3	LO1 LO4
9	FPGA Implementation of a 4-bit ALU or similar complex module.	2, 4	LO5
10	Mini Project: Design and Implementation of a functional block (e.g., Traffic Light Controller, UART, FIFO) from RTL to GDSII or FPGA.	4	LO5 LO6

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. J. Bhasker, A VHDL Primer, 3rd ed. Upper Saddle River, NJ, USA: Prentice Hall, 1999.
2. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Pearson Education.
3. Neil H.E. Weste and David Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", Addison Wesley.
4. Xilinx / Cadence / Synopsys Tool Manuals and User Guides.

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
LO1	3	-	-	-	3	-	-	-	-	-	2	2	-
LO2	3	2	3	-	3	-	-	-	-	-	-	2	2
LO3	3	-	3	-	3	-	-	-	-	-	-	2	3
LO4	3	3	-	2	3	-	-	-	-	-	-	2	2
LO5	3	2	3	2	3	2	-	2	2	2	-	2	3
LO6	2	-	-	-	3	-	-	-	-	-	3	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PCC13EC22	System Security	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Programming fundamentals
After the successful completion students should be able to:		
Learning Outcomes	LO1	Implement Secure Authentication and Access Control Mechanisms
	LO2	Analyze and Mitigate Security Threats and Attacks
	LO3	Develop Secure Data Storage and Communication Technique.
	LO4	Conduct Digital Forensics and Intrusion Detection.
	LO5	Apply Security Best Practices in System and Application Development.

	List of Experiments	Ref.
1	**Authentication and Access Control** Implement a secure user authentication system using multi-factor authentication (MFA). • The system should include password-based authentication, OTP verification (email/SMS). • Ensure that passwords are stored securely using bcrypt hashing and include brute-force attack prevention. Explain cracking by John the ripper attack	1, 2
2	**Network and cloud Security** • Develop a network-based intrusion detection system (NIDS). • System should detect malicious network activities such as port scanning, DoS attacks, and unauthorized access attempts	1, 5
3	**Design and implement a secure cloud storage system.** • Users should encrypt and upload their files. The system should ensure confidentiality (AES encryption), integrity (SHA-256 hashing), and access control (role-based permissions)	1, 3
4	**Simulate a ransom ware attack in a controlled environment and implement a detection and recovery mechanism.** The system should detect abnormal file encryption patterns and block the process before it spreads.	1, 3
5	**Perform penetration testing on a web application.**	1,5

	• Use tools like Burp Suite, OWASP ZAP, or manual SQL injection/XSS testing. Identify security vulnerabilities and propose countermeasures	
6	Develop a secure REST API that prevents common web attacks. • SQL injection, Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF), and API key leaks. • Use OAuth 2.0 for authentication and implement rate limiting for protection.	1, 6
7	Simulate a cybercrime investigation scenario where students must analyze a compromised system. • Perform disk forensics (recover deleted files), memory forensics (extract running processes), and network forensics (trace malicious activity using Wireshark).	1, 5
8	Set up a sandbox environment to analyze the behavior of malicious executables. • Extract features like file system changes, network activity. • Registry modifications using tools like Cuckoo Sandbox or Sysinternals Suite.	1, 2
9	Design a zero-trust security framework. • Users and devices must continuously verify their identity before accessing network resources. • Implement least privilege access control, micro-segmentation, and multi-factor authentication in a simulated enterprise network.	2,1,5
10	Develop a secure communication system where messages are encrypted and embedded into an image using steganography. The recipient should be able to extract and decrypt the hidden message.	2,1

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. William Stallings, "Cryptography and Network Security, Principles and Practice", 6th Edition, Pearson Education, March 2013.
2. Behrouz A. Ferouzan, "Cryptography & Network Security", Tata McGraw Hill
3. Behrouz A. Forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security"3rd Edition, McGraw Hill
4. Bruce Schneier, "Applied Cryptography, Protocols Algorithms and Source Code in C",Second Edition.
5. Bruce Schneier, "Applied Cryptography, Protocols Algorithms and Source Code in C", Second Edition, Wiley.

Online Resources:

1. https://github.com/cmin764/cmiN/blob/master/FII/L3/SI/book/W.Stallings%20-%20Cryptography%20and%20Network%20Security%206th%20ed.pdf
2. https://docs.google.com/file/d/0B5F6yMKYDUbrYXE4X1ZCUHpLNnc/view

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
LO1	3	-	-	-	2	-	-	2	2	2	3	-	2
LO2	3	2	-	-	2	2	-	2	2	2	3	-	2
LO3	2	-	2	-	3	-	-	2	2	2	2	-	2
LO4	2	-	-	-	3	2	-	3	2	2	2	-	2
LO5	2	2	-	-	3	-	-	3	2	2	2	-	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: - 0

Blooms level

Remember✓	Understand ✓	Apply ✓	Analyze✓	Evaluate	Create

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(Autonomous College affiliated to University of Mumbai)

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC13	Power Electronics	2	--	--	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		

Pre-requisite Course Codes	Basic Electrical Engineering Electronic Devices and Applications	
Course Outcomes	CO1	Describe the basic operation and characteristics of various semi controllable and fully controllable devices.
	CO2	Design controlled rectifier and analyze their performance.
	CO3	Design dc to dc converter circuits used in various industrial applications.
	CO4	Analyze dc to ac converter circuits and their industrial applications.
	CO5	Develop embedded control strategies for power converters and motor drives.
	CO6	Simulate and interpret converter performance using software tools

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Power Electronics**	1,2	2
	1.1	Overview of Power electronics, Need of power conversion, Need for power electronics in industry.		
	1.2	Power Electronics in Renewable Energy sector, Power electronics in Automotive sector, Applications in Automation and robotics.		
2		**Power Semiconductor Devices and Applications**	1,2,3	6
	2.1	SCR, Operating Principle and V-I characteristics, MOSFET and IGBT, Switching characteristics.		
	2.2	Silicon Carbide (SiC) and GaN devices, Thermal management in power devices, selection of devices for various applications.		
	2.3	**Controlled Rectifiers** - Principle of operation Single phase Half wave and full wave Rectifier (with R and RL Load).		
3		**DC-DC Converter:**	1,4,5	6
	3.1	Introduction to DC-DC conversion, Operation of Buck converter, Operation of Boost converter, Buck-Boost (CCM mode only).		

	3.2	Discuss design of DC - DC converter related to Switched mode power supply and Robotics power supply applications.		
4		**Inverters:**	1,3	**4**
	4.1	Basic principle of single-phase Inverter, Operation of Single phase half bridge voltage source inverter with R load, Operation of single-phase full bridge inverter with R load,		
	4.2	PWM techniques, Basic working principle of three phase bridge inverter (R load)		
5		**Motors and their speed control applications**	1,3,6	**4**
	5.1	Motors and their applications: **Induction motors**: types, construction, principle of operation, characteristics and control. **BLDC Motor, PMSM Motor** : construction, working, control of BLDC motor, BLDC and PMSM drives.		
	5.2	Selection of motors ,suitability of DC and AC machines for EV and Industrial Automation applications.		
6		**Control, Embedded and Digital Interface**	4,8	**4**
	6.1	Microcontroller-based control, PWM generation using Arduino, DSP-based control overview, IoT-enabled power converters.		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:

ISE:

ISE activities carry 20 marks. These activities will be conducted throughout the semester.

