CURRICULUM STRUCTURE
FINAL YEAR UG: B. E

ELECTRONICS AND COMPUTER SCIENCE

REVISION: FRCRCE-3-26

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

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Dean Academics

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Principal

Society of St. Francis Xavier, Pilar's
Fr. Conceicao Rodrigues College of Engineering
Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050
(Autonomous College affiliated to University of Mumbai)

Vision and Mission –Fr. CRCE

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.

Mission

M1 Develop industry-ready engineers with strong academic foundations, practical skills, and an entrepreneurial mindset 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 [PEOs]

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

Program Specific Outcomes [PSOs]

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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FINAL YEAR Electronics and Computer Science (ECS) Engineering Program

Proposed Scheme for BE ECS 2026-2027

SEM-VII/VIII													
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			
25PEC14ECXX	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25PEC14ECXX	PCPEC	PCC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25PEC14ECXX	PCPEC	PCC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25PEC14ECXX	PCPEC	PCC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25MDM6X	MDC	MDM	MDM Course-1	TH	2	20	30	20	50	100	2	2
25MDM7X	MDC	MDM	MDM Course-2	TH	2	20	30	20	50	100	2	2
25RMC14EC01	EL	RM	Essentials of Research Methodology	TH	2	20	30	20	50	100	2	2
25RMC14EC02	EL	RM	Intellectual Property Rights	TH	2	20	30	20	50	100	2	2
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**

Project or Internship is mutually exclusive in SEM-VII or SEM-VIII
Remaining credits can be acquired in SEM-V to SEM-VIII
Online course 1 Credit=4 Week course from SWAYAM can be taken in SEM V or SEM VIII
Online min 8-week course from SWAYAM can be taken in SEM V to SEM VIII to complete 2 credit course (Combination of two 4-week credit courses shall be allowed with prior approval)
* Online min 12-week course from SWAYAM can be taken in SEM V to SEM VIII to complete 3 credit course

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

Track A:

Course Code	Name of the Course
25PEC14EC18	Power Electronics
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 Algorithms
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 (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC14EC18	Power Electronics	2	--	2	--	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Practical	50	--	--	--	50		

Pre-requisite Course Codes	Basic Electrical and Electronics Engineering, Electronic Devices and Applications	
Course Outcomes	CO1	Describe the basic operation and characteristics of various semi-controllable and fully controllable devices.
	CO2	Analyze various single-phase and three-phase power converter circuits and understand their applications.
	CO3	Analyze DC-to-DC converter circuits and their applications.
	CO4	Analyze DC-to-AC converter circuits and their industrial applications.
	CO5	Apply the basic concepts to select motors and power converters for various applications.

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, Importance and applications in various industries.		
	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	5
	2.1	SCR Construction, Operating Principle and V-I characteristics, Construction and working of MOSFET and IGBT, Comparison of MOSFET and IGBT, applications of MOSFET and IGBT.		
	2.2	Silicon Carbide (SiC) and GaN 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	Design of DC-DC converter, discuss design of Buck/Boost converter related to Solar PV and Battery charger applications.		
4		**Inverters:**	1,3	5
	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	Basic working principle of three phase bridge inverter (R load)		
5		**Motors and their speed control applications**	1,3,6	5
	5.1	Motors and their applications: ***Induction motors***: types, construction, principle of operation, characteristics and control. ***BLDC Motor***: construction, working, electronic commutation, control of BLDC motor.		
	5.2	Selection and sizing of motors, suitability of DC and AC machines for EV/HEV applications, AC and DC Motor drives.		
6		**Power Electronics converters for Grid interfacing**	4,8	3
	6.1	Application of Power converters in renewable and EV applications. Basic EV AC and DC Chargers.		
			Total	**26**

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.

Sr. no	List of 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 Single phase Half wave and Full wave rectifiers.	1,2
4	Study of single phase PWM rectifier.	1,2
5	To simulate a grid-tied inverter with synchronization using PLL.	
6	To design and test a Buck converter for EV battery charging.	1,6
7	Simulation of Bidirectional DC-DC Converter (V2G Concept)	1,6
8	Design of single-phase Bridge Inverter.	1,6,7
9	Study of AC motor drive (speed control using Open loop and closed loop control)	1,6
10	Design of Battery charger for EV. Simulation of Bidirectional DC-DC Converter (V2G Concept)	Online
11	Grid Connected Inverter using SPWM	

Lab Assessment:

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:

NPTEL/ Swayam

Course:

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 (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	2	1	-	-	-	-	2	-	3	2
CO2	3	3	2	-	2	1	-	-	-	-	2	-	3	2
CO3	3	3	2	-	2	1	-	-	-	-	2	-	3	2
CO4	3	3	2	-	2	1	1	-	-	-	2	-	3	2
CO5	3	3	2	-	2	1	1	-	-	-	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 (Hours / Week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
		2	--	2	--	2	--	1	3
25PEC14EC19	Robotics	Examination Scheme							
			ISE	MSE	ESE			Total	
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		25PCC13EC11 (Control Systems)
After the successful completion, students should be able to:		
Course Outcomes	CO1	Define & describe fundamental concepts of robotics including robot anatomy, workspaces, degrees of freedom, actuators, sensors & basic control systems.
	CO2	Solve forward & inverse kinematics problems to determine the position and orientation of a manipulator using homogeneous transformations.
	CO3	Apply trajectory planning algorithms
	CO4	Evaluate and compare different robot trajectory planning techniques based on requirements for smooth motion and task completion time.
	CO5	Select the appropriate robot configuration for a given real-life practical task based on requirements & workspace envelope

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction To Robotics:** Introduction to robotic & industrial automation, laws of robotics, basic components of robot system & elements of a typical industrial robot control system	1, 2	2
	1.2	Specifications of robots, classification of robots, introduction to robotics workspace envelopes & workspace geometry, industrial applications of robots & future trends	1, 2	2
2	2.1	**Direct Kinematics – The Arm Equation:** Dot & cross products, co-ordinate frames, rotations, homogeneous co-ordinates, links co-ordinates & analysis of 1 DOF, 2 DOF planar manipulators	2, 3	3
	2.2	Denavit & Hartenberg (D-H) representation, five-axis articulated robot, the four-axis SCARA robot, the six-axis articulated robot & numerical examples with analysis	2, 3	3
3	3.1	**Inverse Kinematics – Solving the Arm Equation:** The inverse kinematics problem, general properties of solutions (existence & uniqueness of solutions) & tool configurations	2, 3	3
	3.2	Inverse kinematics of four-axis SCARA robot, three-axis planar articulated robot, six-axis articulated robot, numerical examples	2, 3	3

4	**4.1**	**Workspace Analysis & Trajectory Planning:** Workspace analysis, work envelope of the five-axis articulated robot, work envelope of the four-axis SCARA robot, the workspace fixtures	4	3
	4.2	Basics of trajectory planning, joint-space trajectory planning, pick & place operations, continuous path motion, interpolated motion, straight line motion with numerical examples	4	3
5	**5.1**	**Task Planning:** What is task level Programing, uncertainty, configuration space, gross motion planning; grasp planning, fine-motion planning, simulation of planar motions, source & goal scenes, BUG-1, BUG-2 & tangent bug algorithms	1, 4	4
Total				**26**

Course Assessment:

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.

