CURRICULUM STRUCTURE

THIRD YEAR UG: B.E.

COMPUTER ENGINEERING

REVISION: FRCRCE-2-25

Effective from Academic Year 2025-26

Effective from Academic Year 2025-26
Board of Studies Approval: 28/02/2025
Academic Council Approval: 14/02/2025 & 08/03/2025

Dr. DEEPAK BHOIR	Dr. Sujata P. Deshmukh	DR. SURENDRA RATHOD
Dean Academics	HOD (Computer)	Principal

Fr. Conceicao Rodrigues College of Engineering

Fr. Agnel Ashram, Bandstand, Bandra (W), Mumbai – 400 050
(Autonomous College affiliated to University of Mumbai)

Preamble:

Greetings and congratulations to all the education partners Fr Conceicao Rodrigues College of Engineering for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2-10/2023(AC-Policy) dated 23rd Nov 2023 conferred the autonomous status to Fr. Conceicao Rodrigues College of Engineering, Fr. Agnel Ashram, Bandstand, Bandra (West), Mumbai 400050 affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. We look towards autonomy as a great opportunity to design and implement curriculum sensitive to needs of Learner, Indian Society and Industries.

Government of Maharashtra has also directed Autonomous Colleges to revise their curriculum in line with National Education Policy (NEP) 2020 through Government Resolution dated 4th July 2023. We commit to ourselves to the effective implementation of UGC Regulations and NEP 2020 in its spirit.

Based on recent recommendations of the GR, we are pleased to offer our holistic curriculum for 2024-28, a "**H-Tree Model**" of Engineering Education. A unique **"H-Tree Model"** of Engineering Education Curriculum is carefully designed to systematically develop IQ (Intelligence Quotient), PQ (Physical Quotient), EQ (Emotional Quotient) and SQ (Spiritual Quotient) of a learner. This curriculum aims at the development of an **all-rounded** personality with **holistic** approach to education in which learner receives **25% teacher-led learning, 25% peer learning, 25% self-learning and 25% experiential learning**. The curriculum model is outcome based that focuses on learning by doing. Curriculum is designed to provide multiple learning opportunities for students to acquire and demonstrate competencies for rewarding careers. It ensures multiple choices to leaner acquiring skills through systematic planning. It has 7 verticals aligned to GR recommendations with strong science, and mathematics foundation and program core, sequel of electives, Multidisciplinary Minor courses, humanities & management courses and sufficient experiential learning through projects and semester-long industry / research internship along with employable skill-based courses. Learner gets an opportunity to acquire skills through NSDC aligned courses during summer vacations. Learner also gets additional option to choose the kind of degree i.e. Honors or Double Minor or Honors with Research.

Various steps are taken to transform teaching learning process to make learning a joyful experience for students. We believe that this curriculum will raise the bar of academic standards with the active involvement and cooperation from students, academic and administrative units.

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Curriculum Structure for UG Programs at Fr CRCE w.e.f. A.Y. 2025-26

Nomenclature of the courses in the curriculum	
Abbreviation	**Title**
BSESC	Basic Science & Engineering Science Courses
PCPEC	Program Core and Program Elective Courses
MDC	Multidisciplinary Courses
SC	Skill Courses
HSSM	Humanities, Social Sciences and Management
EL	Experiential Learning
LLC	Liberal Learning Courses
BSC	Basic Science Courses
ESC	Engineering Science Courses
PCC	Program Core Courses
PEC	Program Elective Courses
MDM	Multidisciplinary Minor
OE	Open Elective
VSEC	Vocational and Skill Enhancement Course
VSC	Vocational Skill Courses
SEC	Skill Enhancement Courses
AEC	Ability Enhancement Course
EEMC	Entrepreneurship, Economics and Management Course
IKS	Indian Knowledge System
VEC	Value Education
RM	Research Methodologies
CEFP	Community Engagement or Field Project
ELC	Experiential Learning Courses
PRJ	Project
INT	Internship
CC	Cocurricular Courses
HMM	Honors and Multidisciplinary Minor
DM	Double Minor
BC	Bridge Course

Credit Specification:

- ❖ Theory: 1 credit=13 to 15 hrs of teaching
- ❖ Lab: 1 Credit=26 to 30 hrs of lab work
- ❖ Studio Activities: 1 Credit= 26 to 30 hrs of creative activities
- ❖ Workshop Based Activities: 1 Credit=26 to 30 hrs of hands-on activities related to vocation/professional practice/skill based
- ❖ Seminar/Group Discussion: 1 Credit=13 to 15 hrs of participation
- ❖ Internship: 1 Credit=Per 2 weeks OR 36 to 40 hrs of engagement
- ❖ Field Based Learning/Practices: 1 Credit=26 to 30 hrs of learning activities
- ❖ Community Engagement Projects: 1 Credit=26 to 30 hrs of contact time along with 13 to 15 hrs of activities preparation, report writing, independent reading etc.

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Credit requirements for different options of the Degrees:

Degree/SEM	I	II	III	IV	V	VI	VII	VIII	Total
B.E	18	20	22+4#	23+5#	20	20	20	20	163+9#=172
B.E with Honors/Minors	18	20	22+4#	23+5#	20+4*	20+4*	20+6*	20+4*	163+9#+18*=190

 # Bridge courses
*Optional Credits

1. Learners who earn a minimum of total **172 credits** will be awarded "**Bachelor of Engineering**" degree.

2. Learners will have the following options to earn **B. E. in ………(regular) Engineering with Honours/Minor in …….. (specialization)**

Sr. No.	Honors/Minor degree programs	Programs who can offer this Honours Degree Program	Programs who can offer this as Minor Degree program
1	Internet of Things	1. Computer Engineering 2. Artificial Intelligence & Data Science 3. Electronics and Computer Science 4. Mechanical Engineering	--
2	Artificial Intelligence and Machine Learning	1. Computer Engineering 2. Electronics and Computer Science	Mechanical Engineering
3	Data Science	1. Computer Engineering 2. Electronics and Computer Science 3. Mechanical Engineering	
4	Blockchain	1. Computer Engineering 2. Artificial Intelligence & Data Science 3. Electronics and Computer Science	Mechanical Engineering
5	Cyber Security	1. Computer Engineering 2. Artificial Intelligence & Data Science 3. Electronics and Computer Science	Mechanical Engineering
6	Robotics	Mechanical Engineering	1. Computer Engineering 2. Artificial Intelligence & Data Science 3. Electronics and Computer Science
7	3D Printing	Mechanical Engineering	1. Computer Engineering 2. Artificial Intelligence & Data Science 3. Electronics and Computer Science

3. **Honours and Minor Degree Eligibility Criteria for Students:**

    i. Following is the eligibility criteria for students opting the Honours/ Minor Degree program:

        a. Students with no backlog in semester I, II, and III

        b. The CGPI (based on semester I, II, and III) of the students must be 6.75 and above

        c. For direct second year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above

    ii) Each eligible student can opt for maximum one Honour's or one Minor Programs at any time.

    iii) However, it is optional for learners to take Honours/Minor degree program.

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iv) The Honours/ Minor degree program can be opted only during regular engineering studies

v) The student shall complete the Honours/ Minor degree program in stipulated four semesters only.

4. Courses offered during internship semester shall be in online mode

5. Learner can earn additional credits by enrolling to skill courses offered in summer. College shall explore feasibility to offer NSDC aligned skill based courses to the learners

6. Technical support team for registration of Academic Bank of Credits (ABC), registration of elective/optional courses, registration of online courses, registration for degree options etc. under supervision of Dean Academics.

Salient Features of Curriculum:

✓ Framed as per Government Resolution dated 4th July 2023 in line with National Education Policy (NEP) 2020.

✓ Minimum 172 choice-based credit structure with options of Degrees earning additional credits

✓ Unique 'H-Tree' Model of Curriculum: Hybrid model for holistic development with happy learning environment having bridge connecting verticals providing unique path for each learner for 3-dimensional growth, Life Long Learning, bridge courses, inclusive model indicating equal distribution of central resources

✓ More emphasis on laboratory based and experiential learning

✓ More weightage to continuous assessment to reduce examination stress

✓ Mandatory Semester-long internship, courses with emotional & spiritual learning and skill-based learning aligned with NSDC framework

✓ Well balanced curriculum to attain Program Outcomes and skills of 21st century learner

✓ Curriculum is designed to create excitement among learners for education through stories, activities, collaboration, hackathon, contest, case studies, creative art etc.

Curriculum is designed to make graduates responsible citizens of country with future ready skills to handle challenges of 21st Century

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SEMESTERWISE CURRICULUM STRUCTURE

THIRD YEAR Computer Engineering Program:

SEM-V													
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks (1 Credit=50 Marks)					Credits		
						ISE1	MSE	ISE2	ESE	Total	Points	Total	
25PCC13CE11	PCPEC	PCC	Computer Network	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PCC13CE12	PCPEC	PCC	Theory of Computer Science and Compiler Construction	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PCC13CE13	PCPEC	PCC	Operating System with System Programming	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PCC13CE14	PCPEC	PCC	Data Warehousing and Mining	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PEC13CE1X	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PECL13CE1X	PCPEC	PEC	Program Elective Lab	PR	2	20	-	30	-	50	1	1	
25MDM4X	MDC	MDM	1. Health, Wellness and Psychology 2. Emotional and Spiritual Intelligence	TH	2	50	-	50	-	100	2	2	
25OE04X	MDC	OE	Open Elective-4	TH	1	10	15	10	15	50	1	2	
				PR	2	20	-	30	-	50	1		
HXXXC501	HMM/DM	HMM/DM	Honors/Minor Degree Course	TH	4	20	30	20	30	100	4	4*	
Total					TH:TU:PR 13:0:14=27			-	-	1000	-	20	

* Introduced as Optional Honors/Minor Degree Courses

SEM-VI													
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks (1 Credit=50 Marks)					Credits		
						ISE1	MSE	ISE2	ESE	Total	Points	Total	
25PCC13CE15	PCPEC	PCC	Distributed Computing	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PCC13CE16	PCPEC	PCC	Software Engineering	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PCC13CE17	PCPEC	PCC	Artificial Intelligence Lab	PR	2	20	-	30	-	50	1	1	
25PCC13CE18	PCPEC	PCC	Mini Project	PRJ	2	20	-	30	-	50	1	1	
25VSE13CE04	SC	VSEC	Cloud Computing Lab	PR	4	50	-	50	-	100	2	2	
25PCC13CE19	PCPEC	PCC	Cryptography and System Security	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PEC13CE2X	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	30	100	2	3	
				PR	2	20	-	30	-	50	1		
25PECL13CE2X	PCPEC	PEC	Program Elective Lab	PR	2	20	-	30	-	50	1	1	
25PCC13CE20	PCPEC	PCC	Competitive coding	PR	2	20	-	30	-	50	1	1	
25MDM05	MDC	MDM	Public Relations and Corporate Communication	TH	2	50	-	50	-	100	2	2	
HXXXC601	HMM/DM	HMM/DM	Honors/Minor Degree Course	TH	4	20	30	20	30	100	4	4*	
Total					TH:TU:PR 10:0:20=30			-	-	1000	-	20	

* Introduced as Optional Honors/Minor Degree Courses

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Structure of Credits to be completed in Final Year (SEM-VII and/or SEM-VIII):

Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks (1 Credit=50 Marks)					Credits	
						ISE1	MSE	ISE2	ESE	Total	Points	Total
	PCPEC	PEC	Program Elective		Online	As Per SWAYAM					12	12
MDM06	MDC	MDM	MDM		Online	As Per SWAYAM					4	4
RMC14CE01	EL	RM	Essentials of Research Methodology		Online	As Per SWAYAM					2	2
RMC14CE02	EL	RM	Intellectual Property Rights		Online	As Per SWAYAM					2	2
PRJ14CE01	EL	PR	Major Project	PR	12	100	-	100	-	200	6	6
	PCPEC	PEC	Course Seminar		Online	As per Rubrics for Seminar					2	2
INT14CE01	EL	INT	Semester long Internship	PR	36-40 hrs	As Per Internship Manual					12	12
HXXXCXXX	HMM/DM	HMM/DM	Honors/Minor Degree Course	TH	Online	As Per SWAYAM					8	8*
HXXXCXXX	HMM/DM	HMM/DM	Honors/Minor Degree Lab (Project)	PR							2	2*
			Total								40	40+*10

@MDM should be **Non-technical** courses e.g. Principles of Management

Project or Internship is mutually exclusive in SEM-VII or SEM-VIII

Remaining credits can be acquired in SEM-V to SEM-VIII

Online course 1 Credit=4 Week course from SWAYAM can be taken in SEM V or SEM VIII

Online min 8 week course from SWAYAM can be taken in SEM V to SEM VIII to complete 2 credit course (Combination of two 4-week credit courses shall be allowed with prior approval)

* Online min 12 week course from SWAYAM can be taken in SEM V to SEM VIII to complete 3 credit course

List of Program Elective Courses:

Track	Sem. V-PCE1 (Th+Pr) Credits 3	Sem.VI-PCE2 (Th+Pr) Credits 3
Block chain	25PEC13CE11: Block chain Technology	25PEC13CE21: Decentralized finance
AIML	25PEC13CE12: Deep Learning and Reinforcement Learning	25PEC13CE22: LLM and GenAI
Security	25PEC13CE13: Cyber Security	25PEC13CE23: Digital Forensic
Data science	25PEC13CE14: Big data analytics	25PEC13CE24: Business Intelligence
ARVR	25PEC13CE15: Computer Graphics	25PEC13CE25: ARVR
UI	25PEC13CE16: HMI	25PEC13CE26: UX/UI Design
Computing	25PEC13CE17: Geographical Information Systems	25PEC13CE27: Quantum Computing

Sem. V- PECL1: (Lab) Credits 1	Sem.VI- PECL2: (Lab) Credits 1
25PECL13CE11: Image processing Lab	25PECL13CE21: Social Media Analytics Lab
25PECL13CE12: Natural Language Processing Lab	25PECL13CE22: Ethical Hacking Lab
25PECL13CE13: IIOT lab	25PECL13CE23: DevOps Lab
25PECL13CE14: Innovative Product Development Lab-Phase1 (Start-up)	25PECL13CE24: Innovative Product Development Lab-Phase2 (Start-up)
25PECL13CE15: Open-Source Intelligence and Threat Intelligence lab	25PECL13CE25: Explainable AI Lab
--	25PECL13CE26- Software Testing and Quality Assurance Lab

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Open Electives offered to CE students:

SEM-V Any one: Advanced Microprocessor OR Internet of Things OR E-Vehicle
OR Supply Chain Management OR Design of Experiments OR 3D Printing

Honor Degree Offered to Computer Engineering Students from SEM-V to SEM-VIII:

A. Name: **Internet of Things**
1. SEM-V: HIoTC501: IoT Sensor Technologies
2. SEM VI: HIoTC601: IoT System Design
3. SEM VII: HIoTC701: Dynamic Paradigm in IoT
4. SEM VII: HIoTSBL701: Interfacing & Programming with IoT Lab (SBL)
5. SEM VIII: HIoTC801: Industrial IoT

B. Name: **Artificial Intelligence and Machine Learning**
1. SEM-V: HAIMLC501: Mathematics for AI & ML
2. SEM VI: HAIMLC601: Game Theory using AI & ML
3. SEM VII: HAIMLC701: AI & ML in Healthcare
4. SEM VII: HAIMLSBL701: AI & ML in Healthcare: Lab
5. SEM VIII: HAIMLC801: Text, Web and Social Media Analytics

C. Name: **Data Science**
1. SEM-V: HDSC501: Mathematics for Data Science
2. SEM VI: HDSC601: Statistical Learning for Data Science
3. SEM VII: HDSC701: Data Science for Health and Social Care
4. SEM VII: HDSSBL701: Data Science for Health and Social Care Lab
5. SEM VIII: HDSC801: Text, Web and Social Media Analytics

D. Name: **Blockchain**
1. SEM-V: HBCC501: Bit coin and Crypto currency
2. SEM VI: HBCC601: Blockchain Platform
3. SEM VII: HBCC701: Blockchain Development
4. SEM VII: HBCSBL701: Private Blockchain Setup Lab (SBL)
5. SEM VIII: HBCC801: DeFi (Decentralized Finance)

D. Name: **Cyber Security**
1. SEM-V: HCSC501: Ethical Hacking
2. SEM VI: HCSC601: Digital Forensic
3. SEM VII: HCSC701: Security Information Management
4. SEM VII: HCSSBL701: Vulnerability Assessment Penetration Testing (VAPT) Lab
5. SEM VIII: HCSC801: Application Security

Minor Degree Offered to Computer Engineering Students from SEM-V to SEM-VIII:
A. Name: **Robotics**
1. SEM-V: HRC501: Industrial Robotics
2. SEM VI: HRC601: Mechatronics & IoT
3. SEM VII: HRC701: Artificial Intelligence & Data Analysis
4. SEM VII: HRSBL701: Robotics and Automation Lab
5. SEM VIII: HRC801: Autonomous Vehicle Systems

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B. **Name: 3D Printing**

1. SEM-V: HC3DP501: Introduction to CAD
2. SEM VI: HC3DP601: 3D Printing: Introduction & Processes
3. SEM VII: HC3DP701: Applications of 3D Printing
4. SEM VII: H3DPSBL801: Skill Based Lab– Digital Fabrication
5. SEM VIII: HC3DP801: 3D Printing in Medical Technology

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Comparison of Credit Distribution for Four Year UG Program for Fr CRCE and GR:

UG: Computer Engineering

SEM	BSESC		PCPEC		MDC		SC	HSSM				EL				LLC	BC	Total Credits
	BSC	ESC	PCC	PEC	MDM	OE	VSEC	AEC	EEMC	IKS	VEC	RM	CEFP	PRJ	INT	CC	BC	
I	9	9															--	18
II	9	8						3									--	20
III	3		6		2	4			2		2		2			1	4	22+4
IV	3		7		2	2	2	2	2		2					1	5	23+5
V			12	4	2	2												20
VI			12	4	2		2											20
VII & VIII				14	4							4		6	12		--	40
Total Credits as per Fr CRCE	24	17	37	22	12	8	4	5	4		4	4	2	6	12	2	9	163+9 =172
Total Credits as per GR	14	12	44	20	14	8	8	4	4	2	4	4	2	4	12	4	--	160

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PCC13CE11	**Computer Networks**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		PCC12CE09
Course Outcomes	CO1	Interpret the basic network structure and analyze utilization of communication devices.
	CO2	Illustrate the impact of transmission media, multiplexing techniques and switching techniques in computer network.
	CO3	Use various functionalities of MAC & LLC sublayer.
	CO4	Classify Functionalities of static & dynamic routing protocol.
	CO5	Analyze Transport layer protocols and its impact on quality of service.
	CO6	Design network architecture using various network protocol in real time environment.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Computer Networks** Definition of a Computer Network; Components of a computer network: Classification of networks, network types, Network topologies, networking devices (Hub, Switch, Routers, Firewall, Gateway, NIC, Repeater).	1,2, 3	3
	1.2	Basic Communication System, Switching Techniques, Multiplexing.		
	1.3	OSI Reference Model,Introduction to TCP/IP Protocol Suite, Comparison between OSI & TCP/IP Protocol Suite.		
2	2.1	**Data Link Layer** Introduction To Data Link Layer, Error Detection and Correction (Hamming Code, CRC, Checksum).	1,2	6
	2.2	Elementary Data Link Protocol, Sliding Window Protocol, MAC & LLC Sublayers.		
	2.3	Channel Allocation, Multiple Access Protocol: Aloha, CSMA/CD, Collision Free Protocol, Ethernet Protocols, ARP, RARP, 802.X		
3	3.1	**Network Layer** Introduction to Network Layer, Design issues of Network layer.	1,2	7
	3.2	Addressing: Physical Address, Logical Address, Port Address, And Application Specific Address. Introduction to Interface & Services, Introduction to IPV4 Address: Classful Address, Classless Addressing, Special Address, NAT: Address Translation & translation table.		

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	3.3	Routing Algorithm: Shortest Path Routing, Dijkstra Algorithm, Flooding, Link State Routing, Count to Infinity problem, Congestion Control Algorithm, Quality of Services: Leaky Bucket Algorithm, Token Bucket Algorithm.		
4	4.1	**Transport Layer** Introduction of Transport layer Services: Relationship between transport layer & network layer, Multiplexing & Demultiplexing, Connectionless Transport.	1,2	5
	4.2	Transport layer protocol: Go-Back-N, Selective Repeat Protocol, Piggybacking.		
	4.3	Connection-Oriented Transport, Principal of congestion control, TCP congestion control.		
5	5.1	**Application Layer** Introduction of Application layer, principal of network application	1,2, 3,4	5
	5.2	Web & HTTP, FTP, SMTP, DHCP, DNS: The internet Directory Services		
	5.3	Peer to Peer Application, Socket programming with UDP & TCP		
			Total	**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	1	Case Study-Classify various types of cabling used in networking	1,2	2
	2	Illustrate various networking devices using Packet Tracer	1,2	
				2
2	3	Use CRC/ Hamming code for error detection and correction	1,2	
	4	Analyze various Networking Operations and Troubleshooting using command.	1,2, 4	2
3	5	Use IP addressing, Subnet and Subnet Mask for given problem statement	1,2, 3	2
	6	Create a local area network using Static & Dynamic Routing Protocols in network infrastructure.	1,2, 4	2
4	7	Illustrate Socket programming using TCP and Remote Login using Telnet/SSH	1,2, 3	4
	8	Illustrate VLAN in network infrastructure	1,2, 4	2
5	9	Build DHCP Functionality in network infrastructure	1,2, 4	4
	10	Perform Remote login using Telnet server	1,2, 4	2
		Mini project-Build Network Architecture for a given problem Statement.		4
			Total	**26**

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Course Assessment:

Theory:

> **ISE-1:**
> Activity: Quiz and assignments 20 Marks
> **ISE-2:** Two hours 20 Marks
> Activity: Article Discussion, Quiz and Assignments
> Outcome: Reflective Journal
>
> **MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
> **ESE:** 90 minutes 30 Marks written examination based on remaining 50% syllabus after MSE.

Lab:

> **ISE:**
> **1. ISE-1** will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
> **2. ISE-2**
> a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
> b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:

[1] A.S. Tanenbaum, "Computer Networks", Pearson Education, 5th Edition.
[2] B.A. Forouzan, "Data Communications and Networking", 5th edition, McGraw Hill
[3] James F. Kurose, Keith W. Ross, "Computer Networking, A Top-Down Approach Featuring the Internet", 6th edition, Addison Wesley
[4] B.A. Forouzan, "TCP/IP Protocol Suite", 4th edition, McGraw Hill

Online Resources:

1. NPTEL, https://nptel.ac.in/courses/106105081/
2. Stanford University, https://lagunita.stanford.edu/courses/Engineering/Networking-SP/SelfPaced/about
3. www.tutorialpoint.com, https://www.tutorialspoint.com/computer_fundamentals/computer_networking

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PCC13CE12	**Theory of Computer Science and Compiler Construction**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		PCC12CE06, BSC12CE05
Course Outcomes	CO1	Design Finite state machines for recognizing the given formal language.
	CO2	Construct regular expressions to express regular language.
	CO3	Design Pushdown Automata and Turing Machine for recognizing language.
	CO4	Explore knowledge of the key stages of the compilation process
	CO5	Develop a foundation in parsing algorithms, including top-down and bottom-up methods
	CO6	Apply optimization techniques to generate efficient intermediate and target code for basic programming constructs.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**1.1**	Finite Automata and Regular Expression: Importance of TCS, Alphabets, Strings, Languages, Closure properties,	5, 7	1
	1.2	Finite Automata, NFA with ϵ-transitions, NFA to DFA Conversion, Finite Automata with output (Moore and Mealy Machine)	5, 7	4
	1.3	Regular languages and regular expressions, Equivalence of RE and FA	5, 6	1
2	**2.1**	Context Free Grammar and PushDown Automata: Chomsky's hierarchy of languages, Derivations and Parse trees, Ambiguity in grammars, Simplification of grammar. Normal forms for CFG – Simplification of CFG- Chomsky Normal Form (CNF) and Greibach Normal Form (GNF)	5, 6	2
	2.2	Push Down Automata (PDA): The formal definition of pushdown automata, A graphical notation for PDA's, Instantaneous descriptions of a PDA, Design of PDA.	5, 6	3
3	**3.1**	Turing Machine : Formal definition and representation, Instantaneous Description, Design of TM	7, 8	1
	3.2	Halting Problem, Post Correspondence Problem (PCP)	8, 8	1
4	**4.1**	Introduction to Compilers	1	1
	4.2	Role of a compiler in programming languages. Overview of compilation phases: lexical analysis, syntax analysis, semantic analysis, optimization, code generation, and code optimization.	3,4	
	4.3	Compiler vs. Interpreter.	3,4	

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		Real-world examples of compilers.			
5	5.1	Lexical Analysis- Role of Finite State Automata in Lexical Analysis, Design of Lexical analyzer, data structures used.	1,4	1	
	5.2	Syntax Analysis- Role of Context Free Grammar in Syntax analysis, Types of Parsers: Top down parser- LL(1), Bottom up parser- SR Parser, Operator precedence parser, SLR.	1,4	7	
	5.3	Semantic Analysis, Syntax directed definitions	1,4	1	
6	6.1	Intermediate Code Generation: Types of Intermediate codes: Syntax tree, Postfix notation, three address codes: Triples, Quadruples, indirect triple.	1,4	1	
	6.2	Code Optimization: Need and sources of optimization, Code optimization techniques: Machine Dependent and Machine Independent.	1,4	1	
	6.3	Code Generation: Issues in the design of code generator, code generation algorithm. Basic block and flow graph	1,4	1	
Total					**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	1	Design DFA accepting the given language.		2
	2	Design Finite Automata with output (Moore and Mealy Machine), NFA to DFA conversion practice problems.		4
2	3	RE and FA		2
	4	Practice problems on Simplification of Grammar, CFG to CNF, CFG to GNF		2
3	5	Design/ Construct PDA accepting given language.		2
	6	Design a Turing machine to accept the given language.		2
4	7	a) Write Lex programs to recognize tokens such as keywords, identifiers, numbers, and operators from source code. b) Implement a lexical analyzer to identify patterns like valid email addresses or specific keywords in a given text.	1,2	4
5	8	Develop a recursive descent parser for a simple grammar (e.g., arithmetic expressions).	2,4	2
		Use Yacc to create a bottom-up parser for a grammar and simulate parsing using a sample input.	1,2	2
6	9	Generate assembly code for a given set of TAC instructions, targeting a hypothetical CPU.	2,4	2
	10	Implement a simple register allocation algorithm for TAC instructions.	2,4	2
Total				**26**

Course Assessment:
Theory:
ISE-1:
Activity: Tutorial, Quiz and assignments 20 Marks
ISE-2:
Activity: Tutorials, Quiz and Assignments 20 Marks

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MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks (remaining 50% syllabus) written examination

Lab:
ISE:
1. ISE-1 will be conducted for Tutorials on TCS. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks

Recommended Books:
[1] V. Aho, R. Shethi, Monica Lam, J.D. Ulman: Compilers Principles, Techniques and Tools, Pearson Education, Second Edition.
[2] John R. Levine, Tony Mason & Doug Brown, Lex & YACC, O 'Reilly publication, second Edition
[3] D, M. Dhamdhere, Compiler construction 2e, Macmillan publication, second edition.
[4] Kenneth C. Louden, Compiler construction: principles and practices, Cengage Learning
[5] John E. Hopcroft, Rajeev Motwani, Jeffery D. Ullman, "Introduction to Automata
[6] Michael Sipser, "Theory of Computation", 3rd Edition, Cengage learning. 2013
[7] Vivek Kulkarni, "Theory of Computation", Illustrated Edition, Oxford University Press, (12 April 2013) India
[8] J. C. Martin, "Introduction to Languages and the Theory of Computation", 4th Edition, Tata McGraw Hill Publication, 2013.
Online Resources:
1. http://www.nptelvideos.in/2012/11/compiler-design.html
2. https://www.coursera.org/lecture/nand2tetris2/unit-4-1-syntax-analysis-5pC2Z
3. https://nptel.ac.in/courses/106104028
4. https://nptel.ac.in/courses/106104148

Further Reading:
1. Leland L. Beck, System software: An introduction to system programming, Pearson publication, Third Edition
2. 1. D. M Dhamdhere: Systems programming and Operating Systems, Tata McGraw Hill, Revised Second Edition
3. J. J. Donovan: Systems Programming Tata McGraw Hill, Edition 1991
4. Harry R. Lewis, Christos H. Papadimitriou, Elements of the Theory of Computation, Second Edition, Pearson 2015

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PCC13CE13	**Operating System with System Programming**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		PCC12CE06, PCC12CE05
Course Outcomes	CO1	Comprehend system programming concepts to develop OS-level applications.
	CO2	Understand the architecture and functioning of operating systems.
	CO3	Apply concurrency and synchronization techniques in software development.
	CO4	Implement algorithms for memory management, and file systems.
	CO5	Analyze advanced operating system architectures and functionalities through case studies of modern systems

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to System Programming:**	1,2,3	5
	1.1	System Programs: Assemblers, linkers, loaders, and compilers		
	1.2	Assembler: Basics of assembly language, Forward Reference Problem. Two-pass assembler		
	1.3	Macro Processors- Macro definition, call, and expansion. Loaders and Linkers- Types.		
2		**Overview of Operating Systems:**	4,5,6,7	4
	2.1	Role, functions, and evolution of operating systems,Types of OS.		
	2.2	OS Architecture, Components of an OS- Kernel, Shell, and File System.		
	2.3	Processes- Definition, lifecycle, and Process Control Block (PCB),Threads vs. Processes		
3		**Process and Thread Management:**	4,5,6,7	5
	3.1	CPU Scheduling- Goals, criteria, and types of scheduling, Scheduling algorithms		
	3.2	Process Synchronization- Critical sections and race conditions, Semaphores, Monitors, and Mutexes.		
	3.3	Deadlock Handling, IPC Mechanism.		
4		**Memory Management**	4,5,6,7	4
	4.1	Contiguous and Non-Contiguous Allocation		
	4.2	Paging and Segmentation, Page replacement algorithms		