MSE:

The written summative examination of 30 marks based on 50% syllabus for 90 minutes.

ESE :

The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

Sr. no	Suggested List of experiments *(Minimum 8 Experiments)*	Ref.
1	Study of I-V characteristics of SCR.	1,2
2	Study of switching characteristics of Power BJT/ Power MOSFET/ IGBT	1,2
3	Implementation of controlled rectifiers.	1,2
4	Study of single phase PWM rectifier.	1,2
5	Design of small solar inverter (simulation)	1,3
6	Design and simulation of Buck / Boost converter .	1,6
7	Simulation of Bidirectional DC-DC Converter .	1,6
8	Design of single phase Bridge Inverter.	1,6,7
9	PWM generation using Arduino	Online
10	Study of AC motor drive (speed control using Open loop and closed loop control)	1,6,7
11	BLDC Speed Control using Microcontroller.	Online

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Ned Mohan, "Power Electronics", 3rd Edition, John Wiley Publication
2. M. H. Rashid, "Power Electronics", Prentice-Hall of India
3. M.D. Singh and K. B. Khanchandani, "*Power Electronics*", Tata McGraw Hill
4. Rodrigo Garcia-Valle, Joao A. Pecas Lopes, "Electric Vehicle Integration into Modern Power Networks", Springer, 2013
5. Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", Taylor & Francis
6. Umanand /L ,"Power Electronics- Essentials and Applications", Wiely India
7. M.B Patil, V Ramanarayanan ," Simulation of Power Electronics Circuits" ,Narosa
8. Dokić, Branko L. and Blanuša, Branko, Power Electronics Converters and Regulators Springer International Publishing, 2015.

Online Resources:

1. Course: Power Electronics By Prof. G. Bhuvaneshwari (IIT Delhi)
   https://swayam.gov.in/nd1_noc20_ee97/preview
2. Course: Advance Power Electronics And Control – Prof. Avik Bhattacharya (IIT Roorkee)
   https://nptel.ac.in/courses/108/107/108107128/

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	-	-	2	2	-	-	-	-	2	3	2
CO2	3	3	2	-	2	2	-	-	-	-	2	3	2
CO3	3	3	2	-	2	2	-	-	-	-	2	3	2
CO4	3	3	2	-	2	2	2	-	-	-	2	3	2
CO5	3	3	2	-	2	2	2	-	-	-	2	3	2
CO5	3	3	3	-	3	2	2	-	-	-	3	3	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember	Understand✓	Apply✓	Analyze✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC14	Digital Signal Processing	2	--	--	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		

Pre-requisite Course Codes		Signals and Systems
After the successful completion students should be able to:		
Course Outcomes	CO1	Classify CT and DT signals and systems and demonstrate the use of Z-transform
	CO2	Apply Discrete Fourier transform and Fast Fourier transform for DT signal analysis
	CO3	Design digital IIR and FIR filters to satisfy the given specifications and evaluate the frequency response.
	CO4	Derive and analyze the frequency-domain characteristics of Multirate systems.
	CO5	Apply signal processing concepts, algorithms in applications related to the field of biomedical and speech signal processing.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Signals, Systems, and Transforms** Continuous time signals and system classifications, Fourier Transform: Definition, purpose, and important properties (without proof),	1, 2, 3	8
	1.2	A typical real-time DSP system, Sampling, Classification of discrete time signals and systems, Discrete time convolution, Z-transform: Definition, concept of region of convergence, application to DT LTI systems	4	
2	2.1	**Discrete Fourier Transform** Definition and Computation of Discrete Fourier Transform, periodicity and symmetry properties.	1, 2, 5	6
	2.2	Fast-Fourier Transform: Introduction, DIT-FFT & DIF-FFT algorithms, radix-2 FFT		
3	3.1	**Digital Filter Design** FIR filter design– Window & frequency sampling method	1,2,5	7
	3.2	IIR filter design – Impulse invariant & Bilinear Z-transform Method		
	3.3	Realization structures for FIR & IIR filters.		
4	4.1	**Introduction to Multirate DSP** Introduction & concept of multirate processing.	1,3	3

	4.2	Decimation by a factor D, interpolation by a factor I, Polyphase Filter structure		
5		**Applications of Digital Signal Processing**	1,3	**2**
	5.1	Application of DSP for ECG signals analysis.		
	5.2	Application of DSP for Dual Tone Multi Frequency signal.		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

Theory:
ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

	Suggested List of Experiments	**Ref.**
1	Generation of standard test signals in signal processing	1, 3
2	Sampling of signals and its effects	1, 3
3	Convolution of DT signals	1, 3
4	To calculate DFT and IDFT of a sequence.	1, 3
5	Verification of the properties of DFT	1, 3
6	Design FIR filter using window method	1, 3
7	Design FIR filter using Frequency Sampling Method	1, 3
8	Design IIR filter using Impulse-Invariance method	1, 3
9	Design IIR filter using Bilnear Z-Transform method	1, 3
10	Develop realization structures for IIR/FIR filters	1, 3
11	Analysis of ECG/EEG signals	1, 3
12	Add and remove ECHO from the signal.	1, 3
13	Real-time Signal Processing using TMS320C713 DSK	1, 3
14	Labview based Digital Signal Processing	Ref. [3]

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

Textbooks:

1. J. Proakis and D. Manolakis, Digital Signal Processing, 4th Edn, Pearson Education.
2. Ashok Ambardar, Digital Signal Processing", Cengage Learning, 2007
3. Sanjit K Mitra "Digital Signal Processing", 3rd Edition, Tata Mcgraw Hill.
4. Oppenheim A. V. and Schafer R W, "Discrete Time Signal Processing",Prentice Hall (1989).
5. S. Salivahanan, A. Vallavaraj, C. Gnanapriya, Digital Signal Processing", 2nd Edition, Tata-Mcgraw Hill, 2011.

Reference Books:

1. Ifeachor, Emmanuel C., and Barrie W. Jervis. *Digital signal processing: a practical approach*. Pearson Education, 2002.
2. Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, John Wiley & Sons. Inc., 2008.
3. Fawwaz Ulaby, Andrew Yagle, Signals & Systems, 2nd Edition, Michigan Publishing, 2024.

Useful Online Links:

1. NPTEL Course by Dr. Mritunjoy Chakraborty, IITKgP: https://onlinecourses.nptel.ac.in/noc25_ee26/preview
2. NPTEL Course by Dr. Vikram Gadre https://nptel.ac.in/courses/108101174

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	2	-	-	2	3	2	-	2	-
CO2	3	2	3	-	2	-	-	2	3	2	2	2	2
CO3	3	2	2	-	2	-	-	2	3	2	-	2	2
CO4	3	2	-	-	2	-	-	2	3	2	-	2	-
CO5	3	-	2	-	2	2	-	2	3	2	2	2	2

Legends:- High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms level

Remember✓	Understand✓	Apply✓	Analyze✓	Evaluate✓	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC15	Analog VLSI Design	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Analog Electronics
After the successful completion students should be able to:		
Course Outcomes	CO1	Discuss trade-offs involved in analog VLSI Circuits.
	CO2	Demonstrate working of single stage amplifier, differential amplifier.
	CO3	Analyze the differential amplifier with active load.
	CO4	Understand the noise consideration in case of differential Amplifier
	CO5	Analyze the performance of operational Amplifier with stability and frequency response.