No.	List of Experiments	Ref.
1.	Study of Robotic Kinematic Manipulator Arm	1
2.	The Direct / Forward Kinematics Problem	1, 2
3.	The Inverse / Reverse Kinematics Solution	1, 2
4.	Trajectory Planning by Joint – Space Analysis	3, 4
5.	Trajectory Planning by Cartesian Coordinate State Space Analysis	3, 4
6.	Motion Planning by Linear Parabolic Blends	3, 4
7.	Mini – Project	1 – 4
8.	Students' Seminar / Poster Presentation on Self – Learning Topics	1 – 4

Course Assessment:

(a) Practical / 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. Robert Shilling, "Fundamentals of Robotics – Analysis & Control, Prentice Hall of India, 2009
2. Saeed Benjamin Niku, "Introduction to Robotics – Analysis, Control, Applications", Wiley India Pvt. Ltd., Second Edition, 2011
3. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling & Control", Wiley India Pvt. Ltd. 2006
4. Mikell Groover et.al, "Industrial Robots – Technology, Programing & Applications", McGraw Hill, New York, 2008

Suggested CO-PO Articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	3	2	2	-	-	-	-	-	-	2	-	3	-	2
CO-2	3	3	2	2	2	-	-	-	-	-	-	2	-	2
CO-3	2	3	3	2	2	-	-	-	-	-	-	2	-	2
CO-4	2	3	2	3	2	-	-	-	-	-	-	-	-	2
CO-5	3	3	3	2	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
		2	--	2	--	2	--	1	3
		Examination Scheme							
25PEC14EC30	ASIC Verification		ISE	MSE		ESE			Total
						Min		Max	
		Theory	20	30		20		50	100
		Lab	50	--		--		--	50

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Programable Devices and Verification Basics**	1,2	5
	1.1	Programable Devices Different types of Integrated Circuits- CPLD, FPGA, ASIC, SoC (System-on-Chip), SiP (System-in-Package), MCM (Multi-Chip Module), SoP (System-on-Package), Choices based on application and cost, Architecture of FPGA, CPLD (Xilinx and Altera family devices), Difference between ASIC, FPGA and CPLD, ASIC flow and overview of types of tools used in each stage of lifecycle.		
	1.2	Verification Basics Introduction, Verification Process, Verification Plan, Verification Methodology options, Basic Testbench Functionality, Directed Testing, Constrained-Random Stimulus, Functional Coverage, Testbench Components, Layered Testbench, Technology challenges test, Verification languages, Verification IP reuse, Verification approaches		
2		**Data Types, Procedural Statements Connecting the Test bench and Design**	3	6
	2.1	Data Types Built-in Data Types, Logic Data type, Fixed-Size Arrays (Packed and Unpacked arrays), Dynamic Arrays, Queues, associative array, array methods – Reduction, Locator & ordering, Creating New Types with typedef, Creating User-Defined Structures, Enumerated Types, Constants, Strings, Expression width.		
	2.2	Procedural statements		

		Procedural Statements, Tasks, Functions, and Void Functions, routine arguments, returning from a routine, Time values.		
	2.3	Connecting the Test bench and Design Separating the testbench and design, The Interface construct, Grouping Signals in an Interface using Modports, Creating Interface Monitor, Stimulus timing with Clocking Block, Testbench design Race Condition, Program Block, Connecting it all together, Top level Scope, Program-Module interaction		
3		**Basic Object-Oriented Programing (OOP)**	3	4
	3.1	Basic Object-Oriented Programing (OOP) Class, Creating new objects, Where to Define a Class, OOP Terminology, Understanding Dynamic objects, Object Deallocation, using objects, Static vs Global Variables, Class methods, defining methods outside class, Scoping rules, Using one class inside another, Understanding Dynamic objects, Copying objects, public vs. local, Building a testbench.		
4		**Randomization Threads and Inter-process Communication**	1,2	5
	4.1	Randomization Randomization in system Verilog, Constraint details, Solution probabilities, controlling multiple constraint blocks, Valid constraints, In-line constraints, The pre-randomize and post-randomize functions, Random number functions, Constraints tips and techniques.		
	4.2	Threads and Inter-process Communication Working with threads, disabling threads, inter-process communication, Events, Semaphores, Mailboxes, building a testbench with threads and IPC.		
5		**System Verilog Assertions, Functional Coverage**	4,5	3
	5.1	System Verilog Assertions Types of Assertions and examples, Immediate Assertions, Concurrent Assertions, SVA Property and Sequences, Implication (Overlapped & Non-Overlapped) Operator and Repetition Operator, SystemVerilog Assertion built-in methods ($rose, $fell, $stable, $past).		
	5.2	Functional Coverage Coverage Types, Functional Coverage Strategies, Simple Functional Coverage Example, anatomy of a cover group, triggering a cover group, data sampling, cross coverage, generic cover groups, Coverage Options, Parameterized Cover Groups,		

		Analysing Coverage Data, Measuring Coverage Statistics During Simulation		
6		**UVM-Based Verification Methodology, Verification at IP/Subsystem/SoC Level**	2, 3, 4	5
	6.1	UVM-Based Verification Methodology Introduction to Universal Verification Methodology (UVM), UVM Standardization and Benefits, UVM Class Library and Base Classes, UVM Testbench Architecture - Sequencer, Driver, Monitor, Agent (Active and Passive), Scoreboard, Environment, Test. UVM Factory and Configuration Database, UVM Phases (Build, Connect, Run, etc.), UVM Transaction Level Modeling (TLM), UVM Sequence and Sequence Items, UVM Automation Macros (field_macros, object_utils, component_utils), Register Abstraction Layer (RAL) Model basics.		
	6.2	Verification at IP/Subsystem/SoC Level IP Level Verification - Block level testbench structure, Protocol checkers, Verification IP (VIP) integration. Subsystem Level Verification - Integration of multiple IPs, Interface verification, Bus functional models (BFMs), Interconnect verification. SoC Level Verification - Full chip verification strategies, System level testbenches, Co-verification approaches, Power-aware verification, Clock domain crossing (CDC) verification, Low power verification techniques.		
			Total	**26**

Course Assessment:

Theory:

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	List of Experiments	**Ref.**
1	Introduction to EDA Simulation Tool	1
2	System Verilog Data Types and Arrays	1
3	Tasks, Functions and Testbench Basics	3,8
4	Interface and Clocking Blocks	3,8
5	Object-Oriented Programing in System Verilog	3,8
6	Randomization and Constraints	1,2,5
7	Functional Coverage	1,2,5
8	UVM Based Verification	2,5

Course Assessment: -

(Lab)

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

Recommended Books:

1. Chris Spear, "System Verilog for Verification: A guide to learning the testbench language features", Springer, 3rd Edition
2. Janick Bergeron, "Writing Testbenches Using SystemVerilog", Springer 2006.
3. Stuart Sutherland, Simon Davidmann, and Peter Flake, "System Verilog for Design: A
4. guide to using system verilog for hardware design and modeling", Springer, 2nd Edition.
5. Ben Cohen, Srinivasan Venkataramanan, Ajeetha Kumari and Lisa Piper, "SystemVerilog
6. Assertions Handbook", Vhdl Cohen Publishing, 3rd edition

References:

