Agnel Charities

Fr. C. Rodrigues Institute of Technology

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An Autonomous Institute Affiliated to the University of Mumbai

Department of Information Technology

Curriculum Structure and Syllabi of Final Year B.Tech. IT

Prepared by : Board of Studies for Department of Information Technology

Revision: N2024

Effective from :2026-27

Curriculum Structure – B. Tech Semester-VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
ITPCC712	Edge Computing	3	--	--	3	--	--	3
ITPEC703Y	Program Elective Course-III	3	--	--	3	--	--	3
ITPEC704Y	Program Elective Course-IV	3	--	--	3	--	--	3
OEC701Y	Open Elective Course –I	3	--	--	3	--	--	3
ITLBC710	Edge Computing Laboratory	--	2	--	--	1	--	1
ITLBC711	High Performance Computing Laboratory	--	2	--	--	1	--	1
ITMJP701	Major Project-A	--	6	--	--	2	--	2
HSS703	Financial Planning	2	--	--	2	--	--	2
	Total	**14**	**10**	**--**	**14**	**4**	**--**	**18**

Program Elective Course-III and IV:
Every student is required to take two Program Elective Course for Semester VII. Students can take this course from the following list of Program Elective Course-III and IV.

Course Code	**Program Elective Course-III**
ITPEC7031	Quantum Computing
ITPEC7032	Human Computer Interaction
ITPEC7033	Ethical Hacking & Digital Forensic

Course Code	**Program Elective Course-IV**
ITPEC7041	Big Data Analytics
ITPEC7042	Augmented Reality/Virtual Reality
ITPEC7043	Information Retrieval System

Open Elective Course-I:
Every student is required to take one Open Elective Course-I for Semester VII. Students can take this course from the following list of Open Elective Course-I.

Course Code	**Open Elective Course-I**
OEC7011	Product Lifecycle Management
OEC7012	Reliability Engineering
OEC7013	Management Information System
OEC7014	Design of Experiments
OEC7015	Operation Research
OEC7016 @@	Cyber Security and Laws
OEC7017	Digital Business Management
OEC7018	Energy Audit and Management
OEC7019	Development Engineering

@@Students opting for Honours/Minor degree in Cybersecurity or relevant domain need to select other Open Elective.

Examination Scheme – B. Tech Semester-VII

Course Code	Course Name	Examination Scheme					Total
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
ITPCC712	Edge Computing	20	30	50	1.5	2	100
ITPEC703Y	Program Elective Course-III	20	30	50	1.5	2	100
ITPEC704Y	Program Elective Course-IV	20	30	50	1.5	2	100
OEC701Y	Open Elective Course –I	20	30	50	1.5	2	100
ITLBC710	Edge Computing Laboratory	25	--	25	--	--	50
ITLBC711	High Performance Computing Laboratory	25	--	25	--	--	50
ITMJP701	Major Project-A	50	--	--	--	--	50
HSS703	Financial Planning	50	--	--	--	--	50
	Total	**230**	**120**	**250**	--	--	**600**

$Please refer to the Curriculum Book of department for guidelines on in-semester assessments for both theory and laboratory courses.

Curriculum Structure – B. Tech Semester-VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		L	P	T	L	P	T	Total
ITPEC805Y	Program Elective Course-V	3	--	--	3	--	--	3
OEC802Y	Open Elective Course-II	3	--	--	3	--	--	3
ITMJP802	Major Project-B	--	12	--	--	4	--	4
INT801	Internship~	--	--	--	--	8	--	8
	Total	**6**	**12**	**--**	**6**	**12**	**--**	**18**
~ Students have the opportunity to engage in a three-month internship within industry, research organizations, foreign universities, or internal internship for research and product development during the 8th semester, provided they meet the semester requirements and receive approval from the institute.								

Program Elective Course-V:

Every student is required to take Program Elective Course for Semester VIII. Students can choose program Elective Course-V, from one of domains listed below. The list of courses within the individual domains will be made available before the course registration.

Course Code	Program Elective Course-V
ITPEC8051	Block Chain Technology
ITPEC8052	Network and Security
ITPEC8053	Computational Intelligence
ITPEC8054	Internet of Things

Open Elective Course-II:

Every student is required to take one Open Elective Course-II for Semester VIII. Students can take this course from the following list of Open Elective Course-II.

Course Code	Open Elective Course-II
OEC8021	Project Management
OEC8022	Finance Management
OEC8023	Entrepreneurship Development and Management
OEC8024	Human Resource Management
OEC8025	Professional Ethics and CSR
OEC8026	Circular Economy
OEC8027	IPR and Patenting
OEC8028	Disaster Management and Mitigation Measures
OEC8029	Environmental Management

Examination Scheme – B. Tech Semester-VIII

Course Code	Course Name	Examination Scheme					
		In-Semester Assessment$		End Sem Exam (ESE)	Exam Duration for Theory (in Hrs)		Total
		Continuous Assessment	Mid-Sem Exam		Mid-Sem	End-Sem	
ITPEC805Y	Program Elective Course-V	20	30	50	1.5	2	100
OEC802Y	Open Elective Course-II	20	30	50	1.5	2	100
ITMJP802	Major Project-B	50	--	50	--	--	100
INT801	Internship	50	--	50	--	--	100
	Total	**140**	**60**	**200**	--	--	**400**

$Please refer to the Curriculum Book of department for guidelines on in-semester assessments for theory, laboratory, and internship courses.

NOTE: Please note that due to the internship requirement in the VIII semester, theory courses during this semester will be conducted either online synchronously or asynchronously. For more information, please consult the curriculum book of your department.

Course Type	Course Code	Course Name	Credits
PCC	ITPCC712	EDGE COMPUTING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ITPCC406 : Computer Network
2. ITLBC506 : Cloud Computing Laboratory

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5. PO8: Individual and Collaborative team work
6. PO9: Communication
7. PO11: Life-Long Learning

Course Objectives:

1. To prepare students to know fundamentals of Edge computing and architectural aspects of edge server.
2. To equip students to perceive comprehensive knowledge about Edge Data Centre and services.
3. To train students to design of edge storage systems, Docker container and Kubernetes in edge computing.
4. To make students to aware of Edge analytics topologies for M2M and WSN network.
5. To prepare students to gain insight of recent advances of machine learning, deep learning and artificial intelligence with appropriate use cases in edge computing.

Module	Details	Hrs.
00.	**Course Introduction** This course we will cover fundamentals of Edge computing and its applications in low latency and critical real-time computing scenarios. The course brings in theory of Edge computing, focusing on it as a complementary approach that addresses some of the limitations of cloud computing. The course will cover applications where edge computing is a necessity, such as real-time applications that require low latency and	01

	high bandwidth. For example, autonomous vehicles require real-time processing of data from sensors, which cannot be done in a centralized data centre due to latency issues.	
01.	**Introduction to Edge Computing paradigms** ***Learning Objective:*** *To make learner identify and summarize basics of edge computing and IoT edge platforms*	**05-07**
	Contents: Introduction to Cloud and its limitations to support low latency and RTT. From Cloud to Edge computing: Waves of innovation, Introduction to IoT Edge platforms such as Azure IoT hub, AWS.	
	Self-Learning Topics: *Explore recent Edge Computing platforms*	
	Learning Outcomes: A learner will be able to *LO 1.1: Apply fundamental concepts of Cloud and Edge to get insights to Edge Computing (P.I.-1.3.1)* *LO 1.2: Apply the knowledge of cloud and edge computing to find the limitations of traditional cloud systems in achieving low latency and minimal RTT (P.I.-1.4.1)* *LO 1.3: Identify processes for moving from cloud to edge computing (P.I.-2.1.2)* *LO 1.4: Identify the functionalities of IoT edge platform (P.I.-2.2.2)*	
02.	**Edge Computing Architecture and Building blocks** ***Learning Objective:*** *To familiarize with the edge computing Architecture, system modeling and research challenges*	**08-10**
	Contents: Introduction to Edge Computing Architectures, Edge Computing to support User Applications (5G-Slicing, self-driving cars and more), Concepts of distributed systems in edge computing such as time ordering and clock synchronization, distributed snapshot. IoT platform Integrating Cloud+ IoT + Edge Infrastructures: System Modeling and Research Challenges in Federating Edge Resources.	
	Self-Learning Topics: *Identify Career paths and opportunities in Edge Computing.*	
	Learning Outcomes: A learner will be able to *LO 2.1: Identify objectives of edge computing Architecture to support user applications (P.I.-2.1.1)* *LO 2.2: Identify current trends and challenges in edge computing Infrastructure (P.I.-2.1.2)* *LO 2.3: Apply fundamentals concepts of distributed systems in edge computing for clock synchronization and distributed snapshot. (P.I.-1.3.1)* *LO 2.4: Apply different Edge computing models to find research challenges in federated edge resources. (P.I.-1.4.1)*	
03.	**Edge Storage systems** ***Learning Objective:*** *To make learner analyze different storage requirements for edge computing*	**06-08**

	Contents: Introduction to Edge Data Center, Lightweight Edge Clouds and its services provided by different service providers, Management and Orchestration of Network Slices in 5G, Edge, and Clouds Demonstration of Edge storage System using open source tool.	
	Self-Learning Topics: *Identify current trends in edge storage systems available in the market.*	
	Learning Outcomes: A learner will be able to *LO 3.1: Synthesize requirements for edge data center. (P.I.- 3.1.5)* *LO 3.2: Design different Lightweight alternative edge cloud services used for storage at Edge. (P.I.- 3.2.1)* *LO 3.3: Identify role of Edge Data Center in Edge Computing (P.I.-2.2.3)* *LO 3.4: Identify Orchestration of Network Slices in 5G, Edge, and Cloud. (P.I.-2.1.2)* *LO 3.5: Apply edge based data center concepts to analyze requirements of Edge Data Center. (P.I.-1.3.1)* *LO 3.6: Apply edge based data center concepts to management and orchestration of network slices in 5G, edge and clouds. (P.I.-1.4.1)* *LO 3.7: Design and analyze Edge storage solution based edge computing to meet functional requirements and select most appropriate proposal (P.I.-4.1.3, 8.2.1, 9.2.1, 11.2.1)* *LO 3.8: Design and analyze Edge storage solution to meet the criteria and identify tasks required to complete it. (P.I.- 4.2.1, 8.3.1, 9.3.3, 11.3.2)*	
04.	**Introduction to Lightweight Container Middleware for Edge Cloud Architectures** ***Learning Objective:*** *To familiarize with light weight container middleware like Docker and Kubernet in edge computing.*	**06-08**
	Contents: Introduction to Docker container and Kubernetes in edge computing. Design of edge storage systems like key-value stores, Concepts of distributed systems in IoT applications such as time ordering and clock synchronization, distributed snapshot. Demonstration of container techniques using open source tool	
	Self-Learning Topics: *Identify current trends in container technologies available in the market*	
	Learning Outcomes: A learner will be able to *LO 4.1: Synthesize requirements for Docker container and Kubernets in edge computing (P.I.-3.3.1)* *LO 4.2: Design lightweight container for edge cloud system to provide edge computing services (P.I.-3.4.1)* *LO 4.3: Apply different distributed system techniques for IoT applications such as time ordering and clock synchronization and distributed snapshot (P.I.-1.3.1)* *LO 4.4: Apply lightweight containerization concepts for edge cloud computing (P.I.-1.4.1)*	
05.	**Edge computing for IoT and ML** ***Learning Objective:*** *To make learner aware of the different edge computing protocol such as MQTT and Kafka for predictive analysis to support edge applications.*	**06-08**

	Contents: Introduction to MQTT and Kafka for end-to-end edge pipeline. Edge analytics topologies for M2M and WSN network (MQTT): Data Management and Predictive Analysis to Support Edge Application Deployment, Edge Computing Realization for Big Data Analytics. Demonstration of Edge ML techniques using open source tool	
	Self-Learning Topics: *Identify current trends in Edge machine learning technologies available in the market.*	
	Learning Outcomes: A learner will be able to *LO 5.1: Apply appropriate Edge Analytics topologies for M2M and WSN network (P.I.-1.3.1)* *LO 5.2: Apply Edge Analytics topologies for predictive analysis used in investigation of Edge Computing (P.I.- 1.4.1)* *LO 5.3: Identify MQTT and Kafka application for end to end edge pipeline (P.I.-2.2.3)* *LO 5.4: Identify processes used for big data analytics in realization of edge Computing. (P.I.-2.1.2)*	
06.	**Emerging Technologies: Edge AI and Business cases** ***Learning Objective:*** *To make learner aware of emerging technologies in Edge computing based uses cases of predictive maintenance, image classifier and self-driving cars.*	**06-08**
	Contents: Edge computing innovation in sectors like automotive, healthcare, manufacturing, and smart cities. Use cases for Autonomous Vehicles – Edge AI for Real-Time Decision Making (Tesla / NVIDIA), Smart Cities – Edge-Based Traffic Monitoring, Industrial IoT – Predictive Maintenance, Healthcare – Edge Computing for Remote Patient Monitoring, Retail – Smart Store Operations, Agriculture – Edge IoT for Smart Farming, Public Safety – Edge Video Analytics for Surveillance. Demonstration of IoT and Edge Computing techniques using open source tool	
	Self-Learning Topics: Case studies and future trends of Edge computing for different uses cases	
	Learning Outcomes: A learner will be able to *LO 6.1: Synthesize requirements and mitigation of edge computing in smart cities and select most appropriate proposal (P.I.- 3.1.5)* *LO 6.2: Design solution for Predictive maintenance in healthcare and providing alternatives and identify tasks required to complete it (P.I.- 3.2.1)* *LO 6.3: Identify technological advances in edge computing relevance on Edge IoT for smart farming (P.I.- 2.1.2)* *LO 6.4: Identify and analyze impact of IoT on performance and sustainability of Edge Video Analytics for Surveillance (P.I.- 2.3.1)* *LO 6.5: Design and analyze Smart cities solution based for selected edge computing case study to meet functional requirements and select most appropriate proposal (P.I.- 8.2.1, 9.2.1, 11.2.1)* *LO 6.6: Design and analyze Edge IoT solution based on edge computing application to meet the criteria and identify tasks required to complete it (P.I.-8.3.1, 9.3.3, 11.3.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	P.I. Statement
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem
2.1.2	Identifies processes/modules/algorithms of a computer based system and parameters to solve a problem
2.2.2	Identifies functionalities and computing resources.
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions
2.4.4	Arrive at conclusions with respect to the objectives
3.1.5	Explore and synthesize system requirements from larger social and professional concerns
3.2.1	Ability to explore design alternatives
3.2.2	Ability to produce a variety of potential design solutions suited to meet functional requirements
3.3.1	Ability to perform systematic evaluation of the degree to which several design concepts meet the criteria
4.1.1	Define a problem for purposes of investigation, its scope and importance
4.1.2	Ability to choose appropriate procedure/algorithm, data set and test cases.
4.2.1	Design and develop appropriate procedures/methodologies based on the study objectives
4.3.1	Use appropriate procedures, tools and techniques to collect and analyze data
4.3.2	Critically analyze data for trends and correlations, stating possible errors and limitations
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others.
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
11.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
11.3.2	Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to -

1. Analyze and apply key components and architecture blocks of edge computing and its interaction with IoT and cloud ecosystem. (LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)
2. Design edge computing system for latency-critical use cases like 5G slicing and self-driving vehicles(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO 3.6, LO 3.7, LO 3.8)
3. Identify and apply Edge Storage management techniques. (LO 4.1, LO 4.2, LO 4.3, LO 4.4)
4. Identify IoT platforms integrating Cloud + IoT + Edge infrastructures for service delivery. (LO 5.1, LO 5.2, LO 5.3, LO 5.4)
5. Design and analyse cost effective solution using recent IoT and Edge Computing techniques for IT Infrastructure Management. (LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO6.6)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPCC712.1	3	3	3	3	-	-	-	3	3	-	3
ITPCC712.2	3	-	3	-	-	-	-	--	--	-	-
ITPCC712.3	3	3	-	-	-	-	-	-	-	-	-
ITPCC712.4	3	3	-	-	-	-	-	-	-	-	-
ITPCC712.5	-	3	3	-	-	-	-	3	3	--	3
Average	**3**	**3**	**3**	**3**	-	-	-	**3**	**3**	**--**	**3**

Text Books :

1. "Fog and Edge Computing: Principles and Paradigms", Rajkumar Buyya (Editor), Satish Narayana Srirama (Editor), Wiley, 2019
2. Cloud Computing: Principles and Paradigms", Editors: Rajkumar Buyya, James Broberg,Andrzej M. Goscinski, Wiley, 2011
3. "Cloud and Distributed Computing: Algorithms and Systems", Rajiv Misra, Yashwant Patel, Wiley 2020.
4. Edge Computing: Fundamentals, Advances and Applications By K. Anitha Kumari, G. Sudha Sadasivam, D. Dharani, M. Niranjanamurthy, CRC press 2021.
5. IoT Edge Computing for Architects –Second Edition, by Perry Lea, Publisher: Packet Publishing, 2020, ISBN: 9781839214806

Reference Books :

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
2. IoT and Edge Computing for Architects: Implementing Edge and IoT Systems from Sensors to Clouds with Communication Systems, Analytics, and Security by Perry Lea , 2nd Edition
3. Mobile Edge Computing, Anwesha Mukherjee, Debashis De, Soumya K. Ghosh, Rajkumar Buyya, Springer
4. David Jensen, "Beginning Azure IoT Edge Computing: Extending the Cloud to the Intelligent. Edge, Microsoft Azure

Other Resources :

1. NPTEL Course: Edge Computing by Prof. Rajiv Misra, Department of Computer Science and Engineering, IIT Patna :-Web link- https://onlinecourses.nptel.ac.in/noc24_cs66/preview
2. NPTEL Course: Foundation of Cloud IoT Edge ML by Prof. Rajiv Misra, Department of Computer Science and Engineering, IIT Patna :-Web link- https://onlinecourses.nptel.ac.in/noc23_cs65/preview

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

a) Assignment on live problems/ case studies: 10 Marks

Students should be assigned a real life problem statement related to Edge computing domain. Students are expected to research and collect required data to design a system for the selected problem. Students should apply edge computing knowledge to design a system for IT resources including memory, network, server and storage requirements. Students should present their

work in the form of presentation and demonstration in 10-15 minutes. This assignment should be graded for 10 marks like a design assignment based on the parameters such as data acquisition, requirement analysis, designing a system for selected problem statement.

b) Class Test: 05 Marks

c) Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ITPEC7031	QUANTUM COMPUTING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:
NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO6: Engineer and world
7. PO11: Life-long learning

Course Objectives:

1. Identify the fundamental ideas of quantum physics as they apply to information processing and computation.
2. Develop an understanding of qubits, quantum gates, and quantum circuits as the building blocks of quantum algorithms.
3. Explore quantum hardware and designs, such as superconducting qubits, trapped ions, and photonic systems.
4. Evaluate fundamental quantum algorithms, including Deutsch, Deutsch-Jozsa, Grover's search, and Shor's factoring algorithm.
5. Evaluate quantum error correction methods and fault-tolerant quantum computing.
6. Delve into the implementations of quantum computing in optimization, cryptography, and machine learning.

Module	Detailed Contents	Hrs
00.	**Course Introduction** This course introduces the fundamental concepts, mathematical foundations, and architectures of quantum computing. Students will learn how quantum logic gates and circuits are constructed, explore landmark quantum algorithms such as Deutsch–Jozsa, Grover's search, and Shor's algorithm, and understand the implications of quantum computation on cryptography and optimization problems.	01
01.	**Mathematical Foundations and quantum mechanics** ***Learning Objective:*** *Learners should able to get the foundations of social media analytics, including key concepts, platforms, data types, and metrics.*	07-09

	Contents: **Linear Algebra Refresher** • Complex numbers and vectors • Inner and outer products • Matrix multiplication, tensor products • Unitary matrices and Hermitian operators **Probability & Statistics** • Classical probability theory • Random variables and distributions • Expectation values and variance **Dirac Notation** • Ket and bra vectors • Basis states and orthonormality Projection operators	
	Self-Learning Topics: *Study of how measurement affects the state of a quantum system.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply the knowledge of linear algebra, statistics and numerical techniques to solve problems. (P.I.-1.1.1)* *LO 1.2: Apply theory and principles of quantum mechanics and linear algebra to solve an engineering problem. (P.I.-1.4.1)* *LO 1.3: Identifies functionalities and computing resources from perspectives of quantum computing (P.I.- 2.2.2)* *LO 1.4: Identify design constraints for required performance criteria in quantum computing. (P.I.-2.3.2)* *LO 1.5: Able to define problem and identify and describe need of quantum computations; particularly as pertains to protection of public data and classical algorithm efficiency by choosing appropriate tools. (P.I. 3.2.1, P.I. 5.1.1)* *LO 1.6: Able to explore design solution and identify the strengths and limitations of quantum software tools for acquiring information, modelling and simulating. (P.I. 3.2.1, P.I.-5.2.1)*	
02.	**Basics of Quantum Mechanics for Computing *and Quantum Circuits*** ***Learning Objective:*** *Learner is expected to know the concepts of quantum states, superposition, and measurement and differentiate between classical and quantum systems using principles such as linearity and probability amplitudes*	**09-11**
	Contents: **Postulates of Quantum Mechanics** • State vectors and Hilbert space • Quantum measurement and collapse • Unitary evolution (Schrödinger equation) **Single-Qubit Systems** • Bloch sphere representation • Common gates: X, Y, Z, H, S, T, R(θ) **Multi-Qubit Systems** • Tensor product states • Entanglement and Bell states • Controlled gates (CNOT, CZ) **Quantum circuits** **Inner products, orthonormality, and projections** **Limitations of quantum information:** • Irrelevance of global phases • No-cloning theorem	

	Non-orthogonal states cannot be perfectly discriminated	
	Self-Learning Topics *:* *Design quantum circuit using Qiskit.*	
	Learning Outcomes: *A learner will be able to* *LO 2.1: Apply mathematical tools such as amplitudes, phase, tensor products, and normalization to describe and manipulate quantum systems. (P.I.- 1.4.1)* *LO 2.2: Identify the core principles of quantum state representation by working with qubit states, expressing them in vector and Dirac notation, analyzing superposition and entanglement. (P.I.- 2.1.2)* *LO 2.3: Identifies functionalities and computing resources for selected quantum gate. (P.I.- 2.2.2)* *LO 2.4: Identify design constraints for required performance criteria in quantum computing for circuit design and its appropriate performance. (P.I.- 2.3.2)* *LO 2.5: Ability to explore quantum circuit design based on integration of quantum gates and produce variety of solutions. (P.I.-3.2.1, P.I. 3.2.2)* *LO 2.6.: Identify modern engineering tools, techniques and resources for quantum processing. (P.I. 5.1.1)* *LO 2.7: Identify the strengths and limitations of quantum simulation tools for modelling and simulating, monitoring system performance. (P.I. 1.3.1., P.I.-5.2.1)*	
03.	**Quantum Computation Principles, Quantum Hardware & Implementation** ***Learning Objective:*** *Learner is expected to know how to differentiate between various quantum hardware architectures such as superconducting qubits, trapped ions, photonic systems, and neutral atoms.*	**10-12**
	Contents: **Quantum Circuits** • Circuit diagrams and gate sequences • Universality of quantum gates **No-Cloning Theorem** and implications **Reversible Computing** **Physical Qubits** • Superconducting qubits • Trapped ions • Photonic qubits **Gate Implementation** • Pulse-level control • Calibration and readout **Scalability Challenges**	
	Self-Learning Topics: *Survey on various physical qubit structures and topologies.*	

	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply fundamentals of quantum computing and identify the various physical systems in terms of its qubit mechanism, gate sequences, topologies etc. (P.I. 1.3.1)* *LO 3.2: Identify and describe the different physical implementations of quantum qubits such as superconducting qubits, trapped ions, photonic qubits, neutral atoms, and spin-based systems, and explain their fundamental characteristics, advantages, and limitations. (P.I.-2.1.2)* *LO3.3: Identify the functionalities and computing resources for quantum circuit model implementation by using selected gates and architecture. (P.I.- 2.2.2)* *LO 3.4: Explore and compare various physical qubit mechanisms by reviewing their underlying principles (P.I.- 2.2.4)* *LO 3.5: Ability to verify the functionalities various types of physical hardware configurations. (P.I. 3.4.2, P.I.- 3.4.3)* *LO 3.6 Ability to choose appropriate procedure/algorithm, data set and test cases for quantum mechanics procedures to study. (P.I. 4.1.2)* *LO 3.7: Ability to choose appropriate hardware/software tools to simulate and access quantum computers online. (P.I. 4.1.3)* *LO 3.8: Identify the strengths and limitations of tools for modelling and simulating quantum circuits. (P.I. 1.4.1, P.I. 5.2.1)*	
04.	**Quantum Algorithm** ***Learning Objective:*** *Learner is expected to Illustrate the working of basic quantum algorithms such as the Deutsch–Jozsa, Bernstein–Vazirani, and Simon's algorithms and analyze important algorithms like Grover's Search and Shor's Factoring, emphasizing their computational advantages.*	**03-05**
	Contents: Deutsch & Deutsch–Jozsa Algorithms Bernstein–Vazirani Algorithm Simon's Algorithm Grover's Search Algorithm and amplitude amplification Shor's Factoring Algorithm and quantum Fourier transform (QFT) Quantum Phase Estimation Variational Quantum Algorithms (VQE, QAOA) Comparison of various quantum algorithms Classical and quantum advantages of various algorithm Complexity analysis and measures	
	Self-Learning Topics: *Implementation of various quantum algorithms using qiskit.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Identify the core principles of various quantum algorithms w.r.t superposition and entanglement over classical mechanism. (P.I.- 2.1.2)* *LO 4.2: Identifies functionalities and computing resources for selected quantum algorithm modelling. (P.I.- 2.2.2)* *LO 4.3: Analyze why different quantum algorithms are needed by linking them to the problems they solve and the advantages they provide. (P.I.- 2.4.2)* *LO 4.4: Able to choose appropriate quantum algorithm for enhancing technological needs by exploring the computational requirement of given problem. (P.I.- 3.1.4, P.I. 3.2.1)* *LO 4.5: Able to choose appropriate procedure to analyze the performance of algorithm. (P.I. 4.1.2)* *LO 4.6: Able to choose appropriate quantum hardware to conduct the experiment. (P.I.-4.1.3)*	