Module No.	Unit No.	Topics	Ref.	Hrs.
1.		**Analog building blocks**	1,4	**5**
	1.1	Need for CMOS analog and mixed signal designs, MOS Transistor as sampling switch, active resistances, current source and sinks, current mirror.		
	1.2	Voltage References: Band Gap References, General Considerations, Supply-independent biasing,		
	1.3	Temperature independent references, PTAT current generation and Constant Gm biasing		
2		**Amplifier Fundamentals**	1,4	**5**
	2.1	Single Stage Amplifiers: Basic concepts, Gain Bandwidth (GBW)		
	2.2	Common-source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration)		
	2.3	Source follower, common-gate stage, cascode stage, folded cascade stage.		
3		**Differential Amplifiers**	1,2,3	**6**
	3.1	Single ended and differential operation, Basic differential pair		
	3.2	large signal and small signal behavior		
	3.3	Common-mode response, Differential pair with MOS loads		
4		**Noise Consideration**		
	4.1	Statistical Characteristics of Noise, Types of Noise	2,3	**5**

	4.2	Representation of Noise in circuits, Noise in Single stage amplifiers (CS, CD, CG stages)		
	4.3	Noise in differential pairs, noise bandwidth, noise figure, noise temperature		
5		**MOS Operational Amplifiers**	1,2,4	**5**
	5.1	Stability and Frequency Compensation: General Considerations, Multipole systems, Phase margin, Frequency compensation, compensation of two stage op- amps		
	5.2	Op-amp Design: General Considerations, performance parameters, One-stage op-amps, Two-stage op-amps, Gain Boosting, Common-mode feedback, Input range limitations (ICMR), Slew Rate, Power supply rejection, Noise in op-amps		
	5.3	Design of single ended and double ended two stage Op-Amps, Data Converter Fundamentals		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:

ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

Module No.	Sr.no	Suggested List of experiments	Ref.
1	**1**	Study analog VLSI circuits	1,2
	2	Analysis of MOSFETs for analog performance	
	3	Design and simulate various types of current mirror circuits	
	4	Design and simulate various common source amplifier circuits	
	5	Design and simulate various types of single stage amplifiers	
2	**6**	Design and simulate differential amplifier	1,2,3
	7	Design and simulate operational transconductance amplifier	
	8	Design and simulate switch capacitor circuits	

	9	Design and simulate various types of oscillators	
3	**10**	Design and simulate mixed mode circuit	2,3
	11	Study analog VLSI circuits	
	12	Analysis of MOSFETs for analog performance	
	13	Design and simulate various types of current mirror circuits	
4	**14**	Design and simulate various common source amplifier circuits	2,3
	15	Generate layout for the simple and cascode current mirror	
	16	Generate layout for common source amplifier	
5	**17**	Generate layout for the differential amplifier	
	18	Generate layout for the Oscillator	
	19	Generate layout for Phase Detector	

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. B Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill, 1st Edition.
2. R. Jacaob Baker, Harry W. Li, David E. Boyce, "CMOS Circuit Design, Layout, and Simulation", Wiley, Student Edition
3. P. E. Allen and D. R. Holberg, "CMOS Analog Circuit Design", Oxford University Press, 3rd Edition.
4. Gray, Meyer, Lewis, Hurst, "Analysis and design of Analog Integrated Circuits", Willey,5th Edition

Online Resources:

1. https://nptel.ac.in/courses/117/101/117101105/
2. https://www.coursera.org/lecture/vlsi-cad-layout/basics-1MtuT
3. https://www.google.com/search?client=firefox-b-d&q=h

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SUGGESTED CO - PO Articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	2	-	-	-	-	-	2	2	2	2
CO2	3	3	3	2	2	-	-	-	-	2	2	2	2
CO3	3	3	3	3	2	-	-	-	-	2	2	2	2
CO4	3	3	3	2	2	-	-	-	-	2	2	2	2
CO5	3	3	3	3	3	-	-	-	-	2	2	2	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms level

Remember	Understand✓	Apply✓	Analyze✓	Evaluate✓	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13E16	Internet of Things Laboratory	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		25PCC11CS03: Digital Electronics 25PCC12EC06: Computer Organization & Architecture PCC13EC17: Embedded Systems and RTOs
After the successful completion students should be able to:		
Learning Outcomes	LO1	Interface various sensors to any IoT device and push data onto cloud.
	LO2	Remotely control various devices using Blynk App and Node-red environment.
	LO3	Implement IoT protocols to control devices remotely
	LO4	Implement services like Google Assistance, Adafruit I/O, IFTTT, Firebase etc in IoT.

	List of Experiments	Ref.	LOs
1	**Title:** Embedded Hardware–Software Interfacing **Task:** Interface a Sensor (temperature/proximity/optical) using ESP32/ ESP 8266 board/ Raspberry PI	7,8	1
2	**Title:** Porting Sensor Data to the Cloud **Task:** Interfacing DHT 11 sensor to the cloud using Thingspeak	7, Online1	1
3	**Title:** Controlling a device using Blynk **Task:** Blinking an LED connected to NodeMCU using Blynk	7, Online2	2
4	**Title:** Interfacing of a Flex Sensor to monitor the bend angle and pusing data to cloud **Task:** Reading data from a Flex Sensor connected to ESP32/ ESP 8266	7,8	1
5.	**Title:** Understanding the Node-Red environment for IoT applications **Task:** Controlling IoT devices/sensors remotely using Node-Red and Raspberry PI	Online3	2
6.	**Title:** Using Voice commands to control IoT devices **Task:** ESP8266 Voice Control with Google Assistant (Adafruit IO and IFTTT)	Online 4	4

7.	**Title:** Implementation of MQTT protocol **Task:** Implementing Publish-Subscribe model using MQTT protocol and DHT11 sensor	1,2	3
8.	**Title:** AWS IoT Publishing sensor data from ESP32 to AWS IoT Cloud	Online 5	1
9.	**Title:** Google Firebase Controlling LED using Android App	Online6	4
10.	**Title:** IoT Application Development: **Task:** a. Choose an IoT application domain (e.g., smart home, healthcare, agriculture). b. Develop a prototype application using appropriate hardware components, sensors, and actuators. c. Integrate the application with cloud services or a mobile app for remote monitoring and control.	All Online	1,2,3 ,4

Note: In the initial lab sessions, spoken tutorials will be conducted to provide better understanding the concept of IoT.