1. S Prakash Rashinkar, Peter Paterson and Leena Singh, "System on Chip Verification Methodologies and Techniques", Kluwer Academic, 1st Edition
2. System Verilog Language Reference manual
3. Samir Palnitkar, "Verilog HDL: A guide to Digital Design and Synthesis" second edition, Pearson – IEEE 1364-2001 compliant
4. Spartan and Virtex family user manuals from Xilinx
5. Verilog Language Reference manual

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	PO12	PSO1	PSO2
CO1	3	2	-	-	2	-	-	-	-	-	-	1	2	-
CO2	3	3	2	-	3	-	-	-	-	-	-	2	3	2
CO3	3	3	2	2	3	1	-	-	-	-	-	2	3	2
CO4	3	3	3	2	3	1	-	1	-	-	-	3	3	3
CO5	3	3	3	3	3	1	1	1	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 (Hours / Week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
		2	--	2	--	2	--	1	3
		Examination Scheme							
25PEC14EC28	Quantum Computing		ISE	MSE	ESE		Total		
					Min	Max			
		Theory	20	30	20	50	100		
		Lab	50	--	--	--	50		

Pre-requisite Course Codes		--Quantum Mechanics, Linear Algebra
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the fundamental differences between classical and quantum computing paradigms
	CO2	Design and analyze quantum circuits using quantum logic gates.
	CO3	Implement fundamental quantum algorithms, including Shor's algorithm and Grover's algorithm, using quantum computing frameworks.
	CO4	Analyze quantum cryptography techniques, such as quantum key distribution, to evaluate their role in secure communication systems.
	CO5	Evaluate the potential and limitations of quantum computing applications in machine learning, optimization, and cloud-based quantum computing.

Module No.	Unit No.	Topics	Ref.	Hrs.
1.		**Introduction to Quantum Computing & Industry Trends**	1,2,3	4
	1.1	Classical vs. Quantum Computing, Qubits, Entanglement, Superposition and interferences,		
	1.2	Industry Applications: Cybersecurity, AI, Finance, Drug Discovery		
	1.3	Current Quantum Hardware: IBM, Google, Intel, Rigetti, D-Wave		
2		**Mathematical Foundations**	1,2	4
	2.1	Linear Algebra for Quantum Computing, Probability in Quantum Mechanics		
	2.2	Dirac Notation & State Vectors		
	2.3	Tensor Products and Unitary Transformations, Tensor Products of Matrices		
3		**Quantum Gates & Circuits**	1,2,3	5
	3.1	Pauli Gates (X, Y, Z), Hadamard (H), Phase (S, T)		
	3.2	Controlled and Multi-Qubit Gates (CNOT, Toffoli, Fredkin)		

	3.3	Quantum Circuit Design for Optimization & AI, Reversible Computing & its Role in Low-Power Design		
4		**Quantum Algorithms**	2,3	5
	4.1	Shor's Algorithm (Breaking RSA Cryptography)		
	4.2	Grover's Algorithm (Search Optimization)		
	4.3	Variational Quantum Eigensolver (VQE) for AI/ML		
5		**Quantum Cryptography & Security**	1,2,4	4
	5.1	Quantum Key Distribution (BB84, E91)		
	5.2	Post-Quantum Cryptography (NIST Standards)		
	5.3	Quantum Secure Cloud Computing, Quantum-Resistant Blockchain Technologies		
6		**Quantum Hardware & Programing**	4	4
	6.1	Superconducting Qubits vs. Trapped Ions vs. Photonic Qubits		
	6.2	Cloud-Based Quantum Platforms: IBM Quantum, Google Quantum AI		
	6.3	Programing with Qiskit, Cirq, and Braket, Challenges in Scaling Quantum Computers		
			Total	**26**

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.

Sr.	List of Experiments	Ref.
1	Implement $\|0\rangle$ $\|1\rangle$ and superposition states $\|+\rangle$and $\|-\rangle$	4
2	Implement and visualize X, Y, Z, H, S, T gates	4
3	Design a quantum circuit for simple logical operations	4
4	Create an entangled Bell pair and measure correlations	4
5	Implement quantum teleportation using IBM Quantum	4
6	Optimize unstructured search problems using Grover's Algorithm	4
7	Factorize small numbers and analyze RSA vulnerability	4
8	Implement Quantum Neural Networks (QNNs) for classification	4
9	Simulate and test secure quantum key exchange	4
10	Prepare case study for any suitable application for Weather Forecasting and Climate Change	4
11	Prepare case study for any suitable application for Artificial Intelligence	4

Course Assessment: - (Lab)

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

Recommended Books:

1. Michael A. Nielsen, Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 2010 (10th Anniversary Edition)
2. Chris Bernhardt, "Quantum Computing for Everyone", MIT Press
3. Phillip Kaye, Raymond Laflamme, Michele Mosca, "An Introduction to Quantum Computing", Oxford University Press
4. Eric R. Johnston, Nic Harrigan, Mercedes Gimeno-Segovia, "Programing Quantum Computers: Essential Algorithms and Code Samples", O'Reilly Media
5. Post-Quantum Cryptography" — by Daniel J. Bernstein, Johannes Buchmann, and Erik Dahmen
6. Quantum Machine Learning: An Applied Approach" — by Santanu Ganguly

Online Resources:

1. IBM Quantum Experience: https://quantum-computing.ibm.com/ - Cloud-based quantum computing platform with free access to real quantum computers
2. Qiskit Textbook: https://qiskit.org/textbook/ - Comprehensive open-source quantum computing textbook with interactive code examples
3. Google Quantum AI: https://quantumai.google/ - Research papers, Cirq framework documentation, and quantum computing resources
4. Quantum Open Source Foundation (QOSF): https://qosf.org/ - Community-driven quantum computing resources and projects
5. Quantum Algorithm Zoo: https://quantumalgorithmzoo.org/ - Comprehensive catalog of quantum algorithms
6. QuTiP (Quantum Toolbox in Python): http://qutip.org/ - Open-source software for simulating quantum systems

SUGGESTED CO - PO articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	2	-	-	-	-	-	-	-	-	-
CO3	2	2	3	2	2	-	-	-	-	-	-	-	-	-
CO4	2	3	2	2	2	3	-	-	-	-	-	-	-	3
CO5	2	3	2	2	3	2	-	-	-	-	-	2	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
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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
		2	--	2	--	2	--	1	3
25PEC14EC29	Blockchain Technology	Examination Scheme							
			ISE	MSE	ESE			Total	
					Min	Max			
		Theory	20	30	20	50		100	
		Lab	50	--	--	--		50	

Pre-requisite Course Codes		25PCC13CE19
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the fundamental concepts of blockchain technology and distributed ledger systems.
	CO2	Analyze the role of cryptocurrencies, consensus algorithms, and mining in ensuring blockchain security.
	CO3	Explain the working principles and architecture of the Ethereum platform.
	CO4	Design and implement smart contracts using Solidity for decentralized applications.
	CO5	Explore Hyperledger Fabric and its working as a private blockchain.
	CO6	Apply blockchain components and processes to develop solutions for real-world problems.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Blockchain Technology:** Issues with centralized systems, Distributed Ledger Technology (DLT), Decentralization, What is a blockchain, Origin of blockchain, Foundation of blockchain: Genesis block, Merkle trees, Components of blockchain, Block in blockchain. Limitations and applications of blockchain	1,3	3
	1.2	Transactions creation and verification, Mempool, Types of blockchain: Public, Private, and Consortium, Consensus protocols: Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-	1,3	3