	LO 4.7: Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use by applying quantum mechanics. (P.I. 1.4.1, P.I.-5.3.2) *LO: 4.8: Identify and describe various engineering roles; particularly as pertains to protection against use of technology and documentations. (P.I. 6.1.1)* *LO 4.9: Identify gaps in current computation standards and demonstrate an ability to source information to close this gap using advance/ emerging technology. (P.I. 1.3.1, P. I. 11.1.2)*	
05.	**Module 5: Quantum Error Correction & Noise** ***Learning Objective:*** *Learner is expected to know the principles of quantum noise, types of quantum errors, and the mechanisms of quantum error correction (QEC) that protect quantum information.*	**05-07**
	Contents: Sources of Quantum Noise Decoherence, relaxation, and gate errors Quantum Error Correction Codes Shor code, Steane code, surface codes Fault-Tolerant Quantum Computation QBER and Numerical on quantum errors	
	Self-Learning Topics: *Simulate various quantum errors by injecting errors in any selected unitary operation.*	
	Learning Outcomes: *LO 5.1: Apply theory and principles quantum mechanics to know the fundamentals and sources to quantum errors. (P.I. 1.4.1)* *LO 5.2: Identifies various types and causes of quantum errors and noise. (P.I.- 2.2.2)* *LO 5.3: Identify the major types of quantum errors with respect to quantum coherence times. (P.I.-2.1.2)* *LO 5.4: Ability to explore various quantum errors based on physical device and implementations. (P.I.-3.2.1)* *LO 5.5: Ability to review quantum errors that may arise during given computations, relating them to specific operations and system behaviours. (P.I.- 3.1.3)* *LO 5.6: Critically analyze different quantum errors to analyze the characteristics and limitations of various quantum gate architectures. (P.I.-4.3.2)* *LO 5.7: Identify modern engineering tools, techniques and by knowing the role of engineering in designing the solution for problems using quantum computing. (P.I. 5.1.1, P.I. 6.1.1)* *LO 5.8: Recognize the importance of identifying and quantifying the impact of quantum errors on computational accuracy and outcomes. (P.I.-11.2.2)*	
06.	**Module 6: Quantum Machine Learning & Applications, Recent Advances & Research Directions** ***Learning Objective/s:*** *Learner is expected to explore recent research trends, emerging architectures (such as neutral atoms and topological qubits), and future directions in quantum AI and quantum-enhanced learning.*	**03-05**
	Contents: Quantum Machine Learning Quantum Data Encoding Quantum Kernel Methods Hybrid Quantum-Classical Models Quantum Key Distribution and BB84 and its bases QBER and eve intercept Applications in: • Cryptography • Optimization • Material science • Finance Quantum supremacy experiments Post-quantum cryptography Emerging architectures (neutral atoms, topological qubits)	

	Self-Learning Topics: *Explore on various tools/languages associate with quantum computing implementations*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Identify and describe recent research trends and advancements in quantum computing (P.I.-2.2.2)* *LO 6.2: Identify the need for quantum cryptography and compare its principles, security features, and applications with those of classical cryptography. (P.I.- 2.2.3)* *LO 6.3: Apply quantum machine learning techniques and compare their capabilities, performance, and use cases with classical machine learning approaches. (P.I.-1.4.1)* *LO 6.4: Able to explore the various design solutions and analyze potential design solutions suited to meet functional requirements of various protocols in communication, cryptography. (P.I. 3.2.1, P.I.-3.2.2)* *LO 6.5: Ability to find algorithm, data set and test cases w.r.t. classical domain integration with quantum mechanism. (P.I.-4.1.2)* *LO 6.6: Identify quantum techniques and resources for implementation of research needs and choose appropriate tool. (P.I.-5.1.1, P.I. 5.1.2)* *LO 6.7: Define the purpose of problem and identify and describe various engineering roles w.r.t. development of applications in this emerging field. (P.I. 4.1.1, P.I.-6.1.1)* *LO 6.8: Recognize the importance of identifying and quantifying the impact of quantum applications on computational accuracy and outcomes over classical computations. (P.I. 1.3.1, P.I.-11.2.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.1.1	Apply the knowledge of discrete structures, linear algebra, statistics and numerical techniques to solve problems.
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem.
2.1.2	Identifies processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.2.2	Identifies functionalities and computing resources.
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions.
2.2.4	Compare and contrast alternative solution/methods to select the best methods
2.4.2	Analyze and interpret the results using contemporary tools.
3.1.3	Ability to explore design alternatives.
3.1.4	Ability to choose appropriate quality attributes as defined by ISO/IEC/IEEE standard.
3.2.1	Ability to explore design alternatives.
3.2.2	Ability to produce a variety of potential design solutions suited to meet functional requirements.
3.4.3	Ability to verify the functionalities and validate the design.
4.1.2	Ability to choose appropriate procedure/algorithm, data set and test cases.
4.1.3	Ability to choose appropriate hardware/software tools to conduct the experiment.
4.3.2	Use appropriate procedures, tools and techniques to collect and analyze data.
5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at global, regional and local level
6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public

11.1.2 Analyze different forms of financial statements to evaluate the financial status of an engineering project.

11.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field.

Course Outcomes:

Learner will be able to

1. Apply linear algebra, probability theory, and complex number concepts to describe and analyze quantum states and operations. *(LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO1.5, LO1.6)*
2. Use the postulates of quantum mechanics and their application to quantum computation. Design and simulate quantum circuits using standard quantum gates and interpret their operation. *(LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6, LO 2.7)*
3. Compare different quantum hardware architectures (superconducting, trapped ions, photonic) and explain their implementation challenges. *(LO 3.1, LO 3.2, LO 3.3, LO 3.4, LO 3.5, LO3.6, LO 3.7, LO 3.8)*
4. Implement and analyze core quantum algorithms (e.g., Grover's search, Shor's factoring, Quantum Phase Estimation) and evaluate their complexity compared to classical counterparts. *(LO 4.1, LO 4.2, LO 4.3, LO 4.4, LO 4.5, LO 4.6.. LO 4.9)*
5. Use the sources of noise in quantum systems and demonstrate basic quantum error correction techniques. *(LO 5.1, LO 5.2, LO 5.3, LO 5.4. LO 5.5, LO 5.6, LO 5.7, LO 5.8)*
6. Evaluate the potential of quantum computing in applications such as cryptography, optimization, material science, and machine learning. *(LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6, LO 6.7, LO 6.8)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPEC7031.1	3	3	3	-	3	-	-	-	-	-	-
ITPEC7031.2	3	3	3	-	3	-	-	-	-	-	-
ITPEC7031.3	3	3	3	3	3	-	-	-	-	-	-
ITPEC7031.4	3	3	3	3	3	3	-	-	-	-	3
ITPEC7031.5	3	3	3	3	3	3	-	-	-	-	3
ITPEC7031.6	3	3	3	3	3	3	-	-	-	-	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**3**

Text Books:

1. Chris Bernhardt," Quantum Computing for Everyone", (The MIT Press) Hardcover – Illustrate, September 2020,
2. Willi-Hans Steeb; "Problems and Solutions in Quantum Computing and Quantum Information", Yorick Hardy
3. Academic Consulting and Editorial Services (ACES) Private Limited, January 2020.
4. M.A. Nielsen and I. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press 2010.
5. Book: Machine Learning with Quantum Computers, by Maria Schuld, Francesco Petruccione 2021

References Books:

1. Computer Science: An Introduction by N. David Mermin 5. Yanofsky's and Mannucci, Quantum Computing for Computer Scientists.

2. Parag K. Lala, Quantum Computing: A Beginner's Introduction Paperback" , McGraw Hill November 2020.

3. V. Sahni, "Quantum Computing", Tata McGraw-Hill Publishing company,2007.

Other Resources:

1. IBM Quantum Platform
2. Demos — PennyLane

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

a) Numerical Assignment/s (Minimum 20 problems) : 05 Marks

b) Class Test based on above numerical assignment: 05 Marks

c) One Flip classroom activity: 05 Marks

d) Regularity and active participation :05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ITPEC7032	HUMAN COMPUTER INTERACTION	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESL103: Programming Laboratory-I (C)
2. ESL205: Programming Laboratory-II (Java)
3. ITSBL301: Python Laboratory
4. ITSBL402-: Full stack Development Laboratory

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO5: Engineering Tool Usage
5. PO6: The Engineer and The World
6. PO 7: Ethics

Course Objectives:

1. To provide knowledge of the foundations of Human Computer Interaction.
2. To provide the future user interface designer with concepts and strategies for making design decisions.
3. To familiarize with the vocabulary associated with sensory and cognitive systems as relevant to task performance by humans and to apply models from cognitive psychology to predicting user performance in various human-computer interaction tasks.
4. To familiarize with a variety of both conventional and non-traditional user interface paradigms, including virtual and augmented reality, mobile and wearable computing, and ubiquitous computing.
5. To inculcate the HCI implications for designing multimedia/ ecommerce/ e-learning Web sites.
6. To explore emerging trends and technologies in HCI.

Module	Details	Hrs
00.	**Course Introduction** Human computer interaction course introduces the dynamic relationship between humans and computers with the basic principles, theories, and methodologies that makes the design and evaluation of interactive computing systems. HCI is an interdisciplinary field that draws upon insights from psychology, design, computer science, anthropology, and other disciplines to create technology that is intuitive, efficient, and enjoyable for users. students will gain an understanding of how humans	01

	interact with computers and how to design effective and usable computer systems.	
01.	**Introduction to Human Computer Interaction** ***Learning Objective/s:*** *Learner is expected to gain knowledge of basic concepts of human computer interaction and expected to categorize the commonalities and differences in various human computer interfaces.*	**05-07**
	Contents: Introduction to HCI, Importance of user Interface –definition, importance of good design. Benefits of good design. Commonalities and differences in interfaces. A brief history of HCI. User interface design (models, principles, practices) The graphical user interface – popularity of graphics, the concept of direct manipulation, graphical system, Characteristics, Web user –Interface popularity, characteristics- Principles of user interface.	
	Self-Learning Topics: *User-Centered Design, Usability Evaluation.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply basic concepts of human computer interaction to identify benefits of good design. (P.I.-1.3.1)* *LO 1.2: Use concepts of graphical user interface to understand the importance of user interface. (P.I.-1.4.1)* *LO 1.3: Identify commonalities and differences in interfaces. (P.I.-2.1.2)* *LO 1.4: formulate a solution plan and methodology by identifying characteristics and principles of user interface for web user. (P.I.-2.2.2)*	
02.	**Design process and Interaction Techniques** ***Learning Objective/s:*** *Learner is expected to perceive the knowledge of principles of user interface design and interaction techniques useful for design process of human computer interaction and expected to use design principles and analyze the interaction techniques.*	**06-08**
	Contents: User Interface Design: Principles of user-centered design, Interaction design basics, Visual design principles, Information architecture. Interaction Techniques: Input devices and interaction modalities, Gestural interfaces, Voice interfaces, Tangible interfaces. Screen Designing: Design goals – Screen planning and purpose, organizing screen elements, ordering of screen data and content – screen navigation and flow, Technological consideration in interface design.	
	Self-Learning Topics: *Information retrieval on web – statistical graphics Analyzing successful HCI designs.*	
	Learning Outcomes :	

	A learner will be able to *LO 2.1: Apply basic design principles for user interface design. (P.I.-1.3.1)* *LO 2.2: Use interaction techniques and screen design goals for organizing screen elements. (P.I.-1.4.1)* *LO 2.3: Identify the technological considerations in interface design to solve a given problem. (P.I.-2.1.2)* *LO 2.4: Compare and contrast interaction techniques to select the appropriate technique. (P.I.-2.2.4)* *LO 2.5: Demonstrate to explore design principle for human computer interaction. (P.I.-3.2.1)* *LO 2.6: Use interaction technique suited to meet functional requirement according to the requirement. (P.I.-3.2.2)*	
03.	**HCI in the software process** ***Learning Objective/s:*** *Learner is expected to familiarize with the concepts of HCI in software process, evaluation techniques and user interface development and are expected to evaluate the user interface patterns and develop user interface.*	**09-11**
	Contents: The software life cycle Integration of HCI in the software development lifecycle, Usability engineering iterative design and prototyping Design Focus: Prototyping in practice Design rationale, Design rules, Principles to support usability standards, golden rules and heuristics, HCI patterns, Evaluation techniques, Goals of evaluation, Evaluation through expert analysis, Evaluation through user participation, Choosing an evaluation method. Universal design, Universal design principles Multi-modal interaction. User Interface Development: Front-end development technologies (e.g., HTML/CSS, JavaScript) Responsive design and mobile UI development, Accessibility considerations in UI development.	
	Self-Learning Topics: *Analysis of real-world software projects applying HCI principles.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Apply basics of software development in integration of HCI in software process. (P.I.-1.3.1)* *LO 3.2: Use principles of software development for HCI prototyping. (P.I.-1.4.1)* *LO 3.2: Apply concepts of software development life cycle to formulate modules for HCI for the required performance. (P.I.-2.3.1)* *LO 3.4: Identify design constraints for HCI patterns. (P.I.-2.3.2)* *LO 3.5: Demonstrate ability to explore front end development technologies for HCI. (P.I.-3.2.1)* *LO 3.6: Use software development techniques suited to meet functional requirement for designing HCI. (P.I.-3.2.2)* *LO 3.7: Use appropriate procedure or technique to collect data for analyzing HCI patterns. (P.I.-4.3.1)* *LO 3.8: Analyze the evaluation techniques stating possible errors and limitations. (P.I.-4.3.2)*	

04.	**Models, Components and software tools** ***Learning Objective/s:*** *Learner is expected to gain the knowledge of windows navigation schemes, components, interaction tools and various display methods and also expected to select and use suitable windows navigation scheme icons, multimedia colors various function keys to interact with the devices and the software installed on them.* *Learner is expected to familiarize with the concepts of cognitive models and ubiquitous computing and also expected to identify how users perceive, understand, and mentally process information while interacting with a computer system or interface.*	**07-09**
	Contents: Windows navigation schemes, selection of window, selection of devices based on screen based controls. Components – text and messages, Icons, Multimedia, colors problems, choosing colors. Software tools – Specification methods, interface Building Tools. Interaction Devices: Keyboard and function keys. speech recognition digitization and generation image and video displays drivers. Human Factors and Cognitive Psychology: Human perception and cognition Mental models and conceptual models, Socio-Organizational issues and stakeholder requirements.	
	Self-Learning Topics: *Heuristic evaluation, Cognitive walkthrough*	
	Learning Outcomes : *A learner will be able to* *LO 4.1: Use basics of windows navigation methods to, interact with, and manage the contents of their Windows-based devices. (P.I.-1.3.1)* *LO 4.2: Apply principles of cognitive models for understanding user behavior while interacting with the computer system. (P.I.-1.4.1)* *LO 4.3: Identify the issues with of stakeholder's requirements and to form justified assumptions. (P.I.-2.2.3)* *LO 4.4: Compare various interaction devices and select the best one for interacting with the computer system. (P.I.-2.2.4).* *LO 4.5: Identify various user interface design tools for high fidelity interface designs, icons and visual assets. (P.I.-5.1.1).* *LO 4.6: Discuss the limitations of tools identified for user interface design. (P.I.-5.3.1).*	
05.	**Secure User Interface Design** ***Learning Objective/s:*** *Learner is expected to perceive knowledge, skills, and competencies necessary to design secure user interfaces that protect against common security vulnerabilities and implement security features in user interfaces.*	**05-07**
	Contents:	
	Principles and best practices for designing secure user interfaces that prevent common security vulnerabilities such as phishing attacks, clickjacking, and cross-site scripting. Introduction to secure design patterns and guidelines for implementing security features in user	

	interfaces. approaches to designing secure authentication mechanisms that balance security and usability.	
	Self-Learning Topics: *Security in Mobile and Ubiquitous Computing.*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply security principles for designing secure use interfaces. (P.I.-1.3.1)* *LO5.2: Demonstrate knowledge required to prevent common security vulnerabilities while designing user interfaces and apply principles of sustainable design and development of user interfaces (P.I.-1.4.1,6.2.2)*	
06.	**Emerging Trends in HCI** ***Learning Objective/s:*** *Learner is expected to familiarize with emerging trends, paradigms, and methodologies shaping the future of HCI and Analyze the implications of emerging trends interface development.*	**05-07**
	Contents: Designing Web Interfaces, Natural User Interfaces (NUIs): Gesture-based interaction Touch and multi-touch interfaces, voice and speech recognition, Augmented and Virtual Reality (AR/VR), Wearable and Embodied Interaction, Tangible User Interfaces, Brain-Computer Interfaces, Social and Collaborative Interaction.	
	Self-Learning Topics: *Investigate emerging trends in collaborative and social interaction, such as virtual collaboration tools*	
	Learning Outcomes : *A learner will be able to* *LO 6.1: Demonstrate competence in how humans can interact with computers beyond traditional methods. (P.I.-1.3.1)* *LO 6.2: Use concepts related to designing interfaces for wearable devices, smart homes, IoT devices, and ambient intelligence systems. (P.I.-1.4.1)* *LO 6.3: Develop skills to explore designing interfaces and interactions that prioritize user needs, preferences, and behaviors. (P.I.-3.2.1)* *LO 6.4: Ability to produce a variety of designing inclusive interfaces that cater to diverse user needs, including those with disabilities and also examine and ethical and societal implications of emerging HCI trends. (P.I.-3.2.2,7.2.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals.
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem

2.1.2 Identifies processes/modules/algorithms of a computer-based system and parameters to solve a Problem.

2.2.2 Identifies functionalities and computing resources.

2.2.3 Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions.

2.2.4 Compare and contrast alternative solution/methods to select the best methods

2.3.1 Able to apply computer engineering principles to formulate modules of a system with required applicability and performance.

2.3.2 Identify design constraints for required performance criteria.

3.2.1 Ability to explore design alternatives.

3.2.2 Ability to produce a variety of potential design solutions suited to meet functional requirements.

4.3.1 Use appropriate procedures, tools and techniques to collect and analyze data.

5.1.1 Identify modern engineering tools, techniques and resources for engineering activities.

5.3.1 Discuss limitations and validate tools, techniques and resources

6.2.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline.

7.2.2 Examine and apply moral & ethical principles to known case studies.

Course Outcomes:

Learner will be able to

1. Apply and analyse concepts of HCI principles and user interface design concepts. *(LO 1.1, LO1.2, LO1.3, LO1.4)*

2. Use and analyse principles of designing user interfaces and skills to leverage various interaction techniques to create intuitive and engaging user experiences incorporating interaction across different devices and platforms.*(LO2.1,LO2.2,LO2.3,LO2.4,LO2.5,LO2.6, LO3.1,LO3.2,LO3.3,LO3.4,LO3.5,LO3.6, LO3.7, LO3.8)*

3. Apply and analyse models ,and component integration for efficient interface design using colour theory, software tools, and human factors principles to create user-centric solutions. *(LO4.1, LO4.2, LO4.3, LO4.5, LO4.6)*

4. Apply secure design patterns and guidelines to implement robust security features in user interfaces, ensuring the protection of sensitive user information and system integrity. *(LO5.1, LO5.2)*

5. Use and analyse the impact of emerging trends and recent advancements shaping HCI *(LO6.1, LO6.2, LO6.3, LO6.4)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPEC7032.1	3	3	-	-	-	-	-	-	-	-	-
ITPEC7032.2	3	3	3	-	-	-	-	-	-	-	-
ITPEC7032.3	3	3	-	-	3	-	-	-	-	-	-
ITPEC7032.4	3	-	-	-	-	-	2	-	-	-	-
ITPEC7032.5	3	-	3	-	-	-	-	2	-	-	-
Average	**3**	**3**	**3**	**-**	**3**	**-**	**2**	**2**	**-**	**-**	**-**

Text Books:

1. The essential guide to user interface design, Wilbert O Galitz, Second Edition, 2002, Wiley
2. Human – Computer Interaction, Alan Dix, Janet Fincay, Gre Goryd, Abowd, Russell Bealg , Third Edition,2003, Pearson.
3. Designing the User Interface: Strategies for Effective Human-Computer Interaction, Ben Shneiderman , Catherine Plaisant, Maxine Cohen , Fifth Edition, 2009, Pearson.

Reference Books:

1. Interaction Design, Helen Sharp, Jennifer Preece, Yvonne Rogers,5th Edition,2019,Wiley.
2. User Interface Design, Soren Lauesen, First Edition,2004, Addison-Wesley.
3. Human –Computer Interaction, D. R. Olsen, First Edition, 2010, Publisher.

Other Resources:

1. NPTEL Course: User-centric Computing for Human-Computer Interaction, By Prof. Samit Bhattacharya, Department of Computer Science and Engineering, IIT Guwahati:-Web link- https://nptel.ac.in/courses/106103220/
2. NPTEL Course: Introduction to Human Computer Interaction,By Prof. Ponnurangam Kumaraguru, Department of Computer Science and Engineering, IIIT Hyderabad:-Web link- https://nptel.ac.in/courses/106106177

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

Suggested breakup of distribution

a) Two class test: 10 Marks

b) One Think Pair and Share activity: 05 Marks

c) Regularity and active participation :05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAM (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ITPEC7033	ETHICAL HACKING AND DIGITAL FORENSICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ITPCC406: Computer Networks
2. ITPCC611: Computer Network Security

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO 5: Engineering tool usage
4. PO8: Individual and Collaborative team work
5. PO9: Communication
6. PO11: Life-long learning

Course Objectives:

1. To impart knowledge of engineering fundamentals and computer science principles for understanding cybercrimes, types of cybercriminals, ethical hacking methods, and preventive measures.
2. To introduce learners to the digital forensics process, focusing on evidence handling, incident response strategies, and CSIRT roles, while evaluating methodologies and limitations.
3. To introduce learners to collect, acquire, and examine digital evidence from multiple environments using forensic tools, modern engineering practices, teamwork, and emerging technologies.
4. To impart skills for analyzing and interpreting network forensic evidence from wired and wireless networks, IDS, and router logs, while addressing forensic challenges and enhancing communication of findings.
5. To impart skills for analyzing and interpreting network forensic evidence from wired and wireless networks, IDS, and router logs, while addressing forensic challenges and enhancing communication of findings.

Module	Details	Hrs.
00.	**Course Introduction**	**01**

	This course introduces students to the fundamentals of Ethical Hacking and Digital Forensics, focusing on cybercrimes, ethical hacking techniques, and forensic investigation processes. It equips learners with skills to collect, analyze, and interpret digital evidence from computers, networks, and mobile devices using modern forensic tools. The course also emphasizes incident response, report generation, teamwork, and effective communication to address real-world cybersecurity challenges.	
01.	**Cybercrime and Ethical Hacking** ***Learning Objective:*** *To impart learner to apply engineering fundamentals and principles of computer science engineering to analyse types of cybercriminals, their methods, and the role of computers in cybercrimes; identify limitations of ethical hacking solutions and draw conclusions on system vulnerabilities and security measures based on ethical hacking goals, phases, and rules (PI).*	**05-07**
	Contents: Introduction to Cybercrime, Types of Cybercrime, Classification of Cybercriminals, Role of computer in Cybercrime, Prevention of Cybercrime. Ethical Hacking, Goals of Ethical Hacking, Phases of Ethical Hacking, Difference between Hackers, Crackers and Phreakers, Rules of Ethical Hacking.	
	Self-Learning Topics: *Exploring various online hacking tools for Reconnaissance and scanning Phase.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply engineering fundamentals to explain and classify cybercrimes, types of cybercriminals, and their methods. (PI 1.3.1)* *LO 1.2: Apply theory and principles of computer science engineering to solve issues related to the role of computers in cybercrimes and propose preventive measures. (PI 1.4.1)* *LO 1.3: Identify the limitations of ethical hacking solutions and their sources or causes when analyzing hacking activities and attacker classifications. (PI 2.4.3)* *LO 1.4: Arrive at conclusions regarding system vulnerabilities and security measures through the evaluation of ethical hacking goals, phases, and rules. (PI 2.4.4)*	
02.	**Digital Forensics Fundamentals** ***Learning Objective:*** *To introduce learners to analyzing and evaluating the digital forensics process, identifying limitations in evidence handling and incident response, and drawing informed conclusions on evidence management and CSIRT strategies.*	**07-09**
	Contents: Introduction to Digital Forensics, Need and Objectives of Digital Forensics, Types of Digital Forensics, Process of Digital Forensics, Benefits of Digital Forensics, Chain of Custody, Anti Forensics. Digital Evidence and its Types, Rules of Digital Evidences. Incident Response, Methodology of Incident Response, Roles of CSIRT in handling incident.	
	Self-Learning Topics: *Pre Incident preparation and Incident Response process*	
	Learning Outcomes:	