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	4.3	Virtual Memory Memory Allocation Techniques-Fixed, Variable Partitioning, and Buddy System.		
5		**File Systems and I/O Management**	4,5,6,7	5
	5.1	File Systems - File attributes, directory structures, and access methods		
	5.2	File allocation techniques: Contiguous, Linked, and Indexed		
	5.3	Disk Scheduling- FCFS, SSTF, SCAN, C-SCAN.		
	5.4	I/O Management-Device drivers, interrupts, and buffering.		
6		**Advances in Modern Operating Systems**	8,9,10,11,12	3
	6.1	Case Studies- Cloud and Mobile OS, Real-Time and Edge OS		
	6.2	AI and Quantum Computing OS,Modern Linux-Based Systems, Experimental OS		
		Total		**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
3	1	Implement basic scheduling algorithms	4,5,6,7	2
3	2	Simulate producer-consumer synchronization.	4,5,6,7	2
3	3	Simulate a system with processes and resources to detect and resolve deadlocks using a resource allocation graph.	4,5,6,7	2
4	4	Write a program to simulate page replacement algorithms	4,5,6,7	2
4	5	Write a program to simulate memory allocation techniques.	4,5,6,7	2
5	6	Simulate file allocation techniques	4,5,6,7	2
5	7	Implement disk scheduling algorithms.	4,5,6,7	2
5	8	Implement buffering techniques for a simulated I/O device to manage data streams efficiently.	4,5,6,7	2
6	9	Analyze Linux kernel logs for specific events (e.g., scheduling, I/O operations) using tools like dmesg or syslog.	12	2
6	10	Explore OS vulnerabilities using a controlled virtual environment. Analyze patching or mitigation strategies.	8.9.,10,11,12	2
6	11	Simulator based experiments (EduMIPS64, GAIL (General Algorithm Interactive Learning) , NS3 etc)	13	2
		Total		**26**

Course Assessment:
Theory:
  ISE-1:
  Activity: Quiz and assignments 20 Marks

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ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks (remaining 50% syllabus) written examination

Lab:

ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:
1. A. V. Aho, R. Shethi, Monica Lam, J.D. Ulman: Compilers Principles, Techniques and Tools, Pearson Education, Second Edition.
2. D, M. Dhamdhere, Compiler construction 2e, Macmillan publication, second edition.
3. Kenneth C. Louden, Compiler construction: principles and practices, Cengage Learning
4. Silberschatz A., Galvin P., Gagne G. "Operating Systems Principles", Willey Eight edition
5. Achyut S. Godbole , Atul Kahate "Operating Systems" McGraw Hill Third Edition
6. "Operating System-Internal & Design Principles", William Stallings, Pearson
7. Andrew S. Tanenbaum, "Modern Operating System", Prentice Hall.
8. "Cloud Computing: Concepts, Technology & Architecture" by Thomas Erl, Ricardo Puttini, and Zaigham Mahmood
9. "Mobile Operating Systems: Concepts and Practices" by Dr. R. Latha and S. Pavithra
10. "Embedded and Real-Time Operating Systems" by K.C. Wang
11. "Quantum Computing: A Gentle Introduction" by Eleanor Rieffel and Wolfgang Polak
12. "Linux Kernel Development" by Robert Love
13. Official Website of GAIL on GitHub,NS-3 Official Website,EduMIPS64 Official Website

Online Resources:
1. 1.http://www.nptelvideos.in/2012/11/compiler-design.html
2. https://www.coursera.org/lecture/nand2tetris2/unit-4-1-syntax-analysis-5pC2Z
3. **https://onlinecourses.nptel.ac.in/noc21_cs72/preview**
4. **https://www.scaler.com/topics/course/free-operating-system-course/**

Further Reading:
1. Leland L. Beck, System software: An introduction to system programming, Pearson publication, Third Edition
2. 1. D. M Dhamdhere: Systems programming and Operating Systems, Tata McGraw Hill, Revised Second Edition
3. J. J. Donovan: Systems Programming Tata McGraw Hill, Edition 1991

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PCC13CE14	**Data Warehousing and Mining**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	PCC12CE08	
Course Outcomes	CO1	Explain the need of Data warehouse and Mining Principles
	CO2	Design a Data-warehouse using Dimension Modelling and apply OLAP operations
	CO3	Select appropriate Data Pre-processing Technique and apply appropriate Data Mining Algorithm to the given Real World Problem.
	CO4	Compare and Evaluate the different Data Mining techniques like Regression, classification, Clustering and Association Rule Mining.
	CO5	Explain the concepts of Web Mining

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Data Warehousing Fundamentals**	1,2`	4
	1.1	Introduction to Data Warehouse, Data warehouse architecture, Data warehouse versus Data Marts		
	1.2	E-R Modeling versus Dimensional Modeling,		
	1.3	Information Package Diagram, Data Warehouse Schemas; Star Schema, Snowflake Schema, Factless Fact Table, Fact Constellation Schema. Update to the dimension tables		
	1.4	Major steps in ETL process, OLTP versus OLAP, OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot.		
2		**Introduction to Data Mining, Data Exploration and Data Pre-processing**	1,2	5
	2.1	Data Mining Task Primitives, Architecture, KDD process, Issues in Data Mining, Applications of Data Mining.		
	2.2	Data Exploration: Types of Attributes, Statistical Description of Data, Data Visualization		
	2.3	Data Preprocessing: Descriptive data summarization, Cleaning, Integration & transformation, Data reduction, Data Discretization and Concept hierarchy generation.		
3		**Classification**	1,2	5
	3.1	Basic Concepts of Classification		
	3.2	Decision Tree Induction		
	3.3	Naïve Bayesian Classification		

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	3.4	Accuracy and Error measures, Evaluating the Accuracy of a Classifier: Holdout & Random Subsampling, Cross Validation, Bootstrap.		
4		**Clustering**	1,2	4
	4.1	Types of data in Cluster		
	4.2	Partitioning Methods (*k*-Means, *k*- Medoids),		
	4.3	Hierarchical Methods (Agglomerative, Divisive).		
5		**Mining frequent patterns and associations**	1,2	4
	5.1	Market Basket Analysis, Frequent Item sets, Closed Item sets, and Association Rule, Frequent Pattern Mining, Apriori Algorithm		
	5.2	Association Rule Generation, Improving the Efficiency of Apriori, Mining Frequent Itemsets without candidate generation.		
	5.3	Introduction to Mining Multilevel Association Rules and Mining Multidimensional Association Rules.		
6		**Web Mining**	1,2,3	4
	6.1	Introduction, Web Content Mining: Crawlers, Harvest System		
	6.2	Virtual Web View, Personalization		
	6.3	Web Structure Mining: Page Rank, Clever, Web Usage Mining		
Total				26

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	1	One case study on building Data warehouse/Data Mart Write Detailed Problem statement and design dimensional modelling (creation of star and snowflake schema)	1,2	2
	2	Implementation of all dimension table and fact table based on experiment 1 case study	1,2	2
	3	Implementation of OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot based on experiment 1 case study	1,2	2
2	4	Implementation of Data Discretization (any one) & Visualization (any one)	1,2	2
	5	Perform data Pre-processing task and demonstrate Classification, Clustering, Association algorithm on data sets using data mining tool (WEKA/R tool)	1,2	4
3	6	Implementation of Bayesian algorithm	1,2	2
4	7	Implementation of Clustering algorithm (K-means/K-medoids)	1,2	2
	8	Implementation of any one Hierarchical Clustering method	1,2	2
5	9	Implementation of Association Rule Mining algorithm (Apriori)	1,2	2
6	10	Implementation of Page rank/HITS algorithm	1,2,3	2
	11	Implementation of Text Mining	1,2,3	2
		Mini Project		4
Total				**26**

Course Assessment:
> **Theory:**
> **ISE-1:**
Activity: Quiz and assignments 20 Marks

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ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal

MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks (remaining 50% syllabus) written examination

Lab:
ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:
1. Paulraj Ponniah, "Data Warehousing: Fundamentals for IT Professionals", Wiley India.
2. Han, Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann 2nd edition.
3. M.H. Dunham, "Data Mining Introductory and Advanced Topics", Pearson Education.
4. Reema Theraja, "Data warehousing", Oxford University Press 2009.
5. Pang-Ning Tan, Michael Steinbach and Vipin Kumar, "Introduction to Data Mining", Pearson Publisher 2nd edition.
6. Ian H. Witten, Eibe Frank and Mark A. Hall, "Data Mining", Morgan Kaufmann 3rd edition.

Useful Links
1. https://onlinecourses.nptel.ac.in/noc20_cs12/preview
2. https://www.coursera.org/specializations/data-mining

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Course Code	Course Name		Teaching Scheme (Hrs/week)				Credits Assigned			
			L	T	P		L	T	P	Total
			2	--	2		2	--	1	3
25PEC13CE11	**Blockchain Technology**		**Examination Scheme**							
			ISE1	MSE	ISE2	ESE		Total		
		TH	20	30	20	30		100		
		PR	20	--	30	--		50		

Pre-requisite Course Codes		25PCC13CE19	
Course Outcomes	CO1	Explain Blockchain concepts in the context of distributed ledger.	
	CO2	Associate concepts of cryptocurrencies, consensus algorithms and mining with security of blockchain.	
	CO3	Explain basic working principles of Ethereum.	
	CO4	Apply the concepts of smart contact using Solidity programming for a given application.	
	CO5	Explore Hyperledger Fabric and its working as a private blockchain.	
	CO6	Demonstrate the components of blockchain and the processes used in blockchain for a given problem as well as in real world applications.	

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction to Blockchain Technology:** What is a blockchain, Origin of blockchain, Foundation of blockchain: Genesis block, Merkle trees, limitations and applications of blockchain	1,3	3
	1.2	Components of blockchain, Block in blockchain, Types of blockchain: Public, Private, and Consortium, Consensus protocols: Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-Stake (PoS), and Proof-of-Elapsed Time (PoET), mining in blockchain, Mining pool and its methods	1,3	4
2	2.1	**Cryptocurrency:** Bitcoin, Altcoin, and Tokens (Utility and Security), Transactions in Blockchain, UTXO and double spending problem	1,3	03
	2.2	Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Mist Wallet, Ethereum frameworks	1,2	03

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3	3.1	**Programming for Blockchain:** Introduction to Smart Contracts, Types of Smart Contracts, Limitations of Smart Contracts	1	1
	3.2	Introduction to Programming: Solidity Programming – Basics, functions, Visibility and Activity Qualifiers, Address and Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Struct, Mapping, Inheritance, Error handling, events, If-Then-Else, For loop	**Useful Link 5**	4
4		Need of Private Blockchain, Consensus Algorithms for Private Blockchain - PAXOS, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT	**1, Ref.3**	4
5		Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric Hyperledger Fabric Architecture, Components of Hyperledger Fabric, Transaction Flow, application for supply chain management	**1, Ref.3**	4
			Total	**26**

Suggested list of experiments: (Minimum 10)

Sr. no.	Suggested Experiments	Hrs.
1	Construction of Merkle tree and verification of transaction	2
2	MetaMask installation and transfer of ethers	2
3	Solidity program: voting application	2
4	Solidity program: crowd funding	2
5	Solidity program: Transactions using Remix IDE and MetaMask	2
6	Implementation of PAXOS/pBFT algorithm	2
7	Block mining and reward transfer to the account	2
8	Smart contract execution using Ganache	2
9	Genesis block creation using Geth	2
10	Hyperledger installation	2
11	Presentation on research papers	2

Recommended Books:

1. Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.
2. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
3. Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing.
4. Blockchain for Beginners, Yathish R and Tejaswini N, SPD
5. Blockchain Basics, A non-Technical Introduction in 25 Steps, Daniel Drescher, Apress
6. Blockchain with Hyperledger Fabric, Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

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Useful Links:
1. https://www.blockchain.com/explorer/assets/btc
2. https://etherscan.io/
3. https://bitcoin.org/bitcoin.pdf
4. https://ethereum.org/en/whitepaper/
5. https://docs.soliditylang.org/

Course Assessment:

Theory:

ISE-1:

Activity: Quiz/Assignments 20 Marks

ISE-2: Two hours 20 Marks

Activity: Article Discussion/Quiz/Assignments/Seminar

MSE: 90 minutes 30 Marks written examination based on 50% syllabus

ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE

Practical: (10 Nos.)

 ISE1: 20 marks based on first four practical as per the predefined rubrics

 ISE2: 30 marks Mini Project development and presentations

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	–	1	3
25PEC13CE12	**Deep Learning Reinforcement Learning**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	–	30	–	50	

Pre-requisite Course Codes		VSE11CE02, PCC12CE09, BSC12CE06
Course Outcomes	CO1	Comprehend the concepts of Neural Network
	CO2	Apply deep neural network concepts to train and optimize multi-layered feedforward neural networks.
	CO3	Apply convolutional neural network (CNN) concepts, to implement variants of convolution functions, and utilize autoencoders for feature extraction and data reconstruction.
	CO4	Analyze the sequence learning problems and apply recurrent neural network architectures to address complex sequential data tasks.
	CO5	Implement real-world scenarios utilizing Deep Reinforcement Learning techniques.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Neural Networks:** Biological neuron, Mc-Culloch Pitts Neuron, Perceptron, Perceptron Learning, Delta learning, Multilayer Perceptron: Linearly separable, linearly non-separable classes	1	2
2	2.1	**Deep Neural Networks**: Training Feedforward DNN, Multi Layered Feed Forward Neural Network, Hyper Parameter Tuning, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Selection of output function and loss function	2	3
	2.2	Optimization Techniques in Backpropagation: Gradient Descent (GD), Stochastic Gradient Descent (SGD), Mini-Batch Gradient Descent, Momentum-Based Gradient Descent, Nesterov Accelerated Gradient Descent (NAG), AdaGrad, RMSProp, and Adam	2	3
	2.3	Regularization: Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output	2	2
3	3.1	**Convolution Neural Network:** Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer,	3,4	4

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		Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function,		
	3.2	Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders, Vision Autoencoders	3,4	2
4	**4.1**	**Recurrent Neural Network and GAN:** Sequence Learning Problem, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Long Short Term Memory, Gated Recurrent Unit	5	3
	4.2	Introduction to Generative Adversarial Networks: Definition and Concept, Motivation, Architecture Overview, Applications	2,5	2
	4.3	Introduction to Attention Mechanisms, Introduction to Attention Mechanisms, Applications of Attention and Transformers	5	2
5	**5.1**	**Reinforcement Learning:** Basics of Reinforcement Learning (RL), Markov Decision, Processes (MDPs), Policy and Value Function Approximation Q-Learning and Deep Q-Networks (DQN)	6,7	3
	5.2	Applications: Game AI, Robotics, and Autonomous Systems	6,7	1
Total				**26**

Module No.	Sr.no	Suggested List of Experiments	Ref.	Hrs.
1	1	Implement a single-layer perceptron for linearly separable classification. Train a Multi-Layer Perceptron (MLP) to solve the XOR classification problem.	1	2
2	2	Experiment with ReLU, Sigmoid, and Tanh activation functions and analyze their impact on training speed and accuracy. Compare different learning rates.	2	1
	3	Implement and compare Gradient Descent (GD), Stochastic GD (SGD), and Adam Optimizer for a classification task.	2	2
3	4	(Perform any two) Build a CNN for classifying MNIST or CIFAR-10 datasets. Analyze the effect of kernel size, stride, and padding. Apply data augmentation techniques (rotation, flipping, zooming) to improve CNN performance.	3,4	4
4	5	(Perform any one) Implement a basic RNN for sequence prediction (e.g., sine wave prediction, text generation). Implement an LSTM for sentiment analysis on IMDB reviews.	5	4
	6	Implement an Autoencoder to compress and reconstruct images (e.g., MNIST dataset). Design a Basic GAN to generate images (e.g., handwritten digits using MNIST).	2,5	4
	7	Implement a Transformer Model for text classification or translation. Experiment with BERT or GPT for text summarization tasks.	5	4
5	8	Implement a Reinforcement Learning Agent using Q-learning or Deep Q-Networks (DQN) in a basic environment (e.g., OpenAI Gym CartPole).	6,7	4
	9	Mini Project : Students are required to undertake a project based on the syllabus content, integrating the latest trends in DL/RL	Online	

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			Resouces	
Total				**26**

Course Assessment:
Theory:
ISE-1: 20 Marks
Activity: Quiz / Assignments
ISE-2: 20 Marks
Activity: Presentation / Article Discussion

MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE.

Lab:
ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:
[1] Dive into Deep Learning by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola. https://d2l.ai/chapter_introduction/index.html
[2] Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville. MIT Press 2016.
[3] Introduction to Deep Learning by Eugene Charniak. The MIT Press 2019
[4] Deep Learning with Python by Francois Chollet. 1st Edition. Manning Publications https://livebook.manning.com/book/deep-learning-with-python/part-1/
[5] Dive into Deep Learning by Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola. https://d2l.ai/chapter_introduction/index.html
[6] Reinforcement Learning: An Introduction, Richard S. Sutton and Andrew G. Barto, Second Ed. , MIT Press
[7] Foundations of Deep Reinforcement Learning: Theory and Practice in Python (Addison-Wesley Data & Analytics Series) 1st Edition by Laura Graesser and Wah Loon Keng

Online Resources:
NPTEL links:
https://www.youtube.com/playlist?list=PLEAYkSg4uSQ1r-2XrJ_GBzzS6I-f8yfRU
https://www.coursera.org/specializations/generative-adversarial-networks-gans

https://www.udacity.com/course/deep-reinforcement-learning-nanodegree--nd893

Further Reading

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Students are encouraged to explore the following online resources to deepen their understanding of
Deep Reinforcement Learning (DRL) and Transformer models:

1. **Deep Reinforcement Learning with Double Q-learning** – https://arxiv.org/abs/1509.06461
2. **Mastering the Game of Go with Deep Neural Networks and Tree Search** –
   https://github.com/tpn/pdfs/blob/master/Mastering%20the%20Game%20of%20Go%20with%20Deep%20Neural%20Networks%20and%20Tree%20Search.pdf
3. **Rainbow: Combining Improvements in Deep Reinforcement Learning** –
   https://arxiv.org/abs/1710.02298
4. **Playing Atari with Deep Reinforcement Learning** – https://arxiv.org/abs/1312.5602
5. **Mastering Atari, Go, Chess, and Shogi by Planning with a Learned Model** –
   https://arxiv.org/abs/1911.08265
6. **Multi-Armed Bandits & Gradient Bandit Algorithms** –
   https://medium.com/@numsmt2/reinforcement-learning-chapter-2-multi-armed-bandits-part-5-gradient-bandit-algorithms-1af59d4c544c
7. **Attention Is All You Need (Transformers)** – https://arxiv.org/abs/1706.03762

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PEC13CE13	**Cyber Security**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		25PCC13CE12, 25PCC13CE13, PCC12CE08
Course Outcomes	CO1	Comprehend the fundamentals of cybersecurity and cyber law.
	CO2	Explore database security requirements, threats, and security mechanisms.
	CO3	Investigate operating system vulnerabilities, security features, and hardening techniques.
	CO4	Assess network and wireless security concepts fundamentals.
	CO5	Examine web application threats and strategies for implementing secure practices.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Cybersecurity Basics and Cyber Law**		
	1.1	Introduction to Cybersecurity Cybersecurity vs. Information Security, Threat Landscape: Zero-Day Attacks, Insider Threats, Key Principles: CIA, Authentication, Non-Repudiation	1,2	1
	1.2	Categories of Cybercrime: Cybercrime Against Person/Individual, Cybercrime Against Property, Cybercrime Against Organization/Government, Cybercrime Against Society. Types of Cyber Criminals: Hackers, Hacktivists, Cyber Terrorists, Script Kiddies, Insider Threats	1,2	1
	1.3	Cyber Law in India Overview of Indian IT Act 2000 (Amended in 2008), Case Studies: Cybercrime Case Laws in India, Importance of Cyber Ethics and Privacy in Legal Context Key sections of the IT Act 2000 and its amendments in 2008 include: Section 43, Section 66, Section 66A (repealed), Section 66B, Section 66C, Section 66D, Section 67, Section 67A, Section 67B, Section 69, Section 69A, Section 70, Section 72, Section 72A.	3	3
2		**Database Security**		
	2.1	Database Security Requirements: Confidentiality, integrity, availability, authorized access, auditing, accountability.	1,2	1
	2.2	Inference Attacks on Databases: Deduction of sensitive information, aggregate query analysis, data leakage risks.	1	2

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		SQL Injection: Union-based, Boolean-based, Error-based, exploitation of input vulnerabilities.		
	2.3	Database Security Mechanisms: Role-Based Access Control (RBAC), encryption techniques, audit logging, security monitoring.	1,2	1
	2.4	Multilevel Database Security: Discretionary Access Control (DAC), Mandatory Access Control (MAC), Multilevel Secure Databases (MLSDB), database hardening.	1,2	1
3	**Operating System (OS) Security**			
	3.1	Operating System Vulnerabilities: Privilege escalation exploits, file permissions weaknesses, kernel vulnerabilities.	1,2	1
	3.2	Operating System Security Features: Patches and updates, hardening techniques, memory and address protection, file protection mechanisms, user authentication.	1,2	1
	3.3	Linux and Windows Security: Vulnerabilities, file system security.	1,2	2
4	**Network and Wireless Security**			
	4.1	Securing Networks: Virtual Private Networks (VPN), network security tools (Snort, Suricata), firewalls (stateful vs. stateless inspection).	1,2	1
	4.2	Wireless Security: Securing Wi-Fi networks (WEP, WPA, WPA2, WPA3), authentication techniques, wireless threats (packet sniffing, deauthentication attacks), Wireless Intrusion Detection System (WIDS).	1,2, 3	1
	4.3	Mobile Device Security: Security threats, device security measures, Wireless Intrusion Detection System (WIDS).	1,2	1
5	**Web Application Security**			
	5.1	Web Security Considerations: User authentication and session management, cookies, web service security.	1,2	1
	5.2	Threats to Web Applications: Advanced XSS, file inclusion vulnerabilities, clickjacking, Cross-Site Request Forgery (XSRF).	1,2	2
	5.3	Countermeasures: Secure coding practices for web applications, Web Application Firewalls (WAF), secure APIs.	1,2	1
Total				**26**

List of Suggested Labs				
Module No.	**Serial No.**	**Lab**	**Ref.**	**Hours**
1	1	Advanced Network Traffic Analysis and Threat Detection Objective: Analyze network traffic and identify anomalies. Tools Used: Wireshark, Zeek Tasks: Capture live traffic, detect attack patterns, analyze DNS tunneling.	1, 2, 5	2
	2	Designing a Lightweight IDS Using Python and Scapy Objective: Develop an IDS to detect network anomalies. Tools Used: Python, Scapy Tasks: Implement packet sniffer, detect scanning attacks, simulate attack scenarios.	1, 2, 3	2

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2	3	Advanced SQL Injection Attacks & Automated Detection Objective: Perform and mitigate SQL injection. Tools Used: SQLMap, DVWA Tasks: Test time-based SQLi, create AI-based detection model, implement prevention methods.	2, 4	2
	4	Implementing Access Control and Network Segmentation in Cisco Packet Tracer Objective: Configure network segmentation. Tools Used: Cisco Packet Tracer Tasks: Create VLANs, configure ACLs, enforce role-based access control.	1, 2	2
3	5	Exploiting and Patching Privilege Escalation Vulnerabilities Objective: Identify and fix privilege escalation. Tools Used: Metasploit, LinPEAS, WinPEAS Tasks: Perform privilege escalation, mitigate exploits, automate detection.	2, 3	2
	6	Buffer Overflow Attack and Exploit Development Objective: Exploit buffer overflow vulnerabilities. Tools Used: GDB, Immunity Debugger Tasks: Trigger buffer overflow, develop exploit, apply protection techniques.	2, 3	2
4	7	Configuring VPN and Secure Remote Access in Cisco Packet Tracer Objective: Implement secure VPN communication. Tools Used: Cisco Packet Tracer Tasks: Configure IPsec VPN, analyze encrypted traffic, test remote access security.	1, 2	2
	8	Wireless Network Security - Advanced Attack and Defense\ Objective: Simulate and prevent Wi-Fi attacks. Tools Used: Aircrack-ng, Kismet Tasks: Perform Evil Twin attack, crack WPA2, deploy WPA3 security.	1, 2, 5	2
	9	Firewall Evasion and Bypass Techniques Objective: Evade firewall restrictions. Tools Used: Nmap, ProxyChains, Burp Suite Tasks: Bypass using SSH tunneling, analyze firewall logs, implement security controls.	2, 4	2
5	10	Advanced Web Application Security - SSRF & API Exploitation Objective: Exploit API and server-side vulnerabilities. Tools Used: OWASP ZAP, Burp Suite Tasks: Exploit SSRF, analyze API request weaknesses, implement OAuth security.	2, 4	2
	11	Designing a Custom Web Application Firewall (WAF) Using Python Objective: Develop a WAF to filter attacks. Tools Used: Python, Flask	1, 3	2

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		Tasks: Implement input filtering, create anomaly detection rules, test security.		
4	12	Cisco Packet Tracer - Network Forensics & Incident Response Objective: Simulate security breach analysis. Tools Used: Cisco Packet Tracer Tasks: Investigate unauthorized access, log analysis, simulate SIEM deployment.	1, 2	2
3	13	Ransomware Attack Simulation & Defense Mechanisms Objective: Simulate and mitigate ransomware attacks. Tools Used: WannaCry Simulator, Cuckoo Sandbox Tasks: Deploy ransomware, analyze payload behavior, apply endpoint security.	2, 3, 4	2
5	14	Penetration Testing with Custom Exploits Objective: Perform penetration testing using custom exploits. Tools Used: Metasploit, Python Tasks: Create zero-day exploit, perform attack chain simulation, implement security patches.	2, 3	2
	15	AI-Powered Threat Detection System Development Objective: Develop an AI model for cybersecurity threat detection. Tools Used: TensorFlow, Scikit-Learn Tasks: Train anomaly detection model, analyze traffic, integrate AI-based monitoring.	1, 2, 3	2

Course Assessment:
Theory:
ISE-1: Activity: Quiz and assignments 20 Marks/ One hour Test 20 Marks
ISE-2: One hours 20 Marks
Activity: Case studies, Article Discussion, Quiz and Assignments

MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks (remaining 50% syllabus) written examination

LAB:
ISE-1: Lab's/Activity/ Quizzes/Assignments (20 Marks)
ISE-2: Lab's/ Activity: Case studies, Article Discussion/Quiz/Assignments (30 Marks)

Recommended Books:
[1] Stallings, William., & Brown, Lawrie. *Computer Security: Principles and Practice (5th ed.).* Pearson Education, 2023.
[2] Pfleeger, Charles P., Pfleeger, Shari Lawrence., & Coles-Kemp, Lizzie. *Security in Computing (6th ed.).* Addison-Wesley Professional, 2023.
[3] Menezes, Bernard., & Kumar, Ravinder. *Cryptography, Network Security, and Cyber Laws.* Cengage Learning.
[4] Bhushan, Mayank; Rathore, Rajkumar Singh; Jamshed, Aatif. *Fundamentals of Cyber Security.* BPB Publications, 2018.

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[5] Forouzan, Behrouz A.; Mukhopadhyay, Debdeep. *Cryptography and Network Security (2nd ed.).* McGraw Hill Education, 2010.

Online Resources:
1. ITACT 2000: https://www.meity.gov.in/content/information-technology-act-2000-0
2. https://eprocure.gov.in/cppp/rulesandprocs/kbadqkdlcswfjdelrquehwuxcfmijmuixngudufgbuubgu bfugbububjxcgfvsbdihbgfGhdfgFHytyhRtMTk4NzY=

NPTEL:
1. https://nptel.ac.in/courses/128106006
2. https://archive.nptel.ac.in/courses/106/106/106106129/

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
	Big Data Analytics	2	--	2	2	--	1	3
25PEC13CE14		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	25PCC12CE08	
Course Outcomes	Student will be able to	
	CO1	Explain building blocks of Big Data Analytics.
	CO2	Apply fundamental enabling techniques like Hadoop and MapReduce in solving real world problems.
	CO3	Understand different NoSQL systems and how it handles big data.
	CO4	Apply advanced techniques for emerging applications like stream analytics.
	CO5	Achieve adequate perspectives of big data analytics in various applications like recommender systems, social media applications, etc.
	CO6	Apply statistical computing techniques and graphics for analyzing big data.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Big Data and Hadoop**	1,3	
	1.1	Introduction to Big Data, Sources of Big Data, Big Data characteristics-5 V's, Types of Big Data – unstructured, Semi-structured and Structured.		1
	1.2	Big Data Analytics Life Cycle, Case Study of Big Data Solution.		1
	1.3	Concept of Hadoop, Core Hadoop Components, Hadoop Ecosystem, Hadoop Limitations.		2
2		**Big Data Storage and Processing**	2	
	2.1	Hadoop Distributed File System (HDFS), Data Processing in Hadoop (MapReduce and Spark).		2
	2.2	Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections byMapReduce, Computing Projections by MapReduce, Union ,Intersection, and Difference by MapReduce..		2
3		**NoSQL**	2,3	
	3.1	Introduction to NoSQL, NoSQL Business Drivers		2
	3.2	NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores,		2

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		Variations of NoSQL architectural patterns, NoSQL Case Study		
	3.3	NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; NoSQL systems to handle big data problems. Big data for E-Commerce Big data for blogs, Case Studies MongoDB and Cassandra, Graph Databases-Neo4j.		2
4		**Mining Data Streams**	1,3	
	4.1	Data Stream Management System, Issues in Stream Processing, Stream Processing with Apache Kafka, Sampling Data techniques in a Stream, Filtering Streams- Bloom Filter with Analysis.		2
	4.2	Counting Distinct Elements in a Stream, Count Distinct Problem, Flajolet-Martin Algorithm, The Datar- Gionis-Indyk-Motwani Algorithm		2
5		**Real-Time Big Data Models**	2,5	
	5.1	A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering		2
	5.2	Case Study: Product Recommendation		2
6		**Data Analytics with R**	1,2,6	
	6.1	Exploring Basic features of R, Exploring RGUI, Exploring RStudio, Handling Basic Expressions in R, Variables in R, Working with Vectors, Storing and Calculating Values in R, Creating and using Objects, Executing Scripts, Creating Plots, Accessing help and documentation in R		2
	6.2	Reading datasets and Exporting data from R, Manipulating and Processing Data in R, Using functions instead of script, built-in functions in R		2
			Total	**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	**1**	Study and Installation of Hadoop.	1,3	2
	2	Hands on Hadoop HDFS	2,3	2
2	**3**	Write a program to implement Word Count using Map Reduce.	2	2
	4	Write a program to implement Matrix Multiplication algorithm using Map Reduce.	2	2
3	**5**	Write a program to insert, search, update, delete and aggregate data using MongoDB NoSQL Database.	2,3	2
	6	Write a command to perform insert, create, update and delete Cassandra (NoSQL) database.	2,3	2
4	**7**	Create social graphs using NEO4J database.	2,3	2
	8	Data stream Algorithm: Implement DGIM Algorithm using Map Reduce.	1,3	2

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5	9	Write a program to implement k-Means algorithm using any programming language.	1,2,5	2
	10	Write a program to perform Twitter data/Healthcare data analysis using R language.	1,2,6	2
6	11	Write queries to sort and aggregate the data in a table using HiveQL	2,3	2
	12	Mini project: One real life large data application using R language and standard dataset	1,6	4
			Total	**26**

Course Assessment:
Theory:
> **ISE-1:**
> Activity: Quiz and Assignments//Paper Presentation/Article Discussion - 20 Marks
> **ISE-2:**
> Activity: Quiz and Assignments/Paper Presentation/Article Discussion - 20 Marks
>
> **MSE:** 90 minutes, 30 Marks written examination based on 50% syllabus**.**
> **ESE:** 90 minutes, 30 Marks written examination based on remaining syllabus after MSE.