Suggested list of IoT Applications and Case Studies:

1. Smart Homes: Home Automation, Smart Lighting, Smart Security Systems
2. Smart Cities: IoT for Traffic Management, Waste Management, and Public Safety
3. Healthcare IoT: Remote Patient Monitoring, Wearable Health Devices
4. Industrial IoT (IIoT): Smart Manufacturing, Predictive Maintenance, Digital Twins
5. Agriculture IoT: Smart Irrigation, Precision Farming, IoTEnabled Drones
6. Retail and Supply Chain IoT: Smart Inventory Management, RFID, Asset Tracking
7. Automotive IoT: Connected Vehicles, Telematics, V2X Communication
8. Energy and Environment: Smart Grid, Renewable Energy Monitoring, Environmental Sensing

Course Assessment: -
(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach, Universities Press.
2. Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw Hill Education, First Edition
3. David Hanes, Gonzalos Algueiro, "IoT Fundamentals Networking Technologies, Protocols and Use Cases for Internet of Things", Cisco Press, Kindle 2017 Edition
4. Andrew Minteer, "Analytics for the Internet of Things (IoT)", Kindle Edition
5. Adrian McEwen, Hakim Cassimally: Designing the Internet of Things", Paperback, First Edition
6. Yashavant Kanetkar, Shrirang Korde: Paperback "21 Internet of Things (IOT) Experiments", BPB Publications
7. M.A.Mazidi, J.C.Mazidi, Rolin D. McKinlay,"The 8051 Microcontroller and Embedded

Systems
8. Using Assembly and C", Pearson Education, Second Edition, 2007. 9. https://www.arduino.cc

Online Links:

1. https://thingspeak.mathworks.com
2. https://blynk.io/
3. https://nodered.org/
4. https://www.instructables.com/Home-Automation-Using-Google-Assistant-and-Adafrui/
5. https://aws.amazon.com/iot-core/features/
6. https://www.instructables.com/IoT-Using-Firebase-and-NodeMCU-and-Custom-Android-/
7. https://www.electronicsforu.com/
8. https://www.instructables.com/circuits/projects

Suggested CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PSO1	PSO2
LO1	3	2	2	2	3	-	-	-	-	-	-	2	-
LO2	2	2	3	-	3	-	-	-	-	2	2	-	2
LO3	3	3	2	-	2	-	-	-	-	-	2	-	2
LO4	2	2	3	-	3	-	3	-	3	-	2	-	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember ✓	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC17	Image Processing Lab	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Signals and Systems
After the successful completion students should be able to:		
Learning Outcomes	LO1	Implement basic image processing operations and transformations
	LO2	Apply enhancement and filtering techniques for image quality improvement
	LO3	Develop image segmentation and morphological processing algorithms
	LO4	Perform feature extraction and edge detection methods
	LO5	Design and implement image processing applications for real-world problems

	List of Experiments	Ref.	LOs
1	Write a program to read and display images using a library (e.g., OpenCV/Matplotlib).	1, 2	LO1
2	Perform basic operations: grayscale conversion, cropping, resizing, and flipping images.	1, 2	LO1
3	Implement histogram equalization for image enhancement.	1, 2	LO2
4	Apply spatial filters: smoothing (average filter) and sharpening (Laplacian filter).	1, 2	LO2
5	Perform Fourier Transform to enhance images in the frequency domain.	1, 2	LO2
6	Implement edge detection algorithms: Sobel, Prewitt, and Canny.	1, 2	LO4
7	Apply thresholding techniques for image segmentation (global and adaptive thresholding).	1, 2	LO3
8	Perform morphological operations: erosion, dilation, opening, and closing.	1, 2	LO3
9	Write a program to compress an image using a standard technique (e.g., Run-Length Encoding).	1, 2	LO5
10	Perform color image processing: separate and manipulate RGB channels.	1, 2	LO1
11	Extract features from an image using edge and corner detection methods.	1, 2	LO4
12	Design and implement an application (e.g., license plate detection or face recognition).	1, 2	LO5

	Mini Project Topics: • Develop a photo editor application with basic operations Implement an OCR (Optical Character Recognition) system Design a real-time face detection application • Create a histogram-based image matching application • Implement a medical imaging system for noise reduction and enhancement		

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", 4th Edition, Pearson Education
2. Anil K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall

Online Resources:

1. https://opencv.org/
2. https://docs.opencv.org/

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	3	-	-	-	2	2	-	2	-
CO2	3	3	2	2	3	-	-	-	2	2	-	2	2
CO3	3	3	3	2	3	-	-	-	2	2	-	2	2
CO4	3	3	2	2	3	-	-	-	2	2	-	2	2
CO5	2	2	3	3	3	2	2	2	3	3	2	3	3

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember	Understand ✓	Apply ✓	Analyze ✓	Evaluate ✓	Create ✓

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC23	Natural Language Processing	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE		ESE		Total	
						Min	Max		
		Theory	20	30		20	50	100	
		Lab	50	--		--	--	50	

Pre-requisite Course Codes		Machine learning Automata theory
After the successful completion students should be able to:		
Course Outcomes	CO1	Describe the mathematical and linguistic preliminaries necessary for various processes in NLP.
	CO2	Perform Word-Level analysis on a natural language.
	CO3	Perform Syntax-Level analysis on a natural language.
	CO4	Analyze the natural language at Semantic Level.
	CO5	Explain Pragmatics in NLP.
	CO6	Apply NLP techniques to design real-world NLP applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1.		**Introduction to Natural Language Processing**	1,3	4
	1.1	The need of NLP, Levels of NLP		
	1.2	Stages in building a Natural Language Processing System		
	1.3	Challenges and ambiguities in NLP Design		
	1.4	Mathematical preliminaries required for NLP: Probability Theory, Conditional Probability and Independence, Bayes Rule, Probability Distributions, Statistics: Counting, Frequency, Mean and Variance		
2		**Word Level Analysis**	1,3	5
	2.1	Tokenization, Segmentation, Lemmatization, Edit Distance, Collocations, Porter Stemmer		
	2.2	N-gram Language Model, Evaluating N-gram Model: Perplexity, Smoothing		
	2.3	Morphological Analysis, Derivational and Reflectional Morphology		
3		**Syntax Analysis**	3,4	5
	3.1	Tag set for English (Penn Tree bank), Introduction to Parts of Speech Tagging (POST), Types of POS tagging: Rule–based, stochastic and Transform based.		

	3.2	Markov Processes, Hidden Markov Models (HMM), Parts of Speech Tagging using Hidden Markov Models, Viterbi Algorithm		
4		**Semantic Analysis**		
	4.1	Lexical Semantics, ambiguous words, word senses, Relations between senses: synonym, antonym, reversives, hyponym, hypernym, meronym, structured polysemy, metonymy, zeugma	3,4	**4**
	4.2	Study of Various language dictionaries: WordNet (gloss, synset, sense relations in WordNet), Babelnet.		
	4.3	Cosine distance between documents.		
	4.4	Word sense disambiguation: Knowledge based approach (Lesk's Algorithm), Supervised (Naïve Bayes, Decision List), Introduction to Semi-supervised method (Yarowsky) Unsupervised (Hyperlex)		
5		**Pragmatics & Discourse Processing**	5,6	**4**
	5.1	Reference resolution: Discourse model, Reference Phenomenon, Syntactic and Semantic Constraints on co reference		
6		**Applications of NLP**	1,3	**4**
	6.1	Applications of NLP: Machine Translation, Text Summarization, Sentiment Analysis, Named Entity Recognition, Information Retrieval, Question Answer System		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

(a) Theory:

ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE: The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus)for 120 minutes.