	A learner will be able to *LO 2.1: Apply engineering fundamentals to explain the need, objectives, and types of digital forensics. (PI 1.3.1)* *LO 2.2: Apply theory and principles of computer science engineering to analyze the digital forensics process and evaluate its benefits. (PI 1.4.1)* *LO 2.3: identify the limitations of digital evidence handling, incident response methodologies, and anti-forensics techniques, along with their sources or causes. (PI 2.4.3)* *LO2.4: Arrive at conclusions on digital evidence management, incident response strategies, and CSIRT roles by evaluating rules, methodologies, and security measures. (PI 2.4.4)*	
03.	**Computer Forensics** ***Learning Objective:*** *Enable learners to collect, acquire, and analyze digital evidence across multiple environments using appropriate forensic tools, evaluate challenges, apply engineering practices and teamwork, and communicate investigation results effectively while staying updated with emerging forensic technologies* **Contents:** Introduction to Computer Forensics, Evidence collection (Disk, Memory, Registry, Logs etc), Evidence Acquisition, Analysis and Examination(Window, Linux, Email, Web, Malware) , Challenges in Computer Forensics, Tools used in Computer Forensics. ***Self-Learning Topics:*** *Open source tool for Data collection & analysis in windows or Unix* ***Learning Outcomes:*** *A learner will be able to* *LO 3.1: Apply engineering fundamentals to collect, acquire, analyze, and examine digital evidence using appropriate tools while addressing key challenges in computer forensics. (PI 1.3.1)* *LO 3.2: Apply theory and principles of computer science engineering to solve problems involving digital evidence collection, acquisition, analysis, and examination using appropriate computer forensic tools.. (PI 1.4.1)* *LO 3.3: Identify and evaluate existing methods for collecting and acquiring evidence from disks, memory, registries, and logs, including justified approximations and assumptions. (PI 2.2.3)* *LO 3.4: Analyze and evaluate alternative approaches for evidence acquisition and examination across multiple environments, assess challenges in computer forensics, and select appropriate forensic tools to address limitations and ensure accurate, efficient investigations. (PI 2.2.4)* *LO 3.5: Apply modern engineering tools, teamwork skills, technical literature, and emerging forensic technologies to effectively collect, acquire, analyze, and examine digital evidence across multiple environments. (PI 2.4.3,5.1.1, 5.2.1, 8.1.1, 9.1.1, 11.2.1)* *LO 3.6: Use forensic tools, work effectively in teams, communicate investigation results, and stay updated with advances in computer forensics for efficient evidence handling. (PI 2.4.4,5.2.1, 8.3.1, 9.2.2, 11.2.2)*	**07-09**
04.	**Network Forensics** ***Learning Objectives:*** *To impart to learners ability to collect, acquire, analyze, and interpret evidence from wired and wireless networks, including IDS and router data, apply appropriate*	**09-11**

	forensic tools and network forensics principles, address challenges, and communicate findings effectively in professional contexts	
	Contents: Introduction, Evidence Collection and Acquisition (Wired and Wireless), Analysis of network evidences(IDS, Router,), Challenges in network forensics, Tools used in network forensics.	
	Self-Learning Topics: *IDS types and role of IDS in attack prevention.*	
	Learning Outcomes: *A learner will be able to* *LO 4.1: Apply engineering fundamentals to collect, analyze, and interpret wired and wireless network evidence using appropriate forensic tools while addressing key challenges in network forensics...(PI:1.3.1)* *LO 4.1: Apply theory and principles of computer science engineering to solve problems in collecting and analyzing wired and wireless network evidence using suitable forensic tools.(PI:1.4.1)* *LO 4.3: Identify existing forensic methods and tools to analyze network evidence, including forming justified approximations and assumptions necessary for solving network forensics challenges..(PI:2.2.3)* *LO 4.4: Compare and contrast alternative solution/methods (e.g., packet analysis tools vs. flow analysis tools, or different forensic acquisition techniques for wired vs. wireless evidence) to address specific challenges in network forensics (e.g., encrypted traffic or high-volume data), and select the best methods and suitable forensic tools necessary to analyze and interpret network evidence to draw accurate conclusions.(PI: 2.2.4)* *LO 4.5: Apply network forensics principles to collect, analyze, and interpret evidence from wired and wireless networks using appropriate tools, addressing challenges and communicating findings effectively.(PI: .2.2.3,5.1.1, 5.2.1, 8.1.1, 9.1.1, 11.2.1)* *LO 4.6: Collect and acquire evidence from wired and wireless networks, analyze network data including IDS and router logs, address challenges in network forensics, utilize appropriate forensic tools, and communicate findings effectively in professional contexts.(PI: 2.2.4,5.2.1, 8.3.1, 9.2.2, 11.2.2)*	
05.	**Mobile Forensics** ***Learning Objective/s:*** *To enable learners to systematically collect, acquire, and analyze evidence from mobile devices, apply suitable forensic tools, address challenges in mobile forensics, and effectively interpret findings in professional contexts.*	**06-08**
	Contents: Introduction, Evidence Collection and Acquisition, Analysis of Evidences, Challenges in mobile forensics, Tools used in mobile forensics	
	Self-Learning Topics: *Tools / Techniques used in mobile forensics.*	
	Learning Outcomes : *A learner will be able to* *LO 5.1: Apply engineering fundamentals to describe the process of evidence collection, acquisition, and analysis in mobile forensics, including the challenges and tools used. (PI 1.3.1)).*	

	LO 5.2: Apply theory and principles of computer science engineering to solve problems related to collecting, analyzing, and interpreting mobile forensic evidence using appropriate tools. (PI 1.4.1) *LO 5.3: Identify existing solution/methods (including structured forensic methodologies, appropriate tools for data acquisition, and techniques for data parsing/analysis) to solve the problem of systematically collecting, analyzing, and interpreting evidence from mobile devices, while forming justified approximations and assumptions necessary to address inherent challenges such as data encryption, partial extractions, and the verification of device state (PI 2.2.3).* *LO 5.4: Compare and contrast alternative solution/methods (e.g., logical vs. physical extraction, automated vs. manual analysis, or different commercial/open-source forensic tools) based on their ability to address specific challenges in mobile forensics (e.g., encryption, operating system version, or locked devices), and select the best methods for analyzing and assessing mobile device evidence to draw reliable conclusions (PI 2.2.4).* *LO 5.5: Collect, analyze, and interpret evidence from mobile devices using appropriate forensic tools, addressing challenges and communicating findings effectively (PI: 2.2.3,5.1.1, 8.1.1, 9.1.1, 11.2.1).* *LO 5.6: Collect, analyze, and interpret evidence from mobile devices using suitable forensic tools, addressing challenges and communicating findings effectively (PI: 2.2.4,5.2.1, 8.3.1, 9.2.2, 11.2.2).*	
06.	**Report Generation** ***Learning Objective/s:*** *To introduce learners to systematically collecting, analyzing, and interpreting evidence from mobile devices using appropriate forensic tools, addressing challenges in mobile forensics, and effectively communicating findings in professional contexts*	**03-05**
	Contents: Goals of Report, Layout of an Investigative Report, Guidelines for Writing a Report, sample for writing a forensic report.	
	Self-Learning Topics: *For an incident write a forensic report.*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Prepare investigative reports by organizing content, following guidelines, analyzing information, and communicating findings effectively (PI:2.2.3, 5.1.1, 8.1.1, 9.1.1, 11.2.1).* *LO 6.2: Collect, organize, and analyze information to prepare investigative reports following proper layout and guidelines, and communicate findings effectively in professional contexts (PI: 2.2.4,5.2.1, 8.3.1, 9.2.2, 11.2.2).*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem
2.4.3	Identify the limitations of the solution and sources/causes.
2.4.4	Arrive at conclusions with respect to the objectives.
5.1.1	Identify modern engineering tools, techniques and resources for engineering activities

5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs
8.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1 Read, understand and interpret technical and nontechnical information
9.2.2 Deliver effective oral presentations to technical and non-technical audiences
11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
11.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field

Course Outcomes: A learner will be able to -

1. Apply engineering fundamentals and computer science principles to explain cybercrimes, classify cybercriminals, evaluate ethical hacking methods, and propose preventive measures, while identifying limitations and assessing system vulnerabilities (LOs: 1.1, 1.2, 1.3, 1.4).
2. Analyze and evaluate the digital forensics process, including evidence handling, incident response strategies, and CSIRT roles, while identifying limitations, assessing methodologies, and drawing informed conclusions (LOs: 2.1, 2.2, 2.3, 2.4).
3. Collect, acquire, and examine digital evidence from disks, memory, registries, and logs across multiple environments, using appropriate forensic tools, modern engineering practices, teamwork, and emerging technologies to ensure accurate and efficient investigations (LOs: 3.1,3.2,3.3, 3.4, 3.5, 3.6).
4. Collect, analyze, and interpret evidence from wired and wireless networks, including IDS and router data, applying network forensics principles, appropriate tools, and communication skills to address challenges and draw accurate conclusions (LOs: 4.1, 4.2, 4.3, 4.4.4.5,4.6).
5. Collect, analyze, and interpret evidence from mobile devices and prepare investigative reports, applying appropriate forensic tools, addressing challenges, and effectively communicating findings in professional contexts (LOs: 5.1, 5.2, 5.3, 5.4,5.5,5.6, 6.1, 6.2).

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPEC7033.1	3	3	-	-	-	-	-	-	-	-	-
ITPEC7033.2	3	3	-	-	-	-	-	-	-	-	-
ITPEC7033.3	-	3	-	-	3	-	-	3	3	-	3
ITPEC7033.4	-	3	-	-	3	-	-	3	3	-	3
ITPEC7033.5	-	-	-	-	3	-	-	3	3	-	3
Average	**3**	**3**	**-**	**-**	**3**	**-**	**-**	**3**	**3**	**-**	**3**

Text Books :

1. John Sammons, "The Basics of Digital Forensics: The Premier for Getting Started in Digital Forensics", 2nd Edition, Syngress, 2015.
2. Nilakshi Jain, Dhananjay Kalbande, "Digital Forensic: The fascinating world of Digital Evidences" Wiley India Pvt Ltd 2017.
3. Jason Luttgens, Matthew Pepe, Kevin Mandia, "Incident Response and computer forensics",3rd Edition Tata McGraw Hill, 2014.

Reference Books :

1. Sangita Chaudhuri, Madhumita Chatterjee, "Digital Forensics", Staredu, 2019.
2. Bill Nelson,Amelia Phillips,Christopher Steuart, "Guide to Computer Forensics and Investigations" Cengage Learning, 2014.
3. Debra Littlejohn Shinder Michael Cross "Scene of the Cybercrime: Computer Forensics Handbook", 2nd Edition Syngress Publishing, Inc.2008.

Other Resources :

1. NPTEL Course on Ethical hacking by Prof.Indranil Sengupta Department of Computer Science and Engineering, IIT Khargpur https://nptel.ac.in/courses/106105217

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

a) MCQ test strictly as per GATE exam pattern / level): 05 Marks

b) Think Pair Share (TPS) activity: 05 Marks

c) Article reading & summarization: 05 Marks

d) Regularity and active participation :05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ITPEC7041	BIG DATA ANALYTICS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ITPCC304 : Database management System
2. ITSBL301: Python Laboratory

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5. PO8: Individual and Collaborative team work
6. PO9: Communication
7. PO11: Life-Long Learning

Course Objectives:

1. To prepare students to know fundamental concepts of Big Data and Ecosystem.
2. To equip students to learn data storage and processing frameworks like Hadoop and NoSQL.
3. To train students to explore techniques for large-scale data analytics and visualization.
4. To make students to aware of data mining and machine learning techniques for big data.
5. To prepare students to work with real-world big data tools and case studies.

Module	Details	Hrs.
00.	**Course Introduction** Big Data Analytics course is designed to provide an in-depth understanding of the concepts, technologies, and methodologies used to analyze and derive insights from large-scale, complex, and dynamic datasets. Building upon foundational knowledge of big data frameworks like Hadoop and Spark, this course explores modern architectures, real-time analytics, scalable machine learning, and big data applications.	01
01.	**Introduction to Big Data** ***Learning Objective:*** *To make learner identify and summarize basics of big data Analytics and its challenges.*	04-06

	Contents: Definition and characteristics of Big data, Big Data vs. Traditional Data, Types of Big Data, Big Data architecture and life cycle, Big Data issues and Challenges, Applications in business, healthcare, IoT, social media, etc.	
	Self-Learning Topics: *Applications of Big Data Analytics in Research and Development*	
	Learning Outcomes: A learner will be able to *LO 1.1: Apply fundamental concepts of Big Data Analytics to solve big data issues and Challenges (P.I.-1.3.1)* *LO1.2: Apply the knowledge of big data Analytics to find the limitations of traditional data to provide solution to different business applications (P.I.-1.4.1)* *LO 1.3: Identify processes for building Big Data Architecture and life cycle (P.I.-2.1.2)* *LO 1.4: Identify the issues and challenges with respect to big data analytics business applications (P.I.-2.2.2)*	
02.	**Introduction to Big Data Framework** ***Learning Objective:*** *To familiarize with the big data framework like Hadoop and NoSQL*	**08-10**
	Contents: Hadoop: Core components, working, ecosystem overview, HDFS: Architecture, blocks, Name Node, Data Node, I/O operations, MapReduce: Concept, data flow, programming model, Algorithms - Wordcount, Matrix-Vector and Matrix- Matrix. YARN: Resource management, NoSQL: CAP theorem, Types of NoSQL Databases: Key-Value, Column-family, Document, Graph, MongoDB and Cassandra basics, Data ingestion and ETL process, Cloud storage options like AWS S3, Google BigQuery, Azure Data Lake Hadoop tools: Pig, Hive, HBase, Sqoop, Flume, Oozie, Zookeeper. Demonstration with Open source MapReduce and NoSQL tool	
	Self-Learning Topics: *Learn Distributed and Federated NoSQL systems*	
	Learning Outcomes: A learner will be able to *LO 2.1: Apply big data ecosystem components of Hadoop for storing and processing big data (P.I.-1.3.1)* *LO 2.2: Apply different NoSQL models for big data storage and analytics (P.I.-1.4.1)* *LO 2.3: Design solutions based on NOSQL design patterns for big data applications (P.I.-3.2.2)* *LO 2.4: Design solution based on different Hadoop components and NoSQL tools for big data to perform systematic evaluation to meet the criteria and identify tasks required to complete it (P.I.- 3.3.1)* *LO 2.5: Design and analyse solution based on NoSQL database to meet functional requirements and select most appropriate proposal (P.I.-4.1.3, 8.2.1, 9.2.1, 11.2.1)* ***LO 2.6: Design and analyse solution based on different Hadoop components to meet the criteria and identify tasks required to complete it (P.I.- 4.2.1, 8.3.1, 9.3.3, 11.3.2)***	
03.	**Data Processing and Analytics with Spark** ***Learning Objective:*** *To make learner analyse different data processing techniques with spark*	**06-08**
	Contents: Introduction to Apache Spark, Spark Core: RDDs, transformations, actions, Spark SQL and DataFrames, Spark Streaming basics, Introduction to MLlib and GraphX, Comparison: Hadoop MapReduce vs. Spark, Demonstration with Open source Spark tool.	

	Self-Learning Topics: ***Use SPARQL to real time data processing*** ***Learning Outcomes: A learner will be able to*** *LO 3.1: Synthesize requirements of Apache spark for big data Analytics (P.I.- 3.1.5)* *LO 3.2: Design Apache spark based design solutions for big data Analytics and select most appropriate proposal (P.I.-3.2.1)* *LO 3.3: Apply appropriate algorithms to Spark based big data Analytics solution(P.I.-1.4.1)* *LO 3.4: Apply big data concepts to find correlations using MLibX and GraphX. (P.I.-1.3.1)*	
04.	**Mining Big Data Streams** ***Learning Objective:*** *To make learner know different Big data Mining techniques to stream data and application of that to real life scenario.*	**07-09**
	Contents: The Stream Data Model: A DataStream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. Sampling Data in a Stream: Sampling Techniques. Filtering Streams: The Bloom Filter Counting Distinct Elements in a Stream: The Count-Distinct Problem, The Flajolet-Martin Algorithm, Combining Estimates, Space Requirements. Counting Ones in a Window: The Cost of Exact Counts, The Datar-Gionis-Indyk, Motwani Algorithm, Query Answering in the DGIM Algorithm. Demonstration of stream data mining algorithms using open source tools.	
	Self-Learning Topics: *Streaming services like Apache Kafka/Amazon Kinesis/Google Cloud DataFlow, Standard spark streaming library.*	
	Learning Outcomes: A learner will be able to *LO 4.1: Identify and use algorithms required for data stream management. (P.I.-2.1.2)* *LO 4.2: Analyse the stream filtering algorithms for big data by stating approximations and assumptions (P.I.-2.2.3)* *LO 4.3: Apply query answering algorithms for big data (P.I.-1.3.1)* *LO 4.4: Apply information and knowledge required for stream data management (P.I.-1.4.1)*	
05.	**Big Data Mining, Machine Learning, and Visualization** ***Learning Objective:*** *To make learner aware of the different big data mining, machine learning and visualization techniques.*	**06-08**
	Contents: Frequent Pattern Mining: Handling Larger Datasets in Main Memory Basic Algorithm of Park, Chen, and Yu. The SON Algorithm and MapReduce. Clustering Algorithms: CURE Algorithm. Canopy Clustering, Clustering with MapReduce Classification Algorithms: Overview SVM classifiers,Parallel SVM, KNearest Neighbor classifications for Big Data, One Nearest Neighbor. Data preprocessing and feature selection for big data, Recommendation system, Big data analytics tools: Spark MLlib, Mahout, TensorFlow, Data visualization using Tableau / Power BI / Python libraries, Demonstration using Open source visualization tools	

	Self-Learning Topics: *Identify current trends in recent Big data technologies available in the market.* ***Learning Outcomes: A learner will be able to*** *LO 5.1: Apply frequent pattern mining and recommendation algorithms for handling larger data sets (P.I.- 1.3.1)* *LO 5.2: Apply different classification and clustering algorithms to categorize big data (P.I.-1.4.1)* *LO 5.3: Identify frequent pattern mining and recommendation algorithms for handling larger data sets to solve a problem. (P.I.- 2.1.2)* *LO 5.4: Identify and compare different classification and clustering algorithms to arrive at conclusion with respect to objectives (P.I.-2.4.4)*	
06.	**Advanced Topics and Case studies for Big Data Analytics** ***Learning Objective:*** *To make learner aware of emerging technologies in big data and its uses cases.*	**06-08**
	Contents: Deep Learning for Big Data: Transformers on large datasets Visual Language Model, AutoML and Model Optimization: Hyper parameter tuning at scale, Big Data Case Studies: Social media analytics, Healthcare, Smart Cities, image analytics, predictive maintenance.	
	Self-Learning Topics: *Case Studies: Google Search, ChatGPT Search Integration, and Semantic Search Systems* ***Learning Outcomes:*** *A learner will be able to* *LO 6.1: Design big data analytics applications based on deep learning models (P.I.- 3.2.2)* *LO 6.2: Design solution for Predictive maintenance in multiple domain and providing alternatives (P.I.- 3.2.1)* *LO 6.3: Identify technological advances in big data technologies for smart cities applications (P.I.- 4.1.2)* *LO 6.4: Identify and analyse impact of big data on performance of social media analytics (P.I.- 4.3.1)* *LO 6.5: Design and analyse solution based on Deep learning for selected Big data case study to meet functional requirements and select most appropriate proposal (P.I.- 8.2.1, 9.2.1, 11.2.1)* *LO 6.6: Design and analyse solution based on Predictive maintenance based big data business application to meet the criteria and identify tasks required to complete it (P.I.- 8.3.1, 9.3.3, 11.3.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem
2.1.2	Identifies processes/modules/algorithms of a computer based system and parameters to solve a problem
2.2.2	Identifies functionalities and computing resources.
2.2.3	Identify existing solution/methods to solve the problem, including forming justified approximations and assumptions
2.4.4	Arrive at conclusions with respect to the objectives
3.1.5	Explore and synthesize system requirements from larger social and professional concerns
3.2.1	Ability to explore design alternatives
3.2.2	Ability to produce a variety of potential design solutions suited to meet functional requirements

3.3.1 Ability to perform systematic evaluation of the degree to which several design concepts meet the criteria

4.1.2 Ability to choose appropriate procedure/algorithm, data set and test cases.
4.1.3 Ability to choose appropriate hardware/ software tools to conduct the experiment.
4.2.1 Design and develop appropriate procedures/methodologies based on the study objectives
4.3.1 Use appropriate procedures, tools and techniques to collect and analyze data
8.2.1 Demonstrate effective communication, problem solving, conflict resolution and leadership skills

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

9.2.1 Listen to and comprehend information, instructions, and viewpoints of others.
9.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations
11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
11.3.2 Analyse sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to

1. Use basic concepts and framework of big data analytics in the real world scenario. (LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO2.6)
2. Apply data analytics techniques using Spark. (LO 3.1, LO 3.2, LO 3.3, LO 3.4)
3. Use the basic concepts of the big data analytics and Implement several Data Intensive tasks for stream data mining using the Map Reduce Paradigm. (LO 4.1, LO 4.2, LO 4.3, LO 4.4)
4. Analyse large datasets using ML algorithms, libraries and visualization tools. (LO 5.1, LO 5.2, LO 5.3, LO 5.4)
5. Design and implement big data solutions for real-life case studies (LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPEC7041.1	3	3	3	3	-	-	-	3	3	-	3
ITPEC7041.2	3	-	3	-	-	-	-	-	-	-	-
ITPEC7041.3	3	3	-	-	-	-	-	-	-	-	-
ITPEC7041.4	3	3	-	-	-	-	-	-	-	-	-
ITPEC7041.5	-	-	3	3	-	-	-	3	3	-	3
Average	**3**	**3**	**3**	**3**	-	-	-	**3**	**3**	-	**3**

Text Books :

1. Tom White, *Hadoop: The Definitive Guide*, O'Reilly
2. Anand Rajaraman & Jeffrey Ullman, *Mining of Massive Datasets*, Cambridge University Press
3. Holden Karau et al., *Learning Spark: Lightning-Fast Big Data Analysis*, O'Reilly

Reference Books :

1. *Seema Acharya, Subhasini Chellappan,* Big Data and Analytics*, Wiley.*
2. Vignesh Prajapati, *Big Data Analytics with R and Hadoop*, Packt.
3. Arshdeep Bahga, Vijay Madisetti*,* Big Data Science & Analytics*,* Universities Press

Other Resources :

1. Big Data Computing, Indian Institute of Technology Patna, https://onlinecourses.nptel.ac.in/noc20_cs92/preview
2. Algorithms for Big Data, Indian Institute of Technology Madras nptel.ac.in/courses/106106142

3. Introduction to Data Analytics, Indian Institute of Technology Madras, nptel.ac.in/courses/110106072
4. **Data Analytics with Python,** , Indian Institute of Technology Roorkee https://onlinecourses.nptel.ac.in/noc21_cs45/preview

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

a) Assignment on live problems/ case studies: 10 Marks
Students should be assigned a real life problem statement related to big data Analytics domain. Students are expected to research and collect required data to design a system for the selected problem. Students should apply big data knowledge to design a system based on computing resources. Students should present their work in the form of presentation and demonstration in 10-15 minutes. This assignment will be graded for 10 marks like a design assignment based on the parameters such as data acquisition, requirement analysis, designing a system for selected problem statement.
b) Class Test: 05 Marks
c) Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)
Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ITPEC7042	AUGMENTED REALITY/VIRTUAL REALITY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ESL103: Programming Laboratory-I (C)
2. ESL205: Programming Laboratory-II (Java)
3. ITSBL301: Python Laboratory
4. ITLBC507: Mobile Application Development Laboratory

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 3: Design and Development of Solution
4. PO 4: Conduct investigation of Complex Problem
5. PO 5: Engineering Tool Usage
6. PO 8: Individual and Collaborative Team Work
7. PO 9: Communication
8. PO 11: Life-long learning

Course Objectives:

1. To establish a foundational understanding of Augmented and Mixed Reality by exploring their core architecture, historical evolution, and algorithmic processes. It also enables learners to differentiate AR/MR from related immersive technologies like Virtual and Extended Reality.
2. To equip learners with the principles of tracking, calibration, and registration in AR/MR systems, and enable them to analyse and compare various tracking technologies like sensor-based, optical, and outdoor methods.
3. To prepare learners with the ability to classify and apply various interaction modalities and authoring techniques for designing, modelling, and annotating content in augmented environments.
4. To equip learners with the ability to apply 2D/3D geometric transformations and homogenous coordinates for modelling virtual objects and projecting them onto 2D displays.
5. To establish a comprehensive understanding of Virtual Reality systems by analyzing their core hardware and software components, and to evaluate how human visual physiology and perception dictate the design requirements for creating immersive and user-comfortable VR environments.