Lab:
1. ISE-1: Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2:
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Mini project: Presentation for 10 marks.

Recommended Books:

[1] Cre Anand Rajaraman and Jeff Ullman, "Mining of Massive Datasets", Cambridge University Press, 2011.
[2] Alex Holmes, "Hadoop in Practice", Manning Press, Dreamtech Press, 2012.
[3] Dan Mcary and Ann Kelly, "Making Sense of NoSQL – A Guide for Managers and the Rest of Us", Manning Press, 2014.
[4] DT Editorial Services, "Big Data Black Book", Dreamtech Press, 2015.
[5] EMC Education Services, "Data Science and Big Data Analytics", Wiley, 2016.
[6] [Bill Franks, "Taming The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics", Wiley, 2012.

Online Resources:
[1] https://nptel.ac.in/courses/106104189
[2] https://www.coursera.org/specializations/big-data#courses
[3] https://www.digimat.in/nptel/courses/video/106106169/L01.html
[4] https://www.coursera.org/learn/nosql-databases#syllabus
[5] https://www.coursera.org/learn/basic-recommender-systems#syllabus

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PEC13CE15	**Computer Graphics**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	ESC11CE03, BSC11CE01, BSC11CE03	
Course Outcomes	CO1	Describe the basic concepts of Computer Graphics.
	CO2	Demonstrate various algorithms for basic graphics primitives.
	CO3	Apply 2-D geometric transformations on graphical objects.
	CO4	Use various Clipping algorithms on graphical objects
	CO5	Explore 3-D geometric transformations, curve representation techniques and projections
	CO6	Explain visible surface detection techniques and Animation.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction and Overview of Graphics System:**		2
	1.1	Definition and Representative uses of computer graphics, Overview of coordinate system, Definition of scan conversion, rasterization and rendering.	T1, 2	
	1.2	Raster scan & random scan displays, Architecture of raster graphics system with display processor, Architecture of random scan systems.	T1, 2	
2		**Output Primitives:**		4
	2.1	Scan conversions of point, line, circle and ellipse: DDA algorithm and Bresenham algorithm for line drawing, midpoint algorithm for circle, midpoint algorithm for ellipse drawing (Mathematical derivation for above algorithms is expected)	T1, 2,3	
	2.2	Aliasing, Antialiasing techniques like Pre and post filtering, super sampling, and pixel phasing).	T1, 2	
	2.3	Filled Area Primitive: Scan line Polygon Fill algorithm, inside outside tests, Boundary Fill and Flood fill algorithm.	T1, 2,3	
3		**Two Dimensional Geometric Transformations**		5
	3.1	Basic transformations: Translation, Scaling, Rotation	T1, 2	
	3.2	Matrix representation and Homogeneous Coordinates	T1, 2	

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	3.3	Composite transformation	T1, 2	
	3.4	Other transformations: Reflection and Shear	T1, 2	
4		**Two-Dimensional Viewing and Clipping**		5
	4.1	Viewing transformation pipeline and Window to Viewport coordinate transformation	T1, 2,3	
	4.2	Clipping operations: Point clipping, Line clipping algorithms: Cohen Sutherland, Liang: Barsky, Polygon Clipping Algorithms: Sutherland Hodgeman, Weiler-Atherton.	T1, 2,3	
5		**Three Dimensional Geometric Transformations, Curves and Fractal Generation**		5
	5.1	3D Transformations: Translation, Rotation, Scaling and Reflection.	T1, 2,3	
	5.2	Composite transformations: Rotation about an arbitrary axis	T1, 2,3	
	5.3	Projections – Parallel, Perspective. (Matrix Representation)	T1, 2,3	
	5.4	Bezier Curve, B-Spline Curve.	T1, 2	
6		**Visible Surface Detection**		5
	6.1	Visible Surface Detection:Classification of Visible Surface Detection algorithm, Back Surface detection method, Depth Buffer method,Area Subdivision method	T1, 2,3	
			Total	**26**

Exp. No.	Name of the experiment	Ref	Hrs
	LIST OF SUGGESTED EXPERIMENTS		
1	Aim: To implement a basic DDA algorithm to draw straight lines on a digital grid. Objective: The objective of the experiment is to implement and analyze the DDA (Digital Differential Analyzer) line drawing algorithm to generate straight lines with varying styles, including solid, dotted, dashed, and thick lines.	**1, 2**	**2**

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2.	Aim: Implementation of Bresenham's Line Algorithm for Dotted, Dashed, and Thick Lines Objective: The objective of the experiment is to implement Bresenham's line drawing algorithm and modify it to generate straight lines with various styles, including solid, dotted, dashed, and thick lines, while understanding its efficiency and applications in computer graphics.	**1, 2**	**2**
3	Aim: Implementation of Midpoint Circle Drawing Algorithm Objective: The objective of the experiment is to implement the Midpoint Circle Drawing Algorithm to generate circles on a raster display efficiently, understanding its computational advantages, and applying the method to draw circles with varying parameters.	**1, 2**	**2**
4	Aim: Implementation of Area Filling Algorithms: Boundary Fill and Flood Fill. Objective: The objective of the experiment is to implement and compare the Boundary Fill and Flood Fill algorithms for area filling in computer graphics, understanding their methods, and evaluating their efficiency in different scenarios.	**1, 2**	**2**
5	Aim: Implementation of Scan Line Polygon Filling Algorithm Objective: The objective of the experiment is to implement the Scan Line Polygon Filling algorithm to efficiently fill the interior of polygons and analyze its performance in terms of accuracy and computational efficiency when applied to different polygon shapes.	**1, 2**	**2**
6	Aim: Implementation of 2D Transformations: Translation, Scaling, Rotation, Reflection, and Shear Objective: The objective of the experiment is to implement and explore various 2D transformations—Translation, Scaling, Rotation, Reflection, and Shear—on graphical objects, and to analyze the effects of these transformations on the positioning, shape, and orientation of objects in 2D space.	**1, 2**	**2**
7	Aim: Implementation of Line Clipping Algorithms: Cohen-Sutherland and Liang-Barsky Objective: The objective of the experiment is to implement the Cohen-Sutherland and Liang-Barsky line clipping algorithms, compare their performance and accuracy, and understand how these algorithms are applied to clip lines within a specified rectangular window in 2D space.	**1, 2**	**2**

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8	Aim: Implementation of Polygon Clipping Algorithm Objective: The objective of the experiment is to implement a polygon clipping algorithm and examine its ability to clip polygons against a clipping window, while understanding the algorithm's application, performance, and effectiveness in computer graphics for accurate rendering of objects within a given view area.	**1, 2**	**2**
9	Aim: Program to Perform 3D Transformations: Translation, Scaling, Rotation, Reflection, and Shear Objective: The objective of the experiment is to implement and explore various 3D transformations—Translation, Scaling, Rotation, Reflection, and Shear—on 3D objects, and to analyze their effects on the positioning, shape, and orientation of objects in 3D space using transformation matrices.	**1, 2**	**2**
10.	Aim: Implementation of Bezier Curve for n Control Points Objective: The objective of the experiment is to implement the Bezier curve algorithm for n control points, understand its mathematical foundations, and analyze how the curve behaves with different numbers of control points, demonstrating its applications in computer graphics for smooth curve generation.	**1, 2**	**2**
Mini Project: (Suggested list of Mini Project Topics)			

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11	Mini Project to perform using C /C++/Java/OpenGL/Blender/ any other tool (2/3 students per group). Possible Ideas: Animation using multiple objects, Game development, Graphics editor: Like Paint brush, Text editor etc. Refer below for a suggested list of mini projects.	1,2,3

1. 2D Shape Editor
   1. Implement a simple application that allows users to draw, edit, and save various 2D shapes (lines, circles, rectangles, polygons).
   2. Features could include scaling, rotating, and transforming objects using mouse interaction.
2. 3D Object Viewer
   1. Create an interactive viewer for 3D objects (such as cubes, spheres, and pyramids).
   2. Allow for rotation, zooming, and panning of the 3D scene.
   3. Implement basic 3D transformations like scaling, translation, and rotation.
3. Interactive 2D Transformations

   Create an interactive application that allows users to apply 2D transformations (translation, scaling, rotation, reflection, and shear) to shapes and view the result in real-time.
4. Animation of Moving Objects
   1. Create a program where objects like shapes or characters move on the screen.
   2. Implement basic animation principles, such as easing functions, frame rate control, and smooth transitions.
5. Interactive Game with Basic Graphics
   1. Develop a simple 2D game, such as Pong, Snake, or a platformer, with basic graphics.
   2. Integrate basic collision detection, object movement, and score tracking.
6. Real-Time Water Simulation
   1. Create a simple water surface simulation using techniques like wave equations or fluid dynamics.
   2. Visualize water interactions, like ripples and splashes, in real time.
7. 3D Solar System Simulator
   1. Develop a program to simulate a solar system with planets orbiting a star.
   2. Implement orbital mechanics and visualize the simulation with 3D graphics.

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Course Assessment:
Theory:

ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal
MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks (remaining 50% syllabus) written examination

Lab:

ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Textbooks:

1   Hearn & Baker,"Computer Graphics C version", 2nd Edition, Pearson Publication

2   James D. Foley, Andries van Dam, Steven K Feiner, John F. Hughes, "Computer Graphics Principles and Practice in C", 2nd Edition, Pearson Publication

3   Samit Bhattacharya,"Computer Graphics",Oxford Publication

References:

1   D. Rogers, "Procedural Elements for Computer Graphics", Tata McGraw-Hill Publications.

2   Zhigang Xiang, Roy Plastock, "Computer Graphics", Schaum"s Outlines McGraw-Hill Education

3   Rajesh K. Maurya,"Computer Graphics",Wiley India Publication.

4   F.S.Hill, "Computer Graphics using OpenGL", Third edition, Pearson Publications.

Online Resources:
Useful Links
1   https://www.classcentral.com/course/interactivegraphics-2067
2   https://swayam.gov.in/nd2_ntr20_ed15/preview
3   https://nptel.ac.in/courses/106/106/106106090/
4   https://www.edx.org/course/computer-graphics-2

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Online Resources for Lab:
1. Blender Tutorials: https://www.blender.org/
2. Computer Graphics Lab:
   https://www.cse.chalmers.se/edu/course/TDA362/tutorials/index.html

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PEC13CE16	**Human Machine Interaction**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		BSE12CE03, 25PCC13CE16
Course Outcomes	CO1	Identify User Interface (UI) design principles.
	CO2	Analysis of effective user friendly interfaces.
	CO3	Apply Interactive Design process in real world applications.
	CO4	Evaluate UI design and justify.
	CO5	Create applications for social and technical tasks.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**FOUNDATIONS OF HMI:**	1-8	
	1.1	The Human: History of User Interface Designing, I/O channels, Hardware, Software and Operating environments, The Psychopathology of everyday Things, Psychology of eeryday actions, Reasoning and problem solving.		4
	1.2	The computer: Devices, Memory, processing and networks.		
	1.3	Interaction: Models, frameworks, Ergonomics, styles, elements, interactivity, Paradigms.		
2		**DESIGN & SOFTWARE PROCESS:**	1-8	
	2.1	Mistakes performed while designing a computer system, Human interaction with computers, importance of human characteristics human consideration, Human interaction speeds. Interactive Design basics, process, scenarios, navigation, Iteration and prototyping.		4

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	2.2	HMI in software process: software life cycle, usability engineering, Prototyping in practice, design rationale. Design rules: principles, standards, guidelines, rules. Recognize the goals, Goal directed design process.		
	2.3	Evaluation Techniques: Universal Design.		
3		**GRAPHICAL USER INTERFACE:**	1-8	4
	3.1	The graphical User Interface: Popularity of graphics, the concept of direct manipulation, graphical systems, Characteristics.		
	3.2	Web user Interface: Interface popularity, characteristics. The merging of graphical Business systems and the Web. Principles of user interface design.		
4		**SCREEN DESIGNING:**	1-8	4
4	4.1	Design goals, Screen planning and purpose, organizing screen elements, ordering of screen data and content, screen navigation and flow, Visually pleasing composition, amount of information, focus and emphasis, presentation information simply and meaningfully, information retrieval on web, statistical graphics, Technological consideration in interface design.		
	4.2			
5		**INTERFACE DESIGN FOR MOBILE DEVICES:**	1-8	5
	5.1	Mobile Ecosystem: Platforms, Application frameworks: Types of Mobile Applications: Widgets, Applications, Games, Mobile Information Architecture, Mobile 2.0, Mobile Design: Elements of Mobile Design, Tools.		
6		**INTERACTION STYLES AND COMMUNICATION:**	1-8	5
	6.1	Windows: Characteristics, Components, Presentation styles, Types of Windows, Management, operations. Text messages: Words, Sentences, messages and text words, Text for web pages. Icons, Multimedia and colours		
			Total	**26**

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Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	1	**Know the clients** **(Design any one of the applications listed)** a. Children (4-5 years of age): An application to teach Math/English b. Teenagers: Design a digital diary for young teens to help them overcome various social pressures they deal with during their teen years. The diary should also be like a self help tool which would help them deal with incidents like bullying, peer pressure, etc. This is an open project and you can think in any direction to make the children sail through their teen years while trying to discover life around them. c. Older generation: Folks from the older generation has been very wary of using their credit card on the Internet. They have various concerns when it comes to paying their bills. Also because of their old age, it will be beneficial for them to use the internet and pay their phone, electricity, gas, etc. bills d. Rural people: ATVM for train ticketing in rural area		2
1	2	**Know the user/client** Developing an interface for an application for Physically or visually challenged people		2
2	3	**Requirement Gathering Technique** Design story boards from any two scenarios for any software system.		2
3	4	**Understand the trouble of interacting with machines** Redesign interfaces of home appliances like microwave oven, land-line phone, fully automatic washing machine.		2
3	5	**Learn HMI design principles – heuristic evaluation** Identify 5 different websites catering to one specific goal (eg. Goal – on-line shopping and 5 different websites – ebay, amazon, flipkart, zovi, myntra) and perform a competitive analysis on them to understand how each one caters to the goal, the interactions and flow of the payment system and prepare a report on the same		2
4	6	**Learn the importance of menus and navigation** Website redesign: News websites like CNN are always cluttered with information. It takes the user a few minutes to find his way through and maybe more minutes to look for some specific information. Redesign the news websites to make it look less cluttered, provide relevant		2

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		information (a person sitting in Russia should not get US news as top news), intelligently dig Information that he might be interested in based on his searches on the web.		
5	7	**Icon designing** Choose a unique domain, design a few icons and show how it can be accommodated on an interface		2
5	8	**Study of Serial Positioning effect, Webber's Law, Fitt's Law** To study serial Positioning effect, Fitt's law and Webber's law. (Use IITs Virtual labs)		2
6	9	**Redesigning interface** To calculate screen complexity of existing Graphical User Interface and redesign the interface to minimize the screen complexity. (New)		2
6	10	**Study of Technical papers and writing a review of it.** study five recent technical publication belonging to same topic in HMI and write review paper form it. This exercise will help inculcate lifelong learning in students. (New) OR Students can visit various industries and prepare case study of how Interaction design is actually followed in that industry. Students may visit more that one industry and present case study and report on the same		2
			Total	**26**

Course Assessment:
Theory:

       ISE-1: 20 Marks
      Activity: Quiz / Assignments
      ISE-2: 20 Marks
      Activity: Presentation / Article Discussion

      MSE: 90 minutes 30 Marks written examination based on 50% syllabus
      ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE.

Lab:
      ISE-1: Assesses 50% of the experiments. Evaluation is based on continuous assessment using predefined rubrics, totaling 20 marks.

   ISE-2: Assesses the remaining 50% of the experiments, following the same continuous rubric-based evaluation, with a total of 30 marks

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Recommended Books:

Text Books:

1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, *"Human Computer Interaction"*, 3rd Edition, Pearson Education, 2004.

2. Wilbert O. Galitz, *"The Essential Guide to User Interface Design"*, Wiley publication.

3. Alan Cooper, Robert Reimann, David Cronin, *"About Face3: Essentials of Interaction Design"*, Wiley publication.

4. Jeff Johnson, *"Designing with the Mind in Mind"*, Morgan Kaufmann Publication.

5. Donald A. Normann, *"Design of Everyday Things"*, Basic Books; Reprint edition 2002.

6. Brian Fling, *"Mobile Design and Development"*, First Edition, O'Reilly Media Inc., 2009.

7. Rogers Sharp Preece, *"Interaction Design: Beyond Human Computer Interaction"*, Wiley.

8. Guy A. Boy, *"The Handbook of Human Machine Interaction"*, Ashgate Publishing Ltd.

9. Kalbnde, Kanade, Iyer, *"Galitz's Human Machine Interaction"*, Wiley Publications.

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Course Code	Course Name		Teaching Scheme (Hrs/week)				Credits Assigned			
			L	T	P		L	T	P	Total
25PEC13CE17	Geographical Information Systems		2	--	2		2	--	1	3
			Examination Scheme							
			ISE1	MSE	ISE2	ESE		Total		
		TH	20	30	20	30		100		
		PR	20	--	30	--		50		

Pre-requisite Course Codes		BSC11CE03, BSC12CE06, PCC12CE06, PCC12CE08, PCC12CE07
Course Outcomes	CO1	Explain the fundamental concepts, components, and applications of GIS.
	CO2	Discuss spatial data models, data structures, and database management in GIS.
	CO3	Describe the methods of GIS Data Collection and data management.
	CO4	Apply various GIS techniques for spatial analysis and visualization.
	CO5	Analyze case studies to understand GIS applications in various domains.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to GIS**	1,3	2
	1.1	**Georeferencing:** Locating geographic phenomena, Latitude, longitude, Coordinate Systems		
	1.2	Definition, Components of GIS, Function of GIS, GIS Operations, Use and applications of GIS		
2		**GIS Data models and structures**	1	6
	2.1	Raster data models, Vector data models, advantages and disadvantages of Raster and Vector Data models		
	2.2	Spatial data structure: Raster data structure, Vector data structure, Comparison of Vector & raster data		
	2.3	Role of Databases in GIS, Geo-database and relational database, introduction to toposheet. Various open data sources.		
3		**GIS Data Collection and Management**	2	5
	3.1	Sources of Spatial Data: Maps, GPS, and Remote Sensing Data input methods: Digitization, Geo referencing, and GPS-based data collection		
	3.2	Database management in GIS: Spatial databases and SQL for GIS, Data integration and preprocessing		
4		**Spatial Analysis and Visualization**	3	

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	4.1	**GIS Data Analysis**: Processes and steps used in GIS data Analysis, software and tools used, data selection, reclassification, overlaying analysis, buffer analysis, spatial analysis (Dem Analysis,) surface analysis, network analysis, proximity analysis, vector & raster analysis methods.			8
	4.2	**Error Propagation in spatial data processing:** how errors propagate, quantifying error propagation			
	4.3	**Data Visualization:** Qualitative and Quantitative data visualization, Map outputs and its basic elements			
5		**GIS Applications and Case Studies**		1-4	5
	5.1	GIS in Urban Planning and Infrastructure Development			
	5.2	Environmental Monitoring and Climate Change Analysis			
	5.3	Disaster Management and Risk Assessment			
	5.4	GIS in Agriculture and Sustainable Development			
				Total	**26**

Suggested list of experiments: (Minimum 10)

Sr. no.	Suggested Experiments	Hrs.
1	Introduction to GIS software (QGIS, ArcGIS)	2
2	Geo referencing and projection of toposheet, Digitization of map/ Toposheet.	2
3	Spatial Data Analysis	2
4	Preparation of Non-Spatial Data, Linking Spatial and Non-Spatial data.	2
5	Google earth integrations in GIS.	2
6	Spatial and Non spatial Query and Analysis	2
7	Vector data analysis	2
8	Watershed Analysis	2
9	Terrain Analysis	2
10	Network Analysis	2

Recommended Books:

1. Otto Huisman, Rolf A, "Principles of geographic information systems: An Introductory textbook", International Institute for Geo-information science and Earth observation,2009, 4th Edition
2. Jonathan Campbell and Michael Shin, "Essentials of Geographic Information Systems", 2011, Saylor Foundation
3. Chang Kang-tsung (Karl), "Introduction to Geographic Information Systems", McGrawHill,2013, 7th Edition

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4. Heywood, I., Cornelius, S., and Carver S, "An Introduction to Geographical Information Systems", Prentice Hall, U.S.A, 2012

Online Resources:

Esri Training course

IIRS-ISRO course on GIS

NPTEL course on GIS

Course Assessment:

Theory:
    ISE-1: Activity: Quiz- 10 Marks
                        Case study- 10Marks
    ISE-2: Activity: IIRS-ISRO course on GIS- 20 Marks
    MSE: 90 minutes 30 Marks written examination based on 50% syllabus
    ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE

 Practical: (10 Nos.)
    ISE1: 20 marks based on first four practical as per the predefined rubrics
    ISE2: 30 marks based on remaining six practical as per the predefined rubrics

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	**T**	**P**	**L**	**T**	**P**	**Total**
		0	**0**	**2**	**0**	**0**	**1**	**1**
25PECL13CE11	**Image Processing Lab**	**Examination Scheme**						
		ISE	**MSE**	**ISE**	**ESE**		**Total**	
		20		**30**			**50**	

Pre-requisite Course Codes	BSC11CE01	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Implement basic image processing techniques using programming.
	CO2	Develop programs for image enhancement in spatial and frequency domains.
	CO3	Apply image compression and segmentation techniques.
	CO4	Analyze and implement morphological operations and feature extraction methods.
	CO5	Develop mini-projects on real-world applications using image processing concepts.

Exp. No.	Name of the experiment	Ref	Hrs
	LIST OF SUGGESTED EXPERIMENTS		
1	Write a program to read and display images using a library (e.g., OpenCV/Matplotlib).	1, 2	2
2.	Perform basic operations: grayscale conversion, cropping, resizing, and flipping images.	1, 2	2
3	Implement histogram equalization for image enhancement.	1, 2	2
4	Apply spatial filters: smoothing (average filter) and sharpening (Laplacian filter).	1, 2	2
5	Perform Fourier Transform to enhance images in the frequency domain.	1, 2	2
6	Implement edge detection algorithms: Sobel, Prewitt, and Canny.	1, 2	2
7	Apply thresholding techniques for image segmentation (global and adaptive thresholding).	1, 2	2
8	Perform morphological operations: erosion, dilation, opening, and closing.	1, 2	2

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9	Write a program to compress an image using a standard technique (e.g., Run-Length Encoding).	1, 2	2
10.	Perform color image processing: separate and manipulate RGB channels.	1, 2	2
11	Extract features from an image using edge and corner detection methods.	1, 2	2
12	Design and implement an application (e.g., license plate detection or face recognition).	1, 2	2
	Mini Project: (Suggested list of Mini Project Topics)		
13	a. Develop a photo editor application with basic operations. b. Implement an OCR (Optical Character Recognition) system. c. Design a real-time face detection application. d. Create a histogram-based image matching application. e. Implement a medical imaging system for noise reduction and enhancement.	1,2	

Course Assessment:

Lab:

ISE:

1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:

[1] Digital Image Processing Using MATLAB, Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, Tata Mc Graw Hill Pvt. Ltd. Third Edition, 2011.

[2] Digital Image Processing and Analysis: Application with MATLAB and CVIP tools, SE Umbaugh, Taylor & Francis/CRC Press, 3rd Edition, 2018

Online Resources:
1. Image Processing Tutorials: https://scikit-image.org/
2. MATLAB Image Processing Toolbox: https://www.mathworks.com/

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	L	T	P	Total
25PECL13CE12	**Natural Language Processing Lab**	0	0	2	0	0	1	1
		Examination Scheme						
		ISE	MSE	ISE	ESE	Total		
		20	–	30	–	50		

Pre-requisite Course Codes	PCC12CE09 (Analysis of Algorithms), BSC12CE06 (Linear Algebra and Statistics)	
Course Outcomes	On successful completion of the course learner will be able to	
	CO1	Apply text preprocessing techniques, including tokenization, stemming, lemmatization, stopword removal, and normalization, to prepare textual data for NLP applications.
	CO2	Develop and implement word representation techniques such as N-Grams, TF-IDF, and Word Embeddings, enabling feature extraction for machine learning models.
	CO3	Perform Part-of-Speech (POS) tagging and Named Entity Recognition (NER) using rule-based, statistical (HMM, CRF), and deep learning (BiLSTM, Transformer) methods.
	CO4	Implement text classification models using Naïve Bayes, Logistic Regression, and Transformer-based architectures.
	CO5	Design and deploy scalable NLP applications leveraging Large Language Models (LLMs) for real-world use cases, such as conversational AI, summarization, and recommendation systems.