	Suggested List of experiments	Ref.
1.	Preprocessing of text (Tokenization, Filtration, Lower casing, Stop Word Removal etc.)	1,2,6
2.	Perform Stemming and Lemmatization on a given Text	1,2,6
3.	Study different POS taggers and Perform POS tagging on the given text.	1,2,6
4.	Implement N-Gram model for the given text input.	1,2,6
5.	Implement Chunking and Named Entity Recognition	1,2,6
6.	Implement POS tagging using HMM	1,2,6
7.	To extract word senses in a given sentence using WordNet	1,2,6
8.	Implement Text Similarity Recognizer for the chosen text documents (TF-IDF)	1,2,6
9.	Mini project implementation for real-world problems	1,2,6
10.	Mini project presentation/Group activity/ Simulation using modern tools	-

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books :

1. Daniel Jurafsky, James H. and Martin, "Speech and Language Processing", Second Edition, Prentice Hall, 2008.
2. Christopher D. Manning and Hinrich Schutze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.
3. Siddiqui and Tiwary U.S., "Natural Language Processing and Information Retrieval", Oxford University Press, 2008.
4. Daniel M Bikel and Imed Zitouni, "Multilingual natural language processing applications: from theory to practice", IBM Press, 2013.
5. Alexander Clark, Chris Fox, Shalom Lappin, "The Handbook of Computational Linguistics and Natural Language Processing", John Wiley and Sons, 2012.
6. Nitin Indurkhya and Fred J. Damerau, "Handbook of Natural Language Processing", Second Edition, Chapman and Hall/CRC Press, 2010.
7. Steven Bird, Ewan Klein, "Natural Language Processing with Python", O'Reilly, 2009.

Online Resources:

1. Course: Natural Language Processing By Prof. Pawan Goyal, IIT Kharagpur (https://onlinecourses.nptel.ac.in/noc21_cs102/preview)
2. Course: Applied Natural Language Processing By Prof. Ramaseshan R, CMI (https://onlinecourses.nptel.ac.in/noc20_cs87/preview)

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SUGGESTED Co - Po Articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	2	2	2
CO2	3	2	2	-	2	-	-	-	-	-	-	3	3
CO3	3	3	2	2	2	-	-	-	-	-	-	3	3
CO4	3	3	2	2	2	-	-	-	-	-	-	2	2
CO5	2	2	-	-	-	2	2	-	2	-	-	3	3

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: -

Blooms level

Remember	Understand✓	Apply✓	Analyze✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC24	Big Data Analytics	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Database Management Systems, Data structures
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply fundamental Big Data techniques, to develop problem-solving and critical-thinking skills.
	CO2	Classify different forms of Big Data and demonstrate efficient methods for collection, storage, querying, and analysis
	CO3	Apply Hadoop, Map Reduce, and NoSQL for intelligent business and scientific computing applications..
	CO4	Implement Big Data analytics techniques in real-world applications.
	CO5	Analyze business models and scientific computing paradigms while utilizing software tools for Big Data analytics.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Big Data Analytics**		2
	1.1	Introduction to Big Data, Big Data characteristics, Types of Big Data, Traditional vs. Big Data a business approach	T1	
	1.2	Technologies Available for Big Data, Infrastructure for Big Data, Big Data Challenges, Case Study of Big Data Solutions.		
2		**Hadoop and NoSQL**		8
	2.1	Introduction to Hadoop. Core Hadoop Components, Hadoop Ecosystem-Apache HBase, Hive, HCatalog, Pig, Mahout, Oozie, Zookeeper, Sqoop, Physical Architecture, Hadoop limitations.	T1	
	2.2	Introduction to NoSQL, NoSQL business drivers, NoSQL database case studies.		
	2.3	NoSQL data architecture patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, Variations of NoSQL architectural patterns.		
	2.4	Using NoSQL to manage big data:Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; Four ways that NoSQL		

		systems handle big data problems, Managing MongoDB database with CRUD operations.		
		MapReduce		**6**
3	**3.1**	MapReduce and The New Software Stack: Distributed File Systems, Physical Organization of Compute Nodes, Large Scale File-System Organization.	T1 T2	
	3.2	MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping With Node Failures		
	3.3	Algorithms Using MapReduce: MapReduceWordCount Program, Matrix-Vector Multiplication by MapReduce , Relational-Algebra Operations by MapReduce, Matrix Operations,Matrix Multiplication by MapReduce.		
4		**Techniques in Big Data Analytics**		**4**
	4.1	Finding Similar Item: Nearest Neighbor Search, Similarity of Documents, Distance Measures: Euclidean, Jaccard , Cosine , Edit and Hamming Distance with its Examples	T1 T2	
	4.2	Mining Data Streams: Data Stream Management Systems, Data Stream Model, Examples of Data Stream Applications: Sensor Networks, Network Traffic Analysis Filtering streams: The Blooms filter.		
	4.3	Link Analysis: PageRank Definition, Structure of the web, dead ends, Using Page rank in a search engine, Efficient computation of Page Rank: Page Rank Implementation Using MapReduce.		
	4.4	Frequent Itemset Mining: Market-Basket Model, Apriori Algorithm, Algorithm of Park Chen-Yu.		
5		**Big Data Analytics Applications**		**6**
	5.1	Recommendation Systems: Introduction, A Model for Recommendation Systems: Collaborative-Filtering System, Content based system and its Examples.	T1 R1	
	5.2	Mining Social-Network Graphs: Social Networks as Graphs, Types of Social-Network. Clustering of Social Graphs: Applying Standard Clustering Techniques, Counting triangles using MapReduce.		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

Course Assessment:

Theory:

ISE: ISE activities carry 20 marks. These activities will be conducted throughout the semester.
MSE: The written summative examination of 30 marks based on 50% syllabus for 90 minutes.
ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

List of Experiments		
1	Hadoop HDFS Practical: -HDFS Basics, Hadoop Ecosystem Tools Overview. -Installing Hadoop. -Copying File to Hadoop. -Copy from Hadoop File system and deleting file. -Moving and displaying files in HDFS.	T1 R2
2	To install and configure MongoDB/ Cassandra/ HBase/ Hypertable to execute NoSQL commands.	T1
3	Perform CRUD operations in MongoDB	T1
4	Implementing simple algorithms in Map-Reduce: Matrix multiplication, Aggregates, Joins, Sorting, Searching, etc.	T1
5	Write a program to implement word count program using Map Reduce.	T1 R2
6	Implement PageRank using Map-Reduce.	T1 R2
7	Implementing any one Clustering algorithm (K-Means/CURE) using Map-Reduce.	T1 R2
8	Implement Bloom Filter using any programming language	T1
9	To demonstrate use of recommendation system for movie rating prediction	T1
10	To find common friends in social network graph using Map-Reduce.	T1
11	Mini project/presentation/Group activity/ case study using modern tools	T1 R2

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation

Recommended Books

1. Radha Shankarmani and M Vijayalakshmi —Big Data Analytics‖, Wiley
2. Alex Holmes —Hadoop in Practice‖, Manning Press, Dreamtech Press.
3. Dan McCreary and Ann Kelly —Making Sense of NoSQL – A guide for managers and the rest of us, Manning Press.