		Stake (PoS), and Proof-of-Elapsed Time (PoET), Mining in blockchain		
2	**2.1**	**Cryptocurrency:** Bitcoin, Altcoin, and Tokens (Utility and Security), Transactions in Bitcoin, UTXO and double spending problem, The Halving policy	1,3	3
	2.2	Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transactions, Accounts, Architecture and Workflow, Gas, Gas Limit,Gas Price, Ethereum frameworks	1,2	3
3	**3.1**	**Programing for Blockchain 2.0** Introduction to Smart Contracts, Types of Smart Contracts	1	1
	3.2	Introduction to Programing: Solidity Programing – Basics, functions, Visibility and Activity Qualifiers, Address and Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Strings, Structure, Mapping, Inheritance, Error handling, Events	Useful Link 5	4
4		Need of Private Blockchain, Consensus Algorithms for Private Blockchain - PAXOS, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT	1	3
5		**Enterprise Blockchain:** Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric Architecture, Components of Hyperledger Fabric, Transaction Flow.	1, Ref.3	3
6		**Application Blockchain Technology** **Government & Identity:** E-governance solutions, voting systems, decentralized identity management. **Finance & Banking:** Cryptocurrencies, cross-border payments, decentralized finance (DeFi), and asset tokenization. **Supply Chain Management:** Real-time tracking of goods, provenance, reducing fraud, and increasing transparency. **Healthcare:** Secure sharing of electronic health records (EHR), medical data integrity. **Digital Assets & Web 3.0:** Non-fungible tokens (NFTs), Metaverse	1	3
			Total	**26**

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	Construction of Merkle tree and verification of transaction	1,3
2	MetaMask installation and transfer of ethers	Useful Links: 6
3	Create a simple blockchain using Proof of Work (PoW)	1.3
4	Solidity program: voting application	Useful Links: 5
5	Solidity program: crowd funding	Useful Links: 5
6	Solidity program: Transactions using Remix IDE and MetaMask	Useful Links: 5
7	Implementation of PAXOS/PBFT algorithm	6
8	Block mining and reward transfer to the account	2
9	Smart contract execution using Ganache	Useful Links: 5
10	Genesis block creation using Geth	Useful Links: 8
11	Hyperledger installation and execution of application on Hyperledger platform.	6 and Useful Links: 7
12	Mini project – Development of smart contract for Dapps	-

Course Assessment (Lab):

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 Dr. Gavin Wood, O'reilly.
3. Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing.
4. Blockchain for Beginners, Yathish R and Tejaswini N, SPD
5. Blockchain Basics, A non-Technical Introduction in 25 Steps, Daniel Drescher, Apress
6. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

Useful Links:
1. https://www.blockchain.com/explorer/assets/btc
2. https://etherscan.io/
3. https://bitcoin.org/bitcoin.pdf
4. https://ethereum.org/en/whitepaper/
5. https://docs.soliditylang.org/
6. https://metamask.io/
7. https://intellipaat.com/blog/tutorial/blockchain-tutorial/hyperledger/
8. https://www.youtube.com/watch?v=qcjfrUclfyw https://geth.ethereum.org/docs/fundamentals/privatenetwork
9. https://www.geeksforgeeks.org/computer-networks/ethereum-block-structure/
10.https://www.blockchain-council.org/dao/daos-vs-traditional-organizations/
11.https://www.geeksforgeeks.org/blogs/top-applications-of-blockchain-in-the-real-world/ https://mcrhrdi.gov.in/splfc2-2022/week9/Blockchain-Casestudies%20-%20Rukma%20Rekha.pdf 11. https://www.linkedin.com/pulse/real-world-blockchain-case-studies-roland-rust
1 https://www.geeksforgeeks.org/ethical-hacking/blockchain-interoperability/

Suggested CO - PO articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	–	–	1	1	–	–	–	–	1	-	-	2
CO2	3	3	–	1	1	1	1	–	–	–	1	-	-	2
CO3	3	2	1	1	3	–	–	–	–	–	1	-	-	2
CO4	3	2	3	2	3	1	1	-	-	–	1	-	-	2
CO5	2	2	2	1	1	-	1	-	-	-	1	-	-	2
CO6	3	3	3	2	-	2	1	2	3	-	2	-	1	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
		2	--	2	--	2	--	1	3
25PEC14EC40	Soft Computing and Optimization Algorithms	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	Explain concepts of soft computing paradigms and optimization.
	CO2	Design and implement fuzzy inference systems for decision-making problems.
	CO3	Apply genetic algorithm concepts to solve optimization problems in search spaces.
	CO4	Apply swarm intelligence algorithms for solving real-world applications.
	CO5	Design and implement hybrid soft computing models for intelligent system applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Soft Computing** Concept of Soft Computing vs Hard Computing, Need for Optimization in Computing, Basic tools of soft computing – Fuzzy logic, neural network, evolutionary computing. Application scope of neural networks, fuzzy logic, genetic algorithm, and hybrid systems.	1,2	2
	1.2	**Introduction to Learning Rule** Introduction to learning and adaptation, Hebbian learning rule, Perceptron learning rule, Delta (Widrow–Hoff) rule, Backpropagation algorithm, Competitive learning rule, gradient descent and error minimization, convergence concepts, comparison of learning rules, and applications of neural network learning mechanisms	1,2	3
2		**Evolutionary Algorithms** Biological background and Overview of evolutionary computing, Genetic algorithm and search space, Operators in genetic algorithm- encoding, selection, crossover, and mutation, Classification of GA	3	7
3		**Evolutionary Algorithms** Biological background and Overview of evolutionary computing, Genetic algorithm and search space, Operators in genetic algorithm- encoding, selection, crossover, and mutation, Classification of GA	3	4

4		**Swarm Intelligence Algorithms** Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Simulated Annealing (SA), Differential Evolution (Overview), Comparative Study of Swarm Methods, Industrial Use Cases (Routing, Robotics, ML Tuning)	4	6
5	**5.1**	**Hybrid Soft Computing & Case Studies** Neuro-Fuzzy systems, GA–ANN hybrid models, hybrid soft computing architectures. Case study of hybrid computing systems.	4,5	4
			Total	**26**

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.

Sr.	List of Experiments	Ref.
1	1.1 Implement optimization of an objective function using Hard and Soft Computing Techniques 1.2 Implementation of Hebbian Learning Rule / Delta (Widrow–Hoff) Learning Rule	1
2	2.1 Develop a fuzzy logic–based decision support system to evaluate and classify outcomes based on multiple input criteria. 2.2 Implement a multi-parameter evaluation system using fuzzy set theory and fuzzy relations to assess overall system performance.	1
3	3.1 Implement a Fuzzy Inference System (FIS) to dynamically adjust system output based on varying input conditions. 3.2 Implement a fuzzy logic system and compare different defuzzification methods to analyze their impact on the final output.	3,8
4	4.1 Implement a Genetic Algorithm to determine the optimal sequence of tasks or operations in order to minimize overall completion time or system cost. 4.2 Apply a Genetic Algorithm to select an optimal subset of features from a given dataset to improve the performance of a predictive or classification model.	3,8
5	5.1 Apply a Genetic Algorithm to optimize key model parameters in order to enhance the performance and accuracy of a machine learning system.	3,8
6	6.1 Implement Particle Swarm Optimization to minimize or maximize an objective function in a constrained optimization problem. 6.2 Apply Ant Colony Optimization to determine an optimal solution for a combinatorial optimization problem involving path or sequence selection.	1,2,5