Exp. No.	Name of the experiment	Ref	Hrs
Text preprocessing techniques			
1	1.1 Tokenization Methods: Compare different tokenization methods: word, subword, and character-based. Methods: Use NLTK, SpaCy, WordPiece, and Byte Pair Encoding (BPE). 1.2 Stopword Removal: Assess how removing stopwords affects text statistics.Methods: Apply stopword lists from NLTK and SpaCy on datasets. 1.3 Stemming and Lemmatization: Compare stemming and lemmatization in reducing vocabulary size. Methods: Use Porter Stemmer, Lancaster Stemmer, and WordNet Lemmatizer. 1.4 Noise Removal & Text Normalization: Evaluate the effect of noise removal, case transformation, and punctuation removal in text preprocessing.	1,2	3

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Word Level Analysis			
2	2.1 Regular Expressions (Regex) for Information Extraction Design and test regex patterns for extracting URLs,Dates,Email addresses, Phone numbers,Offensive words/phrases, Hashtags, Mentions (@usernames) Tools: Use Python regex (re module), NLTK, SpaCy. 2.2 N-Gram Model Implementation Implement and analyze N-Gram models for given text input. Tasks: Generate unigram, bigram, and trigram models and analyze their impact. Tools: Use NLTK, Scikit-learn, SpaCy. 2.3 Edit Distance Algorithm Implement Levenshtein Distance (Edit Distance) to determine Minimum number of insertions, deletions, or substitutions needed to convert one string into another. Tools: Use Dynamic Programming, NLTK, FuzzyWuzzy library. 2.4 Chunking & Named Entity Recognition (NER) Perform chunking (phrase-level grouping) and Named Entity Recognition (NER). Tasks: Identify nouns, verb phrases, named entities (Person, Location, Organization). Tools: Use SpaCy, NLTK, Hugging Face transformers.	1,2,5	6
POS tagging techniques			
3.	3.1 Understanding POS Taggers Study different POS tagging methods and apply them to a given text dataset. 3.2 Performance Evaluation Compare and analyze the accuracy of different POS tagging approaches. 3.3 Rule-Based POS Tagging Implement rule-based methods using regular expressions and linguistic rules. 3.4 Statistical POS Tagging Apply Hidden Markov Models (HMM) and Conditional Random Fields (CRF) for POS tagging. 3.5 Deep Learning for POS Tagging (optional) Experiment with BiLSTM and Transformer-based models for advanced tagging.	1,2,4	3
Named Entity Recognition			
4	4.1 Introduction to Named Entity Recognition (NER) Understand the concept of Named Entity Recognition (NER) in NLP. Identify named entities such as Persons, Locations, Organizations, Dates, Time, Money, Percentages, and Miscellaneous categories in a given text. 4.2 Data Preprocessing for NER Perform text cleaning (lowercasing, punctuation removal, tokenization). Utilize POS tagging and dependency parsing to assist in named entity extraction.	1,2,5	3

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	4.3 Implementing Rule-Based NER Develop pattern-based entity recognition using regular expressions and heuristics. Example: Extracting dates (DD/MM/YYYY), phone numbers, or email addresses using Regex. 4.4 Implementing Statistical and Machine Learning-Based NER Apply Hidden Markov Models (HMM) and Conditional Random Fields (CRF) for entity recognition. Train and evaluate an NER model on standard datasets (e.g., CoNLL-2003). 4.5 Implementing Deep Learning-Based NER (optional) Use BiLSTM-CRF models for NER. Explore Transformer-based NER models (e.g., BERT, RoBERTa, T5). Fine-tune a pre-trained model using Hugging Face's Transformers library.			
Text Vectorization & Classification			
5	5.1 Understanding Text Vectorization & Feature Extraction Learn different text representation techniques: Bag of Words (BoW), TF-IDF, and Word Embeddings. Compare the impact of these techniques on model performance. 5.2 Implementing Text Vectorization without Standard Libraries Manually implement BoW and TF-IDF by tokenizing text and constructing a term-document matrix. Develop Word Embeddings (Skip-gram, CBOW) without using pre-trained models. 5.3 Preprocessing for Text Classification Apply stopword removal, stemming, lemmatization, and case normalization. Convert text into a structured numerical format using vectorization methods. 5.4 Building Naïve Bayes and Logistic Regression Classifiers Implement Multinomial Naïve Bayes from scratch for probabilistic text classification. Train a Logistic Regression model for binary/multi-class classification. 5.5 Model Evaluation & Performance Comparison Measure classification performance using accuracy, precision, recall, and F1-score. Compare the effectiveness of Naïve Bayes vs. Logistic Regression on real-world text datasets.	2,4	3
Large Language Models			
6	6.1 Understanding Large Language Models (LLMs) Explore the architecture, components, and working principles of large-scale transformers such as GPT, BERT, and LLaMA. 6.2 Using LLMs for NLP Applications Utilize pre-trained LLMs for text classification, machine translation, summarization, and question-answering. 6.3 Transfer Learning and Domain Adaptation	3,4	4

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	Implement transfer learning by fine-tuning LLMs on domain-specific datasets for NLP applications. 6.4 Deployment and Experimentation with LLMs Deploy and experiment with GPT-4, BERT, T5, and Falcon using APIs and open-source frameworks (e.g., Hugging Face). 6.5 Integrating LLMs into Real-World Applications Implement LLMs in chatbots, search engines, and recommendation systems for real-world NLP applications.		
Mini Project: (Suggested list of Mini Project Topics)			
	1. Job Market & Finance Job Recommendation System using NLP – Extract skills from resumes using Named Entity Recognition (NER) and match them with job listings. Financial Literacy Chatbot – Simplify financial terms and budgeting concepts using text summarization. 2. Healthcare & Social Impact Mental Health Sentiment Analysis – Detects signs of depression and anxiety in social media posts using sentiment analysis. Fake Medical News Detector – Identify misinformation in healthcare articles using stance detection. 3. Sustainability & Environment AI-powered Food Donation Assistant – Connect food donors with NGOs and prioritize requests using NLP. Water Crisis Awareness Summarization – Summarize water-related reports for policymakers using extractive summarization. 4. Legal & Accessibility Legal Document Summarization – Simplify legal texts for public understanding using abstractive summarization. Resume Screening & Bias Reduction – Anonymize personal details in resumes using NLP for fair hiring. 5. AI-driven Language & Communication Automated Question Generator – Generate MCQs from textbooks using Named Entity Recognition (NER) and summarization. Hate Speech & Toxicity Detection – Identify and flag harmful online content using NLP Note: Students may also choose any project aligned with the NLP syllabus, incorporating latest trends such as Large Language Models (LLMs), Prompt Engineering, Zero-shot/Few-shot Learning, Multimodal NLP, or Ethical AI considerations in NLP applications	Online Resources	4

Lab:
ISE:
1. ISE-1 will be conducted on 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Miniproject/Innovative experiment for 10 marks

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Recommended Books:
1. Speech and Language Processing, Daniel Jurafsky & James H. Martin, Prentice Hall, 2nd Edition.
2. Foundations of Statistical Natural Language Processing, Christopher D. Manning & Hinrich Schütze, MIT Press.
3. Natural Language Processing with Transformers, Lewis Tunstall, Leandro von Werra & Thomas Wolf, O'Reilly, Revised Edition, 2022.
4. Natural Language Processing with Python, Steven Bird, Ewan Klein & Edward Loper, O'Reilly.
5. The Handbook of Computational Linguistics and Natural Language Processing, Alexander Clark, Chris Fox & Shalom Lappin, Wiley.

Online Resources:
[1] Course: Natural Language Processing By Prof. Pawan Goyal, IIT Kharagpur
[2] https://onlinecourses.nptel.ac.in/noc21_cs102/preview
[3] Course: Applied Natural Language Processing By Prof. Ramaseshan R, CMI
[4] https://onlinecourses.nptel.ac.in/noc20_cs87/preview
[5] IIT Vlabs: Welcome to Virtual Labs - A MHRD Govt of India Initiative (vlabs.ac.in)
[6] Natural Language Processing" by Prof. Pushpak Bhattacharyya (IIT Bombay)

Further Reading
1. A Review towards the Sentiment Analysis Techniques for the Analysis of Twitter Data – Priyanka Tyagi, R.C. Tripathi, SSRN (2019).
   Discusses various sentiment analysis approaches applied to Twitter data, including lexicon-based, machine learning, and deep learning techniques.
   https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3349569
2. Recent Trends in Named Entity Recognition (NER): Advances in Transformer Models, Few-Shot Learning, and Cross-Lingual NER (2021).
   Explores the evolution of NER, covering statistical models, CRFs, deep learning-based approaches (LSTMs, BERT), and emerging trends such as zero-shot and multilingual NER.
   https://arxiv.org/abs/2101.11420
3. Recent Trends in Deep Learning-Based Open-Domain Textual Question Answering Systems, IEEE Access (2020).
   Examines state-of-the-art deep learning models in Question Answering (QA), including attention mechanisms, Transformer-based models, and hybrid approaches.
   https://ieeexplore.ieee.org/document/9156656

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Course Code	Course Name	Teaching Scheme (Hrs/week)						Credits Assigned		
		L	T	P	L	T	P	Total		
		0	0	2	0	0	1	1		
25PECL13CE13	IIOT LAB	Examination Scheme								
		ISE		MSE		ISE		ESE	Total	
		20				30			50	

Pre-requisite Course Codes		C programming, Microcontroller and Applications.
	CO1	Implement Industrial Sensor Networks
	CO2	Configure IIoT Communication Protocols
	CO3	Apply AI and Edge Computing for Industrial Automation
Course Outcomes	CO4	Integrate IIoT with Cloud Computing & Big Data
	CO5	Implement IIoT Security and Data Integrity
	CO6	Develop(Design and simulate) Industry IIOT

Exp. No.	Name of the experiment	Ref	Hrs

1	**Interfacing Industrial-Grade Sensors via LoRaWAN**
	   a) Connect temperature, humidity, vibration, and gas sensors over LoRaWAN
	   b) Transmit & receive sensor data over long distances (1-10 km)
		1, 5	

2.	**5G-Enabled Industrial Data Transmission for Smart Factories**
	   a) Set up ESP32/Raspberry Pi with a 5G modem
	   b) Test real-time high-speed, low-latency IIoT communication
		1, 5	

3	**AI-Based Visual Inspection with Edge AI Cameras**
	   a) Use OpenCV & AI cameras (Raspberry Pi + Coral Edge TPU)
	   b) Detect faulty industrial parts using image processing & deep learning
		1, 5	

4	**Secure IIoT Communication with LoRaWAN & MQTT-TLS** a) Implement encrypted sensor data transfer over LoRa & MQTT	1, 5	

5	**AI-Driven Industrial Anomaly Detection via Edge AI**
	   a) Train & deploy a predictive AI model on ESP32/Raspberry Pi
	   b) Detect machine failures before they happen
		1, 5	

6	**Industrial Cybersecurity: Detecting & Preventing IIoT Attacks**
	   a) Use AI-based intrusion detection to identify malicious activity
	Real-Time Data Integrity Monitoring for Industrial Machines
	   a) Set up SHA-256 hash-based data verification for IIoT sensor logs
		1, 5	

7	**I-Powered Fault Detection in Industrial Equipment**
	   a) Implement machine learning models for real-time fault detection
	   b) Real-Time Energy Management in Smart Grids Using IIoT
		1, 5	

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		Monitor & optimize industrial power consumption
		   a) AI-Based Worker Safety Monitoring in Industrial Environments
		   b) Detect worker movement, PPE compliance, and hazards using AI cameras		

8		**Industry-Oriented IIoT Simulations**
		   a) Design and simulate smart factory automation solutions using IIoT digital twins and simulation tools like Factory I/O, MATLAB Simulink, and Any Logic.
		   b) Implement case studies in a controlled lab environment using emulated IIoT networks (e.g., Node-RED and Cisco Packet Tracer).
		   c) Analyze real-world industry datasets (e.g., predictive maintenance logs from Kaggle or SCADA system logs) to extract insights.		

Lab:
ISE:
1. ISE-1 will be conducted on 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Miniproject/Innovative experiment for 10 marks

Recommended Books:

[1] Giacomo Veneri , Antonio Capasso "Hands on Industrial Internet of Things :Create a powerful Industrial IoT infrastructure using Industry 4.0",Packt Publisher,Edition Nov15th 2024
[2] Olushola Akande "Industrial Automation from Scratch: A hands-on guide to using sensors, actuators, PLCs,HMI's,SCADA to automate Industry Processes". Packt Publishing ,Edition june 2023.
[3] Arshdeep Bahga, Vijay Madisetti "Internet of Things: A Hands-On Approach" Publisher: Orient Blackswan Private Limited - New Delhi
[4] Peter Waher, "Mastering Internet of Things: Design and Create Your Own IoT Applications", Packt Publishing (March 28, 2018); eBook (Free Edition)
[5] Perry Lea," "IoT and Edge Computing for Architects: Implementing Edge and IoT Systems from Sensors to Clouds with Azure IoT and AWS IoT Core", Publisher(s): Packt Publishing ISBN: 9781839214806
[6] Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Publisher New York, NY : Apress
[7] David Hanes, Gonzalo Salgueiro, Rob Barton," IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" Released June 2017Publisher(s): Cisco Press ISBN: 978013430709

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	L	T	P	Total
25PECL13CE14	Innovative Product Development Lab (Phase 1)	0	0	2	0	0	1	1
		Examination Scheme						
		ISE	MSE		ISE	ESE		Total
		20	-		30	-		50

Pre-requisite Course Codes		Innovation and Design Thinking	
		On successful completion of the course learner will be able to	
Course Outcomes	CO1	Understand design thinking, market research, and intellectual property rights for innovation.	
	CO2	Apply market research, competitor analysis, and patent search techniques to identify opportunities.	
	CO3	Develop and validate product concepts, business models, and prototypes using stakeholder feedback.	
	CO4	Evaluate regulatory compliance, cost estimation, and pricing strategies for market readiness.	
	CO5	Create and present a Go-to-Market strategy and investor pitch for product commercialization.	

Exp. No.	Name of the experiment	Ref	Hrs
Generating and Refining Innovative Product Ideas Using Design Thinking			
1)	Activity: Apply design thinking techniques to generate, evaluate, and refine innovative product ideas. Expected Outcome: Develop an Idea Canvas that effectively captures i)The identified problem and its significance ii)The proposed innovative solution iii)The feasibility of implementation based on technological, economic, and market considerations.	1	2
Market Research & Customer Discovery			
2)	Activity: i) Analyze competitors' products and marketing strategies to identify market gaps and opportunities. ii) Conduct surveys to gather insights into customer preferences, behaviors, and pain points. Expected Outcome: Create a Market Segmentation Report that includes customer personas with demographic, psychographic, behavioral, and pain point details. The report should analyze market segmentation based on key	1, 2	2

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	factors, highlight trends, and provide competitor insights with a comparison of customer segments. Finally, students should include strategic recommendations on targeting and positioning products or services effectively for each segment.		
	Concept Development & Validation		
3)	Activity: i) Create initial product concepts in the form of wireframes, sketches, or low-fidelity prototypes. ii) present these concepts to stakeholders, including potential users, industry experts, or mentors iii)refine and improve their concepts to better align with user needs and market expectations. Expected Outcome: A Concept Validation Report including the visual representations of the concept, insights from feedback, and justifications for design modifications.	2, 3	3
	Business Model Development Using the Lean Canvas Approach		
4)	Activity: Develop a Lean Canvas for a selected product idea. Expected Outcome: A Completed Lean Canvas Model outlining the problem-solution fit, key customer segments, value proposition, revenue streams, cost structure, and other essential business elements. The final canvas should provide a clear and concise roadmap for the product's business viability	4	3
	Introduction to Intellectual Property Rights (IPR) & Patent Search		
5)	Activity: i) Explore the fundamentals of Intellectual Property Rights (IPR), focusing on patents, trademarks, and copyrights ii)Conduct a patent search using online databases such as Google Patents, WIPO, USPTO, or the Indian Patent Office to identify existing patents related to a chosen product or technology. iii)Analyze the scope of existing patents, identify potential gaps, and assess opportunities for innovation. Expected Outcome: A Patent Search & Analysis Report summarizing key findings from the search, including details of existing patents, identified innovation gaps, and potential areas for new patentable ideas. The report should highlight how the findings can guide product development while ensuring compliance with intellectual property laws.	6	2
	Patent Registration Process: Steps & Documentation		
6)	Activity: Explore the patent registration process, including drafting a patent application, identifying patentable aspects of an innovation, and understanding the required legal and technical documentation. create a mock patent application for a selected product or technology. Expected Outcome: Draft patent application, covering aspects like the invention's novelty, claims, and technical specifications.	6	3
	Prototyping & Minimum Viable Product (MVP) Development		
7)	Activity: i) Develop a low-fidelity prototype of a product concept using techniques such as paper prototyping, 3D modeling, or digital wireframing. ii) Test the prototypes with potential users or stakeholders to gather initial feedback on usability, functionality, and feasibility. Expected Outcome: A Low-Fidelity Prototype accompanied by a Design Rationale Report, explaining the purpose, structure, and intended user experience of the prototype. The report should also include feedback	3, 4	3

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	received, insights gained, and possible refinements for further development.		
	Introduction to Regulatory Compliance & Certifications		
8)	Activity: Research the regulatory requirements, certifications, and government approvals needed for a selected product within a specific industry, such as healthcare, electronics, food, or consumer goods. Explore key regulatory bodies (e.g., FDA, CE, BIS, ISO, FCC) and understand compliance standards related to safety, quality, and environmental impact. The research will also cover legal frameworks, industry best practices, and challenges in obtaining certifications. Expected Outcome: A Regulatory Compliance & Certification Report detailing the necessary approvals, certification processes, associated costs, timelines, and legal considerations for the chosen product.		**2**
	Product Cost Estimation & Pricing Basics		
9)	Activity: i) Estimate the total cost of developing a product by analyzing key cost components, including raw materials, manufacturing, labor, distribution, and operational expenses. ii) Explore different pricing strategies (cost-based, value-based, and competitive pricing) to determine an optimal price point that ensures profitability while remaining attractive to customers. Expected Outcome: A Cost Breakdown & Pricing Strategy Report justifying the chosen pricing model and highlighting factors affecting cost efficiency and competitive pricing.	**2, 3**	**2**
	Pitching & Storytelling for Investors		
10)	Activity: i) Develop a compelling 3-minute product pitch for funding support from Investors. ii) Presentation of the pitch in front of an audience or recorded as a video for evaluation. Expected Outcome: An Evaluated Pitch Video or Live Presentation, assessed on clarity, engagement, storytelling, and investor appeal.	**2, 3, 5**	**2**
	Designing a Go-to-Market Strategy		
11)	Activity: Students will develop a Go-to-Market (GTM) Strategy outlining how to successfully launch a product into the market by selecting marketing and distribution channels, planning promotional activities, and defining sales strategies considering potential challenges and risks in market entry. Expected Outcome: A Go-to-Market Strategy Document detailing the product positioning, customer acquisition plan, distribution model, and key marketing tactics.	**2, 3, 5**	**2**
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Course Assessment:

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1. ISE-1 will be conducted for five or 50% of experiments/activities. Continuous pre-defined rubrics-based evaluation for 20 marks on reports generated as outcomes of these experiments/activities evaluated on the basis of content accuracy, clarity, analysis, innovation, and presentation.

2. ISE-2 will be conducted for remaining six experiments or 50% of experiments/activities. Continuous pre-defined rubrics-based evaluation for 30 marks on reports generated as outcomes of these experiments/activities evaluated on the basis of content accuracy, clarity, analysis, innovation, and presentation.

Recommended Books:

[1] Tim Brown, Change by Design, 1st Edition, Harper Business, 2009.

[2] Eric Ries, The Lean Startup, 1st Edition, Crown Business, 2011.

[3] Peter Thiel & Blake Masters, Zero to One: Notes on Startups, or How to Build the Future, 1st Edition, Crown Business, 2014.

[4] Alexander Osterwalder & Yves Pigneur, Business Model Generation, 1st Edition, Wiley, 2010.

[5] Scott Hurff, Designing Products People Love: How Great Designers Create Successful Products, 1st Edition, O'Reilly Media, 2016.

[6] B.L. Wadhera, Intellectual Property Rights in India: Legal and Business Implications, 6th Edition, Universal Law Publishing, 2020.

Online Resources:

1) Design Thinking & Innovation: IDEO U: https://www.ideou.com
2) Lean Canvas: https://leanstack.com/lean-canvas
3) Intellectual Property & Patent Search:
   Google Patents: https://patents.google.com
   WIPO Patent Database: https://www.wipo.int
   Indian Patent Office: https://ipindia.gov.in
4) Y Combinator Startup Library: https://www.ycombinator.com/library
5) Low-Fidelity Prototyping (NNGroup): https://www.nngroup.com/articles/low-fidelity-prototyping

Further Reading:

1) Clayton Christensen, The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, 1st Edition, Harvard Business Review Press, 1997.
2) W. Chan Kim & Renée Mauborgne, Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant, Expanded Edition, Harvard Business Review Press, 2015.
3) Chip Heath & Dan Heath, Made to Stick: Why Some Ideas Survive and Others Die, 1st Edition, Random House, 2007.
4) Marty Cagan, Inspired: How to Create Products Customers Love, 2nd Edition, Wiley, 2017.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		0	0	2	0	0	1	1
25PECL13CE15	**Open-Source intelligence and Threat intelligence lab**	**Examination Scheme**						
		ISE	MSE	ISE	ESE	Total		
		20	---	30	---	50		

Pre-requisite Course Codes	Python programming
On successful completion of the course learner will be able to	
Course Outcomes	CO1	Develop practical skills in OSINT tools for data collection and analysis.
	CO2	Analyze cyber threats using threat intelligence frameworks and methodologies.
	CO3	Integrate OSINT and TI data to identify vulnerabilities and mitigate risks.
	CO4	Investigate complex scenarios involving ransomware, dark web intelligence, IoT vulnerabilities, and geospatial analysis.
	CO5	Report findings effectively with actionable recommendations for cybersecurity resilience.

Exp. No.	Suggested Experiments	Ref	Hrs
1	**OSINT Toolkit Setup and Usage** Objective: Develop and use an OSINT toolkit for data collection and analysis while adhering to ethical practices. Activities: Install and configure tools like Maltego CE, SpiderFoot, and theHarvester. Perform domain lookups and subdomain enumeration using SpiderFoot and Amass. Automate workflows with a Python script combining outputs from multiple tools. Discuss ethical and legal considerations in OSINT investigations. Tools: Maltego CE, SpiderFoot, theHarvester, Amass, Python.	1	2
2	**Generalized Media and Account Investigations** Objective: Perform intelligence gathering and account investigations on any social media platform to uncover connections and vulnerabilities. Activities: • Select a social media platform and gather data using open-source tools. • Analyze connections with Gephi and perform sentiment/content analysis. • Investigate usernames with Sherlock, analyze emails with EmailRep, and check breaches using haveibeenpwned API.	1	2

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	Tools: Gephi, Sherlock, EmailRep, haveibeenpwned API, platform-specific OSINT tools.		
3	**Investigating Fake News and Disinformation Campaigns** Objective: Use OSINT techniques to identify and analyze fake news sources and disinformation patterns. Activities: • Perform source analysis using tools like NewsGuard or InVID. • Verify multimedia authenticity using EXIF data and reverse image search. • Map disinformation networks using Gephi. Tools: InVID, NewsGuard, ExifTool, Gephi.	1	2
4	**OSINT for E-commerce Fraud Investigation** Objective: Leverage OSINT tools to identify fraudulent sellers, scam websites, and fake e-commerce platforms. Activities: • Analyze e-commerce website reputations using URLScan and Whois. • Track seller details and reviews through social media scraping. • Detect and analyze fake e-commerce websites using tools like Scamadviser or manual red flag checks (SSL certificates, contact information, etc.). • Map connections between fraudulent profiles and websites using Maltego CE. Tools: Maltego CE, URLScan, Whois, Scamadviser (or equivalent tools).	1	**2**
5	**Geospatial Intelligence** Objective: Utilize geospatial tools to analyze location-based intelligence and extract geotagged data. Activities: Use Google Earth Pro for geospatial analysis; extract image metadata using ExifTool. Tools: Google Earth Pro, OpenStreetMap, ExifTool.	1	2
6	**Phishing and Social Engineering Investigations** Objective: Investigate phishing campaigns and assess social engineering tactics using OSINT techniques. Activities: Analyze phishing emails and URLs with tools like PhishTank; simulate social engineering scenarios and evaluate potential risks. Tools: PhishTank, URLScan, Any.Run.	3	2
7	**OSINT for Geo-Political Risk Analysis** Objective: Assess geo-political risks using multi-source OSINT data and advanced social media analysis tools. Activities: Gather data from news, social media platforms (Twitter, Instagram, Reddit, etc.), official reports, and government datasets to identify conflict zones. Visualize risks using OpenStreetMap and Google Earth Pro. Use social media tools like Twint, OSINTgram, and PRAW for trend and sentiment analysis. Perform comprehensive analysis by integrating social, political, and environmental data. Tools: OpenStreetMap, Google Earth Pro, Twint, OSINTgram, PRAW (for Reddit), and multi-source datasets.	1	2

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8	**Automated OSINT Data Aggregation** Objective: Build an automated pipeline to aggregate OSINT data from various sources. Activities: • Use APIs from Shodan, VirusTotal, and Twint for data collection. • Write Python scripts to process and summarize collected data. • Visualize results using Dash or Matplotlib. • Create a dashboard displaying real-time OSINT insights for a chosen investigation. Tools: Shodan API, VirusTotal API, Twint API, Python (Dash).	1	4
9	**Metadata Extraction and File Analysis** Objective: Extract and analyze metadata from files to uncover hidden information. Activities: Use ExifTool and FOCA to extract metadata from images, documents, and PDFs; analyze potential security risks associated with exposed metadata. Tools: ExifTool, FOCA.	1	2
10	**Threat Intelligence Platform Setup and Analysis** Objective: Configure and utilize Threat Intelligence Platforms (TIPs) to manage, analyze, and share threat data. Activities: Set up MISP and integrate threat feeds from OTX and AlienVault OTX. Analyze threat feeds to identify indicators of compromise (IOCs) and create custom indicators. Simulate collaborative sharing of threat intelligence between fictional organizations. Tools: MISP, Open Threat Exchange (OTX), AlienVault OTX.	2	4
11	**Tracking Cyber Threat Actors** Objective: Identify and profile cyber threat actors using OSINT and TI data. Activities: • Collect data on a mock Advanced Persistent Threat (APT) group using TI feeds. • Map TTPs (Tactics, Techniques, and Procedures) using MITRE ATT&CK. • Profile the threat actor using graphing tools like Maltego. • create an APT group profile and recommend countermeasures. Tools: MITRE ATT&CK, Maltego CE, OTX	2	2
12	**Malware Analysis and Behavior Investigation** Objective: Analyze malware behavior using OSINT tools and open-source platforms to extract intelligence and create detection mechanisms. Activities: Use VirusTotal for file and URL analysis. Analyze malware behavior with Hybrid Analysis and extract IOCs mapped to MITRE ATT&CK. Simulate a ransomware attack and create detection signatures. Tools: VirusTotal, Hybrid Analysis, Cuckoo Sandbox, Any.Run.	3	2

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13	**Ransomware Intelligence and Decryption** Objective: Explore ransomware intelligence sources and attempt decryption techniques. Activities: Use NoMoreRansom to identify and decrypt mock ransomware. Analyze ransom notes and cryptocurrency wallets for patterns. Create a report on ransomware family characteristics. Tools: NoMoreRansom, Blockchain explorers.	2	2
14	**Network Reconnaissance and OSINT Integration** Objective: Conduct network reconnaissance and integrate OSINT data for threat identification. Activities: Use tools like Nmap and Shodan to scan networks; correlate findings with OSINT resources to assess vulnerabilities. Tools: Nmap, Shodan, Censys.	2	2
15	**Dark Web Threat Monitoring and Intelligence** Objective: Use open-source tools to gather and analyze intelligence from the dark web to identify potential threats and data leaks. Activities: • Set up and use the Tor browser and Tails OS for secure access to the dark web. • Explore and crawl hidden services and directories using OnionSearch and Ahmia. • Identify and report on data leaks or threats related to a fictional organization. • Analyze and assess the credibility of threats found in dark web forums or marketplaces. Tools: Tor browser, OnionSearch, Ahmia, Tails OS.	2	2
16	**Threat Intelligence for IoT Devices** Objective: Analyze vulnerabilities and threats specific to IoT devices using TI frameworks. Activities: • Scan IoT devices using Shodan and assess vulnerabilities. • Cross-reference findings with CVEs and TI feeds. • Propose mitigation measures for discovered risks. Tools: Shodan, NVD, Censys.	3	2
17	**Cyber Threat Hunting with Open-Source Tools** Objective: Conduct cyber threat hunting activities using open-source intelligence frameworks. Activities: Use tools like Zeek and ELK Stack for analyzing network traffic; identify indicators of compromise through threat hunting practices. Tools: Zeek, ELK Stack.	3	2
18	**Open Source Vulnerability Assessment** Objective: Perform vulnerability assessments using open-source tools and resources. Activities: Use tools like OpenVAS to scan systems for vulnerabilities; analyze CVE details and suggest remediation measures. Tools: OpenVAS, NVD (National Vulnerability Database).	3	2

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19	**Cyber Threat Attribution** Objective: Use open-source tools to attribute cyber threats to specific actors or groups. Activities: Correlate IOCs with historical threat actor data. Use threat attribution frameworks to link activities to known APT groups. Simulate presenting attribution findings in a formal report. Tools: MITRE ATT&CK, MISP, Maltego CE.	1	2
20	**Mini Project** Investigate and analyze a real-world or simulated cyber threat scenario using Open-Source Intelligence (OSINT) and Threat Intelligence techniques to uncover vulnerabilities, track malicious actors, or identify indicators of compromise. The project should leverage open-source tools to collect, analyze, and correlate data from multiple sources, aiming to propose actionable recommendations for mitigating identified risks." **Examples of Potential Projects:** 1. Tracking Phishing Campaigns: Investigate email phishing activities and map associated domains, emails, and metadata. 2. Dark Web Data Leak Monitoring: Identify and report on leaked information related to a fictional or real-world organization. 3. Social Media Influence Mapping: Analyze the influence of social media trends on a geo-political event. 4. IoT Security Assessment: Identify vulnerabilities in IoT devices using Shodan and propose mitigation strategies. 5. E-commerce Fraud Analysis: Investigate fraudulent sellers or scam websites using OSINT tools.		
		Total	**26 Hrs**

Note: List of experiments above is indicative, and any 10-12 Labs Can be covered and mini-project for this lab is Mandatory.

Lab:

ISE:

1. ISE-1 will be conducted on 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Remaining 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Miniproject/Innovative experiment for 10 marks

Recommended Books:

1. Bazzell, Michael. (2022). *Open Source Intelligence Techniques: Resources for Searching and Analyzing Online Information* (8th ed.).
2. Recorded Future. (2023). *The Threat Intelligence Handbook: A Practical Guide for Security Teams to Unlocking the Power of Intelligence* (4th ed.). CyberEdge Press.
3. Costa-Gazcón, Valentina. (2021). *Practical Threat Intelligence and Data-Driven Threat Hunting: A Hands-On Guide to Threat Hunting with the ATT&CK™ Framework and Open Source Tools*. Packt Publishing.

Online Resources:

1. OSINT Framework: https://osintframework.com/

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2. Maltego Tutorials: https://www.maltego.com/
3. https://www.bu.edu/tech/files/2020/08/BU-Security-Camp-2020-OSINT.pdf
4. https://datajournalism.com/read/handbook/verification-3/investigating-actors-content/how-to-analyze-social-media-accounts
5. https://gijn.org/resource/reporters-guide-investigating-digital-threats-introduction/
6. https://www.howtogeek.com/devops/how-to-use-osint-to-protect-your-organization/
7. https://osintia.com/15-essential-steps-to-set-up-and-use-virtual-machines-for-osint-a-comprehensive-guide-part-1/
8. https://optiminvestigators.com/the-social-sleuth-a-comprehensive-guide-to-conducting-effective-social-media-investigations/
9. https://www.maltego.com/blog/everything-about-social-media-intelligence-socmint-and-investigations/
10. https://thesecmaster.com/blog/a-step-by-step-guide-to-building-your-first-osint-program
11. https://www.neotas.com/osint-framework/
12. https://flashpoint.io/blog/how-to-build-an-osint-strategy/
13. https://www.raebaker.net/blog/getting-started-with-osint-a-beginners-guide
14. https://kalilinuxtutorials.com/seekr/
15. https://gijn.org/resource/reporters-guide-investigating-digital-threats-introduction/

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25OE13CE41	**Advanced Microprocessor**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	15	50	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		PCC12CE05	
Course Outcomes		CO1	Understand the fundamental concepts of RISC architecture and critically analyze its design principles compared to CISC architecture.
		CO2	Apply the knowledge of ARM processor architecture to develop and optimize embedded system applications.
		CO3	Demonstrate the ability to design and implement efficient interrupt handling mechanisms for advanced microprocessor systems
		CO4	Apply the concepts of virtual memory and the functionality of ARM Memory Management Units (MMU) to manage memory efficiently in complex systems.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Advance Microprocessor**		5
	1.1	Compare RISC and CICS Processors, Overview of Modern microprocessors INTEL, AMD, ARM, architecture.		
	1.2	RISC ARCHITECTURE: Hybrid Architecture – RISC and CISC Convergence, Advantages of RISC,		
	1.3	Basic features of RISC Processors, Design Issues of RSIC Processors, Performance Issues in Pipelined Systems.		
2.		**ARM Processor Fundamentals**		4
	2.1	ARM Registers, Current Program Status Registers, ARM Pipeline, Exceptions, Interrupt and vector table		
	2.2	ARM Processor Families: Features and comparison of ARM processor series.		
3.		**ARM Exception and Interrupt Handling**		7
	3.1	Exception Handling: Types and priorities of exceptions., Interrupts, Interrupt Handling Schemes: Interrupt latency and context switching.		