Module	Details	Hrs.
00.	**Course Introduction** This course introduces the core principles and technologies of Augmented Reality (AR) and Virtual Reality (VR). Learner will explore AR architecture, computer vision for tracking, 3D interaction techniques, and the hardware/software components that power immersive experiences. The curriculum is designed to equip you with the skills to model, analyze, and develop solutions for AR/VR systems.	**01**
01.	**Introduction to Augmented Reality and Mixed Reality** Learning Objective: *To make learner able to identify and define Augmented and Mixed Reality, explain their core architecture and historical context, and differentiate them from related fields like Virtual and Extended Reality.*	**06-08**
	Contents: Definition and Scope, A Brief History of Augmented Reality, AR Architecture, Related Fields of AR (like Mixed Reality, Virtual Reality, Immersive Reality, Extended Reality) and Their comparison, General Architecture of Mixed Reality System, Algorithm Steps in Mixed Reality	
	Self-Learning Topics: *Real-World MR Algorithm Applications.*	
	Learning Outcomes: *A learner will be able to* *LO 1.1: Apply engineering fundamentals to analyze the core architecture of Augmented and Mixed Reality systems and their integral algorithmic steps. (P.I. 1.3.1)* *LO 1.2: Apply the theoretical principles of computer science to deconstruct and compare the defining characteristics of related fields like AR, VR, MR, and Extended Reality. (P.I. 1.4.1)* *LO 1.3: Identify the key processes, modules, and parameters of a general Mixed Reality system architecture to define its functional scope. (P.I. 2.1.2)* *LO 1.4: Identify the appropriate mathematical and algorithmic knowledge that applies to the problem of integrating digital content with the real world in a Mixed Reality pipeline. (P.I. 2.1.3)*	
02.	**Tracking and Computer Vision for AR and MR** ***Learning Objective:*** *To make learner able to explain the principles of tracking, calibration, and registration in AR/MR systems. Learner will also be able to analyze and compare the characteristics of different tracking technologies, including sensor-based, optical, and outdoor methods.*	**07-09**
	Contents: Multimodal Displays; Visual Perception; Spatial Display Model; Visual Displays; Tracking, Calibration and Registration; Coordinate Systems; Characteristics of Tracking Technology; Stationary Tracking Systems; Mobile Sensors; Optical Tracking; Sensor Fusion; Marker Tracking; Multiple Camera Infrared Tracking; Natural Feature Tracking by Detection; Incremental Tracking; Simultaneous Localization and Tracking; Outdoor Tracking	
	Self-Learning Topics: *Indoor Tracking, Full Body Tracking.*	
	Learning Outcomes:	

	A learner will be able to *LO 2.1: Compare and contrast various tracking technologies (e.g., marker-based, natural feature, sensor fusion) to select the optimal method for a given AR/MR application based on parameters like accuracy, environment, and cost. (P.I. 2.2.4)* *LO 2.2: Apply computer engineering principles to formulate the functional modules of a complete tracking and registration system; integrate components for sensing, data fusion, and calibration; and arrive at defensible conclusions regarding the system's performance against the specified criteria. (P.I. 2.4.4)* *LO 2.3: Apply engineering mathematics and algorithmic knowledge to implement solutions for core tracking problems, such as coordinate system transformations, sensor fusion for drift correction, and feature detection. (P.I. 2.4.1)* *LO 2.4: Evaluate design alternatives for a complex tracking subsystem (e.g., outdoor vs. indoor, optical vs. inertial) to select a candidate solution; then, implement and integrate the chosen design into a functional subsystem. (P.I. 3.2.1, 3.4.2)*	
03.	**Interaction, Modeling and Annotation and Authoring** ***Learning Objective****: To make learner able to classify various input and output modalities for AR interaction and apply authoring techniques to create, model, and annotate content for augmented environments.*	**06-08**
	Contents: Output Modalities, Input Modalities, Tangible Interfaces, Virtual User Interfaces on Real Surfaces, Multi-view Interfaces, Haptic Interaction, Multimodal Interaction, Specifying Geometry, Specifying Appearance, Semi-automatic Reconstruction, Free-form Modeling, Annotation, Requirement of AR Authoring, Elements of Authoring, Stand-alone Authoring Solutions, Plug-in Approaches, Web Technology	
	Self-Learning Topics: *Case Study on Object Annotation in Real Time, Avatar Modeling.*	
	Learning Outcomes: *A learner will be able to* *LO 3.1: Explore and compare alternative design approaches for user interfaces (e.g., tangible, virtual, multi-view) and modeling techniques (e.g., free-form, semi-automatic) to achieve a specified interaction goal. (P.I. 3.2.1)* *LO 3.2: Justify the selection of a specific multimodal interaction design and authoring methodology by consulting established HCI principles, and demonstrate its viability by implementing and integrating the core functional modules of the system. (P.I. 3.4.2)* *LO 3.3: Investigate a potential application for an interactive Augmented Reality (AR) experience by defining its core problem statement, establishing the scope of the investigation, and justifying its importance. (P.I. 4.1.1)* *LO 3.4: Design and develop a structured procedure for creating an AR application by selecting and integrating appropriate authoring solutions, such as stand-alone tools or web technologies. (P.I. 4.2.1)*	
04.	**Geometry of Virtual World** ***Learning Objectives:*** *To make learner able to apply 2D and 3D geometric transformations using homogenous coordinates, and demonstrate the process of viewport transformation to project 3D models onto a 2D display.*	**06-08**
	Contents: Geometric Modeling, 2D transformations, Homogenous coordinate system, 3D rotation and 6 degree of freedom, Viewport Transformation	
	Self-Learning Topics: *Eye Transformation, demo of 2D transformation*	

	Learning Outcomes:	
	A learner will be able to *LO 4.1: Investigate the problem of representing and manipulating 3D objects in a virtual space by defining its scope and justifying the critical importance of geometric transformations and coordinate systems as a solution. (P.I. 4.1.1)* *LO 4.2: Design and develop a procedural sequence of geometric transformations (including 2D, 3D rotation, and viewport) to correctly render a 3D model for a given display, justifying the methodology. (P.I. 4.2.1)* *LO 4.3: Identify and select modern computer graphics tools and programming techniques to implement and explore alternative design solutions for geometric modeling pipelines. (P.I. 5.1.1)* *LO 4.4: Create and adapt the use of the homogenous coordinate system as a fundamental mathematical tool to efficiently model complex 3D transformations and 6 degrees of freedom. (P.I. 5.1.2)*	
05.	**Introduction to VR** ***Learning Objective/s:*** *To make learner able to define Virtual Reality and identify its core hardware components—including displays, audio, haptic, input, and tracking devices—and software components like Java3D and VRML that together create an immersive simulated environment.*	**07-09**
	Contents: Introduction to VR and definitions and its components., Hardware components: Display devices: LCD, OLED Audio: Speakers, Earphones, Bone conduction Touch: Haptic Device GPU and CPU, Input devices like game controller, data glows, Joysticks Tracking Hardware: Industrial measurement Unit-IMU, Gyroscope, accelerometer Software component: Java3D, VRML	
	Self-Learning Topics: *Feedback mechanisms in VR environment*	
	Learning Outcomes :	
	A learner will be able to *LO 5.1: Explore design alternatives for VR systems by evaluating different combinations of display, audio, input, and tracking hardware to meet varying performance and immersion requirements. (P.I. 3.2.1)* *LO 5.2: Evaluate, select, and justify a candidate VR system design, then implement and integrate the chosen hardware and software components for further development. (P.I. 3.3.2)* *LO 5.3: Define a specific problem statement for a VR-based application, clearly articulating its scope and importance by analyzing the capabilities and limitations of standard VR hardware and software components. (P.I. 4.1.1)* *LO 5.4: Design and develop an appropriate procedural methodology for selecting and testing VR hardware and software components based on the defined objectives of a specific VR application. (P.I. 4.2.1)* *LO 5.5: Investigate the core problem of designing a VR system for a specified application by defining its scope and importance, exploring design alternatives for its core hardware components (display, audio, input, tracking), and identifying modern engineering tools for its development, while demonstrating effective team communication and problem-solving skills. (P.I. 3.2.1, 4.1.1, 5.1.1, 8.2.1)* *LO 5.6: Design and develop a functional VR software module by selecting and adapting appropriate methodologies and tools (e.g., Java3D, VRML), implementing and integrating the chosen hardware components into a cohesive system, and presenting the final results as a unified team. (P.I. 3.4.2, 4.2.1, 5.1.2, 8.3.1)*	

06.	**Visual Physiology, perception and tracking**	**05-07**
	Learning Objective/s: *To make **l**earner able to explain how human visual physiology and perception—including eye function, depth, and motion—influence VR design requirements. You will also analyze the impact of factors like display resolution, frame rates, and tracking systems on visual quality and user comfort in virtual environments.*	
	Contents: Functioning of Eye with photoreceptors, Resolution for VR, Eye movements and issues with it in VR, Neuroscience of vision, Depth and motion perception, Frame rates and display, Orientation tracking, tilt and yaw drift correction, Tracking with camera	
	Self-Learning Topics: *Light House approach*	
	Learning Outcomes: *A learner will be able to* *LO 6.1: Define the problem of visual discomfort in VR by investigating the conflicts between human visual physiology (like photoreceptor function and eye movements) and display system parameters. (P.I. 4.1.1)* *LO 6.2: Design and develop a testing methodology to evaluate the impact of specific technical parameters, such as display resolution and frame rate, on user perception of depth and motion in a virtual environment. (P.I. 4.2.1)* *LO 6.3: Analyze the neuroscience of vision and perceptual challenges in VR (e.g., motion sickness, depth misperception) to identify modern engineering tools and techniques for mitigation, effectively communicating these technical concepts within a team, and explaining the vital importance of staying current with physiological research for VR development. (P.I. 2.1.3, 5.1.1, 8.2.1, 9.1.1, 11.2.2)* *LO 6.4: Design a software-based correction module for a specific VR tracking issue (e.g., yaw drift) by adapting or extending existing algorithms, producing clear, well-supported documentation for the solution, analyzing sourced information for its feasibility, and presenting the integrated results as a team. (P.I. 3.2.1, 5.1.2, 9.1.2, 11.3.2, 8.3.1)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem
2.1.2	Identifies processes/modules/algorithms of a computer-based system and parameters to solve a problem
2.1.3	Identifies mathematical algorithmic knowledge that applies to a given problem
2.2.4	Compare and contrast alternative solution/methods to select the best methods
2.2.5	Compare and contrast alternative solution processes to select the best process.
2.3.1	Able to apply computer engineering principles to formulate modules of a system with required applicability and performance
2.4.1	Applies engineering mathematics to implement the solution.
2.4.4	Arrive at conclusions with respect to the objectives.
3.2.1	Ability to explore design alternatives.
3.4.2	Able to implement and integrate the modules.
4.1.1	Define a problem for purposes of investigation, its scope and importance
4.2.1	Design and develop appropriate procedures/methodologies based on the study objectives
5.1.1	Identify modern engineering tools, techniques and resources for engineering activities

5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems

8.2.1 Demonstrate effective communication, problem solving, conflict resolution and leadership skills

8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

9.1.1 Read, understand and interpret technical and nontechnical information

9.1.2 Produce clear, well-constructed, and well-supported written engineering documents

11.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field

11.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to -

1. Apply and analyze AR/MR architectures to determine the key technologies and algorithms for real-world digital integration. (LO 1.1, LO 1.2, LO 1.3, LO 1.4)
2. Analyze and compare tracking technologies to design a functional sensor-fused tracking system for AR/MR applications. (LO 2.1, LO 2.2, LO 2.3, LO 2.4)
3. Design and develop functional AR applications by selecting and justifying appropriate interaction designs, authoring tools, and structured procedures. (LO 3.1, LO 3.2, LO 3.3, LO 3.4)
4. Implement a 3D geometric transformation pipeline using appropriate modern tools to solve rendering problems in a virtual environment. (LO 4.1, LO 4.2, LO 4.3, LO 4.4)
5. Design, implement, and evaluate a VR system by selecting appropriate hardware and software components to solve problems in user comfort and immersion. (LO 5.1 to LO 5.6 and LO 6.1 to LO 6.4)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPEC7042.1	3	3	-	-	-	-	-	-	-	-	-
ITPEC7042.2	-	3	3	-	-	-	-	-	-	-	-
ITPEC7042.3	-	-	3	3	-	-	-	-	-	-	-
ITPEC7042.4	-	-		3	3	-	-	-	-	-	-
ITPEC7042.5	-	-	3	3	3	-	-	3	3	-	3
Average	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**3**	**3**	**-**	**3**

Text Books:

1. Dieter Schmalsteig and Tobias Hollerer, “Augmented Reality- Principles and Practice”, Pearson Education, Inc. 2016 Edition.
2. Chetankumar G Shetty, “Augmented Reality- Theory, Design and Development”, Mc Graw Hill, 2020 Edition.
3. Maurya, R. K. (2018). Computer Graphics with Virtual Reality (3rd ed.). Wiley India.

Reference Books:

1. Erin Pangilinan, Steve Lukas, and Vasanth Mohan, “Creating Augmented and Virtual Realities- Theory and Practice for Next-Generation Spatial Computing”, O’Reilly Media, Inc., 2019 Edition.
2. Alan Craig and William Sherman,” Understanding virtual reality: Interface, application and
design”, 2nd Edition, Morgan Kaufmann Publisher, 2019

Other Resources:

1. NPTEL Course: Foundations of Virtual Reality, By Prof. M.Manivannan, Prof. Anna Lavalle, Prof. Steven Lavalle | IIT Madras, University of Oulu: -
   Web link - https://onlinecourses.nptel.ac.in/noc25_cs87/preview
2. Intro to AR/VR/MR/XR: Technologies, Applications & Issues, Instructor: Michael Nebeling

https://www.coursera.org/learn/intro-augmented-virtual-mixed-extended-reality-technologies-applications-issues

3. VIRTUAL REALITY, By Steven M. LaValle. Cambridge University Press, 2023. https://lavalle.pl/vr/

A.IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

a) One MCQ Test as per GATE exam pattern / level: 05 Marks

b) Observation and active participation in class :05 Marks

c) Class Test: 05 Marks

d) Article reading with report writing: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
PEC	ITPEC7043	INFORMATION RETRIEVAL SYSTEM	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite:

1. ITPCC304 : Database management System

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO4: Conduct investigations of complex problems
5. PO8: Individual and Collaborative team work
6. PO9: Communication
7. PO11: Life-Long Learning

Course Objectives:

1. To prepare students to know fundamental concepts and advanced information retrieval models and its applications.
2. To train students to learn indexing and searching mechanisms used in IR systems.
3. To quip students to explore web retrieval techniques for performance metrics.
4. To make students aware of web information retrieval, multimedia retrieval, and text mining techniques.
5. To help students to explore emerging trends like semantic web and intelligent retrieval systems.

Module	Details	Hrs.
00.	**Course Introduction** This course introduces the fundamental concepts, models, and techniques used to efficiently store, organize, and retrieve relevant information from large data collections. With the exponential growth of digital data—text, multimedia, and web content—information retrieval plays a crucial role in developing search engines, digital libraries, and intelligent information systems. This course focuses on understanding how documents are represented, indexed, and searched based on user queries. It explores classical retrieval models such as Boolean and Vector Space models, as well as modern techniques like probabilistic retrieval and semantic-based search. Students will also learn how to evaluate retrieval performance using standard metrics such as precision and recall.	**01**

01.	**Introduction to Information Retrieval** ***Learning Objective:*** *To make learner identify and summarize basics of Information Retrieval system*	**05-07**
	Contents: Introduction to Information Retrieval Systems, Motivation, Basic concepts, Components and Architecture of an IRS, Information vs. Data Retrieval, The Retrieval Process, Information System: Components and types of information system; Retrieval. Search Engines and browsers	
	Self-Learning Topics: *Applications of Information Retrieval in Web and Enterprise Systems*	
	Learning Outcomes: A learner will be able to *LO 1.1: Apply basic concepts of Information Retrieval including documents, queries, indexing, and relevance. (P.I.-1.3.1)* *LO 1.2: Apply suitable methods for distinguishing information retrieval tasks from data retrieval tasks. (P.I.-1.4.1)* *LO 1.3: Identify the objectives of an Information Retrieval System by analyzing its motivation, components, and architecture. (P.I.-2.1.1)* *LO 1.4: Identify differences between information and data retrieval using concepts from computing, databases, and information science (P.I.-2.2.2)*	
02.	**IR Models** ***Learning Objective:*** *To familiarize with the basic and advanced Information Retrieval models*	**08-10**
	Contents: Modeling: Taxonomy of Information Retrieval Models, Retrieval: Formal Characteristics of IR models, Classic Information Retrieval, Alternative Set Theoretic models, Probabilistic Models, Structured text retrieval Models, models for Browsing, Relevance Models and Language Models for IR, Cross-Language Information Retrieval	
	Self-Learning Topics: *Distributed and Federated Information Retrieval Systems*	
	Learning Outcomes: A learner will be able to *LO 2.1: Apply fundamental concepts of Information Retrieval Models (P.I.-1.3.1)* *LO 2.2: Apply different Information Retrieval models for representing, matching, and ranking documents based on a user's information needs. (P.I.-1.4.1)* *LO 2.3: Design and Analyze the IR models to find the best model for ranking documents for fast and accurate retrieval of information. (P.I.-3.2.2)* *LO 2.4: Design ranking and relevance estimation strategies used in probabilistic and language models. (P.I.-3.3.1)* *LO 2.5: Design and analyze solution based on different information retrieval models to meet functional requirements and select most appropriate proposal (P.I.- 4.1.3,8.2.1, 9.2.1, 11.2.1)* *LO 2.6: Design and analyze solution based different information retrieval models to meet the relevance criteria and identify rank required to retrieve document. (P.I.- 4.2.1,8.3.1, 9.3.3, 11.3.2)*	
03.	**Indexing and Searching** ***Learning Objective:*** *To make learner analyze indexing and searching techniques*	**06-08**
	Contents: Indexing: Purpose and Methods, Inverted Index, Signature Files, Suffix Trees, and Suffix Arrays, Query Expansion and Relevance Feedback, Boolean Queries, Sequential Searching, Pattern Matching, Structural Queries, Compression; Searching Web: Challenges, Characterizing the web, Search Engines. Browsing, Meta searches, searching using Hyperlinks. Demonstration of Web Information Retrieval tools.	
	Self-Learning Topics: *Build a simple inverted index using any programming language*.	

	Learning Outcomes: A learner will be able to *LO 3.1 Design efficient indexing structures (inverted index, signature files, suffix trees, suffix arrays) for given datasets. (P.I.- 3.2.1)* *LO 3.2: Design systems that utilize query expansion and relevance feedback to improve retrieval effectiveness and develop retrieval strategies that incorporate Boolean queries, structural queries, sequential search, and pattern matching (P.I.- 3.2.2).* *LO 3.3: Apply different techniques to indexing methods for calculating efficiency and scalability. (P.I.- 1.3.1)* *LO 3.4: Apply web retrieval systems that handle scalability, dynamic content, and varying user behaviors for information retrieval. (P.I.1.4.1)*	
04.	**Web Information Retrieval** ***Learning Objective:*** *To make learner identify different web information retrieval techniques.*	**06-08**
	Contents: Web Crawling and Web Graph Structures, Link Analysis Algorithms: PageRank, HITS, Search Engine Architecture and Optimization, Web Query Log Mining and Clickstream Analysis, Ranking Mechanisms and Learning to Rank (LTR), Evaluation Metrics for Web Search Engines (NDCG, MAP, DCG), Demonstration of Web Information Retrieval tools.	
	Self-Learning Topics: *Identify current trends in Web Information retrieval on the internet*	
	Learning Outcomes: A learner will be able to *LO 4.1: Apply web crawling strategies to assess efficiency, coverage, and freshness of collected data. (P.I.-1.3.1)* *LO 4.2: Apply web query logs and clickstream data to derive patterns of user behavior and search intent. (P.I.-1.4.1)* *LO 4.3: Identify and formulate link analysis problems and determine which algorithms (PageRank, HITS) are appropriate for ranking web pages. (P.I.-2.1.3)* *LO 4.4 Identify ranking mechanisms to determine their suitability for different types of search queries. (P.I.-2.2.4)*	
05.	**Multimedia and Cross-Modal Retrieval** ***Learning Objective:*** *To make learner aware of the different multimedia and cross model retrieval techniques.*	**06-08**
	Contents: Content-Based Image and Video Retrieval (CBIR, CBVR), Feature Extraction and Representation (SIFT, SURF, CNN Features), Audio and Speech Retrieval, Text-Image Cross-Modal Retrieval, Deep Learning for Multimedia Retrieval (Transformers, Visual Language Model), Applications in Visual Search and Multimodal Search Engines, Demonstration of Multimedia Retrieval tool	
	Self-Learning Topics: *Identify current trends in Visual query types like query-by-example, sketch, region selection, etc.*	
	Learning Outcomes: A learner will be able to *LO 5.1: Apply different multimedia retrieval techniques for content based image and video retrieval (P.I.-1.3.1)* *LO 5.2: Apply different Feature extraction techniques for text, Image and Cross model retrieval (P.I.- 1.4.1)* *LO 5.3: Design transformer and Visual Language Model for multimedia retrieval (P.I.- 3.2.2)* *LO 5.4: Design Audio and speech retrieval models for multimedia retrieval (P.I.-3.3.1)*	

06.	**Intelligent Information Retrieval and Advanced topics with Applications** ***Learning Objective:*** *To make learner aware of emerging technologies in information retrieval and advanced topics with applications.*	**06-08**
	Contents: Natural Language Processing in IR, Query Reformulation and Clustering, Text Categorization and Summarization, Personalized and Context-aware Retrieval, Semantic Web and Ontology-based Retrieval, Intelligent and Neural IR Systems: Machine Learning and Deep Learning in IR, Neural Ranking Models (DSSM, DRMM, BERT-based models), Document Embedding and Word Representations (Word2Vec, GloVe), Retrieval-Augmented Generation (RAG) and LLM-integrated IR, Explainable and Ethical Information Retrieval	
	Self-Learning Topics: *Case Studies: Google Search, ChatGPT Search Integration, and Semantic Search Systems*	
	Learning Outcomes: A learner will be able to *LO 6.1: Apply Neural Ranking Models for relevant information retrieval (P.I.- 1.3.1)* *LO 6.2: Apply Retrieval-Augmented Generation models to relevant information retrieval (P.I.- 1.4.1)* *LO 6.3: Design Information Retrieval Engine based on natural language processing techniques. (P.I.- 3.2.2)* *LO 6.4: Design solution for Text Categorization and summarization using information retrieval techniques (P.I.- 3.2.1)* *LO 6.5: Identify technological advances in information retrieval for Large Language Models to meet functional requirements and select most appropriate proposal (P.I.- 4.1.2, 8.2.1, 9.2.1, 11.2.1)* *LO 6.6: : Identify and analyze impact of Explainable and Ethical Information Retrieval models to meet the criteria and identify tasks required to complete it (P.I.- 4.2.1, 8.3.1, 9.3.3, 11.3.2)*	
	Course Conclusion	**01**
	Total	**45**

Performance Indicators:

P.I. No.	**P.I. Statement**
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem
2.1.1	Evaluate problem statements and identifies objectives
2.1.3	Identifies mathematical algorithmic knowledge that applies to a given problem
2.2.2	Identifies functionalities and computing resources.
2.2.4	Compare and cntrasr alternative solution/ methods to select the best methods
3.2.1	Ability to explore design alternatives
3.2.2	Ability to produce a variety of potential design solutions suited to meet functional requirements
3.3.1	Ability to perform systematic evaluation of the degree to which several design concepts meet the criteria
4.1.2	Ability to choose appropriate procedure/algorithm, data set and test cases.
4.1.3	Ability to choose appropriate hardware/ software tools to conduct the experiment.
4.2.1	Design and develop appropriate procedures/methodologies based on the study objectives
8.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
8.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
9.2.1	Listen to and comprehend information, instructions, and viewpoints of others.
9.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations

11.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current

11.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

Course Outcomes: A learner will be able to -

1. Analyse basic and advanced retrieval models and their applications. (LO 1.1, LO 1.2, LO 1.3, LO 1.4, LO 2.1, LO 2.2, LO 2.3, LO 2.4, LO 2.5, LO 2.6)
2. Design Indexing and searching techniques for relevant information retrieval. (LO 3.1, LO 3.2, LO 3.3, LO 3.4)
3. Identify Web multimedia retrieval systems and performance metrics (LO 4.1, LO 4.2, LO 4.3, LO 4.4)
4. Design transformer and Visual Language Model for multimedia retrieval (LO 5.1, LO 5.2, LO 5.3, LO 5.4)
5. Integrate different types of advanced Information Retreival models to provide solution to IR engine. (LO 6.1, LO 6.2, LO 6.3, LO 6.4, LO 6.5, LO 6.6)

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITPEC7043.1	3	3	3	3	-	-	-	3	3	-	3
ITPEC7043.2	3	-	3	-	-	-	-	-	-	-	-
ITPEC7043.3	3	3	-	-	-	-	-	-	-	-	-
ITPEC7043.4	3	-	3	-	-	-	-	3	3	-	3
ITPEC7043.5	-	-	3	3	-	-	-	3	3	-	3
Average	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**3**	**3**	**-**	**3**

Text Books :

1. C. Manning, P. Raghavan, and H. Schütze, *Introduction to Information Retrieval*, Cambridge University Press.
2. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, *Modern Information Retrieval: The Concepts and Technology Behind Search*, Addison Wesley.
3. Bruce Croft, Donald Metzler, and Trevor Strohman, *Search Engines: Information Retrieval in Practice*, Pearson.

Reference Books :

1. Stefan Büttcher et al., *Information Retrieval: Implementing and Evaluating Search Engines*, MIT Press.
2. ChengXiang Zhai and Sean Massung, *Text Data Management and Analysis*, ACM Books.
3. Hang Li, *Learning to Rank for Information Retrieval and Natural Language Processing*, Morgan & Claypool.
4. Christopher D. Manning & Hinrich Schütze, *Foundations of Statistical Natural Language Processing*, MIT Press.

Other Resources :

1. Natural Language Processing & Informational Retrieval (IIT Bombay) https://nptel.ac.in/courses/106101007
2. Natural Language Processing (IIT Kharagpur), https://onlinecourses.nptel.ac.in/noc25_cs51/preview

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

a) Assignment on live problems/ case studies: 10 Marks

Students should be assigned a real life problem statement related to IT infrastructure management domain. Students are expected to research and collect required data to design a

system for the selected problem. Students should apply infrastructure management knowledge to design a system for IT resources including memory, network, server and storage requirements. Students should present their work in the form of presentation and demonstration in 10-15 minutes. This assignment should be graded for 10 marks like a design assignment based on the parameters such as data acquisition, requirement analysis, designing a system for selected problem statement.

b) Class Test: 05 Marks

c) Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
LBC	ITLBC710	EDGE COMPUTING LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam(ESE)**	**Total**
25	25	50

Pre-requisite:

1. ESCLC205: Programming Laboratory-II (Java)
2. ITLBC506: Cloud Computing Laboratory

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solution
4. PO5: Engineering tool usage
5. PO8: Individual and Collaborative team work
6. PO9: Communication
7. PO11: Life-long learning

Course Objectives:

1. To prepare learner with basics edge computing architecture and components.
2. To make learner explore edge computing applications, including IoT, 5G slicing, and autonomous systems.
3. To equip learner with skills to experiment with distributed systems concepts in edge environments.
4. To train learner with skills to integrate cloud, IoT, and edge infrastructures for real-time applications.
5. To teach learner with skills to analyse research challenges in federating edge resources.