7	Implement a Neuro-Fuzzy system by integrating fuzzy inference mechanisms with neural network learning capabilities to model and solve nonlinear prediction or classification problems.	1,2,5
8	Implement a hybrid soft computing framework by integrating two or more soft computing techniques (e.g., Fuzzy Logic, Neural Networks, Genetic Algorithms, or Swarm Intelligence) to solve complex optimization or decision-making problems.	2,5

Course Assessment: -

(Lab)

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. S.Rajasekaran and G.A.Vijayalakshmi Pai ,Neural Networks, Fuzzy Logic and Genetic Algorithms PHI Learning.
2. S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing, Wiley publications, 2nd Edition.
3. David E. Goldberg , Genetic Algorithms - Pearson Education, 2006
4. Andries P. Engelbrecht, Computational Intelligence: An Introduction, Pearson Education.
5. *J.-S. R. Jang et al., Neuro-Fuzzy and Soft Computing, Pearson Education.*

References

1. Andries P. Engelbrecht, "Computational Intelligence: An Introduction", 2nd Edition- Wiley India- ISBN: 978-0-470-51250-0
2. N.P.Padhy, "Artificial Intelligence and Intelligent Systems" Oxford University Press, ISBN 10: 0195671546 .
3. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" , Wiley India, ISBN: 978- 0-470-74376-8
4. Eiben and Smith, "Introduction to Evolutionary Computation", Springer, ISBN-10: 3642072852

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SUGGESTED CO - PO articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	_	2	-
CO2	3	3	3	-	3	-	-	-	-	-	-	_	3	-
CO3	3	3	2	-	3	1	1	-	-	-	-	_	3	-
CO4	3	3	3	-	3	1	1	-	-	-	-	_	3	2
CO5	3	3	3	-	3	1	1	1	2	2	-	_	3	2

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

Remember	Understand✓	Apply✓	Analyze ✓	Evaluate	Create

Society of St. Francis Xavier, Pilar's
Fr. Conceicao Rodrigues College of Engineering
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC14EC41	Product, services and IT service management	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		25PCC13CE16(Software Engineering), 25PCC12CE010 (Operating Systems), 25PCC13CE11(Computer Networks)
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply the concepts of IT Service management in Product and Service lifecycle
	CO2	Analyze the underlying components (Infrastructure and Applications) of products and services
	CO3	Design the value co-creation process to improve the overall customer and user experience
	CO4	Apply modern tools, automation, and emerging technologies to manage and improve IT service operations

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Overview of Products and IT Services**: Introduction to industrial revolutions from 1.0 to 5.0, overview of products, services, and their underlying components, IT Infrastructure, Data Centre and Cloud computing, Application management (Development to maintenance	2	5
2	2.1	**IT Service Management and delivery of IT Services:** Introduction to IT Service Management, the standards and frameworks in the industry and its evolution, concepts Value management, 4 Ps of IT service management, Principles and guidelines, IT Service management process and procedures overview	1	6
3	3.1	**IT Service Management best practices:** Application of IT service management best practices in IT Service delivery,	1,3	5
	3.2	**Portfolio, Program and Project Management while delivering IT Product and Services:** Introduction to Portfolio, Program and Project Management structure and its importance while delivering IT products and services. Methodologies and industry practices, Agile overview, Concepts of Scrum, Kanban and Lean, use of Agile mindset, principles and methods in IT products and service delivery		

4	**4.1**	**Everything as a Service:** Different types of Cloud based computing models (IaaS, PaaS, SaaS), Role of service management in service-based cloud model, importance of service integration and management in multi supplier environment	1, 2	6
	4.2	**DevOps and IT Service management:** Introduction to DevOps, management of deployment and releases, improve resilience and reliability of products and IT services, understanding service mindset		
5	**5.1**	**Use of technology to manage services:** How technology enables management of services, tools for IT service management, IT operations management (event monitoring and integration), Toil reduction using automation, Artificial Intelligence infused IT service operations	1,2	6
			Total	**26**

Course Assessment:

Theory:

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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.	List of Experiments	
1	Study of ITIL 4 Service Value System -Identify components of Service Value System and map them to a real IT service	1
2	IT Service Lifecycle Mapping - Map an IT service (e.g., online learning platform) to ITSM lifecycle stages	1
3	Infrastructure Analysis of an IT Service -Analyze infrastructure and application components of a given IT service	2
4	Cloud Service Model Comparison -Compare IaaS, PaaS, and SaaS with respect to service management challenges	2

5	Value Co-Creation Analysis -Identify stakeholders and design a value co-creation model for an IT service	1
6	DevOps Pipeline & ITSM Study -Analyze how CI/CD pipelines integrate with IT service operations	1,3
7	ITSM Tool Exploration -Hands-on study of ticketing, incident, and change management using an ITSM tool	1
8	Automation & Toil Reduction -Identify repetitive IT operations tasks and propose automation strategies	2
9	AI-enabled IT Operations (AIOps) -Study AI-based incident prediction and monitoring use cases	2

Course Assessment: -
(Lab)

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

Recommended Books:

1. Axelos, *ITIL Foundation: ITIL 4 Edition (ITIL 4 Foundation)*, 2nd edition, Axelos UK, 2024.
2. Nikhilesh Mishra, *Mastering IT Infrastructure Management: Concepts, Techniques, and Applications*, Independently Published (Amazon), 2023.
3. Rahul Shah, *Agile Essentials: From Concepts to Customer Delight*, Notion Press Media Pvt. Ltd., 2025.

Useful Links

- https://www.udemy.com/course/agile-fundamentals-scrum-kanban scrumban/?couponCode=CP130525
- https://www.udemy.com/course/certmike-comp:a-it-fundamentals-i'/?couponCode=CP130525

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SUGGESTED CO - PO articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO-1	2	2	2	-	2	1	-	1	1	2	2	-	1	1
CO-2	2	3	2	2	3	1	-	1	-	1	1	-	2	2
CO-3	1	2	3	-	2	2	1	2	2	3	2	-	1	-
CO-4	2	2	2	2	3	1	-	1	-	1	3	-	3	2
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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
25RMC14EC01	Essentials of Research Methodology	2	--	--	--	2	-	-	2

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

Pre-requisite Course Codes	-	
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the basic concepts and types of research
	CO2	Formulate research problems and research design.
	CO3	Apply statistical tools including ANOVA and basic DOE.
	CO4	Interpret multivariate data analysis concepts at introductory level.
	CO5	Analyze ethical issues in research and publication.
	CO6	Prepare structured research report and presentation.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1	**Introduction to Research** Meaning and objectives of research. Characteristics of research. Research process. Types of research – Basic, Applied, Exploratory, Descriptive, Experimental. Research problem identification and formulation. Concept of hypothesis, variables and research gap	1,2	4
2	2	**Research Design & Sampling** Research design types. Measurement & scaling (Nominal, Ordinal, Interval, Ratio). Sampling techniques – Probability & Non-probability sampling. Questionnaire design basics (Marketing research perspective). Literature review methods and referencing styles.	1,2,	4
3	3	**Statistical Analysis & ANOVA** Probability distributions – Normal, Binomial, Poisson (Conceptual). Estimation and hypothesis testing. Z-test,t- test ANOVA – One way ANOVA, Two-way ANOVA Type I and II error.	1,	5
4	4	**Design of Experiments (DOE)** Full factorial design Interaction effects. Introduction to Taguchi method. Applications in Engineering &Manufacturing..	4	4
5	5	**Introduction to Multivariate Data Analysis**	3	4