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	3.2	Memory Protection units: Protected Regions, Initialization of MPU, Use of Caches and write buffer.		
	3.3	Memory Management Units: How Virtual Memory Works, ARM MMU Details: page tables, Translation Lookaside buffer, Memory domains and access permission, Caches and write buffers		
Total				**16**

Course Assessment:
Theory:
ISE-1:
Activity: Quiz 10 Marks
ISE-2: 10 Marks
Activity: Presentation on Research Papers

MSE: One hours 15 Marks written examination based on 50% syllabus
ESE: One hours 15 Marks written examination based on remaining 50% syllabus

Lab:
 ISE: -1-will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
 ISE: -2-Will be conducted for next Four experiments. Continuous pre-defined rubrics-based evaluation for 30 marks.

 Suggested list of experiments
1. Program using ARM LPC 21XX to blink leds connected on I/O ports.
2. Program to transmit a string using the serial port of the LPC 21XX.
3. Program to generate a square wave of pulse width 100 ms using the timer of LPC 21XX.
4. program the ARM LPC 2138 RTC to display current time and date on LCD.
5. Timer Configuration and Delay Generation
   a) Write a program to configure timers for generating specific time delays.
   b) Implement a program to toggle an LED based on a timer interrupt.
   c) Measure the time elapsed between two events using timers.
6. UART Communication
   a) Configure UART for sending and receiving data.
   b) Write a program to send "Hello, World!" over UART and display it on a terminal.
   c) Create a program to echo received data back to the terminal.
7. Hardware-1
8. Hardware-2

Recommended Books:
[1] K. M. Bhurchandani and A. K. Ray, "Advanced Microprocessors and Peripherals", McGraw Hill
[2] ARM Architecture Reference Manual" by David Seal
[3] The Definitive Guide to ARM Cortex-A Series" by Joseph Yiu -
[4] ARM System Developer's Guide: Designing and Optimizing System Software" by Andrew N. Sloss, Dominic Symes, and Chris Wright -

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[5]   ARM Assembly Language: Fundamentals and Techniques" by
        William Hohl -
[6]   "Computer Organization and Design: The Hardware/Software
        Interface – ARM Edition"
        Authors: David A. Patterson, John L. Hennessy
[7]   "Modern Operating Systems"
        Author: Andrew S. Tanenbaum, Herbert Bos
[8] .   "Embedded Systems: Real-Time Interfacing to ARM Cortex-M
        Microcontrollers"
        Author: Jonathan W. Valvano

Reference Books
1   "The Definitive Guide to ARM Cortex-M Processors"
        Author: Joseph Yiu
2   "Memory Systems: Cache, DRAM, Disk"
        Author: Bruce Jacob, Spencer Ng, David Wang
3   "Real-Time Embedded Systems: Design Principles and Engineering
        Practices"
        Authors: Xiaocong Fan

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P		L	T	P	Total
		1	--	2		1	--	1	2
25OE13CE42	**Internet of Things**					**Examination Scheme**			
			ISE1	MSE		ISE2	ESE	Total	
		Theory	10	15		10	15	50	
		Lab	20	--		30	--	50	

Pre-requisite Course Codes		PCC12CE05	
Course Outcomes	CO1	Explain the fundamentals of IoT and Industry 4.0, including their architectures, protocols, and applications.(Cognitive Level: Understand)	
	CO2	Apply networking and communication protocols like MQTT, CoAP, and LoRa to design efficient IoT systems.(Cognitive Level: Apply)	
	CO3	Analyze the requirements for IoT system design and development, integrating hardware platforms and software tools for real-world applications.(Cognitive Level: Analyze)	
	CO4	Use appropriate tools to process and visualize real-time data.(Cognitive Level: Apply)	
	CO5	Examine emerging trends such as AI in IoT, edge computing, and 5G to identify their potential impact on IoT and Industry 4.0 ecosystems. (Cognitive Level: Analyze)	

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Module 1: Introduction to IoT and Industry 4.0**	1	3
	1.1	Concepts of IoT: Architecture, protocols, and standards.		
	1.2	Industry 4.0 Fundamentals: Smart factories, cyber-physical systems (CPS), and digital twins.		
	1.3	IoT Applications: Smart cities, healthcare, agriculture, and autonomous systems.		
	1.4	Technological Pillars of Industry 4.0: IoT, AI, big data, and robotics integration		
2		**Module 2: IoT Protocols and Networking**	1	3
	2.1	Networking Basics for IoT: IP-based and non-IP-based protocols.		
	2.2	IoT Communication Protocols: MQTT, CoAP, HTTP, LoRa, Zigbee, BLE, and 6LoWPAN.		
	2.3	Edge and Fog Computing: Concepts and role in IoT data processing		
	2.4	Security in IoT Networks: Challenges and solutions.		
		Module 3: IoT System Design and Development		
3		**IoT System Design and Development**	2	3
	3.1	IoT Hardware Platforms: Arduino, ESP32, and Raspberry Pi.		

	3.2	IoT Software Tools: IDEs, Node-RED, and cloud platforms (AWS IoT, Google Cloud IoT).		
	3.3	Sensor and Actuator Integration: Types, working, and interfacing techniques.		
	3.4	Design Methodologies: Energy efficiency, scalability, and fault tolerance.		
		Module 4: IoT Data Management and Analytics	3	3
4	4.1	Data Analytics: Role of big data and machine learning in IoT. Visualization Tools: Grafana, Tableau, and Power BI.		
	4.2	IoT Data Lifecycle: Acquisition, transmission, storage, and visualization		
	4.3	IoT Databases: Time-series databases and NoSQL		
		Module5:Industry 4.0 Use Cases and IoT Applications, Future Trends and Emerging Technologies	4	3
5	5.1	Smart Manufacturing: Automation, predictive maintenance, and robotics.		
	5.2	IoT in Logistics and Supply Chain: RFID, smart tracking, and inventory management.		
	5.3	IoT in Renewable Energy: Smart grids, monitoring, and optimization		
	5.4	AI in IoT: Role of machine learning and deep learning. 5G and IoT: Opportunities and challenges. Edge AI: Combining IoT devices with AI at the edge. Sustainability in IoT: Energy-efficient frameworks and green IoT.		
Total				**15**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	1	Experiment: Setup and Configuration of an IoT Development Board Objective: Install and configure ESP32 or Raspberry Pi for IoT projects. Tools: Arduino IDE, Python.		2
2	2	Experiment: Implement MQTT for Sensor Data Communication Objective: Transmit real-time sensor data to a cloud platform using MQTT. Tools: MQTT.fx, HiveMQ.		2
	3	Experiment: Compare IoT Protocols (CoAP vs. MQTT) Objective: Analyze energy consumption and latency differences between protocols. Tools: Python, Wireshark.		
	4	Experiment: LoRa Communication Setup		2

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		Objective: Establish communication between two LoRa nodes and measure range. Tools: LoRa modules, Arduino IDE.	
3	5	Experiment: Interfacing Sensors and Actuators Objective: Interface temperature, humidity, and motion sensors with ESP32 to trigger an actuator. Tools: Arduino IDE, Blynk App.	2
	6	Experiment: Build a Smart Home Automation System Objective: Control appliances using voice commands via Google Assistant. Tools: ESP32, Node-RED, Google API.	4
	7	Experiment: IoT-Based Energy Monitoring Objective: Monitor and analyze household energy consumption in real-time. Tools: ESP32, Current Sensor, ThingSpeak.	4
4	8	Experiment: IoT Data Visualization Using Grafana Objective: Collect sensor data and visualize it in Grafana dashboards. Tools: InfluxDB, Grafana.	2
	9	Experiment: Real-Time IoT Data Analytics Objective: Perform basic analytics on IoT data (e.g., finding temperature trends). Tools: Python, Pandas, Matplotlib.	2
			6
5	10	INDUSTRIAL VISIT	
Total			**26**

Course Assessment:

Theory:

ISE-1:

Activity: Quiz and assignments 10 Marks

Case Study Presentation

ISE-2: Two hours 10 Marks

Activity: Article Discussion, Quiz and Assignments

Outcome: Reflective Journal

MSE: One hour 15 Marks written examination based on 50% syllabus

ESE: One hour 15Marks (remaining 50% syllabus) written examination based on remaining syllabus

Lab:

ISE:

1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

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b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:

[1] Arshdeep Bahga, Vijay Madisetti "Internet of Things: A Hands-On Approach" Publisher: Orient Blackswan Private Limited - New Delhi

[2] Peter Waher, "Mastering Internet of Things: Design and Create Your Own IoT Applications", Packt Publishing (March 28, 2018); eBook (Free Edition)

[3] Perry Lea," "IoT and Edge Computing for Architects: Implementing Edge and IoT Systems from Sensors to Clouds with Azure IoT and AWS IoT Core", Publisher(s): Packt Publishing ISBN: 9781839214806

[4] Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Publisher New York, NY : Apress

[5] "David Hanes, Gonzalo Salgueiro, Rob Barton," IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" Released June 2017Publisher(s): Cisco Press ISBN: 978013430709

Online Resources:

https://onlinelibrary.wiley.com/doi/book/10.1002/9781119740780?msockid=0d711fd0b8706 2382ca90a8bb9c26374(Print ISBN:9781119740759 Online ISBN:9781119740780 |DOI:10.1002/9781119740780)

Further Reading:

1. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things"
2. Klaus Schwab, "The Fourth Industrial Revolution"

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		1	--	2	1	--	2	2
25OE13CE43	Supply Chain Management	Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	15	50	
		Practical	20	--	30	--	50	

Pre-requisite Course Codes	None	
Course Outcomes	CO1	Importance of Supply Chain Management (SCM) and its phases in any business.
	CO2	Identify the drivers of supply chain performance and uncertainty in supply chain management.
	CO3	Understand the core model and distribution technique in Supply chain
	CO4	Understand IT framework, strategies and techniques to minimize overall logistics cost
	CO5	Understand the role of digitization in supply chain management leading to sustainability

Module No.	Topics	Ref	Hrs.
1	Objectives of a Supply Chain Management, Value Chain Process and Cycle view of Supply Chain Process, Push Pull in SC, Design Phases stage, logistics & SCM		02
2	Supply Chain Drivers /decisions and obstacles, Supply chain strategies & strategic fit.		03
3	SCOR Model, Factors influencing distribution network design, Design options for distribution network		02
4	IT Framework and sustainable Supply Chain management, data analysis in SC, IoT role in SC		03
5	Blockchain in: Warehouse Management System (WMS), Transport Management System (TMS), ERP (SAP) and integration of technology, Logistics Vs Reverse Logistics		03
	Total		**13**

Course Assessment:

Theory:
  ISE-1: Quiz (10 Marks)
  ISE-2: Quiz (10 Marks)
  MSE: 60 Minutes of written examination based on 50% syllabus (15 Marks)

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ESE: 60 Minutes of written examination based on the rest of the syllabus covered after MSE (15 marks)

Practical:
ISE:

1. **ISE-1**

   Assignment write up / presentation on
   - Supply Chain Drivers: Strategic fit and Uncertainty
   - Supply Chain Management and its Components in modern Business

   OR
   - Supply Chain Network Design: Facility location analysis, distribution center network optimization
   - Procurement Strategies: Sourcing, supplier selection, negotiation tactics
   OR
   - One assignment each on module 1, 2 and 3. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2**
   - Enterprise Resource Planning (ERP) Systems: Functionality, data integration, modules relevant to SCM
   - Blockchain Technology in SCM: Traceability, transparency, smart contracts
   OR
   - Sustainable Supply Chain Practices: Environmental considerations in sourcing and logistics
   - Transportation Management Systems (TMS): Route planning, carrier selection, shipment tracking
   OR
   - One assignment each on module 4, 5 and 6 followed by Presentation by groups based on recent updates on SC.
   AND
   - Data Analytics in SCM: Data mining, visualization, predictive modeling for supply chain decision-making

Reference Books:

1. Sunil Chopra, P. Meindl, "Supply Chain Management", 6th Edition 2016, Pearson Education Asia.
2. D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, and Ravi Shankar, "Designing and Managing the Supply Chain concepts, Strategies and Case studies", 3rd Edition, Tata McGraw Hill, New Delhi, 2008
3. Rahul V Altekar, "Supply Chain Management: Concepts and cases", Edition 2009, PHI, ISBN: 9788120328594. Quality Control, 3rd edition, D. H. Besterfield, Pearson Education (2012).
4. R.P. Mohanty, S.G. Deshmukh, "Essentials of Supply Chain management", 1st Edition 2004, Jaico Publishing House.
5. Priyanka Chawla, Adarsh Kumar, Anand Nayyar, Mohd Naved "Blockchain, IoT, and AI Technologies for Supply Chain Management", Edition 1, CRC Press.

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		1	--	2	1	--	2	2
25OE13CE44	**Design of Experiments**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	15	50	
		Practical	20	--	30	--	50	

Pre-requisite Course Codes	None	
Course Outcomes	CO1	Learner will be able to plan data collection, to turn data into information and to make decisions that lead to appropriate action
	CO2	Learner will be able to plan and analyse full factorial Experiments
	CO3	Learner will be able to plan and analyse fractional factorial Experiments
	CO4	Learner will be able to apply principles of Robust Design

Module No.	Topics	Ref	Hrs.
1	Introduction 1.1 Strategy of Experimentation 1.2 Typical Applications of Experimental Design 1.3 Guidelines for Designing Experiments		02
2	Two-Level Factorial Designs and Analysis 2.1 The 2^2 Design 2.2 The 2^3 Design 2.3 The General 2^k Design 2.4 A Single Replicate of the 2^k Design		03
3	Two-Level Fractional Factorial Designs and Analysis 3.1 The One-Half Fraction of the 2^k Design 3.2 The One-Quarter Fraction of the 2^k Design 3.3 The General 2^{k-p} Fractional Factorial Design		02
4	Taguchi Approach 4.1 Crossed Array Designs and Signal-to-Noise Ratios 4.2 Analysis Methods 4.3 Robust design examples		03
5	5.1 Latin Square Designs 5.2 Conducting ANOVA 5.3 Regression Analysis 5.4 Response Surface Methodology		03

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	Total		13

Course Assessment:
Theory:

ISE-1:	**Quiz (10 Marks)**	
ISE-2:	**Quiz (10 Marks)**	
MSE:	**60 Minutes of written examination based on 50% syllabus (15 Marks)**	
ESE:	**60 Minutes of written examination based on the rest of the syllabus covered after MSE (15 marks)**	

Practical:

Sr No	Assignment write up / presentation on/Case Study/Mini Project/Computer Based Analysis using suitable Software	No of Hours	ISE Evaluation
1	Deciding Strategy of Experimentation	4	ISE 1_Continuous pre-defined rubrics-based evaluation for 20 marks.
2	Full Factorial Experiment	4	
3	Fractional Factorial Experiment	4	
4	Taguchi's Robust Design Methodology	4	ISE 2_Continuous pre-defined rubrics-based evaluation for 30 marks.
5	Latin Square Design	4	
6	ANOVA	4	
	Total	24 Hours	

REFERENCES:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd 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
6. Quality Engineering Using Robust Design, Madhav S.Phadke

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		1	--	2	1	--	1	2
25OE13CE45	**E-Vehicle**	Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	15		
		Practical	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Describe significance of Electric vehicle for sustainability.
	CO2	Design and modelling of EV power train.
	CO3	Describe Electric motor speed control and regenerative braking.
	CO4	Describe battery monitoring and thermal protection.
	CO5	Describe vehicle control units and communication protocols.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Electric Vehicles**	1,2	3
	1.1	Introduction to Electric vehicles, Advantages and significance of EVs, motors and power electronics		
	1.2	Different powertrain configuration of EVs and Hybrid vehicles.		
		Components of EV Powertrain	1,2	
2				6
	2.1	Vehicle modelling, Vehicle dynamics , drive cycle ,Basics of Power train simulation.		
	2.2	Sizing and specifications of different sub-systems, Role of Power Electronics and Motors in EVs.		
3		**EV Motor Drive and Control:**	1,4,5	6
	3.1	Introduction to different types of motors used in EVs and their comparison, Selection of Electric motor .		
	3.2	Overview of speed control of BLDC and PMSM, Regenerative braking concept, energy saving		
4		**Battery Packs and Battery management System**	1,4,5	6
	4.1	Different battery technologies, Advantages of Lithium ion battery , Battery pack , Battery specifications and selection criteria.		

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	4.2	Battery monitoring and Protection , Thermal management, circuits and techniques for Battery management system (BMS)		
5		**Vehicle Control and Communication**		3
	5.1	Features and functionality of Vehicle Control Unit, Architecture and Protocols of VCUs, Communications requirements		
		EV Safety & Standards:		2
6	**6.1**	Safety aspects and protection arrangements, International and national standards		
			Total	**26**

Module No.	Sr. no	Suggested List of experiments	Ref.	Hrs.
	1	Study of different powertrain configuration.	1,2	2
	2	Vehicle modelling and Simulation .	1,2	3
	3	Drive cycle simulation and plot under various driving conditions.	1,2	2
	4	Design of simple battery charger circuit.	1,2	2
	5	Design of Thermal protection circuit for EV.		3
	6	Study of Electric motor speed control.		3
	7	Mini project , case study :-Design and simulation study of any EV model available in the market.		5
			Total	**20**

Course Assessment:
Theory:
      ISE-1:
Activity: Quiz and assignments 10 Marks
Practical assignment
ISE-2: 10 Marks
Activity: Crossword, MCQs, Quiz and Assignments
Outcome:

MSE: 60 minutes 15 Marks written examination based on 50% syllabus
ESE:60 minutes 15 Marks written examination based on the remaining syllabus after MSE

Lab:
      ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

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2. ISE-2
    a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
    b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

Recommended Books:
1. Ali Emadi, "Advanced Electric Drive Vehicles", CRC Press, 2015
2. Mehrdad Ehsani, Yimin Gao and Ali Emadi, "Modern electric, hybrid electric and fuel cell vehicles : fundamentals, theory and design", CRC Press ; 2010 (available in IITB library)
3. James Larminie, John Lowry "Electric Vehicle Technology Explained", John Wiley & Sons Ltd, 2003 (available in IITB library)
4. Rodrigo Garcia-Valle, Joao A. Pecas Lopes, "Electric Vehicle Integration into Modern Power Networks", Springer, 2013
5. Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", Taylor & Francis, 200

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		1	-	2	1	--	1	2
25OE13CE46	**3D Printing**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	10	15	10	15	**50**	
		Tutorial	20	--	30	--	**50**	

Pre-requisite Course Codes		Basic manufacturing.
Course Outcomes	CO1	Illustrate understanding of various cost-effective alternatives for manufacturing products and select the feasible 3D Printing for specific technical application
	CO2	Understand and apply the principles of liquid-based rapid prototyping and tooling processes to build and generate data for additive manufacturing of various objects.
	CO3	Understand and apply the principles of solid-based rapid prototyping systems for efficient 3D Printing and product development.
	CO4	Understand and apply the principles of powder-based 3D Printing systems for efficient prototyping and production of complex geometries.
	CO5	Understand and apply reverse engineering techniques in additive manufacturing to reconstruct, modify, and optimize existing designs for manufacturing and prototyping.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	**1.1**	Introduction to 3D Printing, its historical development, advantages. Classification of 3D Printing process, Advantages & Disadvantages, Applications to various fields, Rapid Tooling, Design Consideration.	1-8	3
2	**2.1**	**Liquid-Based Systems:** Stereolithography (SLA): Photopolymerization process, Working Principle, Material used, Advantages and limitation, Application	1-8	3
3	**3.1**	**Solid based system:** FDM (Fused Deposition Modelling) System: Working Principle, Material used, Advantages and limitation, Application.	1-8	2
4	**4.1**	**Powder Based Systems:** SLS (Selective Laser Sintering): Working Principle, Material used , Advantages and limitation, Application.	1-8	3
5	**5.1**	**Reverse Engineering:**		2

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		Data Extraction, Data Processing.		
		Total	**13**	

Tutorial:

Sr. No.	Tutorial Details	Hours
1	Modelling of a component using 3D modelling software	3
2	Segmentation in Slicer's Segment Editor module for the purpose of 3D printing.	2
3	Application of various design considerations in 3D component printing.	4
4	Development of physical 3D component using any one of the Additive manufacturing processes	4
	Total Hours	**13**

Course Assessment:
Theory:
>
> **ISE-1:**
> Activity: Quizzes/Assignment on first two modules (10 Marks)
> **ISE-2:**
> Activity: Quizzes/Assignment on last three modules (10 Marks)
> **MSE:** 60 Minutes of written examination based on 50% syllabus (15 Marks)
> **ESE:** 60 minutes 15 Marks written examination based on remaining syllabus after MSE

Practical:
> 1. **ISE-1**
>   First 2 Practical's (20 marks)
>   Continuous pre-defined rubrics-based evaluation for 20 marks.
> 2. **ISE-2**
> i.   Next 2 Practical's (30 marks)
>   Continuous pre-defined rubrics-based evaluation for 30 marks

Recommended Books:

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications",
2. World Publishing Co. Pte. Ltd.
3. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid
4. Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.
5. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer
6. RafiqNoorani, Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., 2006, ISBN 0-471-73001-7
7. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems", Kluwer Academic Publishers.
8. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.

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Links for online NPTEL/SWAYAM courses:

1. https://onlinecourses.nptel.ac.in/noc24_me138/preview
2. https://onlinecourses.nptel.ac.in/noc22_me74/preview
3. https://onlinecourses.nptel.ac.in/noc22_me130/preview
4. https://onlinecourses.nptel.ac.in/noc25_mm02/preview

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PCC13CE15	**Distributed Computing**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	25PCC13CE13
	Student will be able to
	CO1 Design and implement scalable distributed systems.
	CO2 Develop communication models using RPC, RMI, and messaging frameworks.
	CO3 Apply synchronization techniques for coordination in distributed environments.
Course Outcomes	CO4 Optimize resource management through load balancing and process migration.
	CO5 Implement replication, consistency, and fault-tolerance strategies.
	CO6 Deploy distributed applications using containerization and cloud-based technologies.

Module No.	Unit No.	Topics	Ref.	Hrs.
		Introduction to Distributed Systems		
1	1.1	Need of Distributed Systems: Issues, Goals, and Types of distributed systems, Hardware and Software Concepts: NOS, DOS. Middleware: Services offered by middleware.	[1][4]	2
	1.2	Types of Distributed Systems: Cloud Computing, Edge Computing, Serverless Computing.	[1][4]	2
	1.3	Modern Middleware: Containerization (Docker), Kubernetes, API Gateways.	[1][4]	2
		Communication		
2	2.1	Remote Procedure Call (RPC), Remote Method Invocation (RMI).	[1][4]	2
	2.2	Message Oriented Communication, Stream Oriented Communication, Group Communication.	[1][4]	2
		Synchronization		
3	3.1	Clock Synchronization: Physical clocks, Logical Clocks, Bully Election Algorithm.	[1][2]	2
	3.2	Mutual Exclusion: Distributed Mutual Exclusion-Classification of Mutual Exclusion Algorithms, Requirements of Mutual Exclusion Algorithms, Token Based Algorithms and Non-Token based Algorithms, Performance measures.	[1][2]	2

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		Resource and Process Management		
4	**4.1**	Task assignment approach, Load balancing approach, load sharing approach.	[2][3]	2
	4.2	Introduction to process management, Process Migration, Code Migration.	[2][3]	2
		Consistency, Replication and Fault Tolerance		
5	**5.1**	Introduction to replication and consistency, Data-Centric and Client-Centric Consistency Models, Replica Management.	[1][2][5]	2
	5.2	Fault Tolerance: Introduction, Process resilience, Reliable client-server and group communication, Recovery.	[1][2][5]	2
		Distributed File Systems		
6	**6.1**	Introduction, File models, File Accessing models, File-Caching Schemes, File Replication.	[1][2][5]	2
	6.2	Distributed File Systems & Object Storage: Google File System (GFS), HDFS, Amazon S3, IPFS.	[1][2][5]	2
			Total	**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	**1**	Implement a multithreaded Server with clients	[1][4]	2
	2	Implement an RPC client and server	[1][4]	2
2	**3**	Implement an RMI client and server	[1][4]	2
	4	Implement a message-passing system using a middleware framework (e.g., Apache Kafka or RabbitMQ).	[1][4]	2
3	**5**	To implement Election Algorithm.	[1][2]	2
	6	To implement Mutual Exclusion/Clock synchronization algorithms.	[1][2]	2
4	**7**	Design and implement a distributed file system that allows multiple nodes to share and access files in a distributed environment.	[2][3]	2
	8	Implement a simplified version of the MapReduce framework for distributed processing	[2][3]	2
5	**9**	Implementation of Stateful/Stateless servers	[1][2][5]	2
	10	Explore container orchestration tools (e.g., Kubernetes) and deploy a distributed application using containerization.	[1][2][5]	2
		Case Study		
6	**11**	Load Balancing in Cloud Computing	[2][3]	2
	12	SAP HANA Multiple-Host System	[1][2][5]	4
			Total	**26**

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Course Assessment:
Theory:

> **ISE-1:**
> Activity: Quiz and Assignments//Paper Presentation/Article Discussion - 20 Marks
> **ISE-2:**
> Activity: Quiz and Assignments/Paper Presentation/Article Discussion - 20 Marks
>
> **MSE:** 90 minutes, 30 Marks written examination based on 50% syllabus**.**
> **ESE:** 90 minutes, 30 Marks written examination based on remaining syllabus after MSE.

Lab:
1. ISE-1: Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2:
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Case Study: Presentation/ Reflection Journal for 10 marks.

Recommended Books:

[1] Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, 4th edition, Pearson Education, 2023.
[2] Mukesh Singhal, Niranjan G. Shivaratri, "Advanced concepts in operating systems: Distributed, Database and multiprocessor operating systems", MC Graw Hill education, 1994.
[3] Pradeep K. Sinha, "Distributed Operating System-Concepts and design", PHI, 2nd Edition, 2007.
[4] M. L. Liu, ―Distributed Computing Principles and Applications‖, Pearson Addison Wesley, 1st Edition, 2004.
[5] George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems: Concepts and Design", Pearson Education, 4th Edition, 2005.

Online Resources:
[1] https://nptel.ac.in/courses/106106107
[2] https://nptel.ac.in/courses/106106168
[3] http://csis.pace.edu/~marchese/CS865/Lectures/Chap7/Chapter7fin.htm 4.
[4] https://nptel.ac.in/courses/106104182
[5] https://link.springer.com/article/10.1007/s42044-024-00183-y
[6]https://help.sap.com/docs/SAP_HANA_PLATFORM/6b94445c94ae495c83a19646e7c3fd56/d5b6
4eaebd0d4220900ce5404eabca67.html

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PCC13CE16	**Software Engineering**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		PCC13CE13	
Course Outcomes	CO1	Apply appropriate software engineering process models for effective software project development.	
	CO2	Analyze and specify software requirement of a software system in an SRS document.	
	CO3	Apply strategies to effectively plan, schedule, and monitor project progress.	
	CO4	Apply software design concepts to create architectural, user interface, and component-level designs using appropriate patterns and styles.	
	CO5	Identify risks and manage the change to assure quality in software projects.	
	CO6	Apply testing strategies and techniques to a software system.	

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction To Software Engineering and Process Models:** Software engineering- a layered technology, Process Framework and Umbrella Activities, Capability Maturity Model (CMM)	1,2	6
	1.2	Prescriptive Process Models: Waterfall model, Incremental Process Models, Evolutionary Process Models: RAD, Spiral, Prototyping	1,2,5	
	1.3	Agile process model: Agile Principles, Scrum, Kanban, Extreme Programming (XP)	1,2,6	
2	2.1	**Software Requirements Analysis and Modelling:** Types of requirements- Functional and Nonfunctional requirements, system and user requirements, requirement elicitation methods, Requirement Engineering process.	1,2	4
	2.2	Software Requirement Specification document format (IEEE)	1,2	
	2.3	Requirement Modelling: Scenario based Models, Behavioral models, Data flow diagram.	1,4	
3	3.1	**Project estimation, Tracking and Scheduling:** Project Estimation techniques-LOC, FP, COCOMO II	1,6	5

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	3.2	Project Scheduling and Tracking: Defining a Task Set for the Software Project, Gantt Chart, Program Evaluation Review Techniques (PERT), Tracking the Schedule		
4	**4.1**	**Design Engineering:** Software design concepts, design model	1,3	6
	4.2	Architectural Design, User interface design, Component level design, Architectural styles and Patterns.	1,6	
5	**5.1**	**Software Risk & Quality Management** Software Risk, Types of Risk, Risk Identification, Risk Assessment, Risk Projection, RMMM Plan.	1,2	5
	5.2	Software Quality Assurance Task, SCM process, change and version control, Formal Technical Review (FTR), Walkthrough.	1,5,6	
6	**6.1**	**Software Testing:** Unit testing, Integration testing, Validation testing, System testing	1,2,6	4
	6.2	Testing Techniques: white-box testing- Basis path, Control structure testing Black-box testing: Graph based, Equivalence partitioning, Boundary value analysis	1,2,6	
	6.3	Types of Software Maintenance, Re-Engineering, Reverse Engineering	1,2	
Total				**30**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	**1**	Apply different process models (Waterfall, Iterative, Incremental and Spiral) to a selected case study and compare their effectiveness in terms of time, flexibility, and quality.	1,2	2
2	**2**	Gather requirements for a sample software system using requirement elicitation methods and document them in IEEE format. (SRS document)	1,2,4	3
	3	Develop UML diagrams (use case, activity, sequence, DFD etc.) for a selected case study.	1,2,4	3
3	**4**	Estimate size, cost and effort for a selected case study using function point method.	1,6	2
	5	Estimate size, cost and effort for a selected case study using COCOMO Model.	1,6	2
	6	Create a project plan using Gantt and PERT for a software development project and track progress.	1,6	2
	7	Use any project management tool like JIRA, Trello, Asana etc. to learn project management principles and manage the lifecycle of a selected case study.	1,6	3
4	**8**	Design the architecture of a selected case study using architectural styles and patterns.	1,4	2
	9	Design a user interface for a selected case study focusing on usability and accessibility.	1,4	3
	10	Create a component level design of a chosen software system.	1,4	2
5	**11**	Conduct a risk assessment for a software project and create a Risk Mitigation and Management Plan (RMMM).	1	2

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12	Experiments based on manual and automated software testing		
			26

Course Assessment:

Theory:

ISE-1:

Activity: Quiz, Prototype building activity, assignments - 20 Marks

ISE-2: Two hours 20 Marks

Activity: Article Discussion, Quiz and Assignments, software failure analysis case study etc.