Online Resources:

1. https://www.analyticsvidhya.com/blog/2014/05/hadoop-simplified
2. https://www.analyticsvidhya.com/blog/2014/05/introduction-mapreduce/
3. https://www.pdfdrive.com/big-data-analytics-a-hands-on-approach-e158549112.html
4. https://www.pdfdrive.com/data-science-and-big-data-analytics-e58447171.html

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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	-	-	-	2	-	-	2	2	2	2	-	2
CO3	3	2	-	-	2	-	-	2	2	2	2	-	2
CO4	2	2	3	-	3	2	-	2	2	2	2	-	2
CO5	2	2	-	-	-	2	2	2	2	2	2	-	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping: - 0

Blooms level

Remember✓	Understand✓	Apply ✓	Analyze✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC25	Advanced Algorithms	2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Data structure concepts, Discrete structures
After the successful completion students should be able to:		
Course Outcomes	CO1	Analyze the running time and space complexity of algorithms
	CO2	Analyze the complexity of divide and conquer, greedy and dynamic programming strategy
	CO3	Identify appropriate data structures and design techniques for different problems
	CO4	Differentiate polynomial and non-deterministic polynomial algorithms
	CO5	Analyze various algorithms

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to analysis of algorithm**		6
	1.1	Mathematical background for algorithm analysis, Growth of function – Big – Oh, Omega, Theta notation, Complexity derivations	1,2,4	
	1.2	Solving recurrences using Substitution Method, Recursion tree method and Master method		
	1.3	Complexity Classes: P, NP, NP Hard, NP Complete		
2		**Divide and Conquer approach**		4
	2.1	General method, Binary Search, Merge Sort, Quick Sort, Randomized quick sort, and Min-max algorithm	1	
3		**Greedy Algorithms**		6
	3.1	General Method, Knapsack Problem, Huffman's Codes , Minimum Spanning Tree, Kruskal's Algorithm , Prim's Algorithm , Dijkstra's Algorithm	1,2	
4		**Dynamic Programming Approach**		6
	4.1	General Method, Making coin change, Principle of optimality, Knapsack Problem, Matrix Chain Multiplication, Activity Selection Problem, All pair shortest path algorithm.	1,2	
5		**Maximum Flow and Classical Problems in Algorithms**		4
	5.1	Flow networks, Ford Fulkerson method.	1	

	5.2	Travelling Salesman problem, Subset Sum Problem, Matrix Multiplication, 15 puzzle , N-queens problem		
			Total	**26**

Self-Learning:

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content**.**
2. Evaluation of the self-learning components is carried out in all the evaluation components.

(a) Theory:

Course Assessment:

Theory:

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ESE : The written summative examination will be conducted for 50 marks based on the complete syllabus (20% questions on syllabus covered before MSE and 80% questions on the remaining syllabus) for 120 minutes.

List of Experiments			
1	Implementation of Merge and Quick sort using divide and conquer approach.	T1 R2	2
2	Implementation of Fractional Knapsack	T1	2
3	Implementation of Djikstras's algorithms	T1	2
4	Implementation of 0/1 Knapsack using dynamic programming	T1	2
5	Implementation of Longest Common Subsequence	T1,R2	2
6	Implementation of Floyd's Warshall's algorithm	T1,R2	2
7	Implementation of Ford Fulkerson algorithm	T1 R2	2
8	Implementation of Travelling salesman's problem.	T1	4
9	Implementation of sum of subsets algorithm	T1	4
10	Implementation of 15 puzzle problem	T1	4

(b) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to Algorithms", Third Edition, The MIT Press, 2009. 2.
2. Michael T Goodrich and Roberto Tamassia, "Algorithm Design: Foundations, Analysis and Internet Examples", John Wiley and Sons, 2002.
3. Sanjoy Dasgupta, Christos Papadimitriou and Umesh Vazirani, "Algorithms", Tata McGraw-Hill, 2009
4. R. K. Ahuja, TL Magnanti and JB Orlin, "Network flows: Theory, Algorithms, and Applications", Prentice Hall Englewood Cliffs, NJ 1993.
5. M. R. Garey and D.S. Johnson, Computers and Intractability: A Guide to the Theory of NPCompleteness, Freeman, 1979.
6. E. Horowitz and S. Sahni, Fundamentals of Computer Algorithms, Computer Science Press,1978.

Online References:

1. NPTEL course: https://nptel.ac.in/courses/106105164 2.
2. Coursera link: https://www.coursera.org/specializations/algorithms

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	2	2	-	-	2	-	-	2	2	2	2	-	2
CO3	3	-	-	-	2	-	2	2	2	2	2	-	2
CO4	2	2	2	-	3	-	2	2	2	2	2	-	2
CO5	2	-	-	-	2	-	-	2	2	2	2	-	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: - 0

Blooms level

Remember	Understand✓	Apply ✓	Analyze✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13EC26	Deep Learning Laboratory	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE			Total	
					Min	Max			
		Theory	--	--	--	--		--	
		Lab	50	--	--	--		50	

Pre-requisite Course Codes		VSE11EC02 (Creative coding with python), PCC13EC18 (Machine Learning)
After the successful completion students should be able to:		
Learning Outcomes	LO1	Design and Train deep learning models for supervised learning task.
	LO2	Design and Train deep learning models for unsupervised learning task
	LO3	Design, train, and optimize deep learning models by tuning hyperparameters to improve model performance.
	LO4	Select and implement appropriate deep learning model to solve real world problem.

Exp. No.	Topic	Ref.
1	**Introduction to Python Libraries for Deep Learning:** **Objectives:** To introduce various python libraries used for DL models. **Task:** Explore python libraries for deep learning e.g. Theano, TensorFlow, pytorch etc.	**1,2**
2	**Optimization algorithms:** **Objectives:** Implementing Optimization algorithms **Task:** Apply any of the following learning algorithms to learn the parameters of the supervised single layer feed forward neural network. a. Stochastic Gradient Descent b. Mini Batch Gradient Descent c. Momentum GD d. Nestorev GD e. Adagrad GD f. Adam Learning GD	**1,2,3**
3	**Fully Connected Neural Network:** **Objectives:** To design and train Fully connected Neural networks for Image classification. **Task:** Design and implement a fully connected deep neural network for **digit classification**. Use appropriate Learning Algorithm, output function and loss function.	**1,2,3**