Module	Detailed Contents	Hrs
00.	**Course Introduction** The Edge Computing Laboratory provides hands-on experience with edge devices, IoT integration, and distributed systems. Students will learn how to configure edge nodes, deploy applications, implement distributed algorithms, and integrate cloud and IoT platforms for real-time decision-making. Edge computing is an emerging paradigm that brings computation, data storage, and analytics closer to the devices and sensors that generate data, rather than relying solely on centralized cloud infrastructure. This approach reduces latency, improves response times, and enables real-time processing for applications such as autonomous vehicles, smart cities, industrial IoT, and 5G-enabled services.	-
01.	**Introduction of Edge Computing** ***Learning Objective:*** *To impart the knowledge of basic edge computing Architecture and components and comparison with Fog and Cloud*	**02**

	Contents: Definition and motivation for edge computing, Difference between cloud, fog, and edge computing, Characteristics: low latency, proximity to data source, real-time processing, Key advantages and limitations of edge computing, Real-world applications: Smart cities, healthcare, industrial IoT, connected vehicles **Task 1:** Study of Edge Computing Architecture and Components. Setting up Edge Devices with OS installation, configuration, network setup and Testing SSH access. ***Learning Outcomes: A learner will be able to*** *LO 1.1: Apply engineering fundamentals to study edge computing architecture and components to identify clear objectives, and set up edge devices to design solutions that meet functional requirements.* (PI- 1.3.1, 2.1.1, 3.*2.2, 11.1.1, 11.2.2)* ***Self-Learning Topic:*** *Learn Edge computing challenges*	
02.	**Edge Simulation and Environment Setup** ***Learning Objective:*** *To make aware about Edge Computing Environment and simulation setup* **Contents:** Edge Simulation Concepts, Environment Setup for Edge Computing, Network Configuration for Edge Nodes, Edge Orchestration and Resource Management, Tools and Technologies used -- iFogSim, EdgeCloudSim; Platforms: Docker, MicroK8s, Node-RED; Languages: Python, Java, C++ for edge simulation scripting **Task 2:** Setup of an Edge Computing Environment for specific case study using EdgeSimPy or iFogSim or EdgeCloudSim ***Learning Outcome: A learner will be able to*** *LO 2.1: Evaluate problem statements and define clear objectives and scope to identify design constraints and generate suitable design solutions, and applying integrity constraints that meet functional requirements.* (PI- 2.1.1, 2.3.2, 3.1.1, 3.2.2, 11.1.1,11.2.2) **Task 3:** Simulate IoT Data Flow between Sensor, Edge, and Cloud Layers ***Learning Outcomes: A learner will be able to*** *LO 2.2: Simulate problem statements and define clear objectives and scope to identify design constraints and generate suitable solution approaches by creating data flow operations on a Sensor, Edge and cloud layer in order to meet functional requirements. (PI: 2.1.1, 2.3.2, 3.1.1, 3.2.2,* 11.1.1,11.2.2) ***Self-Learning Topic:*** *Learn about Mininet simulator used for edge computing*	**04**
03.	**Edge and Fog Node Deployment** ***Learning Objectives:*** *To understand the process of deploying and managing edge and fog nodes in a distributed environment.* **Contents:**	**08**

	Edge and Fog Node Deployment concepts, Fog and Edge Node Configuration, Application and Service Deployment, Edge–Fog–Cloud Integration, Performance and Fault Tolerance **Smart Home Scenario:** In a traditional smart home, IoT devices such as temperature sensors, motion detectors, and smart lights send all data to the cloud for processing and control which results in high latency, network dependency, and privacy risks. In the edge computing-based smart home, most data processing happens locally on an edge node (e.g., Raspberry Pi or Jetson Nano) before sending summaries or alerts to the cloud. **Task 4:** Develop and Deploy Edge Nodes for Real-time Data Processing. ***Learning Outcomes: A learner will be able to*** *LO 3.1: Evaluate real-world application requirements and define a precise problem statement to identify constraints, document stakeholder needs, and apply engineering fundamentals and computer science principles to develop and deploy Edge nodes using appropriate modern tools for effective Edge computing solution. (PI: 1.3.1, 1.4.1, 2.1.1, 2.3.2, 3.1.1, 3.1.2, 5.1.1, 5.1.2, 11.1.1,11.2.2)* **Task 5:** Develop and Deploy an Application on Edge Device. ***Learning Outcomes: A learner will be able to*** *LO 3.2: Evaluate real-world application requirements and define a precise problem statement to identify constraints, document stakeholder needs, and apply engineering fundamentals and computer science principles to develop and deploy application using appropriate modern tools for effective Edge computing solution. (PI: 1.3.1, 1.4.1, 2.1.1, 2.3.2, 3.1.1, 3.1.2, 5.1.1, 5.1.2, 11.1.1,11.2.2)* ***Self-Learning Topic:*** *Learn and Implement multi-node Orchestration in edge computing*	
04.	**Communication and Offloading** ***Learning Objective:*** *To implement computation offloading techniques between IoT devices, edge, fog, and cloud layers and To evaluate network performance, latency, and task migration efficiency in distributed edge environments.* **Contents:** Computation Offloading Concepts, Edge-to-Cloud Task Migration, Communication Frameworks and Middleware, Performance Evaluation Metrics **Task 6:** Implement Task Offloading between Edge and Cloud Nodes using IFogSim/ EdgeCloudSim. ***Learning Outcomes: A learner will be able to*** *LO 4.1: Apply engineering fundamentals and computer science principles to solve real-time task offloading problems by identifying and using appropriate tools and adapting techniques to execute task effectively. (PI- 1.4.1, 1.3.1, 5.1.1, 5.1.2, 11.1.1,11.2.2)* **Task 7:** Latency and Energy Consumption Measurement in Edge Networks using IFogSim / EdgeCloudSim ***Learning Outcomes: A learner will be able to***	**08**

	LO 4.2: Define clear problem objectives, identify stakeholder requirements and design constraints, interpret relevant technical information, and collaboratively generate well-structured solutions by implementing latency and energy consumption measurement in Edge network using appropriate tools and technologies. (PI- 3.1.2, 3.1.1, 11.2.2, 11.1.1, 2.3.2, 9.1.1, 8.1.1, 2.1.1, 8.3.1, 9.3.1, 11.1.1,11.2.2,5.1.1, 5.1.2)	
	Self-Learning Topics: *Learn about Dynamic Task migration using using IFogSim/ EdgeCloudSim.*	
05.	**Edge AI and Data Analytics** ***Learning Objective:*** *To develop and deploy lightweight AI models for real-time data analytics at the edge.*	**04**
	Contents: Introduction to Edge AI, Edge AI Architecture, Data Analytics at the Edge, Model Deployment and Optimization **Task 8:** Implement Edge-based Machine Learning Inference Models ***Learning Outcomes: A learner will be able to*** *LO 5.1: Evaluate real-time application requirements, identify design constraints, and apply engineering fundamentals and computer science principles to design and demonstrate Machine Learning models by interpreting technical information, generating and selecting effective solution approaches, collaborating efficiently in teams, and staying updated with evolving technologies. (PI- 2.1.1, 2.3.2,9.1.1, 9.3.1, 8.1.1, 8.3.1, 1.3.1, 1.4.1, 2.1.1, 2.3.2, 3.3.3, 3.2.2, 11.1.1, 11.2.2, 5.1.1, 5.1.2)* **Task 9:** Implement Edge Data Aggregation and Filtering techniques. *LO 5.2: Evaluate real-time application requirements, identify design constraints, and apply engineering fundamentals and computer science principles to design and demonstrate edge data aggregation and filtering by interpreting technical information, generating and selecting effective solution approaches, collaborating efficiently in teams, and staying updated with evolving technologies. (PI- 2.1.1, 2.3.2,9.1.1, 9.3.1, 8.1.1, 8.3.1, 1.3.1, 1.4.1, 2.1.1, 2.3.2, 3.3.3, 3.2.2, 11.1.1, 11.2.2, 5.1.1, 5.1.2)*	
	Self-Learning Topics: *Comparative Study – Edge AI vs Cloud AI*	
06.	**Edge Security and Case Studies** ***Learning Objective****: To implement lightweight security mechanisms for data, devices, and communication, and explore real-world case studies demonstrating secure edge computing deployments.*	**04**
	Contents: Overview of Edge Security, Security Requirements in Edge Systems, Lightweight Security Mechanisms, Threats and Mitigation Strategies, Case Studies and Applications • **Smart Healthcare:** Privacy-preserving health monitoring system • **Smart City:** Secure video analytics and surveillance with edge AI • **Industrial IoT:** Blockchain-enabled trust and audit trail in manufacturing edge nodes • **Autonomous Vehicles:** Edge-based authentication and sensor data integrity **Mini Project**	

	Task 10: Implement Secure Data Transmission at the Edge using Edge Containerization with Docker/Kubernetes or Serverless Function Deployment on Edge with OpenFaaS / AWS Greengrass ***Learning Outcomes: A learner will be able to*** *LO 6.1: Evaluate real-world application requirements, identify design constraints, and apply engineering fundamentals and computer science principles to design and demonstrate secure data transmission at edge by interpreting technical information, generating and selecting effective solution approaches, collaborating efficiently in teams, and staying updated with evolving technologies. (PI- 2.1.1, 2.3.2, 9.1.1, 9.3.1, 8.1.1, 8.3.1, 1.3.1, 1.4.1, 2.1.1, 2.3.2, 3.3.3, 3.2.2, 11.1.1, 11.2.2, 4.1.2, 4.3.1, 5.1.1, 5.1.2)*	
	Self-Learning Topics: *Learn QoS-aware Scheduling in Edge Networks*	
	Total	**30**

Performance Indicators:

1.3.1 Apply engineering fundamentals
1.4.1 Apply theory and principles of computer science engineering to solve an engineering problem
2.1.1 Evaluate problem statements and identifies objectives
2.1.2 Identifies processes/modules/algorithms of a computer based system and parameters to solve a problem
2.3.2 Identify design constraints for required performance criteria.
3.1.1 Able to define a precise problem statement with objectives and scope
3.1.2 Able to identify and document system requirements from stake holders
3.2.2 Ability to produce a variety of potential design solutions suited to meet functional requirements
5.1.1 Identify modern engineering tools, techniques and resources for engineering activities
5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2.2 Demonstrate proficiency in using discipline specific tools
8.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
8.3.1 Present results as a team, with smooth integration of contributions from all individual efforts
9.1.1 Read, understand and interpret technical and nontechnical information
9.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations
11.1.1 Describe the rationale for requirement for continuing professional development
11.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field

Course Outcomes: Learner will be able to

1. Apply principles, architecture, characteristics, and working of Edge and Fog Computing environments to configure and simulate edge environments. *(LO 1.1, 2.1, 2.2)*
2. Deploy and manage edge and fog nodes for real-time IoT data processing and communication. *(LO 3.1, 3.2)*
3. Implement efficient communication and computation offloading mechanisms between IoT–Edge–Cloud layers. *(LO 4.1, 4.2)*
4. Develop and deploy lightweight AI/ML models and perform real-time analytics at the edge. *(LO 5.1, 5.2)*
5. Apply security mechanisms and trust management techniques to protect data and communication in edge systems. *(LO 6.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITLBC710.1	3	3	3	-	-	-	-	-	-	-	3
ITLBC710.2	3	3	3	-	3	-	-	-	-	-	3
ITLBC710.3	3	3	3	-	3	-	-	3	3	-	3
ITLBC710.4	3	3	3	-	3	-	-	3	3	-	3
ITLBC710.5	3	3	3	3	3	-	-	3	3	-	3
Average	**3**	**3**	**3**	**3**	**3**	-	-	**3**	**3**	-	**3**

Text Books :

1. "Fog and Edge Computing: Principles and Paradigms", Rajkumar Buyya (Editor), Satish Narayana Srirama (Editor), Wiley, 2019
2. Cloud Computing: Principles and Paradigms", Editors: Rajkumar Buyya, James Broberg,Andrzej M. Goscinski, Wiley, 2011
3. "Cloud and Distributed Computing: Algorithms and Systems", Rajiv Misra, Yashwant Patel, Wiley 2020.
4. Edge Computing: Fundamentals, Advances and Applications By K. Anitha Kumari, G. Sudha Sadasivam, D. Dharani, M. Niranjanamurthy, CRC press 2021.
5. IoT Edge Computing for Architects –Second Edition, by Perry Lea, Publisher: Packet Publishing, 2020, ISBN: 9781839214806

Reference Books :

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press)
2. IoT and Edge Computing for Architects: Implementing Edge and IoT Systems from Sensors to Clouds with Communication Systems, Analytics, and Security by Perry Lea , 2nd Edition
3. Mobile Edge Computing, Anwesha Mukherjee, Debashis De, Soumya K. Ghosh, Rajkumar Buyya, Springer
4. David Jensen, "Beginning Azure IoT Edge Computing: Extending the Cloud to the Intelligent. Edge, Microsoft Azure

Other Resources:

1. NOC: Edge Computing — offered by IIT Kanpur / IIT Patna, taught by Rajiv Misra , https://onlinecourses.nptel.ac.in/noc24_cs66/preview?utm_source=chatgpt.com
2. Foundation of Cloud IoT Edge ML — a broader course on IoT, Cloud, Edge & ML, https://onlinecourses.nptel.ac.in/noc25_cs75/preview?utm_source=chatgpt.com

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (25 Marks)

Suggested breakup of distribution

a) Task Execution :10 Marks

Students will be given 10 tasks based on list as per mentioned in the syllabus. Each task carries 10 Marks. Average will be taken of all tasks. Students are expected to formulate problem statement, create relational schema, implement relational schema by using constraints and retrieve required information. Students will be evaluated based on logic building for the selected problem, rectification of syntax errors and expected output.

Students will be evaluated based on following:

i. Problem Understanding from Edge computing perspective (02 marks)
ii. Working and configuration of open source tools for edge computing (02 marks)
iii. Deployment of Edge nodes and Applications appropriate to problem. (02 marks)

iv. Implement Machine learning and data aggregation models for edge (02 marks)
v. Implement Security and trust mechanism at edge (02 marks)

b) Mini Project Evaluation: 10 Marks

A group of 3-4 students should be assigned a real life problem statement. Students are expected to research and collect required resources to create a frontend and backend for the selected problem. Students should prepare a presentation/problem solving of 10-15 minutes. This project should be graded for 10 marks depending on the parameters as analysis, design, conversion to relational schema, database creation and implementation for selected problem statement.

Students will be evaluated based on following:

2. Regularity & Active participation: 05 Marks

B. END SEMESTER EXAMINATION (25 MARKS)

a) Oral based on Task Explanation: 10 Marks
b) Oral based on Results and discussion, Inferences drawn: 05 Marks
c) Oral based on Mini Project Demonstration and report :10 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
LBC	ITLBC711	HIGH PERFORMANCE COMPUTING LABORATORY	01

Examination Scheme		
Continuous Assessment	**End Semester Exam(ESE)**	**Total**
25	25	50

Pre-requisite:

1. ESL103: Programming Laboratory-I (C)
2. ESL205: Programming Laboratory-II (Java)
3. ITSBL301 : Python Laboratory

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 3: Design/Development of Solutions
4. PO 4: Conduct investigations of complex problems
5. PO 5: Engineering tool usage
6. PO 9: Communication

Course Objectives:

1. To acquaint the learners with the fundamentals of High Performance Computing and analyse different parallel computing models to select the most suitable model for a given problem.
2. To make learner apply shared-memory parallel programming concepts using OpenMP to parallelize computational problems and evaluate performance improvements over sequential execution.
3. To make leaners implement distributed-memory parallel programs using MPI to solve data-parallel problems and analyse execution efficiency and scalability.
4. To make learner develop and optimize GPU-based parallel programs using CUDA by effectively utilizing threads, memory hierarchy, and execution models.
5. To make leaner analyse GPU application performance using CUDA profiling tools and apply optimization techniques to improve computational efficiency.

Module	Detailed Contents	Hrs
00.	**Course Introduction** High-Performance Computing (HPC) enables solving complex scientific, engineering, and data-intensive problems using parallel architectures such as multicore CPUs, GPUs, and distributed clusters. This laboratory provides hands-on skills in parallel programming models (OpenMP, CUDA, MPI) and performance analysis. The course contents equip software engineers with strong skills in parallel programming, performance optimization, and debugging complex systems, making them capable of building fast i.e. high-performance, resource-efficient, and scalable software systems in diverse application domains where computational efficiency plays a critical role.	
01.	**Fundamentals of High Performance Computing**	**04**

	Learning Objective/s: *The learner is expected to identify and analyse different parallel computing models and justify the selection of an appropriate model for a given computational problem.*	
	Contents Fundamentals of High Performance Computing**.** Introduction to Parallel Computing Models (OpenMP, MPI, CUDA). **Task 1:** Study the fundamentals of parallel computing models. Compare different parallel computing models. Analyze the difference between the parallel computing models. Identify a parallelizable problem, Select and document the most appropriate model for solving the identified problem. ***Learning Outcome :*** *A learner will be able to* *LO 1.1: Identify different parallel computing models and a parallelizable problem. Apply the principles of parallel computing to clearly document the details of parallel computing models. Compare design alternatives using different parallel computing models. Select and document the most appropriate model for the given task. (P.I.-1.3.1) (P.I.-1.4.1) (P.I.-2.1.1) (P.I.-2.2.5) (P.I.-3.2.1) (P.I.-3.3.1) (P.I.- 9.1.2) (P.I.- 9.3.2).*	
02.	**Shared-Memory Parallel Programming Using OpenMP** ***Learning Objective/s:*** *The learner is expected to apply basic OpenMP constructs to parallelize a given operation and analyze performance differences between sequential and parallel execution.*	**06**
	Contents Introduction to OpenMP**.** OpenMP architecture and execution model. Thread creation, fork–join model, Compiler directives and environment variables. **Task 2:** Write a C/C++/Python program to compute the sum of all elements in an array of size 1,000,000. • First implement the sequential version. • Then parallelize the summation using OpenMP parallel for with a reduction clause. • Measure and compare the execution time of both versions. • Print the final sum and speedup. ***Learning Outcome:*** *A learner will be able to* *LO 2.1: Explore sequential and parallel design alternatives (using OpenMP) and adopt and apply these techniques to solve the given problem. Execute both sequential and OpenMP-based parallel versions to produce potential design solutions, analyze and interpret the results. Compare these alternative solutions /methods with respect to the execution time and compute speedup to select the best method that results in performance improvement. (P.I.-1.3.1, P.I.-1.4.1, P.I.-2.2.4, P.I.-2.4.2, P.I.-3.2.1, P.I.-3.2.2, P.I.-4.3.1, P.I.-4.3.4, P.I.-5.1.2, P.I.-5.2.2)*	
03.	**Message Passing Interface (MPI)**	**06**

	Learning Objective/s: *The learner is expected to apply basic MPI constructs to parallelize a given operation and analyze performance differences between sequential and parallel execution.*	
	Contents Introduction to MPI and its standards. MPI programming model and execution environment. MPI_init, MPI_send, MPI_Recv. Compiling and running MPI programs. **Task 3:** Implement a given task using multiple processes. Write an MPI program to: 1. Divide the task among available MPI processes. 2. Each process computes partial results. 3. Root process gathers and prints the final result. • First implement the sequential version. • Then parallelize the given task using MPI processes. • Measure and compare the execution time of both versions. • Print the final result and speedup. ***Learning Outcome :*** *A learner will be able to* *LO 3.1: Explore sequential and parallel design alternatives using MPI. Adopt, apply and demonstrate proficiency in using MPI techniques to solve the given problem (E.g. addition of two vectors). Execute both sequential and MPI-based parallel versions of the given problem to produce potential design solutions, analyze and interpret the results. Compare these alternative solution/methods with respect to the execution time and compute speedup, to select the best method that results in performance improvement. (P.I.-1.3.1, P.I.-1.4.1, P.I.-2.2.4, P.I.-2.4.2, P.I.-3.2.1, P.I.-3.2.2, P.I.-4.3.1, P.I.-4.3.4, P.I.-5.1.2, P.I.-5.2.2)*	
04.	**CUDA Programming** ***Learning Objective/s:*** *The learner is expected to develop basic and optimized CUDA kernels for data-parallel problems and manage memory efficiently using global, shared memory.*	**08**
	Contents CUDA programming model. Threads, blocks, grids. Kernel invocation and execution. CUDA Memory model. Global, shared, local, constant memory. **Task 4:** Implement a CUDA program to perform a given task (e.g. vector addition) and compare execution time with a CPU-based implementation. 1. First implement the sequential version for the given task. • Then parallelize the given task using CUDA and execute it on a GPU. • Measure and compare the execution time of both versions. • Print the final result and speedup. ***Learning Outcomes:***	

	A learner will be able to *LO 4.1: Explore sequential and parallel design alternatives. Adopt, apply and demonstrate proficiency in using CUDA Programming to implement the given task. Execute both sequential and CUDA-based parallel versions of the given task to produce potential design solutions. Compare the alternative solution/methods with respect to the execution time and compute speedup, to select the best method that results in performance improvement. (P.I.-1.3.1, P.I.-2.2.4, P.I.-3.2.1, P.I.-3.2.2, P.I.-4.3.1, P.I.-4.3.4, P.I.-5.2.2)* **Task 5:** Study and implementation of CUDA Memory Model. Design a CUDA kernel for a given problem (e.g. matrix addition) using global memory and then optimize it using shared memory. Analyze performance improvement. ***Learning Outcomes:*** *A learner will be able to* *LO 4.2: Explore different types of CUDA memories. Adopt, apply and demonstrate proficiency in using CUDA memory model to design solution for a given problem and use appropriate memory type to optimize the performance of a CUDA kernel. Analyze and interpret the performance using chosen memory models. (P.I.-1.4.1, P.I.-2.4.2, P.I.-3.2.1, P.I.-3.2.2, P.I.-5.1.2, P.I.-5.2.2)*	
05	**CUDA Profilers** ***Learning Objective/s:*** *To profile a CUDA application and analyze the profile report to identify performance bottlenecks. To analyze performance bottlenecks and apply CUDA optimization techniques.*	**06**
	Contents CUDA Profilers (Nsight Systems / Nsight Compute) **Task 6:** Study and implementation of CUDA profiling tool. 1. Use CUDA profiling tools to collect performance metrics of GPU kernels. 2. Interpret profiling data such as kernel execution time, memory access patterns, and occupancy. 3. Identify performance bottlenecks in CUDA programs using profiler reports. 4. Optimize the CUDA kernels and analyze performance gain. ***Learning Outcomes:*** *A learner will be able to* *LO 5.1: Identify different profiling tools for profiling CUDA programs. Apply any one contemporary profiling tool to collect and analyze profile output of a CUDA application program; Interpret the profiling report to identify and document performance bottlenecks/limitations in CUDA programs; Apply different optimizations and Analyze their impact on performance of a CUDA program. (P.I.-1.3.1, P.I.-1.4.1, P.I.-2.4.2, P.I.-2.4.3, P.I.-4.3.1, P.I.-4.3.2, P.I.-9.1.1, P.I.-9.1.2).*	
	Total	**30**

Performance Indicators :

P.I. No.	P.I. Statement
1.3.1	Apply engineering fundamentals
1.4.1	Apply theory and principles of computer science engineering to solve an engineering problem
2.1.1	Evaluate problem statements and identifies objectives
2.2.4	Compare and contrast alternative solution/methods to select the best methods

2.2.5	Compare and contrast alternative solution processes to select the best process.
2.4.2	Analyze and interpret the results using contemporary tools
2.4.3	Identify the limitations of the solution and sources/causes.
3.2.1	Ability to explore design alternatives.
3.2.2	Ability to produce a variety of potential design solutions suited to meet functional requirements.
3.3.1	Ability to perform systematic evaluation of the degree to which several design concepts meet the criteria.
4.3.1	Use appropriate procedures tools and techniques to collect and analyze data
4.3.2	Critically analyse data for trends and correlations, stating possible errors and limitations
4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions.
5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems.
5.2.2	Demonstrate proficiency in using discipline specific tools.
9.1.1	Read, understand and interpret technical and nontechnical information.
9.1.2	Produce clear, well-constructed, and well-supported written engineering documents
9.3.2	Use a variety of media effectively to convey a message in a document or a presentation

Course Outcomes:

Learner will be able to

1. Compare parallel computing models and select an appropriate model for a given problem. *(LO 1.1)*
2. Design OpenMP-based shared-memory parallel programs and analyse performance improvement. *(LO 2.1)*
3. Develop MPI-based distributed-memory programs and analyse sequential versus parallel performance. *(LO 3.1)*
4. Design CUDA program for a given task and apply appropriate memory models to optimize its performance. *(LO 4.1, LO 4.2)*
5. Analyse Profiler's output for CUDA applications to identify performance bottlenecks and apply optimization techniques. *(LO 5.1)*

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ITLBC711.1	3	3	3	-	-	-	-	-	3	-	-
ITLBC711.2	3	3	3	3	3	-	-	-	-	-	-
ITLBC711.3	3	3	3	3	3	-	-	-	-	-	-
ITLBC711.4	3	3	3	3	3	-	-	-	-	-	-
ITLBC711.5	3	3	-	3	-	-	-	-	3	-	-
Average	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**3**	**-**	**-**

Text Books:

1. Parallel Programming in C with MPI and OpenMPI, Michael J. Quinn, 2008, McGraw Hill.
2. Programming Massively Parallel Processors, A Hands-on Approach, David B. Kirk and Wen-mei W. Hwu, 2010, Morgan Kaufmann Publisher- Elsevier.
3. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, Shane Cook, 2012, Morgan Kaufmann.
4. Hands-On GPU Programming with Python and CUDA, Dr. Brian Tuomanen, O'Reilly.

Reference Books:

1. CUDA by Example: An Introduction to General-Purpose GPU Programming, Jason Sanders, Edward Kandrot, 1st edition, 2010, Addison-Wesley.
2. Parallel Programming in MPI and OpenMP, Victor Eijkhout , 2nd edition 2022.
3. Parallel Programming in Open MP, by Rohit Chandra (Editor), Authors- Leonardo Dagum, Dave Kohr, Dror Maydan, Jeff McDonald, Ramesh Menom , 2000, Morgan Kaufmann Pub.

Other Resources:

1. NPTEL Course: High Performance Computing for Scientists and Engineers, By Prof. Somnath Roy, Department of Mechanical Engineering, IIT Kharagpur
   Web link- https://nptel.ac.in/courses/112105293
2. NPTEL Course: High Performance Scientific Computing By Prof. Shivasubramanian Gopalakrishnan, Prof. Om Jadhav, Prof. S Vamshi Krishna, Prof. Ashish Kuvelkar, Department of Computer Science and Engineering, IIT Bombay
   Web link- https://onlinecourses.nptel.ac.in/noc25_ma27/preview

A. CONTINUOUS ASSESSMENT (25 MARKS)

Suggested breakup of distribution

a) Task Execution :10 Marks
Students will be given 6 tasks based on list as per mentioned in the syllabus. Each task carries 10 Marks. Average will be taken of all tasks. Students are expected to apply Parallel Computing Models such as OpenMP, MPI, CUDA to a given problem and observe the performance achievement over the sequential version. Students will be evaluated based on parameters such as analysis and interpretation of the results, comparison of the alternative solution/methods with respect to the execution time and compute speedup.

b) Practical Test : 10 Marks

Students will be given task (different for each student) and they will be evaluated based on the parameters mentioned in continuous assessment.

c) Regularity & Active participation: 05 Marks

B. END SEMESTER EXAMINATION (Oral Exam) (25 Marks)

Suggested breakup of distribution

a) Oral based on entire syllabus:15 Marks

b) Oral based on Task Explanation: 05 Marks

c) Oral based on Results and Inferences drawn: 05 Marks

Two examiners, one Internal and one External will do the evaluation.

Course Type	Course Code	Course Name	Credits
MJP	ITMJP701	Major Project-A	02

Examination Scheme		
Continuous Assessment	**End Semester Exam (ESE)**	**Total**
50	--	50

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO4 : Conduct investigations of complex problems
5. PO5 : Engineering Tool Usage
6. PO6 : The Engineer & The World
7. PO7 : Ethics
8. PO8 : Individual & Collaborative team work
9. PO9 : Communication
10. PO10 : Project Management & Finance
11. PO11 : Life-long learning

Course Objectives:

1. To motivate students to review the knowledge and skills they acquired during their program.
2. To ensure students can analyze a specific problem or issue, and they can demonstrate proficiency in project design, research methods application, data collection and analysis, and results presentation.
3. To foster self-learning and research skills.

Guidelines for the Major Project-A

Guidelines

1. Project Topic Selection and Allocation

- Towards the end of Semester VI, students will be introduced to potential project domains and problem areas.
- Project topics must be finalized in consultation with the guide, ensuring technical feasibility and alignment with the guide's domain expertise.
- Students should refer to recent research papers (preferably from IEEE, Elsevier, ACM, or similar sources) not older than three years.
- Students are encouraged to propose original ideas, including problem statements inspired by Digital India initiatives, Smart India Hackathon (SIH), and other innovation platforms.