MSE: 90 minutes 30 Marks written examination based on 50% syllabus

ESE: 90 minutes 30 Marks written examination based on remaining 50% syllabus after MSE

Lab:

ISE:

1. **ISE-1** will be conducted for five or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. **ISE-2**

   a. Remaining five experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 30 marks.

   b. demonstration of open-source tools used at various levels of SDLC

Recommended Books:

[1] Roger Pressman, "Software Engineering: A Practitioner's Approach", 9th edition , McGraw-Hill Publications, 2019

[2] Ian Sommerville, "Software Engineering", 9th edition, Pearson Education, 2011

[3] Ali Behfrooz and Fredeick J. Hudson, "Software Engineering Fundamentals", Oxford University Press, 1997

[4] Grady Booch, James Rambaugh, Ivar Jacobson, "The unified modeling language user guide", 2nd edition, Pearson Education, 2005

[5] Pankaj Jalote, "An integrated approach to Software Engineering", 3rd edition, Springer, 2005

[6] Rajib Mall, "Fundamentals of Software Engineering", 5th edition, Prentice Hall India, 2014

[7] Jibitesh Mishra and Ashok Mohanty, "Software Engineering", Pearson, 2011

[8] Ugrasen Suman, "Software Engineering – Concepts and Practices", Cengage Learning, 2013

[9]Waman S Jawadekar, "Software Engineering principles and practice", McGraw Hill Education, 2004

Online Resources:

1) Software Engineering specialization by the Hong Kong university of Science and Technology
https://www.coursera.org/specializations/software-engineering

2) https://nptel.ac.in/courses/106/105/106105182/

3) https://onlinecourses.nptel.ac.in/noc19_cs69/preview

4) https://www.mooc-list.com/course/software-engineering-introduction-edx

5) https://www.geeksforgeeks.org/software-engineering/

6) https://www.atlassian.com/software/jira

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned		
		L	T	P	L	T	P	Total
		0	0	2	0	0	1	1
25PCC13CE17	Artificial Intelligence Lab	Examination Scheme					
		ISE	MSE	ISE	ESE	Total	
		20		30		50	

Pre-requisite Course Codes	BSE11CE02	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Formulate a problem and build intelligent agents
	CO2	Apply appropriate searching techniques to solve a real-world problem.
	CO3	Analyze the problem and infer new knowledge using suitable knowledge representation schemes.
	CO4	Develop Expert System on real-world problems.

Exp. No.	Name of the experiment	Ref	Hrs
LIST OF SUGGESTED EXPERIMENTS			
1.	**Aim:** To Solve classical problems for a given database of facts and rules using Prolog. **Objective:** To get the basic idea of how to program in prolog and its working environment.	1, 2	2
2.	**Aim:** Implement and Demonstrate Depth First Search Algorithm on Water Jug Problem. **Objective:** Generate production rules for the given problem. There is no measuring equipment available and jugs do not have any kind of markings. Using two given jugs, agents' task is to fill the X-gallon jug with Y-gallons of water. Consider both jugs are empty initially.	1, 2	2
3	Aim: Implement and Demonstrate Best First Search Algorithm on Missionaries-Cannibals Problems using Python/Prolog **Objective:** Generate production rules for the given problem. To implement and demonstrate a Best First Search (BFS) algorithm on the Missionaries and Cannibals problem using Python or Prolog, the primary objectives are: to design a state representation, define valid actions/transitions between states, implement a heuristic function to prioritize promising states, and then use BFS to find the optimal solution path that safely transports all missionaries and cannibals across the river while adhering to the problem constraints; ensuring the solution is presented in a clear and understandable format, including the sequence of moves taken to reach the goal state.	1, 2	2

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4	**Aim:** Implement A* Search algorithm on Monkey Banana Problem **Objective:** List the constraints so that the monkey can take the bananas. To solve this problem using AI techniques, represent the problem in terms of states, actions, and goals. Represent the moves for each state. The search strategy has to be devised using A* Algorithm.	1, 2	2
5	**Aim:** Implementation of TSP using heuristic approach **Objective:** You are given a list of cities and distances between them, the starting city and the destination city. You are allowed to visit all the cities only once each. Your objective is to find the shortest path to reach the destination.	1, 2	2
6	**Aim:** Implementation of the problem-solving strategies: either using Forward Chaining or Backward Chaining **Objective:** The forward and backward chaining techniques are well-known reasoning concepts used in rule-based systems in Artificial Intelligence. The forward chaining is data driven, and the backward chaining is goal-driven reasoning methods. The matching process between facts and rules, and the conflict resolution strategy in forward chaining are used for a given problem.	1, 2	2
7	**Aim:** Implement resolution principle on FOPL related problems **Objective:** Resolution is a procedure with the empty clause as the search goal. Generate a resolution proof tree to find empty clause, starting from the clauses generated from the axioms and the negation of the theorem. This strategy defines the policy for picking two clauses for resolution. This strategy is complete if its use guarantees that the empty clause is derived.	1, 2	2
8	**Aim:** Implement 8-Puzzle problem using Python/Prolog **Objective:** This problem will have a given initial state and goal state. This puzzle can be solved by moving the tiles one by one in the single empty space to achieve the goal state. **(Calculate Heuristic values of each node to calculate cost function (f=g+h)**	1, 2	2
9	Aim: Implement any Game and demonstrate the Game playing strategies Objective: Implement any Game of your choice which serves as a guiding framework for game developers, helping them shape the gameplay mechanics, level design, and overall structure of the game.	1, 2	2
10.	**Aim:** WAP in prolog for medical diagnosis. **Objective:** To explain how a particular conclusion is reached and why requested information is needed during consultation.	1, 2	2
11.	**Aim:** To construct a Bayesian Network for a given problem to draw inference.		

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	Objective: For any dataset construct a Bayesian Network for the same. Draw the inference about possibility of event happing in future. Observe the changes in probabilities as the network is built.		
Mini Project/Case studies: (Suggested list)			
12	Mini Project/ Case studies to perform using Python/Prolog or any other tool (2/3 students per group). For possible ideas refer the following list. 1. Alibaba: Using Artificial Intelligence to Power the Retail and Business-To- Business Services of The Future 2. Amazon: Using Deep Learning to Drive Business Performance 3. McDonald's: Using Robots and Artificial Intelligence to Automate Processes 4. Walmart: Using Artificial Intelligence to Keep Shelves Stacked And Customers Happy 5. LinkedIn: Using Artificial Intelligence to Solve the Skills Crisis 6. Netflix: Using Artificial Intelligence to Give Us a Better TV Experience 7. Siemens: Using Artificial Intelligence and Analytics to Build the Internet of Trains 8. Tesla: Using Artificial Intelligence to Build Intelligent Cars		

Course Assessment:
Lab:
ISE:
1. ISE-1 will be conducted for four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Will be conducted on remaining Four experiments. Continuous pre-defined rubrics-based evaluation for 15 marks.
b. Simulation using modern tools to solve the given problem statement for 15 marks Mini project/ case studies.

Recommended Books:
   1. Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig, Pearson, Fourth Edition, Pearson Education, 2020.
   2. Prolog Programming for Artificial Intelligence, Ivan Bratko, Addison-Wesley Publishers Limited, 1986.
   3. Artificial Intelligence in Practice: How 50 Successful Companies Used AI and Machine Learning to Solve Problems, Bernard Marr, Matt Ward, Wiley, ISBN: 978-1-119-54898-0 April 2019

Online Resources:
   3. https://www.kdnuggets.com/2019/11/10-free-must-read-books-ai.html
   4. https://www.udacity.com/course/knowledge-based-ai-cognitive-systems--ud409
   5. https://nptel.ac.in/courses/106/105/106105077/
   6. https://nptel.ac.in/courses/106/105/106105078/
   7. https://thestempedia.com/blog/simple-ai-and-machine-learning-projects-for-studentsand-beginners/
   8. https://nptel.ac.in/courses/106/105/106105079/
   9. https://onlinecourses.swayam2.ac.in/nou23_cs14/preview

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PECL13CE26	**Software Testing and Quality Assurance Lab**	0	0	2	0	0	1	1
		Examination Scheme						
		ISE1	MSE	ISE2	ESE	Total		
		20		30		50		

Pre-requisite Course Codes	BSE11CE02, 25PCC13CE16	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Apply software testing techniques across different, Test Levels and Types
	CO2	Implement Black Box and White Box Testing and its techniques
	CO3	Design and execute effective test cases
	CO4	Implement Performance, Mobile, Security and API testing
	CO5	Utilize industry standards tools in Selenium WebDriver, Test Link, Appium, JIRA, Bugzilla, JMeter, SOAPUI, OWASP ZAP

Exp. No.	Name of the experiment	Ref	Hrs
	Module 1: Introduction to Software Testing		
1	**Theory :** Definition of Software Testing, Importance of Software Testing , Testing Levels (Unit Testing, Integration Testing, System Testing, Acceptance Testing),Types of Software Testing (Manual vs. Automated), Testing Life Cycle (SDLC & STLC), Defect Life Cycle, Verification and Validation , Exhaustive Testing. **Practical:** Use a tool like **JIRA** to track and manage defects. Implement a simple test case for Unit Testing in **TestNG** Compare different SDLC models (Waterfall, Agile, V-Model).	1,2	
	Module 2: Testing Techniques		
2	**Theory :** Black Box Testing Techniques-Equivalence class partitioning, Boundary Value Analysis, Cause Effect Graphing, Decision Table Testing, Error Guessing, State Transition Testing, Use Case Based Testing. White Box Testing Techniques-Statement Coverage, Decision Coverage **Practical:** **Problem 1: Age Validation System** You are testing an age validation system where the user needs to input their age, and the system validates if the user is eligible to vote. The valid age range is 18 to 100 years (inclusive). The system should: - Return "Eligible to vote" if the age is between 18 and 100. - Return "Not eligible to vote" if the age is below 18 or above 100. 1. Identify the equivalence partitions for this system. 2. Create test cases based on these partitions.		

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Problem 2: Bank Account Deposit System

You are testing a bank deposit system where the minimum deposit amount is $50, and the maximum deposit amount is $5000. The system should:

- Accept deposits between $50 and $5000.
- Reject deposits that are below $50 or above $5000.
1. Identify the boundary values.
2. Create test cases for the system based on boundary value analysis.

Problem 3: Discount System for a Shopping Cart

You are tasked with testing a **Discount System** for a retail e-commerce platform. The system provides discounts based on the following conditions:

1. **Customer Type**:
   o Regular customer.
   o Premium customer.
2. **Order Value**:
   o Order value greater than or equal to $100.
   o Order value less than $100.
3. **Discount Rules**:
   o **Regular customer**:
      ▪ Order value >= $100 → 5% discount.
      ▪ Order value < $100 → No discount.
   o **Premium customer**:
      ▪ Order value >= $100 → 10% discount.
      ▪ Order value < $100 → 2% discount.
1. Create a **decision table** based on the above conditions and rules.
2. Write test cases that cover all the possible combinations.

Problem 4:

You are testing an **Online Account Locking System** that locks a user's account after three failed login attempts. The system follows the following state transitions:

- **State 1**: User is in **Initial State** (Account is unlocked).
   o **Event**: User attempts to log in with incorrect credentials.
   o **Action**: Transition to **Failed Attempt State 1** (1 failed attempt).
- **State 2**: **Failed Attempt State 1** (1 failed attempt).
   o **Event**: User attempts to log in again with incorrect credentials.
   o **Action**: Transition to **Failed Attempt State 2** (2 failed attempts).
- **State 3**: **Failed Attempt State 2** (2 failed attempts).
   o **Event**: User attempts to log in again with incorrect credentials.
   o **Action**: Transition to **Account Locked State** (Account is locked).
- **State 4**: **Account Locked State** (Account is locked).
   o **Event**: User attempts to log in again with incorrect credentials.

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- o **Action**: Stay in **Account Locked State** (Account remains locked).
- o **Event**: User resets the password.
- o **Action**: Transition back to **Initial State** (Account is unlocked).
1. Draw the **state transition diagram** for this system.
2. Create test cases to cover all possible state transitions and conditions.

Problem 5: **Online Shopping Cart System**
Problem Description:
You are testing the **Online Shopping Cart System** for a retail website. A user can perform the following actions:
1. **Add an item to the cart**.
2. **Remove an item from the cart**.
3. **Proceed to checkout**.
4. **Apply a discount coupon**.
5. **Place an order**.

There are different types of users:
- **Guest User** (not logged in).
- **Registered User** (logged in).

The **Use Case** for the system:
1. A **Guest User** can browse items but cannot place an order without logging in.
2. A **Registered User** can:
   - o Add items to the cart.
   - o Remove items from the cart.
   - o Apply a discount coupon.
   - o Place the order.
   - o Complete the payment process.
1. Identify **primary use cases** for both Guest and Registered Users.
2. Write **test cases** based on the use cases, covering different user actions and scenarios.

Problem 6: Cause-Effect Graph Testing Problem: ATM Withdrawal System
You are testing an ATM Withdrawal System where the following conditions apply:
- The system accepts PIN (4-digit number).
- A user can withdraw an amount (multiples of $10) from their account.
- If the withdrawal is successful, the ATM dispenses the cash.
- If the account has insufficient funds or the amount is invalid, an error is displayed.
- If the PIN entered is incorrect, the system displays an error and allows 3 retry attempts.

Conditions:
- Correct PIN: The user enters the correct 4-digit PIN.
- Incorrect PIN: The user enters an incorrect PIN (up to 3 attempts).
- Account Balance: The user has sufficient funds in their account.

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	• Invalid Amount: The withdrawal amount is not a multiple of $10 or is higher than the available balance. 1. Identify the causes (conditions) and effects (results) of the system. 2. Create a Cause-Effect Graph for this system. 3. Write test cases based on the cause-effect graph. Problem 7: Statement coverage and Decision Coverage Take a piece of code in python say find if the number is positive, negative , zero ,even or odd number. **Questions:** **Statement Coverage**: What are the minimal test cases required to achieve 100% statement coverage? **Decision Coverage**: What are the minimal test cases required to achieve 100% decision coverage?		
Module 3: Test Case Design		
3	**Theory:** What is a Test Scenario Components of Test Cases Writing Good Test Cases Types of Test Cases (Positive, Negative, Boundary Value, etc.) Equivalence Partitioning Boundary Value Analysis		
	Practical: **Writing Test Cases**: Create test cases for a login page manually and using an automation tool Identifying Test Scenarios: Identify test scenarios for Flight Reservation Application **Test Case Execution**: Execute the created test cases manually on a sample application as well as using selenium webdriver **Equivalence Partitioning & Boundary Value Analysis**: Apply these techniques to create effective test cases. Use selenium webdriver to apply the above techniques for any website. Test the website function with multiple data values. Use selenium webdriver to automate parametrization.		
Module 4: Manual Testing		
4	**Theory** Manual Testing vs. Automated Testing Types of Manual Testing (Functional, Non-Functional, Usability, Regression, Compatibility testing, Recovery testing , Installation testing)Bug reporting and tracking **Practical** • **Manual Testing on Web Application**: Test a basic web application (e.g., a login or registration form) using manually created test cases. • **Defect Reporting**: Report defects using a bug tracking tool like **Bugzilla**. • **Test Execution**: Perform regression testing manually after bug fixes using selenium webdriver		

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Module 5: Introduction to Automation Testing			
5	**Theory** Need for Test Automation Benefits and Challenges of Automation Automation Testing Tools (Selenium, Appium, etc.) When to Automate vs. Manual Testing Benefits and Risks of Automation Tools TDD Test Automation Framework **Practical** Basic Selenium Script: Write a Selenium WebDriver script to open a webpage and perform basic operations (e.g., clicking a button, checkbox, radio button , link , filling out a form). Test Automation Framework: Set up a simple test automation framework using TestNG . Simple Automation Scripts: Write scripts for web browser actions (clicking, typing, verifying text). Alert and Popup window handling using selenium webdriver, POM and page factory in selenium webdriver. How to Drag and Drop in Selenium WebDriver.		
Module 6: Performance Testing			
6	**Theory** Importance of Performance Testing Load Testing, Stress Testing, and Volume Testing Performance Testing Tools (JMeter) Key Performance Metrics (Response Time, Throughput, etc.) **Practical** Load Testing with JMeter: Use JMeter to create a test plan and simulate virtual users accessing a website. Analyze Performance Metrics: Capture and analyze performance metrics during a load test.		
Module 7: Mobile Testing			
7	**Theory** Mobile Testing Basics (Difference Between Mobile and Web Testing) Types of Mobile Testing (Functional, Performance, Usability) Tools for Mobile Testing (Appium) **Practical** Basic Mobile Testing with Appium: Write a script to automate testing for a mobile application (Android or iOS).		
Module 8: API testing			
8	**Theory** Introduction to APIs (REST, SOAP) Tools for API Testing (Postman, SoapUI) Creating Test Cases for APIs Validating API Responses (Status Codes, Response Body, etc.) **Practical**		

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	API Testing with Postman: Test a simple API (GET, POST requests) and validate the response. Automating API Tests: Write automated tests for APIs using SOAP UI.		
Module 9: Introduction to Test Management Tool		
9	**Theory:** What is Test Link Advantages of Test Link Creating a Test Project Creating a Test Plan Creating Test Suite Creating Test Cases Creating a Build **Practical:** Perform Hands on Test Link		
Module 10: Security Testing		
10	**Theory:** Common Security Vulnerabilities (SQL Injection, XSS, CSRF) Security Testing Types (Penetration Testing, Vulnerability Scanning) Tools for Security Testing (OWASP ZAP, Burp Suite) **Practical:** SQL Injection Testing: Use tools like **OWASP ZAP** to test for SQL injection vulnerabilities on a web application. Vulnerability Scanning: Perform a basic vulnerability scan using **OWASP ZAP** to detect common security flaws		
Module 11: Quality Assurance and Standards			
11	**Theory:** Definition and importance of Quality Assurance (QA) Difference between Quality Assurance, Quality Control, and Testing What is Quality Assurance Quality models and frameworks (ISO 9001, CMMI, Six Sigma, TQM) Test Metrics such as Defect Density, Defect Discovery Rate, Code Coverage, Requirement Coverage, Test Case Coverage **Practical:**		
12	**Web Application Functional Testing** • Project Description: Choose a simple web application (e.g., a login page, registration form, or e-commerce site) and perform functional testing. The goal is to validate if the application performs as expected, based on given requirements. • Testing Focus: • Manual functional testing of the main features (e.g., login, registration, password reset). • Positive and negative test cases. • Boundary testing for input fields. • Tools: • JIRA or Trello for bug tracking. • Selenium for automated functional testing.		

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	• Deliverables:
	  • Test Plan and Test Cases.
	  • Bug reports in JIRA.
	  • Test Execution Report.			

Recommended Books:
1. Software Testing: Principles, Techniques and Tools by M. G. Limaye
2. Foundations of Software Testing by Dorothy Graham, Erik van Veenendaal, Isabel Evans, Rex Black

Online Resources:
1. Website link
   https://www.softwaretestinghelp.com/
   https://www.geeksforgeeks.org/
   https://www.guru99.com/
   https://www.stickyminds.com/
   https://softwaretestingfundamentals.com/
   https://softwaretestingmentor.com/

Further Reading:
1. Software Testing: Ron Patton
2. Hands-On Mobile App Testing – 2nd Edition: A guide for mobile testers and anyone involved in the mobile app business
3. Lessons Learned in Software Testing: A Context-Driven Approach by Cem Kaner , James Bach
4. Art of software Testing-By Glenford Myers

Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	L	T	P	Total
		--	--	4	--	--	2	2
25VSE13CE04	Cloud Computing Lab	Examination Scheme						
		ISE1	MSE	ISE2	ESE			Total
		50	--	50	--			100

Pre-requisite Course Codes	25PCC13CE11, 25PCC13CE13,	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Analyze cloud computing service models and develop real-world web applications for deployment on commercial cloud platforms.
	CO2	Apply various virtualization techniques in practical scenarios.
	CO3	Create and deploy real-world web applications on commercial cloud platforms.
	CO4	Implement serverless solutions with messaging services like AWS Lambda, SQS, and SNS for event-driven architectures.
	CO5	Explore key security mechanisms in the cloud and propose solutions to mitigate associated challenges.
	CO6	Apply the principles of containerization to practical implementations.

Exp. No.	Name of the experiment	Ref	Hrs
Cloud basics			
1	**Title: Introduction and overview of cloud computing.** Objective: To understand the origin of cloud computing, cloud cube model, NIST model, characteristics of cloud, different deployment models, service models, advantages and disadvantages	3	2
Virtualization			
2	**Title: To study and implement Hosted Virtualization using VirtualBox& KVM.** Objective: To know the concept of Virtualization along with their types, structures and mechanisms. This experiment should have demonstration of creating and running Virtual machines inside hosted hypervisors like VirtualBox and KVM with their comparison based on various virtualization parameters.	3	2
3	**Title: To study and Implement Bare-metal Virtualization using Xen, HyperV or VMware Esxi.** Objective: To understand the functionality of Bare-metal hypervisors and their relevance in cloud computing platforms. This experiment should have demonstration of install, configure and manage Bare Metal	3	

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

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

Lab:

ISE:

1. ISE-1 will be conducted on 50% of experiments/Assignments. Continuous pre-defined rubrics-based evaluation for 50 marks.

2. ISE-2

a. Remaining 50% of experiments/Assignments. Continuous pre-defined rubrics-based evaluation for 40 marks.

b. Mini-project/Innovative experiment for 10 marks

Recommended Books:

1. Bernard Golden, "Amazon Web Services for Dummies", John Wiley & Sons, Inc.
2. Michael Collier, Robin Shahan, "Fundamentals of Azure, Microsoft Azure Essentials", Microsoft Press.
3. RajkumarBuyya, Christian Vecchiola, S ThamaraiSelvi, "Mastering Cloud Computing", Tata McGraw-Hill Education.
4. Barrie Sosinsky, "Cloud Computing Bible", Wiley publishing ,John Paul Mueller, "AWS for Admins for Developers", John Wiley & Sons, Inc.

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6. Ken Cochrane, Jeeva S. Chelladhurai, NeependraKhare , "Docker Cookbook - Second . Edition", Packt publication
7. Jonathan Baier, "Getting Started with Kubernetes-Second Edition", Packt Publication

Online Resources:

Website link :

Docker Containers and Kubernetes Fundamentals – Full Hands-On Course

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

Docker and Kubernetes Tutorials Playlist

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

Docker and Kubernetes Tutorial for Beginners

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

Complete Kubernetes Tutorial for Beginners

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

NPTEL link :

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

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

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

Certification link :

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

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PCC13CE19	**Cryptography and System Security**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		25PCC13CE11
Course Outcomes	CO1	Apply concepts of modular arithmetic and number theory to classical encryption techniques to achieve system security goals.
	CO2	Apply modern cryptographic techniques to a given problem
	CO3	Analyze various hash functions and digital signature algorithms to authenticate and verify integrity
	CO4	Analyze various attacks on network security, and different security protocols.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction - Number Theory and Basic Cryptography**	1,2	**8**
	1.1	Security Goals, Security Attacks, Security Services and Security Mechanisms		
	1.2	Modular Arithmetic: Prime No, Euclidean Algorithm, Extended Euclidean Algorithm		
	1.3	Classical Encryption techniques, mono-alphabetic and polyalphabetic ciphers.		
	1.4	Substitution techniques: Vigenère cipher, Playfair cipher, Hill cipher, transposition techniques: keyed and keyless transposition ciphers		
2		**Symmetric and Asymmetric key Cryptography and key Management**	1,2	**6**
	2.1	Block cipher principles, DES, Double DES, Triple DES		
	2.2	Stream Ciphers: RC4 algorithm		
	2.3	Public key cryptography: Principles of public key cryptosystems- The RSA Cryptosystem		
	2.4	Symmetric key agreement: Diffie Hellman Key Exchange		
	2.5	Public key Distribution: Digital Certificate: X.509, PKI		
3		**Cryptographic Hash Functions**	1,2	**3**
	3.1	Cryptographic hash functions, Properties of secure hash function, MD5, SHA-1		
	3.2	MAC, HMAC		
4		**Authentication Protocols and Digital Signature Schemes**	1,2	**4**

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	4.1	Symmetric Key Distribution: Needham-Schroeder protocol(symmetric), Kerberos Authentication protocol		
	4.2	RSA as a Digital Signature		
5		**Network and System Security**	2,4	**5**
	5.1	Network security basics: TCP/IP vulnerabilities (Layer wise)		
	5.2	Network Attacks: Packet Sniffing, ARP spoofing, port scanning, IP spoofing		
	5.3	Denial of Service: DOS attacks, ICMP flood, SYN flood, UDP flood, Distributed Denial of Service		
	5.4	Firewall Characteristics Types of Firewalls, Intrusion Detection Systems: Host based and Network Based IDS		
	5.5	SSL and IPSEC :AH , ESP		
	5.6	**System Security:** Buffer Overflow, malicious Programs: Worms and Viruses, SQL injection, Trojan Horse		
			Total	**26**

Module No.	Sr.no	Suggested List of experiments (Any 10)
1	**1**	Design and Implementation of a product cipher using Substitution and Transposition ciphers
2	**2**	Implementation and analysis of public key cryptography.
	3	Implementation of Diffie-Hellman Key exchange algorithm.
3	**4**	For varying message sizes, test integrity of message using MD-5, SHA-1, and analyse the performance of the two protocols.
4	**5**	Implementation and analysis of Digital signature scheme
	6	Implementation of Salt and Pepper password protection technique
	7	Implement Needham Schroeder authentication protocol.
5	**8**	Explore the GPG tool of Linux to implement email security
	9	Study and Implement SQL Injection
	10	Study and Implement DOS Attacks
	11	Using NMAP for ports monitoring.
	12	Using open SSL for web server - browser communication.
	13	Explorer Kali Linux operating system and explain any one tool of kali Linux
	14	EXPLORING N-STALKER : To download the N-Stalker Vulnerability Assessment Tool and exploring the features.