4	**Convolutional Neural Networks (CNNs) for Image Classification:** **Objective**: Apply CNNs for image classification tasks. **Task:** Design and implement a CNN model for image classification. Use **CIFAR-10** (images of 10 classes: airplanes, cats, etc.). Build a CNN model with: • Convolutional layers (with filters, e.g., 32 filters of size 3x3) • Pooling layers (max pooling) • Fully connected layers at the end • Softmax output layer **Optimization:** Use Adam optimizer and categorical cross-entropy loss function. **Evaluation:** Monitor accuracy and loss during training, and test on the validation dataset. **Experimentation:** Change the architecture of CNN for example change the number of filters and kernel sizes, the number of layers. And observe the model performance.	**1,2,3**
5	**Transfer Learning with Pre-Trained Models:** **Objectives**: Learn how to use pertained models for transfer learning. **Task:** Use a smaller dataset (e.g., Flowers dataset with 5 classes). Classify flower species using a pre-trained models such as **VGG16, ResNet50**, or **InceptionV3** from Keras. Remove the final fully connected layers. Add a custom fully connected layer suited for your task. **Optimization:** Use fine-tuning on the last layers and train the modified model. **Evaluation:** Track accuracy on the validation dataset. **Experiment Variations**: • Freeze earlier layers and fine-tune later layers. • Compare performance with and without transfer learning.	**3,4**
6	**Time-Series Forecasting with Recurrent Neural Networks (RNNs):** **Objective**: Introduce sequence modeling with RNNs and use them for time-series forecasting. **Task:** Use Stock price data, temperature data, or any time-series dataset. Build and train an RNN/LSTM/GRU to predict future values based on historical data.	**3,4,5**
7	**Auto encoders for Dimensionality Reduction and Anomaly Detection:** **Objective**: Learn how auto encoders can be used for unsupervised tasks like anomaly detection and dimensionality reduction. **Task:** The **MNIST dataset** (or a custom dataset with normal and anomalous data).	**3,4,5**

	Task: Detect anomalous data points (e.g., outlier detection). Build an autoencoder with: • Encoder: A few convolutional or dense layers to reduce dimensionality. • Decoder: Reconstructs the input data. **Optimization**: Use **Mean Squared Error (MSE)** as the loss function. **Evaluation**: Evaluate reconstruction error. Data points with high reconstruction error can be considered anomalies. **Experiment Variations**: • Use a bottleneck layer with varying sizes. • Implement Variational Autoencoders (VAE) for generative capabilities.	
8	**Generative Adversarial Networks (GANs) for Image Generation:** **Objective**: Introduce generative models, focusing on GANs, to generate new images. **Task:** Use the **CelebA** dataset (celebrity faces). Generate realistic-looking faces from random noise. Implement a GAN with: • A **generator** network to generate fake images from random noise. • A **discriminator** network to distinguish real vs. fake images. **Training**: Use adversarial training where both networks compete and improve simultaneously. **Evaluation**: Evaluate the quality of generated images using visual inspection or Inception Score/FID. **Experiment Variations**: • Modify the architecture of the generator and discriminator. • Try conditional GANs where the generation is conditioned on certain labels (e.g., age, gender).	**6,7**

9	**Hyperparameter Tuning and Model Optimization:**
	
	Objective: Learn how to tune hyperparameters for better model performance.
	Task: Use **CIFAR-10** dataset. Build a neural network (MLP or CNN).
	1. **Hyperparameters to tune**:
	  ○ Learning rate, batch size, number of epochs.
	  ○ Number of layers, units per layer, activation functions.
	2. **Method**: Use **Grid Search** or **Random Search** for hyperparameter optimization.
	3. **Evaluation**: Track training and validation accuracy.
	4. **Experiment Variations**:
	  ○ Use early stopping or learning rate decay.
		6,7

	○ Try more advanced methods like **Bayesian Optimization** or **Hyperband**.	
10	**Attention Mechanisms and Transformer Models:** **Objective**: Explore transformer-based models and attention mechanisms in NLP tasks. **Task:** Use a **text dataset** (e.g., sentiment analysis with IMDB dataset). Classify movie reviews as positive or negative. Implement a transformer model using attention mechanisms (For example BERT). **Optimization**: Use **cross-entropy loss** and **Adam optimizer**. **Evaluation**: Evaluate accuracy, precision, recall, and F1-score. **Experiment Variations**: • Try pre-trained transformer models (like BERT or GPT). • Fine-tune a pre-trained model on your specific task.	**7,8**
11	**Mini Project:** **Task:** Defining the problem statement and objectives. Select, implement and train a suitable deep learning model to solve the real world problem. Evaluate the model based on suitable evaluation metrics. Interpret the results to understand how well the model addresses the problem. **Mini Project based on the content of the syllabus (Group of 2-3 students)**	

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville. ―Deep Learning, MIT Press Ltd, 2016
2. Li Deng and Dong Yu, ―Deep Learning Methods and Applications, Publishers Inc.,2013.
3. Satish Kumar "Neural Networks A Classroom Approach", Tata McGraw-Hill, 2nd Edition.
4. Deep Learning from Scratch: Building with Python from First Principles- Seth Weidman by O`Reilley
5. François Chollet. ―Deep learning with Python ―(Vol. 361). 2018 New York: Manning.
6. Douwe Osinga. ―Deep Learning Cookbook, O'REILLY, SPD Publishers, Delhi.
7. M. J. Kochenderfer, Tim A. Wheeler. ―Algorithms for Optimization, MIT Press.
8. Learning Deep Learning: Theory and Practice of Neural Networks, Computer Vision, NLP, and Transformers using TensorFlow, Magnus Ekman, Released August 2021, Addison-Wesley Professional

Online Repository:

1. DeepLearning.AI Coursera: https://www.coursera.org/specializations/deep-learning
2. NPTEL course on Deep Learning: https://onlinecourses.nptel.ac.in/noc20_cs62/preview
3. https://keras.io/
4. https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-recurrent-neuralnetworks
5. https://keras.io/examples/vision/autoencoder/
6. https://stanford.edu/~shervine/teaching/cs-230/cheatsheet convolutional-neuralnetworks

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
LO1	3	2	3	2	3	-	-	-	-	-	2	2	2
LO2	3	2	3	2	3	-	-	-	-	-	2	2	2
LO3	2	3	2	3	3	-	-	-	-	-	2	2	2
LO4	3	3	3	2	3	2	2	2	2	2	3	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember ✓	Understand ✓	Apply ✓	Analyze ✓	Evaluate	Create

Society of St. Francis Xavier, Pilar's
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
PEC13EC27	Software Testing and Quality Assurance Lab	--	--	**2**	--	--	--	**1**	**1**
		Examination Scheme							
			ISE	**MSE**	**ESE**		**Total**		
					Min	**Max**			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Software Engineering, Programming fundamentals
After the successful completion students should be able to:		
Learning Outcomes	LO1	Demonstrate an understanding of fundamental software testing concepts, differentiate between effective and exhaustive testing strategies.
	LO2	Analyze software requirements to find testable components and create effective test strategies.
	LO3	Identify and formulate test scenarios based on software requirements, use cases, and risk analysis to ensure comprehensive test coverage.
	LO4	Apply white box and black box testing techniques for structural and functional testing
	LO5	Apply Quality Assurance principles, processes, and methodologies to ensure software reliability.