Course Assessment:

		Need for multivariate techniques. Multiple regression (concept). Factor analysis (basic idea). Cluster analysis (conceptual verview). Applications in Engineering and Marketing research.		
6	**6**	**Research and Publication Ethics** Research integrity and scientific conduct. Falsification – Fabrication – Plagiarism, Plagiarism – types and detection tools. Authorship ethics and conflicts of interest. Predatory journals Indexing databases – Scopus, Web of Science. Research metrics – Impact Factor, h-index. Structure of journal paper and conference.	1,2,6	5
			Total	**26**

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 ISE activities:

- Research Proposal Preparation
- Questionnaire Design
- ANOVA based problem solving
- Literature Review Matrix
- Ethics Case Study
- Instructor approved activity.
- Small experimental study using DOE
- Survey-based research study
- Statistical data analysis using Excel/JASP/JAMOVI.
- Research publication review with ethics analysis
- Any other Instructor approved topic
- Continuous pre-defined rubrics-based evaluation along with Viva (30 marks).

References

1. Kothari, C.R., *Research Methodology – Methods and Techniques*.
2. Malhotra, Naresh K., *Marketing Research – An Applied Orientation*.
3. Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., *Multivariate Data Analysis*.
4. Montgomery, D.C., *Design and Analysis of Experiments*.
5. Dawson, Catherine, *Practical Research Methods*.
6. UGC – Research & Publication Ethics Guidelines

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SUGGESTED CO - PO articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	1		1	1	-	-	1	-	1	-	1	1	1
CO2	-	3	2	2	2	-	-	-	-	2	-	1	1	1
CO3	-	2	2	3	2	-	-	-	-	-	-	-	1	1
CO4	-	2	2	3	3	-	-	-	-	-	-	-	1	1
CO5	-	-	-	-	-	2	1	3	-	-	-	-	1	1
CO6	-	1	-	-	-	-	-	-	1	3	-	-	1	1

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
		2	--	--	--	2	-	-	2
25RMC14ME02	Intellectual Property Rights	Examination Scheme							
			ISE	MSE	ESE			Total	
					Min	Max			
		Theory	20	30	20	50		100	

Pre-requisite Course Codes	-	
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the basic concepts and need of Intellectual Property Rights.
	CO2	Differentiate between patents, trademarks, copyrights and other IP forms.
	CO3	Interpret national and international IPR laws and conventions.
	CO4	Apply procedures for filing patents, trademarks, and copyrights.
	CO5	Analyze infringement issues and legal remedies.
	CO6	Evaluate the role of IPR in innovation, research, and industrial growth.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1	**Introduction to Intellectual Property** Concept and meaning of Intellectual Property. Nature and characteristics of IPR. Importance of IPR in knowledge economy. Types of Intellectual Property. Need for IPR in Engineering and Research.	1,2,3, 5,6	4
2	2	**Patents** Meaning and objectives of patents. Patentable subject matter. Patentability criteria – novelty, inventive step, industrial applicability. Non-patentable inventions. Patent specification and claims. Patent filing procedure in India. Rights of patentee and infringement.	1,2,3, 5,6	4
3	3	**Trademarks, Copyrights and Industrial Design** Trademark: Definition, types, registration process, infringement. Copyright: Subject matter, ownership, duration, infringement. Industrial Design: Meaning, registration procedure, rights and protection.	1,2,3, 5,6	6

4	**4**	**Geographical Indications, Trade Secrets and Semiconductor IC Layout Design** GI:Concept, registration, protection. Trade Secrets: Meaning, protection strategies. Semiconductor Integrated Circuit Layout Design protection.	1,2,3, 5,6	4
5	**5**	**International Treaties and Agreements** TRIPS Agreement. WIPO conventions. Paris Convention and Berne Convention. Patent Cooperation Treaty (PCT). Role of WTO in IPR regulation	4	4
6	**6**	**IPR Management and Case Studies** Technology transfer and licensing. IPR in academic institutions and research organizations. Patent search and documentation. Case studies on infringement and litigation. IPR strategy for startups and MSMEs.	1,2,3, 5,6	4
			Total	**26**

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 ISE Activities:

- Patent Drafting
- Copyright Registration Process
- GI study
- Prepare IPR strategy for product/startup
- Expired Patent as Source of New Business

References

1. P. Narayanan, Intellectual Property Law, Eastern Law House.
2. W.R. Cornish, Intellectual Property: Patents, Copyright, Trademarks and Allied Rights.
3. B.L. Wadhera, Law Relating to Intellectual Property.
4. WIPO Publication on Intellectual Property Handbook.
5. N.S. Gopalakrishnan& T.G. Agitha, Principles of Intellectual Property.
6. Bare Acts: Indian Patent Act 1970, Trademark Act 1999, Copyright Act 1957.

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SUGGESTED CO - PO articulation Matrix

Course Outcomes (CO)	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	-	1	1	-	-	-	-	1	1
CO2	-	-	-	-	-	1	-	-	-	-	-	-	1	1
CO3	-	-	-	-	-	2	-	-	-	-	-	-	1	1
CO4	-	-	-	-	-	1	-	-	-	-	-	-	1	1
CO5	-	-	-	-	-	1	-	2	-	-	-	-	1	1
CO6	-	-	-	-	-	-		-	-	-	-	1	1	1

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
25PRJ14EC01	Capstone Project	--	--	12	--		--	6	6
		Examination Scheme							
			ISE			ESE		Total	
		Theory	--			--		--	
		Lab	200			100		300	

Pre-requisite Course Codes		--
After the successful completion students should be able to:		
Course Outcomes	CO1	Identify and define real-world engineering problems through literature review and data analysis.
	CO2	Analyze existing literature to determine problem scope, research gaps, and feasibility of identified real world problem.
	CO3	Design and implement engineering solutions using appropriate techniques and modern tools.
	CO4	Evaluate the prototype/working model using appropriate validation metrics, considering societal, environmental, and sustainability aspects.
	CO5	Demonstrate effective written and oral communication, teamwork, and leadership skills.
	CO6	Exhibit professional ethics, and commitment to lifelong learning in engineering practice.

Project Guidelines

1. Project Topic Selection and Allocation

1.1 Project Orientation

- Project orientation shall be begin at the end of Semester VI.
- Students shall be informed about available domains and domain experts for guidance.
- Students should be encouraged to refer to problem statements from Digital India Portal, Smart India Hackathon (SIH), INPASS patent database and other hackathon portals.

1.2 Topic Finalization Criteria

Projects should satisfy the following criteria:

- **Novelty:**
  Topics should be product-based, application-based, or research-based and preferably address gaps in existing systems.

- **Relevance:**
  Should align with current industrial trends and specialization area. Also address relevant Sustainable Development Goals (SDGs) with consideration for environmental and societal impact.
- **Technology:**
  Use of modern tools and latest technologies is encouraged.
- **Originality:**
  Work should not repeat projects carried out in the last three years.
- **Literature Review:**
  Students must refer to recent papers (preferably within last 3 years) from reputed sources such as IEEE, Elsevier, ACM, Springer, etc.
- Students may take inspiration from existing ideas but must evolve them uniquely to suit their project requirements.
- Student's projects may be undertaken in research institutes, industries, or business establishments.