Criteria for Topic Finalization:

- Novelty: The work should introduce new contributions or address clear gaps in existing systems.
- Technological Relevance: Use of current and emerging tools, platforms, methods, and technologies.
- Originality: Avoid repetition of projects undertaken in the past three years.
- Product Orientation (Preferred): Solutions that can evolve into a deployable product or prototype.

Project Team & Execution:

- Each group must consist of 3–4 students (within the same or across departments).
- Projects may be executed internally or in collaboration with industry, research organizations, or external agencies.
- Guides will be allotted to monitor progress, review weekly work, and maintain attendance and log records.
- Topic proposals will be reviewed domain-wise, and final approval will be given by the HoD and the project coordination committee.

2. Project Progress Monitoring

- Each department shall constitute a Project Progress Monitoring Committee.
- Minimum two formal progress presentations must be conducted during the semester.
- Internal guides may coordinate with industry/external partners for off-campus project supervision if required.

3. Project Report Format

The final report should follow the institute guidelines and include:

1. Abstract
2. Introduction
3. Literature Review / Existing System
4. Research Gap / Limitations
5. Problem Statement and Objectives
6. Proposed System
    - Analysis / Algorithm / Framework
    - Design Methodology
7. Experimental Setup
    - Input Data / Dataset Details
    - Software and Hardware Specifications
    - Evaluation Parameters
8. Results and Discussion
9. Conclusion and Future Scope
10. References
11. Appendices (if applicable: Certificates, Publications, etc.)

Students are encouraged to complete relevant certification courses that support the technical requirements of their project.

Course Outcomes:

At the end of the course, students will be able to:

1. Identify and define a problem of societal or research relevance through a comprehensive literature review and a detailed problem analysis.
2. Apply appropriate engineering principles, analytical methods, and modern tools to design feasible and effective solutions for the identified problem.
3. Conduct investigations using suitable research methodologies, data collection, and analysis techniques to validate the proposed solution.
4. Evaluate the proposed solution considering societal, environmental, and ethical aspects to ensure sustainable engineering practices.
5. Demonstrate effective teamwork, project management, and communication skills in preparing and presenting project outcomes.
6. Engage in self-directed learning and continuous improvement to enhance technical competence and professional growth.

In-Semester Continuous Assessment Guidelines:

Total Marks: 50 (Semester VII)

Component	Description	Marks
Topic Approval Presentation	Evaluation by Project Monitoring Committee	10
Mid-Semester Progress Presentation	Demonstration of progress in methodology and implementation	15
Final Report & Presentation	Quality of report, implementation, teamwork, and final demonstration	20
Regularity and active participation	Consistent attendance, timely submission of weekly progress logs, proactive involvement in group discussions, task ownership, and meaningful contribution to project development throughout the semester.	05

Quality Evaluation Parameters

- Relevance and quality of the problem selected
- Clarity in problem definition, objectives, and scope
- Originality and relevance to current industry/research trends
- Quality of system design, methodology, and implementation
- Clarity, organization, and technical depth of the report
- Effectiveness of oral presentation
- Individual contribution and teamwork

Course Type	Course Code	Course Name	Credits
HSS	HSS703	FINANCIAL PLANNING	02

Program Outcomes addressed:

1. PO2 : Problem Analysis
2. PO6 : The Engineer & The World
3. PO10: Project Management and Finance

Course Objectives :

1. Develop a foundational understanding of financial principles and their relevance to personal financial planning
2. Enhance analytical skills to assess financial situations and propose effective solutions.
3. Acquire practical financial management skills through budgeting, investment analysis, and debt management
4. Foster ethical and responsible financial behaviour in alignment with professional standards and societal values

Module	Details
01.	**Setting Financial goals, Budgeting & cash flow management** Understanding financial goals: short, medium, long-term, and setting them using the SMART criteria, Introduction to budgeting: covering income, expenses, savings, and investments, Budgeting techniques: zero-based budgeting, envelope system, and the 50/30/20 rule, Cash flow management strategies for maintaining financial stability.
02.	**Saving Strategies & Investments, Borrowing & Credits** Importance of saving and investing for financial growth, Introduction to different types of savings accounts and investment options, Understanding the risk-return tradeoff in investing, Diversification and asset allocation strategies, Responsible borrowing practices and managing debt, Credit management: credit scores, types of credit, and building good credit history.
03.	**Risk Management** Concept of financial risk and its implications, Types of financial risks: market risk, inflation risk, interest rate risk, credit risk, Introduction to insurance: types of insurance (life, health, property, auto), coverage options, Importance of emergency fund and risk mitigation strategies Evaluating risk tolerance and creating a risk management plan
04.	**Income tax Fundamentals** Basics of income tax: taxable income, tax deductions, tax credits, Understanding tax brackets and marginal tax rates, Types of taxes:

	income tax, payroll tax, capital gains tax, Filing tax returns: forms, deadlines, filing options, Tax-saving strategies: deductions, credits, retirement accounts
05.	**Understanding balance sheet** Introduction to personal financial statements, Components of a balance sheet: assets, liabilities, net worth, Understanding the relationship between income statement and balance sheet, Importance of tracking and analyzing personal financial position, Evaluating financial health using key ratios (debt-to-income ratio, savings ratio, etc.)
06.	**Project management & Finance** Introduction to project management principles, Project planning and scheduling: defining objectives, work breakdown structure, Gantt charts Budgeting for projects: estimating costs, resource allocation, contingency planning, Project risk management: identifying risks, assessing impact, developing risk response strategies, Financial analysis techniques for project evaluation (NPV, IRR, payback period)
Total no. of hours: **30**	

Course Outcomes :

1. Demonstrate a comprehensive understanding of financial concepts
2. Analyze complex financial scenarios, identify financial challenges, and propose effective strategies to achieve financial goals.
3. Apply financial planning principles and techniques to develop personalized financial plans aligned with individual goals and circumstances.
4. Utilize financial tools, software applications, and online resources proficiently
5. Adhere to ethical standards and professional codes of conduct in financial decision-making
6. Recognize the societal impact of financial decisions and promote responsible financial behavior

Text Books :

1. Personal Finance by Jeff Madura and Hardeep Rai, Pearson Education
2. Financial Management: Principles and Applications, by Sheridan Titman, Arthur J. Keown, and John D. Martin, Pearson Education
3. Project Management: The Managerial Process, by Erik W. Larson and Clifford F. Gray, McGraw-Hill Education

Reference Books :

1. The Total Money Makeover: A Proven Plan for Financial Fitness, by Dave Ramsey, Thomas Nelson
2. Investing 101: From Stocks and Bonds to ETFs and IPOs, an Essential Primer on Building a Profitable Portfolio, by Michele Cagan , Adams Media
3. Financial Risk Management: A Practitioner's Guide to Managing Market and Credit Risk, by Steve L. Allen (Publisher: Wiley)

Other Resources:

1. NPTEL Course: Behavioral And Personal Finance, By Prof. Abhijeet Chandra, Vinod Gupta School of Management, IIT Kharagpur :-Web link- https://onlinecourses.nptel.ac.in/noc24_mg07/preview
2. NPTEL Course: Financial Management, By CA Amita Bissa, Jai Narain Vyas University, Jodhpur:-Web link- https://onlinecourses.swayam2.ac.in/cec20_mg05/preview

Course Type	Course Code	Course Name	Credits
OEC	OEC7011	PRODUCT LIFE CYCLE MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO3 : Design / Development of Solutions
2. PO6 : The engineer & The World
3. PO10: Project Management and Finance

Course Objectives :

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Introduction to Product Lifecycle Management (PLM)**	**09-11**
	Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications, PLM Strategies: Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	
02.	**Product Design**	**09-11**
	Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase,	

	Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	
03.	**Product Data Management (PDM)**	**05-07**
	Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	
04.	**Virtual Product Development Tools**	**05-07**
	For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	
05.	**Integration of Environmental Aspects in Product Design**	**05-07**
	Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	
06.	**Life Cycle Assessment and Life Cycle Cost Analysis**	**04-06**
	Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes : Learner will be able to

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7011.1	-	-	-	-	-	3	-	-	-	3	-
OEC7011.2	-	-	3	-	-	-	-	-	-	3	-
OEC7011.3	-	-	3	-	-	-	-	-	-	-	-
OEC7011.4	-	-	3	-	-	-	-	-	-	3	-
Average	**-**	**-**	**3**	**-**	**-**	**3**	**-**	**-**	**-**	**3**	**-**

References :

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environmentA life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – (20 Marks)**
2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7012	RELIABILITY ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO 4: Conduct investigations of complex problems
5. PO 5: Engineering Tool Usage

Course Objectives:

1. To familiarize the students with various aspects of probability theory.
2. To acquaint the students with reliability and its concepts.
3. To introduce the students to methods of estimating the system reliability of simple and complex systems.
4. To understand the various aspects of Maintainability, Availability and FMEA procedure.

Module	Details	Hrs.
00.	**Course Introduction** Reliability Engineering is a vital discipline within engineering that focuses on ensuring systems and components perform their intended functions consistently over their expected lifetime. The course introduces students to the principles, tools, and methodologies used to analyze, predict, and improve the reliability of engineering systems. Students will explore key concepts such as failure mechanisms, probability models, reliability metrics, system configurations, maintenance strategies, and life data analysis. Through theoretical understanding and practical applications, the course aims to develop the ability to design reliable products, evaluate system performance, and implement reliability improvement programs in real-world engineering environments. By the end of the course, learners will gain a strong foundation in reliability concepts and become capable of applying these principles across various domains including mechanical, electrical, electronic, and manufacturing systems.	**01**

01.	**Contents:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. Rules for combining probabilities, independent, mutually exclusive, complimentary, conditional events, simultaneous occurrence of events.	**05-07**
02.	**Reliability Concepts** **Contents:** Reliability definitions, Reliability functions, Importance of Reliability, Quality Assurance and Reliability. Failure- causes of failures, modes of failures, Bath Tub Curve Failure Data Analysis: Failure density, Mean Time to Failure (MTTF), Mean time between failure (MTBF).	**07-09**
03.	**Reliability Hazard Models** **Contents:** Hazard rate, Constant Hazard, Hazard Models –Constant Failure Rate, linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution MTTF in terms of failure Density, Mean time in failure in integral form functions and reliability analysis.	**06-08**
04.	**System Reliability** **Contents:** System Configurations: Series, parallel, mixed configuration, k- out of n structure, Complex systems. Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis.	**05-07**
05.	**Maintainability and Availability** **Contents:** Maintainability, System Down time, Reliability and Maintainability tradeoff. Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability– qualitative aspects, Availability measures	**07-09**
06.	**Failure Mode, Effects & Criticality Analysis and Fault Tree Analysis** **Contents:** Failure Mode, Effects and Criticality Analysis: Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, Fau1t tree analysis and Event Tree Analysis. Fault Tree Analysis, basic symbols, development of functional reliability block diagram, Fault tree analysis and Event Tree Analysis.	**07-09**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes : Learner will be able to

1. Apply the concept of Probability theory to engineering problems.
2. Understand fundamental concept of reliability to calculate different reliability parameters.
3. Differentiate between reliability hazard models.

4. Illustrate the understanding of System Reliability.
5. Illustrate the various aspects of Maintainability and Availability
6. Familiarize with the FMECA and able to construct fault tree diagrams.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7012.1	3	3	--	--	--	--	--	--	--	--	--
OEC7012.2	3	3	--	--	3	--	--	--	--	--	--
OEC7012.3	3	3	--	3	--	--	--	--	--	--	--
OEC7012.4	3	3	3	3	--	--	--	--	--	--	--
OEC7012.5	3	3	3	--	--	--	--	--	--	--	--
OEC7012.6	3	3	3	--	--	--	--	--	--	--	--
Average	**3**	**3**	**3**	**3**	**3**	--	--	--	--	--	--

Text Books :

1. L.S. Srinath, “Reliability Engineering”, Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, “Reliability and Maintainability Engineering”, Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, “Engineering Reliability”, John Wiley & Sons, 1980.
4. E. Balagurusamy, “Reliability Engineering”, Mcgraw Hill Education (India), 2003.

Reference Books :

1. P.D.T. Conor, “Practical Reliability Engineering”, John Wiley & Sons, 1985.
2. K.C. Kapur, L.R. Lamberson, “Reliability in Engineering Design”, John Wiley & Sons.3
3. Murray R. Spiegel, “Probability and Statistics”, Tata McGraw-Hill Publishing Co. Ltd.

Other Resources :

1. Introduction to Reliability Engineering
   Link - https://nptel.ac.in/courses/127105234

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

Suggested breakup of distribution

Class Test	:	05 Marks
MCQ test as per GATE exam pattern / level	:	05 Marks
Open book Test	:	05 Marks
Regularity and active participation	:	05 Marks

1. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7013	MANAGEMENT INFORMATION SYSTEM	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO6 : The engineer & The World
3. PO10: Project Management and Finance

Course Objectives :

1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
4. Identify the basic steps in systems development

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Introduction To Information Systems (IS)**	**03-05**
	Contents: Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS	
02.	**Data and Knowledge Management**	**07-09**
	Contents: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	
03.	**Ethical issues and Privacy**	**07-09**
	Contents:	

	Information Security. Threat to IS, and Security Controls	
04.	**Social Computing (SC)**	**07-09**
	Contents: Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	
05.	**Computer Networks**	**06-08**
	Contents: Wired and Wireless technology, Pervasive computing, Cloud computing model	
06.	**Information System within Organization**	**07-09**
	Contents: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes : Learner will be able to

1. Explain how information systems Transform Business.
2. Identify the impact information systems have on an organization
3. Describe IT infrastructure and its components and its current trends
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7013.1	3	-	-	-	-	3	-	-	-	-	-
OEC7013.2	3	-	-	-	-	3	-	-	-	-	-
OEC7013.3	3	-	-	-	-	-	-	-	-	-	-
OEC7013.4	3	-	-	-	-	-	-	-	-	3	-
OEC7013.5	3	-	-	-	-	-	-	-	-	3	-
Average	**3**	-	-	-	-	3	-	-	-	3	-

References :

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – Theory (20 Marks)**
2. **Mid Semester Exam (30 Marks)**

   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage

Course Type	Course Code	Course Name	Credits
OEC	OEC7014	DESIGN OF EXPERIMENTS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO4 : Conduct Investigations of Complex Problems
4. PO5 : Engineering Tool Usage

Course Objectives :

1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Introduction**	**05-07**
	Contents: Strategy of Experimentation, Typical Applications of Experimental Design, Guidelines for Designing Experiments, Response Surface Methodology	
02.	**Fitting Regression Models**	**08-10**
	Contents: Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of new response observation, Regression model diagnostics, Testing for lack of fit	
03.	**Two-Level Factorial Designs** **Contents:** The 2^2 Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^k Design, The Addition of Center Points to the 2^k Design, Blocking in the 2^k Factorial Design, Split-Plot Designs	**07-09**

04.	**Two-Level Fractional Factorial Designs** **Contents:** The One-Half Fraction of the 2k Design, The One-Quarter Fraction of the 2 k Design, The General 2k-p Fractional Factorial Design, Resolution III Designs, Resolution IV and V Designs, Fractional Factorial Split-Plot Designs	**07-09**
05.	**Response Surface Methods and Designs** **Contents:** Introduction to Response Surface Methodology , The Method of Steepest Ascent, Analysis of a Second-Order Response Surface, Experimental Designs for Fitting Response Surfaces	**07-09**
06.	**Taguchi Approach** **Contents:** Crossed Array Designs and Signal-to-Noise Ratios, Analysis Methods, Robust design examples	**03-05**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes: Learner will be able to

1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7014.1	3	3	-	3	-	-	-	-	-	-	-
OEC7014.2	3	3	-	-	3	-	-	-	-	-	-
OEC7014.3	3	-	-	3	3	-	-	-	-	-	-
Average	**3**	**3**	**-**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**

References :

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3 rd edition,John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley

4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2

5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T.Voss

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – Theory (20 Marks)**

2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7015	OPERATION RESEARCH	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL
Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO6: The Engineer & The world
5. PO10: Project Management & Finance
6. PO11: Lifelong Learning

Course Objectives:

1. To introduce the concept of formulation of a real-world problem as a mathematical programming model.
2. To impart the knowledge of the mathematical tools that are needed to solve optimization problems.
3. To make learner able to use mathematical software to solve the proposed models.
4. To impart the mathematical understanding to analyse and solve integer programming from a wide range of applications.

Module	Detailed Contents	Hrs
00.	**Course Introduction** Operations Research (OR) course is an interdisciplinary field that applies advanced analytical, mathematical, and statistical methods to make better decisions in complex systems, optimizing processes and resource allocation. Students learn to identify problems, formulate mathematical models like linear programming, and use algorithms to find optimal solutions for real-world issues in areas such as engineering, management, finance, and logistics.	01
01.	**Introduction to Operations Research** **Content:** Introduction, Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming:** Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method, Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness	15-17

	Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis Transportation Problem: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem **Integer Programming Problem:** Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	
02.	**Queuing models** **Contents:** Queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population.	**04-06**
03.	**Simulation** **Contents:** Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	**06-08**
04.	**Dynamic programming** **Contents:** Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	**06-08**
05.	**Game Theory** **Contents:** Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	**04-06**
06.	**Inventory Models** **Contents:** Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model	**04-06**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes: Learner will be able to

1. Apply simplex method, analyse the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change
3. Solve specialized linear programming problems like the transportation and assignment problems.
4. Solve network models like the shortest path, minimum spanning tree, and maximum flow problems
5. Analyse the applications of integer programming and a queuing model and compute important performance measures

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7015.1	3	3	3	-	-	-	-	-	-	-	-
OEC7015.2	3	3	-	-	-	-	-	-	-	-	-
OEC7015.3	3	3	3	-	-	3	-	-	-	3	3
OEC7015.4	3	3	3	-	-	3	-	-	-	3	3
OEC7015.5	3	3	3	-	-	3	-	-	-	-	3
Average	**3**	**3**	**3**	**-**	**-**	**3**	**-**	**-**	**-**	**3**	**3**

Text Books :

1. Operations Research - An Introduction, Taha, H.A., Seventh Edition 2002, Prentice Hall.
2. Operations Research, S. D. Sharma, First Edition, 2012, KedarNath Ram Nath-Meerut Company
3. Operations Research, Kanti Swarup, P. K. Gupta and Man Mohan, Twentieth Edition, 2022 Sultan Chand & Sons

Reference Books :

1. Operation Research-Methods and problems, Saiesini M.,Yaspan A., First Edition, 1959, Prentice Hall
2. Operations Research: Principles and Practice, Ravindran, A, Phillips, D. T and Solberg, J. J., Second edition, 2009, John Willey and Sons.
3. Introduction to Operations Research, Hiller, F. S. and Liebermann, G. J., Fourth edition, 2002, Tata McGraw Hill

Other Resources :

1. NPTEL Course: Introduction to Operation Research, Prof. G.Srinivasa, IIT Madras
   Web Link- https:// nptel.ac.in/courses/110106062
2. NPTEL Course: Operations Research, Prof. Kusum Deep, IIT Roorkee

Web Link- https://onlinecourses.nptel.ac.in/noc22_ma48/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – Theory (20 Marks)**
2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7016	CYBER SECURITY AND LAWS	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO 1: Engineering knowledge
2. PO 2: Problem analysis
3. PO 3: Design and Development of Solution
4. PO 4: Conduct investigation of Complex Problem
5. PO 5: Engineering Tool Usage
6. PO 11: Life-long learning

Course Objectives:

1. To define and categorize various forms of cybercrime, including malware attacks, social engineering, financial fraud, and network intrusions, while understanding their technical and societal impacts.
2. To analyse the legal frameworks governing cyber activities, with a focus on distinguishing between different types of cyber laws at national and international levels.
3. To examine the key provisions and structure of the Indian IT Act, 2008, and to evaluate the implications of its latest amendments on digital governance, privacy, and cybercrime adjudication.
4. To identify and compare global information security standards and compliance frameworks, such as ISO 27001, PCI-DSS, GDPR, HIPAA, and NIST, and their relevance to organizational security postures.
5. To apply legal and compliance knowledge in practical scenarios, enabling students to assess organizational compliance requirements and recommend appropriate security controls within legal boundaries.

Module	Details	Hrs.
00.	**Course Introduction** This course provides a comprehensive introduction to the principles, practices, and legal frameworks of cyber security. Students will explore various types of cybercrimes, attack methodologies, and defensive strategies, with a strong emphasis on legal and regulatory compliance. The course covers Indian cyber laws and compliances, including the IT Act 2000 and its amendments, as well as global security standards. Through theoretical insights, learners will be equipped to identify, analyse, and respond to cyber threats within a legal and ethical context.	**01**
01.	**Introduction to Cybercrime** **Contents:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	**05-06**
02.	**Cyber offenses & Cybercrime** **Contents:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops.	**07-08**
03.	**Tools and Methods Used in Cyberspace** **Contents:** Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	**07-08**
04	**The Concept of Cyberspace** **Contents:** The Concept of Cyberspace, E-Commerce, The Contract Aspects in Cyber Law, The Security Aspect of Cyber Law, The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law, The Criminal Aspect in Cyber Law, Global Trends in Cyber Law, Legal Framework for Electronic Data Interchange, Law Relating to Electronic Banking, The Need for an Indian Cyber Law.	**07-08**
05	**Indian IT Act** **Contents:** Cyber Crime and Criminal Justice, Penalties under the IT Act, 2000, Adjudication Mechanism, Appeals under the IT Act, Information Technology Act, 2000, IT Act, 2008 and its Amendments.	**05-06**
06	**Information Security Standard compliances** **Contents:** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	**04-05**

	Course Conclusion This course equips learners with essential knowledge of cybercrime, cybersecurity practices, and cyber laws governing the digital ecosystem. Students gain an understanding of the Indian IT Act and its amendments, various aspects of cyber law, cybercrime investigation and adjudication processes, and major information security compliance standards. Overall, the course enables learners to analyze cyber threats, interpret legal and regulatory requirements, and apply security and compliance principles for secure and lawful use of information systems.	**01**
	Total	**45**

Course Outcomes: A learner will be able to –

1. Classify various types of cybercrimes, cyber threats, and attack techniques, and analyze their technical and societal impacts in digital environments.
2. Analyze cyberattack scenarios and security challenges to identify vulnerabilities, attack vectors, and appropriate technical and organizational security measures.
3. Interpret and apply provisions of the Indian Information Technology Act, 2000 and its amendments to address cybercrime investigation, adjudication, and legal issues.
4. Analyze different aspects of cyber law, including cyberspace governance, e-commerce, digital contracts, intellectual property, electronic evidence, and criminal liability.
5. Apply cybersecurity, legal, and compliance knowledge to real-world scenarios to recommend lawful, secure, and compliant practices in the design and use of information systems.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7016.1	3	-	-	-	-	-	-	-	-	-	-
OEC7016.2	3	3	3	3	3	-	-	-	-	-	3
OEC7016.3	3	3	-	-	-	-	-	-	-	-	-
OEC7016.4	3	3	-	-	-	-	-	-	-	-	-
OEC7016.5	3	3	-	-	-	-	-	-	-	-	-
Average	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**3**

Text Books:

1. Nina Godbole, Sunit Belapure, “Cyber Security”, Wiley India, New Delhi.
2. “The Indian Cyber Law” by Suresh T. Vishwanathan; Bharat Law House New Delhi.
3. “The Information technology Act, 2000”; Bare Act- Professional Book Publishers, New Delhi.

Reference Books:

1. “Cyber Law & Cyber Crimes” By Advocate Prashant Mali; Snow White Publications, Mumbai.
2. William Stallings, “Cryptography and Network Security”, Pearson Publication.
3. Kennetch J. Knapp, Cyber Security & Global Information Assurance Information Science Publishing.

Other Resources:

1. The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
2. A Compliance Primer for IT professional: https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer professionals-33538

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested breakup of distribution

One MCQ test as per GATE exam pattern/ level: 05 marks.

One Class test: 05 Marks

One Open Book Test: 05 Marks

Regularity and Active participation: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7017	DIGITAL BUSINESS MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO3: Design/ Development of Solution
4. PO5: Modern tool Usage
5. PO7: Ethics

Course Objectives:

1. To familiarize students with fundamental concepts, models, and transformation drivers that define digital business ecosystems.
2. To convey strategic frameworks, digital roadmaps, organizational readiness, and performance metrics used in digital transformation.
3. To explain key digital marketing techniques, customer acquisition methods, automation tools, and attribution models.
4. To provide understanding of ecommerce and Omni channel operations, including platforms, logistics, payments, and customer service systems.
5. To develop competency in data-driven decision-making, analytics tools, dashboards, SQL basics, and AI applications in business.
6. To familiarize with platform business models, API integrations, agile/lean product development, and ethical, legal, and security considerations in digital environments.