Experiment No	Title	Ref.
1	Concepts of software testing, Exhaustive testing	1,2
2	Requirement analysis for testing	1,2
3	Identifying test scenarios	1,2
4	Black box techniques – Equivalence partitioning	1,2
5	Black box techniques – Boundary value analysis	1,2
6	Black box techniques – Decision table	1,2
7	Black box techniques – Cause effect graphing	1,2
8	Black box techniques – Error guessing	1,2
9	White box techniques – Statement and decision coverage	1,2
10	White box techniques – Basis path testing	1,2
11	White box techniques – Loop testing	1,2
12	STLC – perform all activities in STLC	1,2
13	Quality Assurance – activities for QA review, checklist, training	1,2

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. Software Testing Principles and Practices Naresh Chauhan Oxford Higher Education

2. Software Testing and quality assurance theory and practice by Kshirasagar Naik,

Priyadarshi Tripathy, Wiley Publication

3. Effective Methods for Software Testing, third edition by Willam E. Perry, Wiley Publication

4. Software Testing Concepts and Tools by Nageswara Rao Pusuluri, Dreamtech press

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	-	-	-	-	-	-	-	2	2	3
CO2	2	3	3	2	2	-	-	2	2	-	2	2	3
CO3	2	3	2	3	3	-	-	2	2	-	2	2	3
CO4	2	2	3	2	2	2	3	2	2	2	2	3	3

Legends :- High: 03, Medium: 02,Low: 01, No Mapping: -

Blooms level

Remember✓	Understand✓	Apply✓	Analyze✓	Evaluate	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25OE13CE4X	Public Relations and Corporate Communication (Semester-VI)	2	--	--	2	2	--	--	2
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	100	--	--	--	100		

Pre-requisite Course Codes	Speaking, Listening, Writing and Reading Skills	
Course Outcomes	CO1	Develop employable communication skills through practical usage
	CO2	Draft professional documents with precision
	CO3	Develop effective communication strategies for diverse, cultural and global business environment

Sr. No	Unit	Module	Ref.	Hrs
1		**Career Advancement Skills**	R-1,3	**8**
	1.1	Resume Writing & Cover Letter for Employment		
	1.2	Group Discussion		
	1.3	Impressive Grooming		
	1.4	Communication Simulation		
	1.5	Interview Techniques		
2		**Synergy Communication**	R-4	**8**
	2.1	Presentation Skills		
	2.2	Report Writing- Importance, Objective, types…		
	2.3	Meetings and Documentation: Notice, Agenda, Minutes		
3		**Cross-Cultural Communication**	R-2,4	**5**
	3.1	Cultural awareness		
	3.2	Language barriers		
	3.3	Global communication strategies		
4		**Corporate Identity and Branding**	R-5	**5**
	4.1	Corporate image and reputation		
	4.2	Branding strategies		
	4.3	Visual identity		
	4.4	Messaging and tone		
			Total	**26**

Self Learning Component:

a. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
b. Evaluation of the self-learning components is carried out in all the evaluation components.

Assessment:

ISE Activities

1. Report & Power point Slides 20 marks
2. Presentation skills: 10 marks
3. Assignments 20 marks
4. Assignments/ Role Play/ Case studies 20 marks
5. Group Discussion 20 marks
6. Mock Interviews 10 marks

Sr. No.	List of Assignments	COs
a	Resume/ Cover Letter: prepare resume and draft a customized cover letter for internship or a specific job role.	CO1
b	GD Practices: Participate in structured group discussions on current and general topics.	C01
c	Mock Interview HR Question: Undergo simulated HR interviews.	C01
d	Team Building Activity: Role play, Engage in interactive group tasks and problem-solving activities.	CO1
e	Notice & Agenda and Minutes of the Meeting: practice by organizing a mock meeting and documenting the proceedings accurately	CO2
f	Report and PPT Making: Prepare formal reports on assigned topics following proper structure and formatting guidelines and design PowerPoint Presentations	CO3
g	Corporate Identity and Branding: Role play and Case studies	CO4

Recommended Textbooks:

- Dr. K.Alex, Soft Skills- Know Yourself & know the World, S.Chand
- John Hayes, Interpersonal Skills at Work, McGraw Hill Education
- Ankur Malhotra,Campus Placement: A Comprehensive Guide, McGraw Hill Education
- Meenakshi Raman,Sangeeta Sharma, Communication Skills, Oxford, India
- Courtland L. Bovee, Business Communication Today, Pearson

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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Program Outcomes (POs)											Program Specific Outcomes* (PSOs)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	–	–	–	–	–	2	–	2	–	2	–	3	2
CO2	–	2	2	–	–	2	–	2	3	2	2	2	3
CO3	–	2	2	–	–	–	2	3	2	2	2	2	2

Legends :- High: 03, Medium: 02,Low: 01, No Mapping

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze ✓	Evaluate✓	Create

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25VSE13EC04	Data Acquisition and Processing	--	--	2	--		--	1	1
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	--	--	--	--	--		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		Signals and Systems Electronic Devices
After the successful completion students should be able to:		
Learning Outcomes	LO1	Describe the characteristics of sensors and transducers.
	LO2	Design and Implement signal conditioning circuit.
	LO3	Demonstrate the working of Sample and Hold Circuit and Data Converters.
	LO4	Differentiate among various types of Data Acquisition Systems.
	LO5	Analyze the significance of Virtual Instrumentation in Data Acquisition Systems (DAS).
	LO6	Apply modern instrumentation tools for data acquisition applications.

	List of Experiments	Ref.	LOs
1	Draw the characteristics of the Linear Transducer (Thermistor/ RTD/ Strain Gauge etc.)	1,2, 3	LO1
2	Digital Transducer working (Speed measurement, Shaft Encoder)	1,2, 3	LO1
3	Design of Instrumentation Amplifier	1,2, 3	LO2
4	Design of 4-20 mA current loop in measurement	1,2, 3	LO2
5	Dual Slope A/D converter working	1,2, 3	LO3
6	SAR Type 3-bit A/D Converters	1,2,3	LO3
7	2-bit Flash type A/D Converter	1,2,3	LO3
8	Single Channel DAS	1,2,3	LO4

9	Multiple Channel DAS system	1, 2, 3	LO4
10	Data Logger	1, 2, 3	LO4
	Total	**26**	

Course Assessment: -

(a) Laboratory:

ISE: Laboratory ISE is divided into two components: 25 marks for submission of experiments and 25 marks for oral/practical evaluation.

Recommended Books:

1. A. K. Sawhney, Ä Course in Electrical and Electronic"Measurements and Instrumentation", Dhanpat Rai & Sons.
2. Helfrick, Albert D., and William David Cooper. Modern electronic instrumentation and measurement techniques. Englewood Cliffs, NJ: Prentice Hall, 1990.
3. Rangan, C. S., Garimella R. Sarma, and V. S. V. Mani. "Instrumentation: devices and systems.", 1983..
4. Bela G. Liptak, Instrument Engineers Handbook Vol. 1 and 2, 4th Edition, CRC Press.

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	**Program Outcomes (POs)**											**Program Specific Outcomes* (PSOs)**	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
LO1	3	-	-	2	-	-	-	-	-	-	2	3	2
LO2	3	2	3	-	2	-	-	-	-	-	-	3	2
LO3	3	2	-	3	2	-	-	-	-	-	-	2	3
LO4	3	3	-	-	2	-	-	-	-	-	2	2	2
LO5	3	2	3	2	3	2	-	2	2	2	-	3	3
LO6	2	-	-	-	3	-	-	-	-	-	3	2	2

Legends: - High: 03, Medium: 02, Low: 01, No Mapping

Blooms level

Remember ✓	Understand✓	Apply✓	Analyze ✓	Evaluate	Create