1.3 Group Formation

- Project must be carried out in a group of **minimum 2 and maximum 4 students**.

1.4 Approval Process

- Proposal presentations shall be scheduled domain-wise.
- Evaluation shall be carried out by faculty experts in the respective domain.
- Final approval shall be granted by the Head of Department, internal domain wise faculty members, and project coordinators.
- Guide allocation shall be done after topic approval.

2. Monitoring and Progress Tracking

- Students are required to meet their assigned guide regularly, discuss their progress, and submit a weekly progress report (log book) to the internal guide for review and monitoring.
- Internal guide shall:
  - Monitor technical progress
  - Maintain attendance records
  - Evaluate contribution of each student
- Progress reports shall be considered as continuous assessment.

3. Project Implementation Framework

The Capstone Project is structured into two sequential stages: Phase I, conducted during the 7th semester, and Phase II, completed in the 8th semester.

Phase I: Research & Methodology (Semester VII)

Target Outcomes: CO1, CO2, CO3

Phase I focuses on the foundational stages of the engineering lifecycle. Students will conduct a comprehensive literature review, identify critical research gaps, and assess the feasibility of a real-world problem. Emphasis is placed on designing engineering solutions through the application of modern tools and appropriate technical methodologies.

- **In-Semester Evaluation (ISE):** 100 Marks

ISE-phase1- Literature review and Methodology (50M)

ISE-phase2- Design and Implementation (50M)

- **End-Semester Evaluation (ESE):** 50 Marks

Phase II: Implementation & Professional Practice (Semester VIII)

Target Outcomes: CO4, CO5, CO6

Phase II transitions into the execution and validation of the project. This stage involves evaluating the prototype or working model against performance benchmarks. Furthermore, students must demonstrate proficiency in technical communication, collaborative teamwork, and leadership. The phase concludes with a focus on professional ethics and a commitment to continuous lifelong learning.

- **In-Semester Evaluation (ISE):** 100 Marks

ISE-phase1- Full demonstration of Project and Draft of Publication/Patent (50M)

ISE-phase2- Black book and Evidence of outcome (50M)

End-Semester Evaluation (ESE): 50 Marks

Evaluation Components:

1. Weekly Log Report
2. Project Work Contribution
3. Completeness of Work
4. Mid-term Presentations (ISE- (100 Marks) With well-defined rubrics)
5. The End Semester Examination (ESE) shall be conducted in the presence of both an internal and an external examiner. The ESE shall be evaluated based on the demonstration of the project, quality of the final report, and submission of a technical paper to a reputed journal or an international conference/ Publication of patent.

   Evaluation shall be based on department-defined rubrics.

   Final certification of Project Work ensures satisfactory performance in the above components.

4. Project Report Format

At the end of the semester, each group must submit:

- **Hard Copy (Black Book)**
- **Soft Copy** including:
  - Report
  - Source Code
  - Executable
  - Required utilities/software
  - User Manual
  - Documentation
  - Submission on GitHub

The Report Shall Contain:

1. Abstract
2. Introduction
3. Literature Survey / Existing System
4. Limitations / Research Gap
5. Problem Statement and Objectives
6. Proposed System
7. Analysis / Framework / Algorithm
8. Design Details
9. Methodology
10. Experimental Setup
11. Database / Input Details
12. Performance Evaluation Parameters (Validation)
13. Software and Hardware Setup
14. Results and Discussion
15. Conclusion and Future Scope
16. Timeline Chart (Project Management Tools)
17. Implementation details
18. References
19. Appendix (Publications / Certifications if any)

5. Desirable Activities

Students should be encouraged to:

- Complete relevant certification courses aligned with project domain.
- Participate in project competitions and hackathons.
- Publish at least one technical paper in a reputed journal/Present work at National / International Conferences.
- Submission of GitHub repository

6. Suggested Quality Evaluation Parameters:

- Quality and relevance of problem selected
- Clarity of problem definition and feasibility
- Relevance to specialization / industrial trends
- Address relevant Sustainable Development Goals (SDGs) with consideration for environmental and societal impact
- Originality and innovation
- Use of modern tools
- Quality of analysis and design
- Implementation completeness
- Validation of results
- Impact on society/environment and business value
- Quality of written and oral presentation
- Individual contribution and teamwork
- Participation in hackthons and project competitions

SUGGESTED CO - PO articulation Matrix

Laboratory Outcomes	**Program Outcomes (POs)**													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	1	1	1	-	-	-	-	-	3	3
CO2	3	3	1	-	2	1	1	-	-	-	-	-	3	3
CO3	3	3	3	1	3	1	1	1	1	1	1	2	3	3
CO4	1	3	1	1	3	-	3	3	2	-	1	2	3	3
CO5	-	-	-	-	-	-	-	1	3	3	-	2	-	-
CO6	-	-	-	-	-	-	-	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
			--	-	-		--	2	2
		Examination Scheme							
25SEM14EC01	Course Seminar		ISE	MSE	ESE				Total
					Min		Max		
		Theory	--	--	--		--		--
		Lab	100	--	--		--		100

Pre-requisite Course Codes		--
After the successful completion students should be able to:		
Course Outcomes	CO1	Identify a real-world engineering advancements across diverse domains.
	CO2	Analyze research literature and technical data to determine problem scope and feasibility.
	CO3	Demonstrate awareness of advanced engineering developments and emerging technologies.
	CO4	Exhibit professional ethics, independent learning ability, and commitment to lifelong learning.
	CO5	Present structured technical reports with effective written and oral communication skills.

1. Seminar Guidelines

1.1 Topic Finalization Criteria

The selected seminar topic must satisfy the following criteria:

- **Novelty:** The topic should address emerging trends, innovative ideas, or recent technological advancements.
- **Relevance:** The selected topic should align with current industrial trends, address relevant Sustainable Development Goals (SDGs) with consideration for environmental and societal impact, and be closely related to the student's area of specialization.
- **Technology Orientation:** Usage of modern tools, platforms, frameworks, and latest technologies is encouraged.
- **Literature Review:**
  - Students must refer to recent research papers (preferably within the last 3 years).
  - References should be from reputed sources such as IEEE, Elsevier, ACM, Springer, etc.
  - A maximum number of quality research papers should be reviewed and critically analyzed.

1.2 Group Formation

- The seminar shall be carried out as an **individual (single student) activity** to encourage independent research and learning.

1.3 Approval Process

- Topic presentations shall be conducted domain-wise.
- Evaluation shall be carried out by faculty experts in the respective domain.
- Final approval shall be granted by the Head of Department and panel wise domain internal faculty members.
- Guide allocation shall be done after formal topic approval.