Module	Details	Hrs.
00.	**Course Introduction** Digital Business Management focuses on how digital technologies transform traditional business systems, processes, and decision-making. This course introduces foundations of digital business, digital strategy, marketing, ecommerce, data analytics, platforms, and product delivery, emphasizing the differences between traditional and digital business models. With growing reliance on cloud platforms, analytics, AI, and Omni channel systems, engineering graduates must understand how technical solutions enable digital transformation and value creation. The	**01**

	course equips with managerial and analytical perspectives required to design, evaluate, and manage technology driven business solutions in modern digital enterprises.	
01.	**Foundations of Digital Business** **Contents:** Introduction to Digital Business: Definition and scope Key terminology: digitization, digitalization, transformation Traditional vs Digital Business Models Digital Transformation Drivers Digital Maturity & Culture Digital Business Models – Marketplaces, Subscription, Freemium, PaaS, Value Chains Network Effects & Customer Experience	**06-08**
02.	**Digital Strategy & Transformation** **Contents:** Strategy Frameworks for Digital Initiatives Organizational Change & Governance Digital Roadmap Development Digital Leadership skills: innovation, risk-taking, cross-functional alignment Metrics for Digital Success (Engagement, Retention, Lifetime Value, Customer Acquisition Cost) KPI Dash boarding & Review	**06-08**
03.	**Digital Marketing & Customer Acquisition** **Contents:** Digital Marketing Fundamentals Search Engine Optimization & Search Engine Marketing Basics Social Media & Influencer Marketing Content Marketing & Campaign Design Customer Journey Mapping Personalization & CRM Tools Attribution Models & Optimization Campaign optimization: A/B testing basics	**06-08**
04.	**Ecommerce & Omni channel Operations** **Contents:** Ecommerce Models (B2B, B2C, C2C, D2C) Payments, Fulfilment, Returns, Last-mile Logistics Omni channel Commerce Inventory Visibility & Order Management Digital Customer Service Tools Platform Selection & vendor Evaluation	**06-08**
05.	**Data, Analytics & AI for Business** **Contents:** Data-driven Decision Making Data Pipelines & SQL Basics Descriptive & Diagnostic Analytics Predictive Analytics Recommendation Engines	**07-09**

	KPI Dashboards (Tools) Communicating Data Insights	
06.	**Platforms, Ecosystems, Product Delivery & Ethics**	**06-08**
	Contents: Platform Business Models & Ecosystems Product Management Basics Agile & Lean Startup API Economy & Partnerships Ethical, Legal & Security Considerations	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes: A learner will be able to -

1. Summarize the fundamental concepts, models, transformation drivers and customer experience elements of digital business.
2. Analyse the digital strategies, organizational reediness, transformation plans & business performance metrics to evaluate digital initiatives.
3. Apply digital marketing, customer acquisition methods, automation tools, and attribution techniques to develop data driven marketing insights.
4. Classify ecommerce and omnichannel models, evaluate digital platform, and analyse operational workflow to propose process improvements.
5. Use analytical tools, dashboards, SQL fundamental and AI concepts to interpret business data and communicate insights effectively.
6. Analyse platform ecosystem, select product development methodologies, interpret API based integrations and identify ethical/ legal concerns in digital system.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7017.1	3	3	-	-	-	-	-	-	-	-	-
OEC7017.2	3	3	3	-	-	-	-	-	-	-	-
OEC7017.3	-	3	3	-	3	-	-	-	-	-	-
OEC7017.4	-	3	-	-	3	-	-	-	-	-	-
OEC7017.5	-	3	-	-	3	-	3	-	-	-	-
OEC7017.6	-	3	-	-	-	-	-	-	-	-	-
Average	**3**	**3**	**3**	**-**	**3**	**-**	**3**	**-**	**-**	**-**	**-**

Text Books :

1. K. C. Laudon and J. P. Laudon, Management Information Systems: Managing the Digital Firm, latest ed. Harlow, U.K.: Pearson Education.
3. D. L. Rogers, The Digital Transformation Playbook: Rethink Your Business for the Digital Age, New York, NY, USA: Columbia Business School Publishing, 2016.
   K. Sandeep & J. J. Jose, Digital Business Management, Himalaya Publishing House.
4. A. Osterwalder and Y. Pigneur, Business Model Generation, Hoboken, NJ, USA: Wiley, 2010.
5. E. Brynjolfsson and A. McAfee, The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies, New York, NY, USA: W. W. Norton & Company, 2014.
6. P. Kotler, H. Kartajaya, and I. Setiawan, Marketing 5.0: Technology for Humanity, Hoboken, NJ, USA: Wiley, 2021.

Reference Books :

1. T. Eisenmann, G. Parker, and M. Van Alstyne, Platform Revolution: How Networked Markets Are Transforming the Economy, New York, NY, USA: W. W. Norton & Company, 2016.
   R. T. Rust, M.-H. Huang, and S. J. Lin, Service Analytics and Digital Transformation, Springer,
2. Cham, Switzerland, 2019.
   S. Sharda, D. Delen, and E. Turban, Business Intelligence, Analytics, and Data Science: A
3. Managerial Perspective, 4th ed. Boston, MA, USA: Pearson, 2020.
   M. Porter and J. Heppelmann, How Smart, Connected Products Are Transforming Companies,
4. Boston, MA, USA: Harvard Business Review Press, 2015.
   A. Chaffey and F. Ellis-Chadwick, Digital Marketing: Strategy, Implementation and Practice,
5. 8th ed. Harlow, U.K.: Pearson Education, 2022.

Other Resources :

1. Digital Business – IIT Kharagpur (Prof. S. Ray) NPTEL Course – Highly aligned with Digital Strategy, Platforms, Digital Models.

2. Marketing Management – IIT Roorkee / IIT Kanpur (Digital marketing modules included) Covers customer journey, campaigns, analytics basics.

3. Introduction to Industry 4.0 and Industrial Internet of Things – IIT Kharagpur Useful for Module 1 (Digital Transformation Drivers).

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory-(20 Marks)

Suggested break up of distribution:

a) Activities/Case studies: 10 Marks

c) Open book test/Class assignment: 05 Marks

d) Regularity and active participation: 05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7018	ENERGY AUDIT AND MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem analysis
3. PO4: Conduct investigations of complex problems
4. PO6: The Engineer and The World
5. PO11: Life-long learning

Course Objectives:

1. To understand the importance of energy security in achieving sustainable development and to learn the fundamental principles of energy conservation.
2. To introduce performance evaluation criteria for electrical and thermal installations to support effective energy management.
3. To utilize data obtained from performance evaluations to identify and prioritize energy-saving measures.

Module	Details	Hrs.
00.	**Course Introduction** Energy is a critical resource for economic growth, industrial productivity, and sustainable development. With rising energy costs, increasing demand, and growing environmental concerns, efficient use of energy has become essential across all sectors. Energy Audit and Management focuses on the systematic evaluation, monitoring, and optimization of energy consumption to improve efficiency, reduce operating costs, and minimize environmental impact. This course introduces the principles and practices of energy management, including energy auditing techniques, energy efficiency measures, and the use of modern tools for energy analysis. Students will learn how to assess energy usage in industrial, commercial, and residential facilities, identify energy-saving opportunities.	01
01.	**Energy Scenario** **Contents:** Primary and Secondary Commercial and non- commercial energy Renewable and Non Renewable Energy, Present Global and Indian Energy Scenario, Energy Security, Energy Conservation and its	05-07

	Importance, Energy efficiency benefits. Energy Conservation Act-2001 and its Features. Schemes of BEE under EC Act-2001.	
02.	**Energy Audit Principles:**	**08-10**
	Contents: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit Instruments. Elements of monitoring& targeting, benefits of M&T; Data and information-analysis. Investment need, Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	
03.	**Energy Management and Energy Conservation in Electrical System:**	**09-11**
	Contents: Basics of Electrical Energy, power factor, Motor loading calculations, relationship between power, voltage and current. Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, harmonics. Energy efficiency measures in lighting system, lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers, General energy saving opportunities in lighting system, Energy conservation opportunities in induction motors, Energy efficient motors, Motor retrofitting, soft starters, variable speed drives. Case studies based on P.F improvement, EEM, Lighting system	
04.	**Energy Management and Energy Conservation in Thermal Systems:**	**09-11**
	Contents:	
	Thermal Energy basics, specific heat, sensible heat, latent heat, energy content in fuel, Heat transfer basics Energy unit and conversions. Review of different thermal loads: Boiler System, performance evaluation of boilers, energy conservation opportunities in boiler Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, efficient steam utilization and energy saving opportunities. Characteristics of efficient furnace, performance evaluation of a typical fuel fired furnace, general fuel economy measures in furnaces Need and benefits of insulation, simplified formula for heat loss calculation, Purpose of heat exchanger, LMTD HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and energy savings opportunities.	

	Case Studies based on boiler, furnace and insulation	
05.	**Energy Performance Assessment:**	**03-05**
	Contents: On site Performance evaluation techniques, Energy performance assessment and its improvement: lighting system, Installed Load Efficacy Ratio (ILER) method, Motor, Heat Exchanger-LMTD, Boiler and Furnace.	
06.	**Energy conservation in Buildings:**	**03-05**
	Contents: Energy Conservation Building Codes (ECBC), ECBC guidelines on HVAC system, lighting system, Electric power, energy efficiency measures in buildings, Energy performance assessment of buildings, Green Building.	
	Course Conclusion This course provides a comprehensive understanding of energy auditing principles and energy management practices. Learners gain knowledge of energy consumption patterns, audit methodologies, and energy performance evaluation techniques for electrical and thermal utilities. The course emphasizes the identification of energy conservation opportunities, and implementation of energy-efficient technologies.	**01**
	Total	**45**

Course Outcomes :

1. Understand global and Indian energy scenario, Energy Conservation Act-2001, ECBC guidelines, to promote energy-efficient and sustainable buildings.
2. Conduct energy audits, analyse energy performance, identify energy-saving opportunities, and evaluate the financial feasibility of energy conservation measures.
3. Apply energy efficiency measures in lighting and motor systems, improve power factor, and identify practical energy conservation opportunities through case studies.
4. Apply energy-saving opportunities in boilers, furnaces, steam distribution, insulation, and HVAC systems, and practical solutions through case studies to improve energy efficiency.
5. Analyse the energy performance of lighting, motors, boilers, furnaces, and heat exchangers on-site and recommend effective energy-saving improvements.

CO-PO mapping table with correlation level:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7018.1	3	-	-	-	-	3	-	-	-	-	-
OEC7018.2	3	3	-	3	-	3	-	-	-	-	3
OEC7018.3	3	-	-	-	-	-	-	-	-	-	-
OEC7018.4	3	-	-	-	-	-	-	-	-	-	-
OEC7018.5	-	3	-	-	-	3	-	-	-	-	3
Average	**3**	**3**	**-**	**3**	**-**	**3**	**-**	**-**	**-**	**-**	**3**

Text Books:

1. General Aspects of Energy Management and Energy Audit, BEE, Fourth Edition,2015
2. Energy Efficiency in Thermal Utilities, BEE, Fourth Edition,2015
3. Energy Efficiency in Electrical Utilities, BEE, Fourth Edition,2015
4. Energy Performance Assessment for Equipment and Utility Systems, BEE, Fourth Edition,2015

Reference Books:

1. Handbook of Electrical Installation Practice, by Geoffrey Stokes, Blackwell Science, 4th Edition
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press

Web References:

1. http://www.bee-india.nic.in/
2. https://nceexam.in/

IN-SEMESTER ASSESSMENT (50 MARKS)

Suggested breakup of distribution

1. **Continuous Assessment (20 Marks)**
   - 01 MCQ test: 05 Marks
   - 01 Class test: 10 Marks
   - Regularity and active participation: 05 Marks
2. **Mid Semester Exam (30 Marks)**

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC7019	DEVELOPMENT ENGINEERING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO6 : The engineer & The World
2. PO7 : Ethics
3. PO11: Life-long learning

Course Objectives :

1. To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural Development
2. To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
3. An exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life' in the context of work life and the personal life of modern Indian professionals
4. To understand the Nature and Type of Human Values relevant to Planning Institutions

Module	Details	Hrs
00.	**Course Introduction**	**01**
01.	**Introduction to Rural Development**	**08-10**
	Contents: Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	
02.	**Post-Independence rural Development**	**04-06**
	Contents: Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development	

03.	**Rural Development Initiatives in Five Year Plans** **Contents:** Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	**06-08**
04.	**Post 73rd Amendment Scenario** **Contents:** 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments	**04-06**
05.	**Values and Science and Technology** **Contents:** Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom	**10-12**
06.	**Ethics** **Contents:** Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	**03-05**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes : Learner will be able to

1. Apply knowledge for Rural Development.
2. Apply knowledge for Management Issues.
3. Apply knowledge for Initiatives and Strategies
4. Develop acumen for higher education and research
5. Master the art of working in group of different nature.
6. Develop confidence to take up rural project activities independently

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC7019.1	-	-	-	-	-	3	-	-	-	-	-
OEC7019.2	-	-	-	-	-	3	-	-	-	-	-
OEC7019.3	-	-	-	-	-	3	-	-	-	-	-
OEC7019.4	-	-	-	-	-	3	-	-	-	-	3
OEC7019.5	-	-	-	-	-	3	3	-	-	-	-
OEC7019.6	-	-	-	-	-	3	3	-	-	-	3
Average	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**-**	**-**	**3**

References :

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V. , Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory andPractice, Vol. 4, No.4, pp.395 – 407

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage

Course Type	Course Code	Course Name	Credits
MJP	ITMJP802	Major Project-B	04

Examination Scheme		
Continuous Assessment	**End Semester Exam(ESE)**	**Total**
50	50	100

Program Outcomes addressed:

1. PO1 : Engineering knowledge
2. PO2 : Problem Analysis
3. PO3 : Design/Development of Solutions
4. PO4 : Conduct investigations of complex problems
5. PO5 : Engineering Tool Usage
6. PO6 : The Engineer & The World
7. PO7 : Ethics
8. PO8 : Individual & Collaborative team work
9. PO9 : Communication
10. PO10 : Project Management & Finance
11. PO11 : Life-long learning

Course Objectives:

1. To motivate students to review the knowledge and skills they acquired during their program.
2. To ensure students can analyze a specific problem or issue, and they can demonstrate proficiency in project design, research methods application, data collection and analysis, and results presentation.
3. To foster self-learning and research skills.

Guidelines for the Major Project-B

1. Project Continuation

- The project initiated in Semester VII (Major Project – A) continues in Semester VIII.
- Project Objectives, Outcomes, and POs remain the same.

2. Focus for Semester VIII

- This phase emphasizes completion, optimization, testing, performance evaluation, and deployment (where applicable).
- Students should work toward:
  - Validation through experiments, benchmarking, or user trials
  - Technical documentation and dissemination (paper, poster, demonstration)

3. Research and Innovation Encouragement

- Teams are encouraged to:
  - Present papers in conferences/symposia/workshops
  - Participate in inter-college / national project competitions or hackathons
  - Submit project outcomes to innovation cells, incubation centres, etc.
- Such activities carry marks under In-Semester Continuous Assessment (CIA).

4. Project Execution and Supervision

- The guide continues to monitor weekly progress and maintain:
  - Work logs
  - Attendance
  - Contribution records
- The department's Project Progress Monitoring Committee shall evaluate at least two progress reviews during the semester.

5. Project Report (Final Submission)

The final project report must include:

- Revised/Final Abstract
- Literature Review (updated if needed)
- Final System Design, Implementation, and Architecture
- Experimental Setup and Evaluation Parameters
- Results with Comparative Analysis
- Discussion, Conclusion & Limitations
- Future Scope and Applications
- References (IEEE format preferred)
- Appendices (Certificates, Publications, Competition Participation, etc.)

Course Outcomes:

At the end of the course, students will be able to:

1. Identify and define a problem of societal or research relevance through a comprehensive literature review and a detailed problem analysis.
2. Apply appropriate engineering principles, analytical methods, and modern tools to design feasible and effective solutions for the identified problem.
3. Conduct investigations using suitable research methodologies, data collection, and analysis techniques to validate the proposed solution.
4. Evaluate the proposed solution considering societal, environmental, and ethical aspects to ensure sustainable engineering practices.
5. Demonstrate effective teamwork, project management, and communication skills in preparing and presenting project outcomes.
6. Engage in self-directed learning and continuous improvement to enhance technical competence and professional growth.

In-Semester Continuous Assessment Guidelines:

Total Marks: 50 (Semester VIII)

Component	Description	Marks
Progress Review Presentation I	Demonstration of implementation progress with clarity in design and execution	10
Progress Review Presentation II	Demonstration of testing, validation, and refinement; readiness for final deployment	10
Research / Innovation Activities	• Participation/winning in project competitions, hackathons, etc. • Technical paper writing/presentation/publication	05 10
Final Draft Report (Spiral/Soft Copy)	Quality of documentation, structure, clarity, proper referencing, and reflection of actual work	10
Regularity & Active Participation	Consistent attendance, timely submissions, teamwork, individual responsibility, and weekly log progress	05

End Semester Examination (ESE) — Total: 50 Marks

Examination by Internal + External Examiners

Component	Description	Marks
Project Demonstration / Prototype Performance	Functional correctness, performance, robustness, completeness of implementation	20
Oral Presentation and Defence	Clarity in explaining methodology, decisions, results, and the ability to answer technical questions	15
Project Report (Final Hard-Bound Submission)	Technical depth, coherence, experimental analysis quality, formatting standards, and completeness	10
Individual Contribution Assessment	Clear evidence of individual technical contribution and responsibility within the team	05

Course Type	Course Code	Course Name	Credits
OEC	OEC8021	PROJECT MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering Tool Usage
5. PO9: Communication
6. PO10: Project Management and Finance
7. PO11: Life-long learning

Course Objectives:

1. To familiarize students with fundamental project management concepts, frameworks, tools, and standard terminology relevant to engineering projects.
2. To enable students to analyze project requirements and apply systematic project selection techniques and portfolio management approaches for informed decision-making.
3. To enable students to plan projects effectively by developing work breakdown structures, schedules, budgets, and comprehensive risk management plans.
4. To equip students to monitor and control project progress using quantitative performance measurement techniques, including Earned Value Management.
5. To evolve students' leadership, communication, ethical awareness, and technical documentation skills necessary for effective project execution and formal project closure.

Module	Detailed Contents	Hrs.
00.	**Course Introduction** In today's technology-driven and highly competitive engineering environment, effective project management has become critical for delivering complex projects within defined time, cost, quality, and resource constraints. Rapid technological advancements, multidisciplinary teams, and increased stakeholder expectations demand a structured approach to planning, execution, monitoring, and control of projects. This course provides students with a comprehensive understanding of project management principles, practices, and tools essential for managing engineering projects successfully. It covers key areas such as project selection and feasibility analysis, scope definition, scheduling techniques, cost and quality management, risk assessment, and performance monitoring using methods such as Earned Value Management. The course also addresses leadership, communication, and ethical considerations, enabling students to manage projects systematically in professional and industry-oriented environments.	01
01.	**Fundamentals of Project Management**	04-06
	Contents: Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager, Negotiations and resolving conflicts, Project management in various organization structures, PM knowledge areas as per Project Management Institute (PMI).	
02.	**Project Selection, Initiation, and Feasibility Analysis**	06-08
	Contents: How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio	
03.	**Project Planning and Scheduling Techniques**	07-09
	Contents: Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart, Introduction to Project Management Information System (PMIS).	
04.	**Planning Project and Risk Management**	06-08
	Contents: Planning Projects: Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan, Risk Management in projects: Risk management planning, Risk identification and risk register, Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks.	
05.	**Project Monitoring, Control, and Contracting**	06-08

	Contents: Executing Projects: Planning monitoring and controlling cycle, Information needs and reporting, engaging with all stakeholders of the projects, Team management, communication and project meetings. Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep, Project audit. Project Contracting, Project procurement management, contracting and outsourcing.	
06.	**Project Leadership, Closure and Documentation**	**04-06**
	Contents: Introduction to project leadership, ethics in projects, Multicultural and virtual projects. Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lesson learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	
	Course Conclusion: Upon completion of the Project Management course, students will be able to systematically plan, manage, monitor, and close engineering projects using established project management principles and tools. They will demonstrate the ability to work effectively in teams, manage risks and stakeholders, make informed managerial decisions, and document lessons learned. The course prepares students to take on professional roles that require project coordination, leadership, and ethical responsibility in real-world engineering and organizational environments.	**01**
	Total	**45**

Course Outcomes: A learner will be able to-

1. Apply engineering fundamentals to interpret project management concepts, project life cycle phases, stakeholder roles, and organizational structures required for systematic project execution.
2. Analyze and evaluate project proposals using structured selection and feasibility techniques, identify tasks and resources for project initiation, assess economic viability, and apply engineering principles to understand team development and dynamics.
3. Design and develop comprehensive project plans using work breakdown structures, cost estimation, and scheduling techniques, apply modern project management tools to optimize time and resource utilization, and evaluate project plans based on economic and financial considerations.
4. Apply project planning, communication, and risk management techniques to allocate and optimize resources, manage schedule uncertainties, engage stakeholders effectively, and analyze project risks to select appropriate response strategies for successful project execution.

5. Analyze, Monitor and control project performance using planning and execution parameters, applying quantitative measurement and modern project management tools, managing stakeholder communication and team coordination, and identifying procurement and contracting activities to ensure effective project execution.
6. Apply, demonstrate, and document project leadership and communication skills to execute project closure activities, manage project termination processes, ensure customer acceptance, and prepare formal closure reports and lessons learned for professional growth and knowledge management.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8021.1	3	-	-	-	-	-	-	-	-	-	-
OEC8021.2	3	3	-	-	-	-	-	-	-	3	-
OEC8021.3	-	-	3	-	3	-	-	-	-	3	-
OEC8021.4	-	3	-	-	-	-	-	-	3	3	-
OEC8021.5	-	3	-	-	3	-	-	-	-	3	-
OEC8021.6	3	-	-	-	-	-	-	-	3	-	3
Average	**3**	**3**	**3**	**-**	**3**	**-**	**-**	**-**	**3**	**3**	**3**

Text Books:

1. Project Management: A Managerial Approach, Meredith, J. R. and Mantel, S. J. Jr., 2017, Wiley India, ISBN: 978-1-119-36911-7, 9th Edition.
2. Project Management: Planning, Scheduling, and Controlling, Chitkara, K. K., 2014, Tata McGraw-Hill Education, ISBN: 978-0-070-67713-9, 2nd Edition.
3. Project Management: The Managerial Process, Gray, C. F. and Larson, E. W., 2018, McGraw-Hill Education, ISBN: 978-1-259-66271-6, 7th Edition.
4. Project Management, Gopalan, M. R., 2014, Wiley India Pvt. Ltd., ISBN: 978-8126550807, 2nd Indian Edition.

Reference Books:

1. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), Project Management Institute, 2017, PMI Publications, ISBN: 978-1-62825-664-2, 6th Edition.
2. Successful Project Management, Gido, J. and Clements, J. P., 2018, Cengage Learning, ISBN: 978-1-337-10067-2, 6th Edition.
3. Project Management, Lock, D., 2014, Gower Publishing, ISBN: 978-1-409-46228-6, 10th Edition.

Other Resources:

1. NPTEL Course: Project Management by Prof. K. K. Aggarwal / Prof. S. C. Dutta, IIT Delhi
   Web Link – https://onlinecourses.nptel.ac.in
2. Project Management Institute (PMI), PMBOK® and Standards Repository, Online Resource
   Web Link – https://www.pmi.org

3. MIT OpenCourseWare, Project Management and Systems Engineering, Massachusetts Institute of Technology. Web Link – https://ocw.mit.edu
4. Coursera, Project Management Principles and Practices, University of California, Irvine Web Link – https://www.coursera.org

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment (20 Marks)

1. Assignment on live problems/case studies: 10 Marks

   (Assignment on live problems/ case studies, wherein problems are given prior. Students are expected to research and collect required resources. They can use the resources and solve the problem on assigned date and time in Institute premises in presence of faculty member.)

2. Technical Report Writing: 05 Marks
3. Regularity and active participation: 05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination(MSE)

carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8022	FINANCE MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1 : Engineering Knowledge
2. PO2 : Problem Analysis
3. PO10: Project Management & Finance

Course Objectives :

1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Overview of Indian Financial System**	**05-07**
	Contents: Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	
02.	**Concepts of Returns and Risks**	**6-8**
	Contents: Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.	

	Time Value of Money: Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuit y Due; Continuous Compounding and Continuous Discounting	
03.	**Overview of Corporate Finance** **Contents:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	**09-11**
04.	**Capital Budgeting** **Contents:** Meaning and Importance of Capital Budgeting; Inputs forCapital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's10 Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	**10-12**
05.	**Sources of Finance** **Contents:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	**05-07**
06.	**Dividend Policy** **Contents:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani- Miller Approach	**02-04**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes: Learner will be able to

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8022.1	3	3	-	-	-	-	-	-	-	-	-
OEC8022.2	3	3	-	-	-	-	-	-	-	3	-
Average	**3**	**3**	**-**	**-**	-	-	-	-	-	**3**	**-**

References :

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – Theory (20 Marks)**
2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8023	ENTREPRENEURSHIP DEVELOPMENT AND MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO6: The Engineer & The world
3. PO8: Individual and team work
4. PO9: Communication
5. PO10: Project Management & Finance
6. PO11: Lifelong Learning

Course Objectives:

1. To introduce the fundamental concepts of entrepreneurship and effective management of business enterprises.
2. To develop understanding of business planning, ownership structures, and legal aspects related to entrepreneurship.
3. To familiarize students with the Indian entrepreneurial environment, including MSMEs, government policies, and support institutions.
4. To encourage entrepreneurial thinking by highlighting innovation, sustainability, and problem-solving in small and medium enterprises.

Module	Detailed Contents	Hrs
00.	**Course Introduction** This course is designed to develop a clear understanding of entrepreneurship as a career option and as a driver of economic growth. It covers the fundamentals of starting, organizing, and managing new ventures with special reference to the Indian business environment. The course explains business planning, legal frameworks, financial management, and government support for entrepreneurs. Emphasis is given to MSMEs, innovation, and sustainable development. Through practical insights and case discussions, the course prepares learners to identify opportunities and manage entrepreneurial challenges effectively.	01
	Overview of Entrepreneurship	

01.	**Content:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship.	**05-07**
02.	**Business Plans and Importance of Capital to Entrepreneurship**.	**06-08**
	Contents: Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur. Entrepreneurship and Business Development: Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations.	
03.	**Women and Social Entrepreneurship**	**08-10**
	Contents: Concept and evolution of women entrepreneurship in India. Role and importance of women entrepreneurs in economic and social development. Characteristics, strengths, and challenges faced by women entrepreneurs. Government policies, schemes, and institutional support for women entrepreneurship. Role of self-help groups (SHGs), NGOs, and microfinance institutions in promoting women-led enterprises. Case studies of successful women entrepreneurs. Concept, meaning, and scope of social entrepreneurship. Difference between social entrepreneurship and traditional entrepreneurship. Role of social entrepreneurs in addressing social, economic, and environmental issues. Models of social enterprises and sources of funding.	
04.	**Indian Environment for Entrepreneurship**	**07-09**
	Contents: key regulations and legal aspects, MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organizations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc.	
05.	**Effective Management of Business**	**04-06**

	Contents: Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	
06.	**Achieving Success In The Small Business**.	**04-06**
	Contents: Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business.	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes:

Learner will be able to

1. Understand entrepreneurship fundamentals and collaboratively present a basic business plan using effective teamwork, analysis, and communication skills.
2. Interpret business planning, financing, legal, and operational aspects of entrepreneurship, demonstrating the ability to develop, evaluate, and present comprehensive business strategies.
3. Understand the principles of women and social entrepreneurship and associated support systems.
4. Comprehend MSME regulations, financial schemes, and government support systems, and present structured reports for informed decision-making.
5. Identify challenges faced by micro and small enterprises and develop practical solutions, collaboratively presenting integrated case studies and informed management decisions.
6. Understand the small business life cycle and growth strategies, and collaboratively present solutions to real world business challenges.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8023.1	2	-	-	-	-	-	-	3	3	-	-
OEC8023.2	2	-	-	-	-	-	-	-	3	3	-
OEC8023.3	2	-	-	-	-	3	-	3	-	-	3
OEC8023.4	2	-	-	-	-	3	-	-	3	-	-
OEC8023.5	2	-	-	-	-	-	-	3	3	-	-
OEC8023.6	2	-	-	-	-	-	-	3	3	-	-
Average	**2**	**-**	**-**	**-**	**-**	**3**	**-**	**3**	**3**	**3**	**3**

Text Books :

1. Poornima Charantimath, Entrepreneurship Development – Small Business Enterprise, Pearson Education.

2. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Entrepreneurship, McGraw-Hill Education.
3. Vasant Desai, Entrepreneurial Development and Management, Himalaya Publishing House.