Course Assessment:
Theory:
ISE-1: Activity: Regular Quizzes 20 Marks
ISE-2: Two hours 20 Marks
        Activity: Article Discussion, Assignments
        Outcome: Reflective Journal
MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks (remaining 50% syllabus) written examination

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Lab:
ISE:
1. ISE-1 Continuous pre-defined rubrics-based evaluation for experiments (20 marks)
2. ISE-2 Simulation using modern tools or mini project (30 marks)

Recommended Books:

[1] Cryptography and Network Security, Atul Kahate, Tata McGraw-Hill Education, Fourth Edition, 2003.
[2] Cryptography and Network Security: Principles and Practice, William Stallings, Pearson Education, 8th Edition.2020
[3] Cryptography and Network Security, Behrouz A. Forouzan & Debdeep Mukhopadhyay, 3rd Edition, McGraw Hill.
[4] Network Security Bible, Eric Cole, Wiley Publication, Second Edition, 2009

Video Lectures
1. http://nptel.ac.in/courses/106105031/ lecture by Dr. Debdeep MukhopadhyayIIT Kharagpur
2. https://archive.nptel.ac.in/courses/106/105/106105162/
3. https://www.geeksforgeeks.org/cryptography-and-network-security-principles/

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Course Code	Course Name		Teaching Scheme (Hrs/week)				Credits Assigned			
			L	T	P		L	T	P	Total
			2	1	--		2	1	--	3
25PE13CE21	**Decentralized Finance**					Examination Scheme				
			ISE1	MSE	ISE2	ESE		Total		
		TH	20	30	20	30		100		
		TU	20	--	30	--		50		

Pre-requisite Course Codes		25PEC13CE11
Course Outcomes	CO1	Explain basics of DeFi and the various tokens.
	CO2	Discuss DeFi components, its primitives and metrics.
	CO3	Describe DeFi architecture, ecosystem and protocols, and risks and challenges involved in DeFi.
	CO4	Describe how DeFi protocols are used for exchange of tokens.
	CO5	Discuss applications and dark side of DeFi.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Introduction:** Difference between Centralized and Decentralized Finance, the DeFi ecosystem, problems that DeFi solves	1, 2, Link4, Link5	2
	1.2	Fungible and non-fungible tokens (NFT), ERC20 and ERC721 tokens, their comparison, Initial Coin Offering (ICO), Security Token Offering (STO)		3
2	2.1	**DeFi Components**: Blockchain, Cryptocurrency, Smart Contract platform, Oracles, stablecoins **DeFi primitives:** Transactions, Supply adjustment, Bonding curves, Incentives, and Keepers, Collateralized Loans, Flash Loans	1, 2	3
	2.2	**DeFi key metrics**: Total Value Locked, Daily Active Users, Market Cap		1
3	3.1	**DeFi Architecture:** Consumer Layer: Blockchains, Cross-Blockchain networks, Oracles, **Digital Asset Layer:** Cryptocurrencies, Infrastructure Layer: Wallets and Asset Management, DEXes and Liquidity, Lending and Borrowing, Prediction Markets, Synthetic Assets, Insurance	1, 2, 3	2
	3.2	**DeFi EcoSystem and Protocols:** On-chain Asset Exchange, Loanable Fund Markets on-chain assets, Stablecoins, Portfolio Management, Derivatives, Privacy-preserving mixers		2
	3.3	**DeFi Risk and Challenges:** Security Risks, Liquidity Risks, Regulation Risk, smart contract risk, scaling risk		2
4	4.1	**Maker DAO**: Maker Protocol: Dai Stablecoins, Maker Vaults, Maker Protocol Auctions	1, 2, Link6,	5

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		Maker Actors: Keepers, Price Oracles, Emergency Oracles, DAO Teams, Dai Savings Rate	**Link7, Link8**	
	4.2	**UniSwap:** UniSwap Protocol Overview: How UniSwap Works, EcoSystem Participants, Smart Contracts **UniSwap Core Concepts**: Swaps, Pools, Flash Swaps, Oracles		
	4.3	**wBTC and technology**: Need for wBTC: Tokenization and common Issues, Users, Minting, Burning wBTC Governance, wBTC vs Atomic Swaps, Fees, Legal Binding, Trust Model and Transparency		
5	5.1	DeFi Applications: Real World Assets, Asset Management, Compliance and Know Your Transactions (KYT)	**1,2 Link1,**	1
	5.2	Criminalities in DeFi space, DeFi security practices		2
6	6.1	Decentralized Insurance Decentralized Exchanges Decentralized Synthetix		3
			Total	**26**

Recommended Books:

1. How to DeFi, Darren Lau, Daryl Lau, Teh Sze Jin, Kristian Kho, Erina Azmi, TM Lee, Bobby Ong-1st Edition, March 2020
2. DeFi and the Future of Finance-Campbell R. Harvey
3. DeFi Adoption 2020 A Definitive Guide to Entering the Industry

Useful Links:
6.   https://www.binance.com/en/research/analysis/real-world-assets
7.   https://research.binance.com/static/pdf/navigating-defi-derivatives-.pdf
8.   https://docs.soliditylang.org/
9.   https://ethereum.org/en/developers/docs/standards/tokens/erc-20/
10. https://ethereum.org/en/developers/docs/standards/tokens/erc-721/
11. https://makerdao.com/da/whitepaper/
12. https://uniswap.org/
13. https://wbtc.network/assets/wrapped-tokens-whitepaper.pdf

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Suggested list of experiments: (Minimum 10)

Sr. no.	Suggested Experiments
1	Creation of ERC20 and ERC721 tokens and ERC20 token exchange
2	Setting up a DApp Environment
3	Implementation of Decentralized Application (DApp)
4	Digital Assets Tokenization of Central Bank Digital Currency (CBDC)
5	Implementation of Blockchain Applications for Central Bank Digital Currencies (CBDC)
6	Implementation of Metaverse
7	Implementation of KYC for banks
8	Implementation of DApp for insurance
9	Case study of blockchain in FinTech industry
10	Case study of Aave protocol
11	Case study of Compound/Yearn Finance

Course Assessment:
Theory:
ISE-1:
Activity: Quiz/Assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion/Quiz/Assignments/Seminar
MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE

Tutorials: (6 Nos.)
ISE1: 20 marks based on first five practical as per the predefined rubrics
ISE2: 30 marks based on remaining five practical as per the predefined rubrics

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	–	2	2	--	1	3
25PEC13CE22	**LLM and GenAI**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	–	30	--	50	

Pre-requisite Course Codes		PCC12CE09 (Analysis of Algorithms), BSC12CE06 (Linear Algebra and Statistics)
Course Outcomes	CO1	Apply foundational concepts of Neural Networks and Deep Learning to implement basic Generative AI models
	CO2	Utilize Transformer-based architectures (BERT, GPT, T5, LLaMA) for text generation and NLP tasks.
	CO3	Implement Generative AI frameworks using Python, TensorFlow, PyTorch, and Hugging Face for model training and deployment.
	CO4	Develop applications of Generative AI in image, video, and text generation, such as chatbots, DeepFakes, and AI-assisted content creation.
	CO5	Demonstrate an understanding of AI ethics, bias mitigation, and adversarial robustness in real-world AI applications.
	CO6	Apply emerging Generative AI techniques, including multimodal AI, low-resource models, and AutoGPT, for real-world industry solutions.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Foundations of Generative AI and Large Language Models** Evolution of AI & Machine Learning, Basics of Neural Networks and Deep Learning, Introduction to Generative Models (GANs, VAEs, Transformers), Key Architectures: RNNs, LSTMs, Attention Mechanisms, Pre-training & Transfer Learning in LLMs	1, 2	4
2	2.1	**Generative AI Models and Their Architectures** Overview of Transformer-based Models, BERT, GPT, T5, LLaMA, and their Variants, Diffusion Models for Image and Video Generation, Self-Supervised Learning & Prompt Engineering, Training and Fine-Tuning Strategies for LLMs	1, 2	6
3	3.1	**Tools and Frameworks for Generative AI** Python Libraries: TensorFlow, PyTorch, Hugging Face Transformers, Model Deployment: ONNX, TFLite, and Cloud Platforms (AWS, GCP, Azure), AutoML and No-Code AI Platforms, Techniques for Optimizing AI Models for Efficiency, Hands-on with Model Training & Fine-Tuning	3,4	4
4	4.1	**Applications of Generative AI in Real-World Domains**	5,8	5

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		Text Generation: Chatbots, Summarization, Code Generation, Image & Video Generation: DeepFakes, Style Transfer, Art Generation, Audio & Speech: Voice Cloning, Music Composition, AI for Science: Drug Discovery, Material Synthesis, Healthcare; Generative AI in Finance & Business		
5	5.1	**Ethical Considerations, Security, and Risks in Generative AI** Bias and Fairness in AI Models, Misinformation, Deepfakes, and Societal Impacts, AI Copyrights, Intellectual Property, and Licensing Issues, AI Safety: Adversarial Attacks, Hallucinations, and Guardrails, Responsible AI Development & Governance	6,7	4
6	6.1	**Future Directions & Emerging Trends in Generative AI** Multimodal AI (e.g., Gemini, GPT-4V, CLIP), Efficiency in Large Models (Sparse Models, Mixture of Experts), Role of AI Agents and AutoGPT, Low-Resource LLMs & Democratization of AI, Quantum AI and Beyond	8,9	3
Total				**26**

Module No.	Sr.no	Suggested List of Experiments	Ref.	Hrs
1	1	Implementing an Attention Mechanism in Sequence Models	1,2	2
	2	Comparing Pre-training and Transfer Learning in Neural Networks. (Use a pre-trained model (e.g., MobileNet, ResNet) and fine-tune it on a custom dataset.)		2
2	3	Train a Text Generation Model using GPT-2	1,2	2
	4	Build a Variational Autoencoder (VAE) for Image Generation.		2
	5	Train a DCGAN for Synthetic Face Generation		2
3	6	Develop a Transformer-Based Text Summarization Model	3,4	2
	7	Deploy a Generative AI Model as a Web App		2
4	8	Generate DeepFake Videos using GANs	5,8	2
	9	Train an AI Model for AI-Composed Music using LSTMs		2
	10	Implement Image Captioning with CNNs and LSTMs		2
	11	Develop a Financial News Summarization Tool		1
5	12	Develop a Model for Detecting AI-Generated Text	6,7	1
	13	Analyze Bias in Large Language Models		1
	14	Implement an Adversarial Attack on an AI Model		1
6	15	Optimize a Low-Resource LLM for Edge AI	8,9	1
	16	Experiment with Stable Diffusion for Text-to-Image Generation		1
Total				26

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Course Assessment:
Theory:
ISE-1: 20 Marks
Activity: Quiz / Assignments
ISE-2: 20 Marks
Activity: Presentation / Article Discussion
MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE.

Lab:

ISE-1: Assesses 50% of the experiments. Evaluation is based on continuous assessment using predefined rubrics, totaling 20 marks.

ISE-2: Assesses the remaining 50% of the experiments, following the same continuous rubric-based evaluation, with a total of 30 marks

Recommended Books:

1. **Deep Learning**, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 1st Edition, 2016.
2. **Transformers for Natural Language Processing**, Denis Rothman, Packt Publishing, 1st Edition, 2021.
3. **Generative AI with Python and TensorFlow 2**, Joseph Babcock and Raghav Bali, Packt Publishing, 1st Edition, 2024.
4. **Quick Start Guide to Large Language Models**, Sinan Ozdemir, Addison-Wesley, 1st Edition, 2023.
5. **GPT-3: Building Innovative NLP Products Using Large Language Models**, Sandra Kublik and Eric Nichols, O'Reilly Media, 1st Edition, 2023.
6. **Responsible AI: Implementing Ethical and Unbiased Algorithms**, Shashin Mishra and Sray Agarwal, Wiley, 1st Edition, 2023.
7. **AI Ethics**, Mark Coeckelbergh, MIT Press, 1st Edition, 2020.
8. **Advancements in Generative AI: A Comprehensive Review of GANs, GPT, Autoencoders, Diffusion Models, and Transformers**, Staphord Bengesi et al., Springer, 1st Edition, 2024.
9. **The Alignment Problem: Machine Learning and Human Values, Brian Christian, W. W. Norton & Company, 1st Edition, 2020.**

Online Resources:
1. Hugging Face – The Ultimate LLM and Generative AI Learning Hub
https://huggingface.co/course/
2. Deep Learning Specialization – Andrew Ng (Coursera)
https://www.coursera.org/specializations/deep-learning
3. OpenAI & Google AI Research Papers + Model APIs
OpenAI: https://platform.openai.com/docs/
Google AI: https://ai.googleblog.com/
4. TensorFlow & PyTorch Generative AI Tutorials
TensorFlow: https://www.tensorflow.org/tutorials/generative
PyTorch: https://pytorch.org/tutorials/
5. MIT AI Ethics & Adversarial AI Security Course
https://www.media.mit.edu/projects/ai-ethics/overview/

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PEC13CE23	**Digital Forensics**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		25PCC13CE11, 25PCC13CE13, 25PCC12CE08,
Course Outcomes	CO1	Explain concepts of cybercrime, computer crime, and digital forensics processes.
	CO2	Develop proficiency in forensic techniques, including setting up forensic workstations and acquiring evidence from storage systems.
	CO3	Apply computer forensic tools to analyze artifacts from operating systems or cloud environments.
	CO4	Demonstrate incident response methodology, including network and memory forensics, to trace malicious activity.
	CO5	Analyze network, mobile, and web application forensics.
	CO6	Prepare comprehensive forensic reports, correlating findings across multiple domains, and explore advanced topics through real-life scenarios.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Cybercrime and Computer-crime**	1,2	4
	1.1	Definition and classification of cybercrimes: Definition, Hacking, DoS Attacks, Trojan Attacks, Credit Card Frauds, Cyber Terrorism, Cyber Stalking, Hackers, Crackers, Phreakers.		
	1.2	Definition and classification of computer crimes: Computer Viruses, Computer Worms.		
2		**Introduction to Digital Forensics and Digital Evidences**	1,2	5
	2.1	Introduction to Digital Forensics: Introduction to Digital Forensics and lifecycle, Principles of Digital Forensic, Types of Digital Forensics – Computer Forensic, Network Forensics, Mobile Device Forensics, Database Forensics		
	2.2	Introduction to Digital Evidences: Challenging Aspects of Digital Evidence, Scientific Evidence, Presenting Digital Evidence.		
	2.3	Digital Investigation Process Models: Physical Model, Staircase Model, Evidence Flow Model.		
3		**Computer Forensics**	1,2	3
	3.1	OS File Systems Review: Windows Systems- FAT32 and NTFS, UNIX File Systems, MAC File Systems		
	3.2	Memory Forensics: RAM Forensic Analysis, Creating a RAM		

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		Memory Image, Volatility framework, Extracting Information		
	3.3	Computer Forensic Tools: Types of Computer Forensic Tools, Tasks performed by Computer Forensic Tools		
4		**Incident Response Management, Live Data Collection and Forensic Duplication**	3	5
	4.1	Incidence Response Methodology: Goals of Incident Response, Initial Response, Investigation, Remediation, Tracking of Significant Investigative Information.		
	4.2	Live Data Collection: Live Data Collection on Microsoft windows, Systems Tools: Windows Registry, Event logs.		
	4.3	Forensic Duplication: Forensic Duplicates as Admissible Evidence, Forensic Duplication Tools: Creating a Forensic evidence, Duplicate/Qualified Forensic Duplicate of a Hard Drive.		
5		**Network Forensics and Mobile Forensics**	4	6
	5.1	Network Forensics: Sources of Network-Based Evidence, Principles of Internetworking, Internet Protocol Suite, Evidence Acquisition, Analyzing Network Traffic: Packet Flow and Statistical Flow, Network Intrusion Detection and Analysis, Investigation of Routers, Investigation of Firewalls		
	5.2	Mobile Forensics: Mobile Phone Challenges, Mobile phone evidence extraction process, Android OS Architecture, Android File Systems basics, Types of Investigation, Procedure for Handling an Android Device, Imaging Android USB Mass Storage Devices.		
6		**Advanced Topics and Case Studies**	5,6	2
	6.1	**Cloud Forensics**		
	6.2	**IOT Forensics**		
	6.3	**Case Studies and Practical Examples : Real-life case studies of digital forensic investigations,** Discussion of emerging trends in digital forensics.		
Total				**26**

Suggested List of Experiments	

1.	**Forensic Workstation Setup and Data Acquisition**
	• **Objective**: Set up a forensic workstation and perform data acquisition from storage devices.
	• **Tools**: Ubuntu Linux, Autopsy, Sleuth Kit, Guymager, dd, FTK Imager Lite.
	• **Activities**:
	   o Install Ubuntu Linux and configure forensic tools (Autopsy, Sleuth Kit).
	   o Use Guymager and dd to create disk images.
	   o Verify image integrity with hash values (MD5/SHA-256).
	Document the process with timestamps and chain-of-custody details.

2.	**File System Forensics** • **Objective**: Analyze and recover data from different file systems.

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	• **Tools**: Autopsy, Sleuth Kit.	
	• **Activities**:	
	o Explore NTFS, FAT32, and EXT4 file systems.	
	Recover deleted files and analyze metadata.	
3.	**Windows Forensics**	
	• **Objective**: Investigate forensic artifacts in Windows systems.	
	• **Tools**: RegRipper, FTK Imager Lite.	
	• **Activities**:	
	o Extract and analyze the Windows Registry.	
	Investigate event logs and user activity traces.	
4.	**Linux Forensics**	
	• **Objective**: Conduct forensic investigations on Linux systems.	
	• **Tools**: Sleuth Kit, grep.	
	• **Activities**:	
	o Analyze log files (e.g., /var/log).	
	Recover deleted files from an EXT4 file system.	
5.	**Memory Forensics**	
	• **Objective**: Analyze volatile memory dumps for forensic evidence.	
	• **Tools**: Volatility Framework.	
	• **Activities**:	
	o Extract memory dumps using memdump.	
	Identify processes, hidden artifacts, and malware.	
6.	**Network Forensics**	
	• **Objective**: Capture and analyze network traffic to reconstruct events.	
	• **Tools**: Wireshark, NetworkMiner.	
	• **Activities**:	
	o Capture live traffic and analyze packets.	
	Reconstruct network sessions to identify suspicious activities	
7.	**Mobile Device Forensics**	
	• **Objective**: Extract and analyze data from mobile devices.	
	• **Tools**: Andriller, Autopsy (mobile modules).	
	• **Activities**:	
	o Extract call logs, messages, and app data from Android devices.	
	Analyze mobile backups.	
8.	**Email Forensics**	
	• **Objective**: Recover and analyze email communications.	
	• **Tools**: MIME-Tools, Email Parser.	
	• **Activities**:	
	o Extract and analyze email headers and metadata.	
	Recover deleted emails and attachments.	
9.	**Browser Forensics**	
	• **Objective**: Investigate web browsing history and cached data.	
	• **Tools**: Browser History Capturer, NirSoft Tools.	
	• **Activities**:	
	o Recover browsing history, cookies, and cached files.	
	Analyze artifacts to determine user activity.	

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10.	**Malware Analysis**
	• **Objective**: Analyze malware behavior using static and dynamic methods.
	• **Tools**: REMnux, Cuckoo Sandbox.
	• **Activities**:
	o Perform static analysis on malware samples.
	Use Cuckoo Sandbox for dynamic analysis of malware behavior.
11.	**Cloud Forensics**
	• **Objective**: Investigate forensic artifacts in cloud environments.
	• **Tools**: AWS CloudTrail, Google Cloud Audit Logs.
	• **Activities**:
	o Analyze logs from cloud platforms.
	Investigate user activity and data breaches in the cloud.
12	**Steganography and Data Hiding**
	• **Objective**: Detect and analyze hidden data in digital files.
	• **Tools**: StegExpose, Stegdetect.
	• **Activities**:
	o Use steganalysis tools to uncover hidden data in images and audio files.
	Extract and analyze steganographic content.
	Disk Encryption and Decryption
	• **Objective**: Analyze encrypted disks and decrypt data for forensic analysis.
	• **Tools**: VeraCrypt, Autopsy.
	• **Activities**:
	o Encrypt and decrypt data using VeraCrypt.
	Analyze encrypted disks and extract evidence.
	Incident Response and Log Analysis
	• **Objective**: Investigate a simulated security incident by analyzing logs.
	• **Tools**: Graylog, ELK Stack (Elasticsearch, Logstash, Kibana).
	• **Activities**:
	o Analyze system logs to identify suspicious activity.
	Generate and document a forensic incident report.
	Legal and Ethical Aspects of Forensics
	• **Objective**: Prepare a forensic report while understanding legal and ethical implications.
	• **Tools**: Case studies and reporting templates.
	• **Activities**:
	o Review forensic cases and identify legal challenges.
	Prepare comprehensive reports following ethical standards.

Course Assessment:
Theory:
ISE-1: Activity: Regular Quizzes/Test/ Open Book Test 20 Marks
ISE-2: Two hours 20 Marks
Activity: Group Discussion/Article Discussion/ Case Study/Assignments

MSE: 90 minutes 30 Marks written examination based on 50% syllabus
ESE: 90 minutes 30 Marks written examination based on remaining syllabus after MSE.

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Tutorial:

ISE-1 will be conducted for 50% of experiments/assignments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Will be conducted for remaining experiments/assignments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks OR Research papers analysis presentation.

Recommended Books (Theory):

1. Digital Forensics, Dr. Dhananjay R. Kalbande Dr. Nilakshi Jain, Wiley Publications, First Edition, 2016
2. Digital Evidence and Computer Crime, Eoghan Casey, Elsevier Academic Press, Third Edition, 2011.
3. Incident Response & Computer Forensics, Jason T. Luttgens, Matthew Pepe and Kevin Mandia, McGraw-Hill Education, Third Edition , 2014.
4. Network Forensics: Tracking Hackers through Cyberspace, Sherri Davidoff and Jonathan Ham, Pearson Education,2012
5. Cloud Security: Attacks, Techniques, Tools and Challenges, Emmanuel S Pilli, Preeti Mishra, and R. C. Joshi, CRC Press, 2021
6. IOT Forensics: A Comprehensive Guide to Investigating the Internet of Things, Vijay Gupta, Elnitial Publication,2024

Recommended Books(Practical)

1. Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software, Michael Sikorski and Andrew Honig, No Starch Press, First Edition.
2. Digital Forensics with Open-Source Tools, Cory Altheide and Harlan Carvey, Syngress Media, U.S, First Edition, 2011
3. The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory, Michael Hale Ligh, Andrew Case, Jamie Levy, Aron Walters, Wiley Publication, 1st Edition
4. Practical Mobile Forensics, Satish Bommisetty, Rohit Tamma, Heather Mahalik, Packt Publication, Fourt Edition, 2020
5. The Fascinating World of Digital Evidences, Dr. Nilakshi Jain and Dr. Dhananjay R. Kalbande, Wiley Publication, 2016
6. Advancements in Cybercrime Investigation and Digital Forensics edited by A. Harisha, Amarnath Mishra, and Chandra Singh, Apple Academic Press, 2023

Online Resources (Theory)
1. https://tools.kali.org/
2. https://www.sleuthkit.org/autopsy/
3. https://accessdata.com/product-download/ftk-imager-version-4-3-0
4. https://www.pearsonitcertification.com/articles/article.aspx?p=462199&seqNum=2

Online Resources (Practical)
1. https://www.cfreds.nist.gov/

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2. https://www.sleuthkit.org/autopsy/docs/user-docs/4.15/
3. https://github.com/keydet89/RegRipper3.0
4. https://forensicswiki.xyz/wiki/Linux_Forensics
5. https://volatilityfoundation.org/
6. https://www.wireshark.org/docs/wsug_html_chunked/
7. https://github.com/abrignoni/ALEAPP
8. https://dfir.training/resources-and-tools
9. https://resources.infosecinstitute.com/category/computer-forensics/network-forensics/web-browser-forensics/
10. https://practicalmalwareanalysis.com/

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PEC13CE24	**Business Intelligence**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		25PCC13CE14
		Student will be able to
Course Outcomes	CO1	Explain Business Intelligence (BI) fundamentals and their impact on decision-making.
	CO2	Utilize industry-standard ETL tools for data extraction, transformation, and loading.
	CO3	Work with BI tools for business data visualization.
	CO4	Analyze business efficiency using Data Envelopment Analysis (DEA) and evaluate key performance metrics.
	CO5	Analyze case studies to understand BI applications in different industries.

Module No.	Unit No.	Topics	Ref.	Hrs.
		Introduction to Business Intelligence		
1	1.1	Overview of Business Intelligence, Importance of BI in decision-making, Effective and timely decisions, Data, information and knowledge, The role of mathematical models, Business intelligence architectures, Ethics and business intelligence.	[1]	2
	1.2	Decision support systems- Definition of system, Representation of the decision-making process, Evolution of information systems, Definition of decision support system, Development of a decision support system.	[1]	2
		Data Warehousing & ETL (Extract, Transform, Load)		
2	2.1	Data Warehouse Design & Architectures: Star Schema vs. Snowflake Schema, Fact and Dimension Tables, Slowly Changing Dimensions (SCD).	[2][3]	2
	2.2	ETL (Extract, Transform, Load) Concepts: Data Extraction Techniques, Data Cleaning & Transformation, Data Loading & Optimization, ETL Tools & Technologies: Apache NiFi, Talend, Informatica.	[2][3]	2

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		BI Tools & Technologies		
3	**3.1**	Introduction to BI Tools: Microsoft Power BI, Tableau, QlikView.	[1]	2
	3.2	Data Visualization & Dashboards: Designing Dashboards for Business Users, KPI (Key Performance Indicator) Analysis, Storytelling with Data, Report Generation & Performance Monitoring.	[1][2]	2
		Business Intelligence Applications		
4	**4.1**	Marketing models: Relational marketing, Sales force management.	[1]	2
	4.2	Logistic and production models: Supply chain optimization, Optimization models for logistics planning, Revenue management systems.	[2][3]	2
	4.3	Data envelopment analysis: Efficiency measures, Efficient frontier, The CCR model, Identification of good operating practices.	[2][3]	2
		Advanced BI & Cloud Integration		
5	**5.1**	BI in the Cloud: AWS QuickSight, Google Data Studio, Cloud-based Data Warehousing (Snowflake, BigQuery).	[1]	2
	5.2	Real-Time BI & Streaming Analytics: Apache Kafka for Streaming Data, Apache Spark for Big Data Analytics, Case Studies & Industry Applications, BI in E-commerce, Healthcare, and Finance, Implementing BI in Small & Large Enterprises.	[1][2]	2
			Total	**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	**1**	Implement Data Cleaning and Preparation for Analysis using BI Tool.	[1]	2
	2	Design a basic Decision Support System (DSS) for a real-world business scenario.	[1]	2
2	**3**	Design a data warehouse using both Star and Snowflake schemas for a retail business domain.	[2]	2
	4	Implement an ETL process for transforming raw data into structured data for analysis.	[2]	2
3	**5**	Perform visualization of business data and create interactive dashboards using Power BI.	[1]	2

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	6	Implement a sample data warehouse to handle slowly changing dimensions (SCD Type 1 and Type 2). Simulate the changes in data over time and track those changes using SCD techniques.	[2]	2
4	7	Implement Real-Time Data Analytics Using Apache Kafka.	[1]	2
	8	Create data visualizations and story-driven dashboards using Tableau.	[1]	2
5	9	Implement model and optimize marketing strategies using BI tool.	[3]	2
	10	Implement Cloud-Based BI Solutions Using AWS QuickSight.	[1]	2
		Case Study		
6	11	Decision Support System for Supply Chain Optimization	[1]	3
	12	Customer Segmentation and Market Analysis	[2]	3
			Total	26

Course Assessment:
Theory:
 ISE-1:
 Activity: Quiz and Assignments//Paper Presentation/Article Discussion - 20 Marks
 ISE-2:
 Activity: Quiz and Assignments/Paper Presentation/Article Discussion - 20 Marks

 MSE: 90 minutes, 30 Marks written examination based on 50% syllabus**.**
 ESE: 90 minutes, 30 Marks written examination based on remaining syllabus after MSE.

Lab:
1. ISE-1: Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2:
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
 b. Case Study: Presentation/ Reflection Journal for 10 marks.

Recommended Books:

 [1] Ramesh Sharda, Dursun Delen, and Efraim Turban, *"Business Intelligence: A Managerial Perspective on Analytics"*, Pearson Education, 2014.
 [2] Paulraj Ponniah, *"Data Warehousing Fundamentals"*, Wiley, 2010.
 [3] Ralph Kimball, *"The Data Warehouse Toolkit"*, Wiley, 2013.

Online Resources:
[1] https://www.coursera.org/learn/business-intelligence-fundamentals
[2] https://www.udemy.com/course/power-bi-and-tableau-hands-on-training
[3] https://www.kaggle.com/datasets

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	--	2	2	--	1	3
25PEC13CE25	**Augmented Reality and Virtual Reality**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	Knowledge of C Programming and Basic Mathematics, Computer Graphics.	
Course Outcomes	CO1	Describe how AR systems work and analyze the hardware requirement of AR
	CO2	Analyze and understand the working of various state-of-the-art AR devices.
	CO3	Describe how VR systems work and list the applications of VR
	CO4	Understand the design and implementation of the hardware that enables VR systems to be built.
	CO5	Explain the concepts of motion and tracking in VR systems.
	CO6	Understand the design and implementation of the hardware that enables VR systems to be built.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Terminology and Marker Detection in AR**		4
	1.1	Terminology, Simple augmented reality, Augmented reality as an emerging technology, Augmented reality applications, Marker detection, Marker detection procedure, Pre-processing, Fast acceptance/rejection tests for potential markers, Marker pose, Camera transformation, Camera calibration matrix and optical distortions, Pose calculation, Detection errors in pose calculation, Continuous tracking and tracking stability, Rendering with the pose, Template markers, Template matching, 2D barcode markers, Decoding binary data markers, Error detection and correction for binary markers, Data randomizing and repetition, Barcode standards, Circular markers, Imperceptible markers, Image markers, Infrared markers, Miniature markers, Discussion on marker use, When to use marker-based tracking, How to speed up marker	4,5, 7	

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			detection, How to select a marker type, Marker design, General marker detection application.		
2			**AR Development & Applications**		2
		2.1	User interfaces, Avoiding physical contacts, Practical experiences with head-mounted displays, Authoring and dynamic content, AR applications and future visions, How to design an AR application, Technology adoption and acceptance, Where to use augmented reality	4,5, 6,7	
3			**Introduction to Virtual Reality**		5
		3.1	What is virtual reality? The beginnings of VR, VR paradigms, Collaboration, Virtual reality systems, Representation, User interaction	1,2, 3	
4			**The Geometry of Virtual Worlds.**		5
		4.1	Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations.	1,2, 3	
5			**Motion in Real and Virtual Worlds**		5
		5.1	Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection**.**	1,2, 3	
6			**Applying Virtual Reality (T3)**		5
		6.1	Virtual reality: the medium, Form and genre, What makes an application a good candidate for VR, Promising application fields, Demonstrated benefits of virtual reality, More recent trends in virtual reality application development, A framework for VR application development.	1,2, 3	
				Total	**26**

Exp. No.	Name of the experiment	Ref	Hrs
	LIST OF SUGGESTED EXPERIMENTS		
1.	Installation and setting of Unity, Visual Studio for VR development, and understanding documentation.	**7,8**	**2**
2.	Demonstration of the working of Google Cardboard, Google Daydream or Samsung gear VR.	**7,8**	**2**

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3	Develop a scene in Unity that includes a cube, plane and sphere, apply transformations on these objects. Also add a video and audio source	**7,8**	**2**
4	Exploring transformation and animation of 2D or 3D models. Assign different materials and texture to models. Design and Simulation of Lighting, reflections and shadows in a model	**7,8**	**2**
5	Design and Simulation of Collision & Physical System	**7,8**	**2**
6	Design and simulation of Dynamic particles and Sprite Systems.	**7,8**	**2**
7	Design and integration of spatial audio and Sound effects.	**7,8**	**2**
8	Develop a simple UI (User interface) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene.	**7,8**	**2**
9	Implementation of AR and VR navigation system (UX).	**7,8**	**2**
10.	Implementation of VR and AR interaction system.	**7,8**	**2**
11.	Exploring rendering pipelines and post-processing systems.	**7,8**	**2**
12.	Optimizing and exporting a VR software build.	**7,8**	**2**
Mini Project/Case studies: (Suggested list)			

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13	Mini Project to perform using Unity or any other tool (2/3 students per group). For possible ideas refer the following list.	7,8		
	1. Develop a VR Ball Game. The scene should contain a play area surrounded by four walls and a ball that acts as a player. The objective of the game is to keep the ball rolling without colliding with the walls. If it collides with either of the walls, the wall color should change and a text should display on the screen indicating the collision. 2. Develop a VR Golf Game. The scene should contain a play area (golf course), which consists of a series of cups/holes each having different scores. Display the score card. 3. Develop a VR game in Unity such that on each gun trigger click, destroy the cubes placed on the plane and gain a score point . Make a score UI and display it on the screen. 4. Develop a VR Basketball Game. The scene should contain a basketball court. The developed game should be a single player game. The objective of the game is to let the player put the ball in the basket maximum number of times. Display the score card.			