2. Internal Assessment (ISE – I & II)

2.1 Evaluation Components

- Fortnightly Log Report (Progress Monitoring)
- Mid-term Presentation (ISE-I & ISE-II) as per department-defined rubrics for 50 marks each
- Completeness and Quality of Work

3. Suggested Quality Evaluation Parameters

Evaluation shall be based on the following:

- Quality and relevance of topic selected
- Clarity of problem definition and feasibility
- Relevance to specialization and industrial trends
- Address relevant Sustainable Development Goals (SDGs) with consideration for environmental and societal impact
- Use of modern tools and technologies
- Quality of analysis
- Societal and environmental impact
- Quality of written report
- Effectiveness of oral presentation

4. Seminar Report Structure

The seminar report must include the following sections:

1. Abstract
2. Introduction
3. Literature Survey / Existing System
4. Comparative study of different technical papers
5. Analysis / Framework / Algorithm of the study
6. Design Details studied
7. Methodologies used in the study
8. Proposal for the new concept/solution/algorithm etc.
9. Conclusion
10. References (in standard citation format)
11. Appendix (Publications / Certifications / Additional Documents if any)

5. Desirable Academic Enrichment Activities

Students are encouraged to:

- Complete relevant certification courses aligned with their seminar domain.
- Present their seminar findings to junior students to promote awareness of emerging technologies.
- Publish e-content related to their seminar topic on the department's official YouTube channel.

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	PO12	PSO1	PSO2
CO1	3	2	1	-	2	1	1	-	-	1	-	2	3	3
CO2	3	3	2	-	2	2	2	-	-	1	-	2	3	3
CO3	3	2	1	-	2	2	2	-	-	1	-	3	3	3
CO4	1	-	-	-	-	-	-	3	2	2	-	3	1	1
CO5	1	-	-	-	1	-	-	1	2	3	-	2	1	1

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	L	T	P	Total
25PEC14EC31	High Performance Computing	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		25PCC12CE010, 26PEC13CE18, 25PCC12CE05
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the fundamental concepts of High Performance Computing and modern processor architectures used in parallel systems.
	CO2	Analyze communication models and communication patterns used in parallel Programing environments.
	CO3	Apply parallel Programing techniques using APIs such as OpenMP and MPI.
	CO4	Implement GPU-based parallel programs using CUDA architecture and Programing model.
	CO5	Optimize the performance of parallel algorithms using metrics, benchmarking, and data access techniques in High Performance Computing.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Module Name-Introduction to High Performance Computing (HPC) and Parallel Programing** Introduction to High Performance Computing (HPC), Need and applications of HPC, Basic concepts of parallel computing, Types of parallelism: data parallelism, task parallelism, pipeline parallelism, Classification of parallel computers using Flynn's Taxonomy (SISD, SIMD, MISD, MIMD), Recent parallel system classifications: multicore systems, manycore processors, GPU computing, cluster computing.	1,2	2
	1.2	Modern Processor Architectures in Parallel Systems: Shared memory vs distributed memory architectures, Shared memory systems: Uniform Memory Access (UMA), Cache coherence, Cache-coherent Non-Uniform Memory Access (ccNUMA), Distributed memory computers and interconnection networks, Overview of modern processors: multicore processors and GPU-based parallel systems	1,2	2

2	**2.1**	**Module Name-Communication Models in Parallel Systems** Role of communication in parallel computing systems, Communication mechanisms used in modern HPC and data center environments, Shared memory communication model used in multicore processors and enterprise servers, Message passing communication model used in clusters and supercomputers	1,2,4	2
	2.2	Point-to-point communication, Collective communication patterns (broadcast, scatter, gather, reduce), Synchronization and coordination mechanisms, Communication overhead and latency in parallel systems, Analysis of communication performance in parallel programs	1,2,4	2
3	**3.1**	**Module Name-Introduction to parallel Programing using OpenMP and MPI** Shared memory parallel Programing using OpenMP: directives, parallel regions, work-sharing constructs for loops, synchronization mechanisms, reductions, loop scheduling, and tasking.	3,4	4
	3.2	Distributed memory Programing using MPI: basic communication routines and collective communication operations, Programs using MPI: process creation, rank identification, program execution, and advanced communication routines.	3,4	3
4	**4.1**	**Module Name-GPU Architecture and Programing** CUDA architecture and execution model: grids, blocks, and threads, CUDA memory hierarchy: global memory, shared memory, constant memory, and registers, Kernel Programing in CUDA: writing and launching CUDA kernels, Thread hierarchy and synchronization mechanisms in CUDA, Basic CUDA Programing examples (vector addition, matrix operations), Performance optimization techniques for GPU programs.	2,4,5	3
	4.2	OpenCL platform model: host, devices, compute units, and processing elements, OpenCL execution model: kernels, work-items, and work-groups, OpenCL memory model: global, local, constant, and private memory, Writing and executing simple OpenCL kernel programs	2,4,5	3
5	**5.1**	**Module Name-Performance and Optimization** Performance metrics and Benchmarking techniques, Hardware scaling via Moore's Law, Theoretical limits using Amdahl's Law, Scalable performance using Gustafson's Law.	1,2,4	2
	5.2	Data Access Optimization: Balance analysis and lightspeed estimates, Storage order, Case studies: The Jacobi algorithm, Dense matrix transpose	1,2,4	3
			Total	**26**

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			
	Topics	**Ref.**	**Hrs.**
1	Simulation of Flynn's Taxonomy Using Vector/Matrix Tasks	1,2	2
2	Implementation of MPI_Send and MPI_Recv between two processes; measure communication latency and overhead	1,2, 3	2
3	Implementation of MPI collective communication operations (broadcast, scatter, gather, reduce) and analyze their performance in a single program.	1,2, 3	2
4	Implementation of OpenMP Directives and Work Sharing Constructs for parallelizing loops	1,2, 3	2
5	Implementation of OpenMP synchronization mechanisms and reductions	1,2, 3	2
6	Writing and Launching CUDA Kernels for Matrix Operations	2,3, 5	2
7	OpenCL Kernel Programing on Host-Device Model	1,2, 4	2
8	Amdahl's Law Simulation and Speedup Analysis	1,2	2
9	Gustafson's Law Simulation on Scalable Problems	1,2	2
10	Implementation of parallel row-major vs column-major matrix transpose; measure execution time.	1,2	4
11	Solve linear system in parallel: Implement OpenMP tasking for different rows.	1,2, 3	4
	Total		26

Course Assessment: - (Lab)

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

Recommended Books:

[1] Georg Hager, Gerhard Wellein, Introduction to High Performance Computing for Scientists and Engineers, Chapman & Hall / CRC Computational Science series, 2011.

[2] Gene Wagenbreth and John Levesque, High performance Computing: Programing and Application,CRC press, Taylor and francis group, 2010.

[3] Michael J Quinn, Parallel Programing in C with MPI and Open MP, McGraw Hil, International Editions, Computer Science Series, 2004

[4] Michael J Quinn, MaciejBrodowicz, Matthew Anderson, and Thomas Sterling, High Performance Computing: Modern Systems and Practices, Morgankaufmann publishers, 2017.

[5] Jason Sanders, Edward Kandrot, "CUDA by Example", Addison-Wesley, ISBN-13: 978-0- 13-138768-3

Useful Links:
1. https://hpc.llnl.gov/documentation/tutorials/introduction-parallel-computing-tutorial
2. https://www.nvidia.com/en-us/glossary/high-performance-computing/
3. https://onlinecourses.nptel.ac.in/noc22_cs21/preview

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
CO2	3	3	-	-	-	-	-	-	-	-	2	2	2
CO3	3	-	-	-	3	-	-	-	-	-	2	2	2
CO4	3	-	-	-	3	-	-	-	-	-	2	2	2
CO5	3	1	3	-	-	-	-	-	-	-	2	2	2

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

Blooms Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create