Reference Books :

1. T. N. Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi.
2. Madhurima Lall & Shikha Sahai, Entrepreneurship, Excel Books.
3. C. N. Prasad, Small and Medium Enterprises in Global Perspective, New Century Publications, New Delhi,

Other Resources :

1. www.msme.gov.in
2. www.dcmesme.gov.in
3. www.msmetraining.gov.in

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory (20 Marks)

Suggested breakup of distribution

One class test	:	05 Marks
Article reading and summarization	:	05 Marks
A task based group activity	:	05 Marks
Regularity and attentiveness	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8024	HUMAN RESOURCE MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO7 : Ethics
2. PO8 : Individual and Collaborative Teamwork
3. PO10: Project Management and Finance

Course Objectives:

1. To introduce the students with basic concepts, techniques and practices of the human resource management
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations
3. To familiarize the students about the latest developments, trends & different aspects of HRM
4. To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Introduction to HR**	**04-06**
	Contents: - Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions - Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues	
02.	**Organizational Behaviour (OB)**	**07-09**

	Contents: - Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues - Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness - Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior - Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor); - Group Behaviour and Group Dynamics: Work groups formal and informal groups and stages of group development, Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. - Case study	
03.	**Organizational Structure &Design** **Contents:** - Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. - Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. - Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	**06-08**
04.	**Human resource Planning** **Contents:** - Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale - Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning - Training & Development: Identification of Training Needs, Training Methods	**05-07**
05.	**Emerging Trends in HR** **Contents:** - Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development, managing processes & transformation in HR. Organizational Change, Culture, Environment - Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation	**6-8**
06.	**HR -MIS, Strategic HRM and Labor Laws & Industrial Relations**	**09-11**

	Contents: - Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries - Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals - Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes:

1. Understand the concepts, aspects, techniques and practices of the human resource management
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8024.1	-	-	-	-	-	-	3	3	-	3	-
OEC8024.2	-	-	-	-	-	-	3	3	-	3	-
OEC8024.3	-	-	-	-	-	-	3	3	-	3	-
OEC8024.4	-	-	-	-	-	-	3	3	-	-	-
Average	-	-	-	-	-	-	**3**	**3**	-	**3**	-

References:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – (20 Marks)**
2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8025	PROFESSIONAL ETHICS & CSR	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO6 : The engineer & The World
2. PO7 : Ethics
3. PO10: Project Management and Finance

Course Objectives:

1. To understand professional ethics in business
2. To recognized corporate social responsibility

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Professional Ethics and Business**	**03-05**
	Contents: The Nature of Business Ethics; Ethical, Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	
02.	**Professional Ethics in the Marketplace, Professional Ethics and the Environment**	**08-10**
	Contents: - Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy - Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	
03.	**Professional Ethics of Consumer Protection, Professional Ethics of Job Discrimination**	**06-08**
	Contents: - Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy	

	- Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	
04.	**Introduction to Corporate Social Responsibility** **Contents:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	**05-07**
05.	**Corporate Social Responsibility** **Contents:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	**08-10**
06.	**Corporate Social Responsibility in Globalizing India** **Contents:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	**07-09**
	Course Conclusion	**01**
	Total	**45**

Course Outcomes : Learner will be able to

1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8025.1	-	-	-	-	-	3	3	-	-	3	-
OEC8025.2	-	-	-	-	-	3	3	-	-	3	-
OEC8025.3	-	-	-	-	-	3	3	-	-	-	-
OEC8025.4	-	-	-	-	-	3	3	-	-	3	-
Average	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**-**	**3**	**-**

References:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.

3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – Theory (20 Marks)**
2. **Mid Semester Exam (30 Marks)**
   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8026	CIRCULAR ECONOMY	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/development of solutions
4. PO6: The Engineer & The world
5. PO7: Ethics
6. PO10: Project Management & Finance
7. PO11: Lifelong Learning

Course Objectives:

1. To introduce the fundamentals and need for Circular Economy (CE)
2. To impart the knowledge about environmental and economic impacts of products.
3. To make learner understand circular materials and product strategies.
4. To impart the knowledge of CE business models in engineering industries.

Module	Detailed Contents	Hrs
00.	**Course Introduction** This course introduces the Circular Economy (CE) paradigm—a transformative approach that shifts from linear consumption to restorative and regenerative systems. By embracing CE principles, engineers can contribute to designing products, processes, and infrastructures that maximize resource efficiency, reduce waste, and promote economic, environmental, and social sustainability.	01
01.	**Introduction to Circular Economy** **Content:** Linear economy, Role of the Industrial revolution in Linear economy, Disadvantages of Linear economy, Replacing Linear by Circular economy, History and evolution of circular economy, Global CE initiatives (EU Circular Economy Action Plan, UN SDGs), Role of R's in circular economy, Value	05-07

	optimization, Design out waste, Renewable energy, A differential- Linear vs. Circular economy, Building a resilient economy, Role of engineers in CE	
02.	**Systems Thinking and Life Cycle Thinking**	**06-08**
	Contents: Systems Thinking in CE, Core principles of Systems Thinking in CE, Application in the Circular Economy Concept of Loops, Circularity, Life Cycle Analysis(LCA), Importance of LCA, An efficient approach by Neptune Pumps, Case study-winnow solutions, Embodied energy and material flows, Input-output analysis in industrial systems	
03.	**Circular Design and Materials Engineering**	**07-09**
	Contents: Material recovery, waste reduction, Reducing negative externalities, Connecting Businesses and people for circularity, Butterfly diagram, Design for disassembly, modularity, repairability, Materials selection for durability and recyclability , Bio-based and regenerative materials, Eco-design principle	
04.	**Circular Business Models and Industrial Applications**	**07-09**
	Contents: Circular Business Models, Product-as-a-Service (PaaS), Reverse logistics, remanufacturing, and refurbishment, Industrial symbiosis and closed-loop systems, Digital technologies enabling CE (IoT, blockchain, AI)	
05.	**Waste Management and Resource Recovery**	**06-08**
	Contents: Circular waste hierarchy, Urban mining and e-waste recycling, Industrial and agricultural waste valorization, Waste-to-energy and bioconversion technologies	
06.	**Circular Economy Implementation and Policy**	**06-08**
	Contents: CE indicators and metrics (e.g., Circularity Gap Report), National and international CE policies, Corporate sustainability and ESG frameworks, Roadmaps and barriers to implementation	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes:

Learner will be able to

1. Analyze the need for Circular Economy (CE) and apply systems and life cycle thinking to engineering

2. Integrate CE in design and material selection
3. Analyse real-world industrial circular practices
4. Apply engineering approaches to waste minimization and resource recovery
5. Analyse policy, regulations, and corporate strategies and integrate CE into engineering practice

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8026.1	3	3	-	-	-	3	3	-	-	3	3
OEC8026.2	3	3	3	-	-	3	-	-	-	3	-
OEC8026.3	3	3	-	-	-	3	3	-	-	-	3
OEC8026.4	3	3	-	-	-	3	3	-	-	-	3
OEC8026.5	3	3	3	-	-	3	3	-	-	-	3
Average	**3**	**3**	**3**	**-**	**-**	**3**	**3**	**-**	**-**	**3**	**3**

Text Books :

1. Circular Economy: Principles and Benefits, Ken Webster., First Edition 2017, Ellen MacArthur Foundation Publishing.
2. Product Design and Life Cycle Assessment, Ireneusz Zbicinski, Danuta Romanowska, Barbara Bednarowska, First Edition, 2021, Springer
3. Designing for the Circular Economy, Martin Charter, Ursula Tischner, First Edition, 2017 Routledge

Reference Books :

1. The Circular Economy: A User's Guide, Subramanian Senthilkannan Muthu, First Edition, 2020, Springer
2. Industrial Ecology and Circular Economy: Energy and Resource Efficiency in Industry, Yasemin Gursoy, Bilge Sener, First edition, 2021, Springer.
3. Cradle to Cradle: Remaking the Way We Make Things, William McDonough, Michael Braungart, First edition, 2002, North Point Press

Other Resources :

1. NPTEL Course: Sustainable Engineering Concepts and Life Cycle Analysis, Prof. Brajesh Kumar Dubey | IIT Kharagpur
   Web Link- https://onlinecourses.nptel.ac.in/noc24_ce61/preview
2. NPTEL Course: Linear to Circular Economy, Prof Shalini Goyal Bhalla, IIT Roorkee
   Web Link- https://onlinecourses.swayam2.ac.in/aic21_ge19/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment – Theory (20 Marks)

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage

Course Type	Course Code	Course Name	Credits
OEC	OEC8027	IPR AND PATENTING	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO5: Engineering Tool Usage
4. PO6: The Engineer and The World
5. PO7: Ethics
6. PO8: Individual and Collaborative Team work
7. PO9: Communication
8. PO10: Project Management and Finance

Course Objectives:

1. To introduce students to the significance of Intellectual Property and its impact on innovation and professional growth.
2. To clarify the essential concepts and distinctions among patents, copyrights, trademarks, industrial designs, trade secrets, and GI.
3. To simplify statutory provisions and legal procedures so students can confidently interpret various IPR frameworks.
4. To guide students in applying practical steps for obtaining, managing, and safeguarding different IP rights.
5. To foster ethical reasoning, holistic professional judgement, and awareness of cyber laws relevant to IPR.

Module	Details	Hrs.
00.	**Course Introduction** The course introduces students to the fundamental concepts, legal frameworks, procedures, and applications of Intellectual Property Rights (IPR). With rapid technological advancement, understanding how to protect innovations is essential for engineers. This course equips learners with the knowledge to identify different forms of intellectual property, file and maintain IP rights, and manage IP assets ethically and strategically. Students will also develop awareness of cyber laws as they relate to digital content and IP.	**01**
01.	**Introduction to IPR** **Contents:** Concept of Property, Tangible and Intangible Property, Intellectual Property: Definition, Need & Importance, Types of IPR: Patents, Copyright, Trademark, GI, Trade Secrets, Industrial Design, Evolution of IP laws: Paris Convention, Berne Convention, WIPO creation, TRIPS, Indian IPR system: CGPDTM, Copyright Office, GI Registry, PVPFR Authority, Role of IPR in R&D, Innovation, and International Trade.	**07-09**
02.	**Patents** **Contents:** Patent definition, objectives, values and advantages, Criteria of patentability: Novelty, Inventive Step, Industrial Application, Non-patentable inventions under Indian law, Types of Specifications: Provisional, Complete, Parts of a Patent: Title, Field, Background, Description, Drawings, Claims, Abstract, Filing procedure: Forms (1, 2, 3, 5, 9, 18, 26), Examination, FER, Grant, Renewal, PCT Filing, Priority Date, Patent Cooperation Treaty, Revocation, Opposition: Pre-Grant & Post-Grant, Prior art search: Keywords, Boolean operators, Databases (WIPO, USPTO, Google Patents)	**08-10**
03.	**Trademarks, Industrial Designs and GI** **Contents:** Trademarks: Definition, Functions, Brand Value, Distinctiveness, Types of marks (word, device, shape, color), Registration process, challenges in non-conventional marks, Infringement, Passing off, Domain name disputes, well-known marks. Industrial Designs: Definition, Novelty, Originality, Registration process, Infringement and remedies. Geographical Indications (GI): Meaning & Importance, Registration of GI goods, Indian GI examples.	**08-10**
04.	**Copyright, Trade Secrets & Emerging IP** **Contents:** Copyright: Meaning, Subject Matter, Economic and Moral Rights, Ownership, Transfer, Licensing, Fair dealing, infringement, remedies, Copyright in the digital era. Trade Secrets: Conditions for protection, Misappropriation, NDAs, employment contracts.	**07-09**

	Emerging IPR: Plant varieties, Integrated circuit layout designs, Undisclosed information, Digital content issues (streaming, snippet tax)	
05.	**Cyber Laws for Digital IP Protection**	**04-06**
	Contents: Cyber Laws: IT Act 2000**,** Cybercrimes: identity theft, phishing, e-commerce fraud**,** Digital signatures, data protection, privacy**,** International cyber law issues.	
06.	**IP Management, Documentation and Commercialization**.	**03-05**
	Contents: Managing IP: IP documentation, Letters of instruction, Joint collaboration agreements, NDA, Cease & Desist, Settlement memorandum, Assignment & Licensing, Technology Transfer (ToT), IP valuation basics.	
	Course Conclusion	**01**
	The course provides a comprehensive understanding of Intellectual Property Rights and their relevance in engineering, innovation, and global business. Learners gain practical insights into patent drafting, trademark and design registration, copyright compliance, and cyber law frameworks. By the end of the course, students are equipped with knowledge and skills necessary to create, protect, and manage intellectual assets responsibly.	
	Total	**45**

Course Outcomes: Learner will be able to -

1. Compare fundamental IPR concepts by classifying major IP types and outlining key elements of India's IPR policy.
2. Identify key elements of patent fundamentals by outlining patentability criteria, filing steps and prior-art search procedures.
3. Identify essential aspects of trademarks, industrial designs and GI by interpreting legal and registration documentation.
4. Apply copyright, trade-secret and emerging IP provisions by identifying protected subject matter and reviewing case documentation.
5. Analyze cyber laws for digital IP protection by examining cybercrimes, preparing structured reports and evaluating credible cybersecurity and data-privacy information.
6. Evaluate IP management practices by assessing key documentation and critically examining clauses in licensing and collaboration agreements.

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8027.1	--	3	--	--	--	3	3	--	--	--	--

OEC8027.2	--	3	--	--	2	3	3	--	--	--	--
OEC8027.3	--	3	--	--	2	3	--	3	3	3	--
OEC8027.4	3	3	--	--	--	3	--	--	--	--	--
OEC8027.5	3	--	--	--	--	3	--	--	--	--	--
OEC8027.6	--	3	--	--	--	3	--	--	--	--	--
Average	**3**	**3**	**--**	**--**	**2**	**3**	**3**	**3**	**3**	**3**	**--**

Text Books :

1. D. E. Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents & Trade Secrets, Cengage Learning, 2012.
2. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, 2nd ed., McGraw-Hill Education, 2010.
3. P. Narayanan, Intellectual Property Law, 3rd ed., Eastern Law House, 2010.

Reference Books :

1. F. Ali, The Law of Patents, LexisNexis, 2017.
2. R. Stim, Patent, Copyright & Trademark, 17th ed., NOLO Press, 2019.
3. WIPO, WIPO Intellectual Property Handbook, World Intellectual Property Organization, 2020.
4. K. C. Kailasam and R. Vedaraman, Law of Trademarks and Passing Off, LexisNexis, 2013.

Other Resources :

1. NPTEL Course: Intellectual Property Rights and Competition Law
   Web link- https://onlinecourses.nptel.ac.in/noc25_mg132/preview

IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment - Theory (20 Marks)

Suggested breakup of distribution

One class test	:	05 Marks
Article reading and summarization	:	05 Marks
A task based group activity	:	05 Marks
Regularity and attentiveness	:	05 Marks

2. Mid Semester Exam (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8028	DISASTER MANAGEMENT AND MITIGATION MEASURES	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Exam (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO5: Modern Tool usage
5. PO6: The Engineer and The World
6. PO7: Ethics
7. PO8: Individual and Collaborative Team Work
8. PO10: Project Management and Finance

Course Objectives:

1. To introduce fundamental concepts of disasters and relevance of disaster studies in engineering practice.
2. To convey causes and impacts of natural, human-induced, and emerging disasters
3. To familiarize students with disaster management frameworks and governance by studying national institutions, policies and international disaster risk reduction frameworks
4. To introduce modern technologies, geospatial tools, and data-driven approaches used in disaster management for risk reduction.
5. To teach concepts of disaster response, financing, and recovery mechanisms by analysing relief operations, logistics, medical response, risk financing, and Build Back Better principles.
6. To guide students about mitigation, preparedness, and community resilience by emphasizing structural and non-structural mitigation and ethical responsibility of engineers.

Module	Details	Hours
00.	**Course Introduction** Disaster Management and Mitigation Measures is an interdisciplinary course that equips engineering students with essential knowledge to understand, assess, and reduce the impacts of natural and human-induced disasters. The course introduces fundamental disaster concepts, global and Indian disaster trends, and the growing influence of climate	01

	change and extreme events on society and infrastructure. Emphasis is placed on the role of engineers in disaster risk reduction through safe design, planning, technology adoption, and resilient infrastructure development. Students gain insights into disaster preparedness, response, mitigation strategies, and emerging risks, enabling them to contribute effectively to sustainable development, community safety, and national resilience in an increasingly hazard-prone world.	
01.	**Foundations of Disaster Risk Science**	**06-08**
	Contents: Disaster Concepts & Impacts: Direct, indirect and cascading effects, Social, economic & environmental consequences, Disaster-induced development challenges. Risk & Hazard Assessment: Components of disaster risk, Hazard identification & vulnerability assessment, Multi-hazard environment. Climate Change & Emerging Risks: Heatwaves, drought intensification, extreme rainfall, Sea-level rise & coastal vulnerability, Urban heat islands. Indian Context, India's hazard zonation: seismic, cyclone, landslides, flood, drought, Disaster statistics & case studies	
02.	**Natural & Human-Induced Disasters**	**05-07**
	Contents: Natural Disasters: Geological: Earthquakes, Tsunamis, Volcanoes, Landslides, Hydro-meteorological: Flood, Flash Flood, Drought, Cyclones, Cloudburst, Climate-related: Heatwaves, extreme weather events. Human-Induced & Technological Disasters: Industrial accidents, Chemical disasters (Bhopal), Nuclear hazards (Fukushima), Fire hazards (urban & industrial) Transportation accidents (rail/road/air/maritime), Infrastructure failures (dams, bridges, tunnels), Cyber-disasters & critical infrastructure cyber threats.	
03.	**Disaster Management Frameworks, Policy & Governance**	**07-09**
	Contents: Disaster Management Principles: Disaster management cycle, prevention, preparedness, response, recovery. Indian Disaster Governance: NDMA, SDMA, DDMA, NIDM roles and frameworks, National & state policies. International Frameworks & Standards: Sendai Framework for Disaster Risk Reduction, UNDRR, Sphere Standards, Global Humanitarian Principles, ESG & resilience reporting.	
04.	**Technology, Tools & Geospatial Intelligence**	**07-09**
	Contents:	

	GIS, Remote Sensing & GPS Applications: Demand Assigned Access Hazard mapping, Flood/landslide susceptibility mapping, Satellite-based early warning Modern Technologies: Drones & UAVs for reconnaissance, Web GIS platforms AI/ML & Data Analytics: ML models for rainfall, cyclone, flood prediction, Computer vision for damage assessment Smart Disaster Technologies: IoT-based early warning systems, Digital twins for urban planning, Smartphone apps (GEM, IMD, NDMA tools.	
05.	**Financing, Response, Relief & Rehabilitation**	**06-08**
	Contents: Disaster Financing Mechanisms: Risk financing & risk transfer, Insurance models (crop, property, catastrophe bonds), Pradhan Mantri Fasal Bima Yojana & other Indian schemes. Response & Relief Operations: Search & Rescue by NDRF, SDRF, NGOs, armed forces, Logistics management & supply chain resilience, Medical triage & emergency health systems. Recovery, Rehabilitation & Build Back Better: Post-disaster needs assessment (PDNA), Reconstruction policies, Resilient infrastructure design, Community resilience & social inclusion.	
06.	**Preventive, Mitigation & Community-Based Approaches**	**06-08**
	Contents: Structural Mitigation: Seismic design, retrofitting, Cyclone shelters & bio-shields, Flood protection structures, Storm-water management. Non-Structural Mitigation: Policy intervention & awareness, Capacity building, Early warning & communication systems, Land-use planning/zoning. Community Based Disaster Risk Reduction: Role of community institutions, NGOs & volunteers, Risk communication models, Indigenous knowledge systems	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes:

Learners will be able to

1. Summarize disaster concepts and analyse impacts and risk components in multi-hazard environments.
2. Classify and evaluate natural, human-induced, and technological disasters with reference to Indian and global case studies.

3. Interpret disaster management policies, governance frameworks, and institutional roles at national and international levels.

4. Apply modern tools and technologies such as GIS, remote sensing, and data analytics for disaster risk reduction.

5. Formulate/Design mitigation, preparedness, and recovery strategies incorporating community participation, sustainability, and resilience principles.

CO-PO Mapping Table with Correlation Level:

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8028.1	3	3	-	-	-	-	-	-	-	-	-
OEC8028.2	3	-	-	-	-	3	-	-	-	-	-
OEC8028.3	-	3	-	-	-	-	3	-	-	-	-
OEC8028.4	-	-	-	-	3	3	-	-	-	-	-
OEC8028.5	-	-	3	-	-	3	3	-	-	-	-
Average	**3**	**3**	**3**	**-**	**3**	**3**	**3**	**-**	**-**	**-**	**-**

Text Books:

1. D. P. Coppola, *Introduction to International Disaster Management*, 3rd ed. Oxford, U.K.: Butterworth-Heinemann (Elsevier), 2015.
2. R. Shaw, S. Srinivas, and A. Sharma, *Disaster Risk Reduction: Methods, Approaches and Practices*, Singapore: Springer, 2014.
3. P. Sammonds, T. Glade, and M. Bubeck, *Disaster Management and Mitigation: Early Warning Systems, Community Resilience and Sustainability*, London, U.K.: Springer, 2016.
4. D. Alexander, *Natural Disasters*, 2nd ed. Dordrecht, The Netherlands: Springer, 2000.
5. A. S. Arya, *Disaster Management: Institutions and Policies*, New Delhi, India: Gyan Publishing House, 2006.

Reference Books:

1. A. K. Jha, R. Duyne Barenstein, P. M. Phelps, D. Pittet, and S. Sena, Safer Homes, Stronger Communities: A Handbook for Reconstructing after Natural Disasters, Washington, DC, USA: World Bank, 2010.
2. United Nations Office for Disaster Risk Reduction (UNDRR), Sendai Framework for Disaster Risk Reduction 2015–2030, Geneva, Switzerland: United Nations, 2015.
3. D. Alexander, Principles of Emergency Planning and Management, Oxford, U.K.: Oxford University Press, 2002.
4. National Disaster Management Authority (NDMA), Government of India, National Disaster Management Plan, New Delhi, India, Latest Edition.
5. C. Emdad Haque and M. Q. Zaman, Disaster Risk Reduction: Methods, Approaches and Practices, New York, NY, USA: Springer, 2014.

Other Resources :

1. NPTEL: Satellite communication, Prof. Kalyan Kumar Bandyopadhyay, IIT Kharagpur. https://nptel.ac.in/courses/117105131
2. NPTEL/SWAYAM: Climate Change — Science, Impacts & Extreme Events https://onlinecourses.nptel.ac.in/noc25_ce135/preview

3. UDEMY: Advances in Disaster Management: Principles and Practices
https://www.udemy.com/share/10aBGu/

4. ISRO IIRS E-Learning: Geospatial Technology for Disaster Risk Reduction (GIS, RS & GPS)
https://elearning.iirs.gov.in/courses/paper_05/default.htm

5. **NDMA, Government of India – Policies, Guidelines & SOPs**
https://ndma.gov.in/

A. IN-SEMESTER ASSESSMENT (50 MARKS)

1. Continuous Assessment-Theory (20 Marks)

Suggested breakup of distribution

a) Case studies: 10 Marks

c) Open book test/Class assignment: 05 Marks

d) Regularity and active participation: 05 Marks

2. Mid Semester Examination (30 Marks)

Mid semester examination will be based on 40% to 50% syllabus.

B. END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20% to 30% weightage, and the syllabus covered from MSE to ESE, carrying 70% to 80% weightage.

Course Type	Course Code	Course Name	Credits
OEC	OEC8029	ENVIRONMENTAL MANAGEMENT	03

Examination Scheme					
Distribution of Marks			Exam Duration (Hrs.)		Total Marks
In-semester Assessment		End Semester Examination (ESE)			
Continuous Assessment	Mid-Semester Exam (MSE)		MSE	ESE	
20	30	50	1.5	2	100

Pre-requisite: NIL

Program Outcomes addressed:

1. PO6 : The engineer & The World
2. PO7 : Ethics
3. PO10: Project Management and Finance

Course Objectives:

1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Module	Details	Hrs.
00.	**Course Introduction**	**01**
01.	**Introduction and Definition of Environment**	**09-11**
	Contents: Significance of Environment Management for contemporary managers, Career opportunities, Environmental issues relevant to India, Sustainable Development, the Energy scenario	
02.	**Global Environmental concerns**	**06-08**
	Contents: Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	
03.	**Concepts of Ecology**	**05-07**
	Contents: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	
	Environmental Management and Government Regulation	**10-12**

04.	**Contents:** Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	
05.	**Quality-Based Environmental Management and ISO 14000 Framework**	**05-07**
	Contents: Total Quality Environmental Management, ISO-14000, EMS certification.	
06.	**Overview of Environmental and Industrial Legislations**	**02-04**
	Contents: General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	
	Course Conclusion	**01**
	Total	**45**

Course Outcomes: Learner will be able to

1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

CO-PO Mapping Table with Correlation Level

CO ID	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
OEC8029.1	-	-	-	-	-	3	3	-	-	3	-
OEC8029.2	-	-	-	-	-	3	3	-	-	-	-
OEC8029.3	-	-	-	-	-	3	3	-	-	3	-
Average	-	-	-	-	-	**3**	**3**	-	-	**3**	-

References:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

IN-SEMESTER ASSESSMENT (50 MARKS)

1. **Continuous Assessment – Theory (20 Marks)**
2. **Mid Semester Exam (30 Marks)**

   Mid semester examination will be based on 40% to 50% syllabus.

END SEMESTER EXAMINATION (50 MARKS)

End Semester Examination will be based on syllabus coverage up to the Mid Semester Examination (MSE) carrying 20%-30% weightage, and the syllabus covered from MSE to ESE carrying 70%-80% weightage