Course Assessment:
Theory:
>   **ISE-1:** 20 Marks
>   Activity: Quiz / Assignments
>   **ISE-2:** 20 Marks
>   Activity: Presentation / Article Discussion

>   **MSE:** 90 minutes 30 Marks written examination based on 50% syllabus
>   **ESE:** 90 minutes 30 Marks written examination based on remaining syllabus after MSE.

>   **Lab:**
>   ISE-1: Evaluation is based on 50 % Lab experiments using predefined rubrics, 20 marks.
>   ISE-2: Evaluation is based on remaining 50 % Lab experiments using predefined rubrics, 30 marks

Recommended Textbooks:

1   Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016

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2   Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics). Morgan Kaufmann Publishers, San Francisco, CA, 2002

3   Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.

4   AR Game Development, Allan Fowler, 1st Edition, Apress Publications, 2018, ISBN 978-1484236178

5   Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016), ISBN-10: 9332578494

6   Learning Virtual Reality, Tony Parisi, O'Reilly Media, Inc., 2015, ISBN-9781491922835

7   3D User Interfaces, Theory and Practice, Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, Addison Wesley, USA, 2005.

Online Resources:
Here are some URLs for AR/VR references:
1.   https://arvrjourney.com
2.   https://iste.org/blog/23-resources-for-bringing-ar-and-vr-to-the-classroom
3.   https://www.classvr.com/vr-ar-resources/
4.   https://cndls.georgetown.edu/resources/tools/vr/
5.   https://www.eschoolnews.com/digital-learning/2024/05/22/3-ar-vr-resources-that-nurture-student-curiosity/
6.   https://sites.google.com/view/virtuarealities/vr-resources
7.   https://soeonline.american.edu/blog/benefits-of-virtual-reality-in-education/
8.   https://www.princetonreview.com/ai-education/vr-and-ar
9.   https://arxiv.org/abs/2305.07842

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PEC13CE26	**UI/UX Design**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		PCC11CE01
Course Outcomes	CO1	Identify and explore the iterative, user-centered design process for creating graphical user interfaces.
	CO2	Apply the user Interfaces to different devices and requirements.
	CO3	Design prototype for the given design problems.
	CO4	Apply typography and color theory in UI/UX design, including font selection, readability, contrast, and color usage guidelines.
	CO5	Apply simulation, prototyping, and usability testing techniques to design user-centered interfaces using modern UI/UX tools.

Module No.	Unit No.	Topics	Ref.	Hrs.
		Foundational Concepts of UI and UX Design		
1	1.1	Case Study of Boeing 707-Redefining User Experience and Interface in Commercial Aviation: Introduction to User Interface (UI) and User Experience (UX) Design, Understanding User Needs in UX/UI Design and Its Importance. UI vs UX Design, Industry Requirements for UI/UX Designers. Responsibilities of a UI/UX Designer.	1, 2, 3	2
	1.2	Iterative Design Process, Popular UI/UX Design Tools and Software, Key UI/UX Design Considerations, Interactive Elements in UI/UX Design, Usability Heuristics for UI Design.	3, 4	2
		User Interface(UI) Design		
2	2.1	UI Design Elements, Page Layout, Approaches to Screen Based UI, Template vs Content, Formal vs Active Elements of Interface Design, Composing the Elements of Interface Design.	3, 4	2
	2.2	UI Design Thinking, UI Design Process, Visual Communication Design Component in Interface Design, Spacing and the grid.	3, 4	2

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		UI/UX Design Essentials: Color Schemes & Typography		
3	**3.1**	Headings and Body Text, Legibility, Type Trends, Typeface Selection & Pairing, Where to Get Web Fonts, Column Width (Line Length), Hyphenation and Justification.	2, 3	2
	3.2	Color Harmonies, Creating Contrast with Color, Guidelines for Proper Color Usage.	2, 3	2
		User Experience (UX) Design		
4	**4.1**	Foundation of UX Designs, Good and Poor Design, Understanding Your Users, Principles and Elements of Visual Design that impact UX, Google's HEART framework: Measuring & improving UX.	1, 2	2
	4.2	Functional Layout, Interaction design, Introduction to the Interface, Navigation Design, User Testing, Developing and Releasing Your Design.	1, 2	4
		UI/UX Design Tools		
5	**5.1**	Mobile UI/UX Design Process, Widgets and Mobile Components, Strong UI/UX Design, Recent Trends in Mobile UI/UX Design, Testing an App for UI UX Quality	2, 4	2
	5.2	Simulation and Prototyping techniques, Usability Testing Methods, Interface technologies and User Centered Design, Wireframe and Prototype Fidelity, Adobe Photoshop, Illustrator, Figma, AdobeXD, Pencil Project tool.	2, 4	6
			Total	**26**

Module No.	Sr.no	Suggested List of experiments	Ref.	Hrs.
1	**1**	To explore UI elements for Zomato/Swiggy/Zepto app.	1, 2, 3	2
	2	To design a modern and innovative logo in Adobe XD that reflects the cutting-edge technology and forward-thinking nature of the startup.	3, 4	2
2	**3**	To create a basic app in Adobe XD for users to create and customize their own profiles.	3, 4	2
	4	To design unique rating icons using the Pencil tool. Apply your own creative style.	3, 4	2
3	**5**	To customize typography for logo for weather app in UI design using Pencil tool. Use your own creativity.	2, 3	2
	6	To evaluate Good and Bad Design of UI elements for IRCTC's Next Generation eTicketing System website.	2, 3	2

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4	7	To creatively customize typography for an agriculture-related logo, focusing on plants, pots, and fertilizers, using the Illustrator tool.	1, 2	2
	8	To design a GUI for a feedback form, using familiar icons and colors suited to the scenario, for gathering feedback from students and teachers, while explaining the rationale behind the color choices.	1, 2	2
5	9	To design a simple web UI for a pencil brand (similar to Doms, Apsara, Nataraj etc.) using various types of menus in an application with Figma.	2, 4	2
	10	To create a flower-selling application in mobile, laptop, and desktop layouts using Figma, and compare the designs across different devices for consistency and usability.	2, 4	2
		Mini project		
	11	Mini project/presentation/Group activity/ Simulation using modern tools	1, 2, 3	6
		Total		**26**

Course Assessment:
Theory:

> **ISE-1:**
> Activity: Quiz and assignments/Case Study of Corporate UI/UX Design 20 Marks
> **ISE-2:** Two hours 20 Marks
> Activity: /Quiz and Assignments/Design Contest/ Pitch Video
>
> **MSE:** 90 minutes, 30 Marks written examination based on 50% syllabus**.**
> **ESE:** 90 minutes, 30 Marks written examination based on remaining syllabus after MSE.

Lab:
1. ISE-1: Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2:
a. Five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
 b. Mini project: Implementation using modern tools to solve the given problem statement for 10 marks.

Recommended Books:

[1] Joel Marsh, "UX FOR BEGINNERS", O'Reilly Media, Inc, First Edition, First Indian Colour Reprint, 2024.
[2] Jon Yablonski, Laws of UX using Psychology to Design Better Product & Services, O'Reilly Media, Inc., Second Edition, 2024.
[3] Donald A. Norman, "The design of Everyday Things", MIT Press, Revised and Expanded Edition, 2013.
[4] Wilbert O. Galitz, "The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques", Wiley Publishing, 2007.

Online Resources:

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[1] https://www.interaction-design.org/literature/topics/5-whys

[2] https://www.figma.com/resource-library/difference-between-ui-and-ux/

[3] https://www.coursera.org/specializations/ui-ux-design

[4] https://www.smashingmagazine.com/category/design/

[5] https://material.io/design

[6] https://archive.nptel.ac.in/courses/124/107/124107008/

[7] https://www.freecodecamp.org/news/ui-ux-design-tutorial-from-zero-to-hero-with-wireframe-prototype-figma/

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PEC13CE27	**Quantum Computing**	2	--	2	2	--	1	3
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	20	30	20	30	100	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes		
Course Outcomes	CO1	Differentiate between classical and quantum computing paradigms.
	CO2	Design and analyze quantum circuits using quantum logic gates.
	CO3	Implement fundamental quantum algorithms such as Shor's and Grover's.
	CO4	Apply quantum cryptography concepts for secure communication.
	CO5	Develop quantum programs using Qiskit, Cirq, and IBM Quantum Experience.
	CO6	Assess the potential of quantum computing in machine learning, optimization, and cloud-based quantum computing.

Module No.	Unit No.	Topics	Ref.	Hrs.
		Introduction to Quantum Computing & Industry Trends		4
1	1.1	Classical vs. Quantum Computing, Qubits, Entanglement, Superposition and interferences,	1,2,3	
	1.2	Industry Applications: Cybersecurity, AI, Finance, Drug Discovery		
	1.3	Current Quantum Hardware: IBM, Google, Intel, Rigetti, D-Wave		
		Mathematical Foundations		4
2	2.1	Linear Algebra for Quantum Computing, Probability in Quantum Mechanics	1,2	
	2.2	Dirac Notation & State Vectors		
	2.3	Tensor Products and Unitary Transformations, Tensor Products of Matrices		
		Quantum Gates & Circuits		5
3	3.1	Pauli Gates (X, Y, Z), Hadamard (H), Phase (S, T)	1,2,3	
	3.2	Controlled and Multi-Qubit Gates (CNOT, Toffoli, Fredkin)		
	3.3	Quantum Circuit Design for Optimization & AI, Reversible Computing & its Role in Low-Power Design		
		Quantum Algorithms		5
4	4.1	Shor's Algorithm (Breaking RSA Cryptography) Grover's Algorithm (Search Optimization)	1,2	

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	4.2	Variational Quantum Eigensolver (VQE) for AI/ML		
	4.3	Quantum Approximate Optimization Algorithm (QAOA)		
		Quantum Cryptography & Security		4
5	**5.1**	Quantum Key Distribution (BB84, E91)	1,2	
	5.2	Post-Quantum Cryptography (NIST Standards)		
	5.3	Quantum Secure Cloud Computing, Quantum-Resistant Blockchain Technologies		
		Quantum Hardware & Programming		4
6	**6.1**	Superconducting Qubits vs. Trapped Ions vs. Photonic Qubits	4	
	6.2	Cloud-Based Quantum Platforms: IBM Quantum, Google Quantum AI	4	
	6.3	Programming with Qiskit, Cirq, and Braket, Challenges in Scaling Quantum Computers	4	
Total				**26**

Sr.no	Suggested List of experiments	Ref.	Hrs.
1	Implement $|0\rangle$, $|1\rangle$, and superposition states $|+\rangle$ and $|-\rangle$	4	2
2	Implement and visualize X, Y, Z, H, S, T gates	4	2
3	Design a quantum circuit for simple logical operations	4	2
4	Create an entangled Bell pair and measure correlations	4	2
5	Implement quantum teleportation using IBM Quantum	4	2
6	Optimize unstructured search problems using Grover's Algorithm	4	2
7	Factorize small numbers and analyze RSA vulnerability	4	2
8	Implement Quantum Neural Networks (QNNs) for classification	4	2
9	Simulate and test secure quantum key exchange	4	2
10	Prepare case study for any suitable application for Weather Forecasting and Climate Change	4	2
11	Prepare case study for any suitable application for Artificial Intelligence	4	2

Course Assessment:
Theory:
ISE-1:
Activity: Quiz and assignments 20 Marks
ISE-2: Two hours 20 Marks
Activity: Article Discussion, Quiz and Assignments
Outcome: Reflective Journal
MSE: 90 minutes- 30 Marks written examination based on 50% syllabus
ESE: 90 minutes- 30 Marks written examination based on remaining 50% syllabus
Lab:
ISE:
1. ISE-1 will be conducted for four or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining Four experiments or 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Simulation using modern tools to solve the given problem statement for 10 marks/Mini project

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Recommended Books:

[1] Michael A. Nielsen, Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 2010 (10th Anniversary Edition)

[2] Chris Bernhardt, "Quantum Computing for Everyone"   , MIT Press

[3] Phillip Kaye, Raymond Laflamme, Michele Mosca, "An Introduction to Quantum Computing", Oxford University Press

[4] Eric R. Johnston, Nic Harrigan, Mercedes Gimeno-Segovia, "Programming Quantum Computers: Essential Algorithms and Code Samples", O'Reilly Media

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PECL13CE21	Social Media Analytics Lab	--	--	2	--	--	1	1
		Examination Scheme						
		ISE	MSE	ISE	ESE		Total	
		20	--	30	--		50	

Pre-requisite Course Codes		Data Mining, Data Analytics
		On successful completion of the course learner will be able to
Course Outcomes	CO1	Acquire hands on skills needed to work with social media data
	CO2	Demonstrate data collection from different social media platforms.
	CO3	Analyse & Visualize social media data from multiple platforms.
	CO4	Develop content and structure based SMA model
	CO5	Implement SMA model for business

Exp. No.	Name of the experiment	Ref	Hrs
1	Study various - i)Social Media platforms (Facebook, twitter, youtube etc) ii)Social Media analytics tools (facebook insights, google analytics netlytic etc) iii) Social Media Analytics techniques and engagement metrics (page level, Post level, member level) iv) Applications of Social media analytics for business. e.g. Google Analytics https://marketingplatform.google.com/about/analytics/ https://netlytic.org/	1, 2	2
2.	Data Collection-Select the social media platforms of your choice (Twitter, Facebook, LinkedIn, Youtube,Web blogs etc) ,connect to and capture social media data for business (scraping, crawling,parsing).	1, 2	
3	Data Cleaning and Storage- Preprocess, filter and store social media data for business (Using Python, MongoDB, R, etc).	3, 2	
4	Text Analytics: Exploratory Data Analysis and visualization of Social Media Data for business.	3, 4	
5	Develop Content(text, emoticons, image, audio, video) based social media analytics model for business. (e.g.Content Based Analysis :Topic , Issue ,Trend, sentiment/opinion analysis, audio, video, image analytics)network classifier to explain decision boundaries.	4,5	
6	Develop Structure based social media analytics model for any business. (e.g. Structure Based Models -community detection, influence analysis)	1, 2	

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7	Develop a dashboard and reporting tool based on real time social media data.	1, 3	
8	Design and analyze the creative content for promotion of your business on social media platforms.	1, 3	
9	Develop social media text analytics models for improving existing product/ service by analyzing customers reviews/comments.	1, 3	
10	Mini Project based on real social media data.	3, 4	

Lab:

ISE:

1. ISE-1 will be conducted on 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Remaining 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Miniproject/Innovative experiment for 10 marks

Recommended Text / Reference Books:

[1] **Python Social Media Analytics: Analyze and visualize data from Twitter,**
[2] **YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee , Michal Krystyanczuk**
[3] **Learning Social Media Analytics with R,by Raghav Bali, Dipanjan Sarkar, Tushar Sharma.**
[4] Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013
[5] Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013
[6] Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		--	--	2			1	1
25PECL13CE22	**Ethical hacking Lab**	**Examination Scheme**						
			ISE1	MSE	ISE2	ESE	Total	
		Theory	--	--	--	--	--	
		Tutorial	20	--	30	--	50	

Pre-requisite Course Codes	Essential Computing Skills for Engineers, Database Management Systems, Operating System , Computer Networks	
Course Outcomes	CO1	**Demonstrate** techniques for reconnaissance, enumeration, and vulnerability analysis to assess security posture.
	CO2	**Execute** system hacking, session hijacking, and privilege escalation to understand attack vectors and exploitation techniques.
	CO3	**Evaluate** security flaws in networks, web applications, wireless systems, and IoT devices
	CO4	**Analyze** evasion techniques against intrusion detection systems, firewalls, and honeypots.
	CO5	**Implement** security measures to mitigate malware threats, cryptographic weaknesses, and cloud security risks.

Suggested Labs			
Sr. No.	Labs	Ref.	Hours
1	**Enumeration – Performing network enumeration to extract system details, user information, and shared resources. (CO1)** **Objectives:** • Perform NetBIOS, SNMP, and LDAP enumeration. • Extract usernames, shares, and system details. • Analyze enumeration data for potential attack vectors. **Tools/Technology Required:** Nmap, Enum4linux, Netcat, SNMPWalk, **Metasploitable**.	1, 4	2
2	**Vulnerability Analysis – Identifying security weaknesses in networks, systems, and applications using automated tools and manual analysis. (CO1)** **Objectives:** • Perform vulnerability scans using automated tools. • Analyze scan results to identify security weaknesses. • Prioritize vulnerabilities based on impact and exploitability. **Tools/Technology Required:** Nessus, OpenVAS, Nikto.	1, 2, 4	2
3	**Vulnerability Analysis – Identifying security weaknesses in networks, systems, and applications using automated tools and manual analysis. (CO1)**	1, 4	2

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	Objectives: - Perform vulnerability scans using automated tools. - Analyze scan results to identify security weaknesses. - Prioritize vulnerabilities based on impact and exploitability. **Tools/Technology Required:** Nessus, OpenVAS, Nikto, **Metasploitable**.		
4	**Session Hijacking – Capturing and manipulating session tokens to hijack active user sessions. (CO2)** **Objectives:** - Capture session tokens using MITM attacks. - Perform session fixation and session replay attacks. - Apply session security mechanisms for prevention. **Tools/Technology Required:** Burp Suite, Ettercap, Wireshark, SEED Labs/DVWA.	2, 4	2
5	**Malware Threats – Analyzing and detecting different types of malware to understand their behavior and mitigation techniques. (CO5)** **Objectives:** - Analyze malware behavior using static and dynamic techniques. - Identify Indicators of Compromise (IoCs). - Apply defensive measures to mitigate malware threats. **Tools/Technology Required:** Ghidra, Process Monitor, VirusTotal, Cuckoo Sandbox.	3, 4	2
6	**Sniffing – Capturing and analyzing network traffic to extract sensitive information and detect vulnerabilities. (CO3)** **Objectives:** - Capture and analyze live network traffic. - Extract credentials from unencrypted protocols. - Implement countermeasures against sniffing attacks. **Tools/Technology Required:** Wireshark, Tcpdump, Ettercap, **SEED Labs**.	3	2
7	**Social Engineering – Simulating phishing and credential harvesting attacks to exploit human vulnerabilities. (CO3)** **Objectives:** - Simulate phishing and spear-phishing attacks. - Perform credential harvesting using cloned websites. - Analyze social engineering defenses and awareness strategies. **Tools/Technology Required:** Social-Engineer Toolkit (SET), Evilginx, GoPhish.	1, 4	2
8	**Denial-of-Service (DoS) – Launching DoS and DDoS attacks to analyze their impact on network availability. (CO3)** **Objectives:** - Conduct DoS attacks on web servers and network services. - Simulate a DDoS attack using botnet emulation tools. - Implement mitigation techniques such as rate limiting and firewalls. **Tools/Technology Required:** LOIC, Hping3, Slowloris, Torshammer, SEED Labs.	3, 4	2
9	**Evading IDS, Firewalls, and Honeypots – Bypassing security monitoring systems and avoiding detection. (CO4)** **Objectives:**	3, 4	2

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	• Perform IDS evasion using obfuscation techniques. • Bypass firewall rules using tunneling methods. • Detect and evade honeypots in a network. **Tools/Technology Required:** Metasploit, Nmap, Snort, Tcpdump, SEED Labs.		
10	**Hacking Web Servers and Applications – Exploiting web application vulnerabilities to gain unauthorized access. (CO3)** **Objectives:** • Perform directory traversal, file inclusion, and command injection attacks. • Exploit misconfigurations in web servers. • Secure web applications using best practices. **Tools/Technology Required:** Nikto, Burp Suite, OWASP ZAP, DVWA.	2, 4	2
11	**Session Hijacking Prevention – Implementing security measures to prevent unauthorized session hijacking. (CO5)** **Objectives:** • Implement secure session management techniques. • Configure secure cookies and HTTPS encryption. • Analyze session hijacking mitigation strategies. **Tools/Technology Required:** Burp Suite, OWASP ZAP, Wireshark, DVWA.	2, 4	2
12	**Hacking Wireless Networks – Analyzing and exploiting wireless security flaws to test for vulnerabilities. (CO3)** **Objectives:** • Capture WPA2 handshake packets and crack Wi-Fi passwords. • Perform deauthentication and Evil Twin attacks. • Implement wireless security hardening techniques. **Tools/Technology Required:** Aircrack-ng, Wireshark, Reaver.	1, 4	2
13	**Hacking Mobile Platforms – Testing mobile application security to identify and exploit vulnerabilities. (CO3, CO5)** **Objectives:** • Analyze Android and iOS application security vulnerabilities. • Perform reverse engineering on mobile apps. • Apply secure coding practices for mobile development. **Tools/Technology Required:** MobSF, Apktool, Frida, Drozer.	1, 4	2
14	**IoT Hacking – Identifying security weaknesses in IoT devices and exploiting misconfigurations. (CO3, CO5)** **Objectives:** • Identify common vulnerabilities in IoT devices. • Exploit misconfigurations and weak authentication. • Implement security controls for IoT environments. **Tools/Technology Required:** Shodan, Nmap, Firmware Analysis Toolkit.	1, 4	2
15	**Cloud Computing Security – Analyzing cloud security risks and implementing security controls. (CO5)** **Objectives:** • Analyze cloud misconfigurations and security gaps. • Perform privilege escalation in cloud environments.	1, 4	2

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	• Secure cloud storage and IAM configurations. **Tools/Technology Required:** AWS CLI, Azure Security Tools, CloudGoat, ScoutSuite.		
16	**Cryptography and Encryption Attacks – Testing encryption mechanisms for weaknesses and cryptographic vulnerabilities. (CO5)** **Objectives:** • Analyze and break weak encryption algorithms. • Implement secure encryption and hashing techniques. • Conduct cryptographic attacks on insecure protocols. **Tools/Technology Required:** OpenSSL, John the Ripper, Hashcat.	1, 4	2

17	**Activity 1: Capture The Flag (CTF) – Full-Scope Ethical Hacking Simulation**
	Objective: Apply ethical hacking techniques across multiple domains, including reconnaissance, vulnerability exploitation, privilege escalation, and forensic analysis.
	• Participants compete in a Jeopardy-style or Attack-Defense-style CTF where they solve challenges across different categories:
	  − Reconnaissance & Enumeration (Identifying open ports, finding hidden directories)
	  − Exploitation (SQL Injection, Command Injection, Buffer Overflow)
	  − Privilege Escalation (Kernel exploits, misconfigurations)
	  − Cryptanalysis (Cracking encrypted messages, password hashes)
	  − Network Traffic Analysis (Extracting credentials from PCAP files)
	  − Forensics (Analyzing malware-infected systems)
	• Challenges will be hosted using CTFd or PicoCTF in a controlled lab environment with Metasploitable, DVWA, and SEED Labs.
	Note: students can also choose real life CTF/ Bug bounty challenges for completion of this activity
	
	Activity 2: Cyber Threat Intelligence Report & Research Paper Presentation
	Objective: Research and analyze emerging cyber threats, present findings, and propose security countermeasures.
	• Each participant selects a real-world cyber attack case study, such as Advanced Persistent Threats (APTs), zero-day vulnerabilities, ransomware campaigns, or AI-driven cyber attacks.
	• Reports must include:
	  − Attack lifecycle analysis (Recon, weaponization, exploitation, exfiltration)
	  − Threat actor profiling (TTPs based on MITRE ATT&CK framework)
	  − Incident impact analysis (Business, financial, reputational damage)
	  − Countermeasures & defense strategies
	• The presentation format includes:
	  − Technical deep dive into the attack mechanics
	  − Live demonstration of exploitation techniques (if applicable)
	  − Audience Q&A and expert feedback		

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Tools Required: VirusTotal, MITRE ATT&CK, Shodan, Open Threat Exchange (OTX), CVE databases**.**
 	
Activity 3: Secure Coding Workshop & Code Auditing
Objective: Identify and remediate security vulnerabilities in application source code**.**
• Participants analyze insecure code samples with common vulnerabilities:
   o SQL Injection
   o Cross-Site Scripting (XSS)
   o Insecure Direct Object References (IDOR)
   o Broken Authentication & Session Management
   o Privilege Escalation due to poor input validation
• Code auditing will be conducted using manual analysis and automated tools.
• Participants must refactor insecure code following secure coding guidelines (OWASP, CERT).
• The workshop concludes with a secure coding hackathon, where teams compete to patch vulnerabilities in a given codebase.
Tools Required: SonarQube, Bandit, FindSecurityBugs, Semgrep, OWASP ZAP, DVWA.
 	
Activity 4: Red vs. Blue Team Exercise – Offensive & Defensive Security Simulation
Objective: Simulate real-world cyber-attacks and defenses through an adversarial engagement.
• Participants are divided into Red Team (Attackers) and Blue Team (Defenders).
   o Red Team tasks:
      • Perform reconnaissance using OSINT techniques.
      • Exploit web, network, and system vulnerabilities.
      • Maintain persistence and evade detection.
   o Blue Team tasks:
      • Detect and analyze Red Team attack patterns.
      • Configure SIEM alerts and log analysis.
      • Harden security configurations and implement incident response.
• The Red Team must document attack vectors and exploits used.
• The Blue Team must produce a defense strategy and post-incident report.	

Course Assessment:
1. **ISE-1:** will be conducted for 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. **ISE-2:**
   a. The remaining 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
   b. Mini project or any one Activity for 10 marks.

Recommended Books:

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1. Abhinav Ojha, "Beginners Guide To Ethical Hacking and Cyber Security," Revised Edition, Notion Press Media Pvt. Limited, 2024.
2. Rafay Baloch, "Web Hacking Arsenal: A Practical Guide to Modern Web Penetration Testing," 1st Edition, CRC Press, 2024.
3. Manish Sharma, "Ethical Hacking and Network Analysis with Wireshark: Exploration of Network Packets for Detecting Exploits and Malware," 1st Edition, BPB Publications, 2024.
4. Shane Hartman, "Hands-On Ethical Hacking Tactics: Strategies, Tools, and Techniques for Effective Cyber Defense," 1st Edition, Packt Publishing, 2024.

Online Resources:
1. NPTEL's "Ethical Hacking": https://archive.nptel.ac.in/courses/106/105/106105217/
2. Great Learning's "Introduction to Ethical Hacking": https://www.mygreatlearning.com/academy/learn-for-free/courses/introduction-to-ethical-hacking
3. Offensive Security's "Metasploit Unleashed": https://www.offsec.com/metasploit-unleashed/
4. Alison's "Introduction to Ethical Hacking": https://alison.com/course/introduction-to-ethical-hacking
5. How to Build Your Private Hacking Lab with VirtualBox - https://medium.com/@manishmshiva/how-to-build-your-private-hacking-lab-with-virtualbox-6eb56e6a6a01
6. How to Setup Your Ethical Hacking Home Lab - https://intellectualpoint.com/how-to-setup-your-ethical-hacking-home-lab/
7. Complete Hacking Lab Setup Tutorial 2025 - https://www.youtube.com/watch?v=8RKLCIAP_yY
8. Setup Homelab to Practice Penetration Testing: Step-by-Step Guide - https://www.safeaeon.com/security-blog/how-to-setup-homelab-to-practice-penetration-testing-at-home/
9. Setting Up Your Ethical Hacking Lab: Tools and Resources for Beginners - https://medium.com/@jaber_5689/setting-up-your-ethical-hacking-lab-tools-and-resources-for-beginners-31d1ed1c73e4
10. Build the Ultimate Hacking Lab (Cheap)! - https://www.youtube.com/watch?v=eJlJYSH0Q2w

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned		
		L	T	P	T	P	Total
25PECL13CE23	DevOps Lab	--	--	2	--	1	1
		Examination Scheme					
		ISE1	MSE	ISE2	ESE	Total	
		20	--	30	--	50	

Pre-requisite Course Codes	Computer Networks, Operating System, Database management systems, basics of Web technology	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	**Apply** DevOps principles, automation tools, and key technologies for efficient software delivery.
	CO2	**Develop** Git version control strategies, implement CI/CD pipelines, and automate build, test, and deployment.
	CO3	**Build** containerized applications using Docker and Kubernetes to deploy scalable microservices.
	CO4	**Configure** infrastructure as code using Terraform and Ansible to provision cloud resources and ensure security.
	CO5	**Assess** monitoring, logging, security, and performance optimization to enhance system reliability.

Exp. No.	Name of the experiment (suggested list)	Ref	Hrs
1	**Introduction to DevOps and Setting Up the Lab Environment (CO1)** Objective: Install and configure Linux, Docker, Kubernetes, Terraform, Ansible, and Jenkins. Understand the DevOps lifecycle, workflow, and cultural aspects in modern software development.	1, 4	2
2	**Git and Version Control Best Practices (CO2)** **Objective:** Set up **Git** on a local machine, create a repository, explore **branching strategies**, resolve **merge conflicts**, and use **Git hooks** for automation.	3, 6	2
3	**Jenkins Installation and Initial Configuration** *(CO2)* **Objective: Install Jenkins, configure user authentication and security settings, set up Jenkins plugins, and connect Jenkins with GitHub/GitLab repositories.**	1, 3, 6	2
4	**Automating Builds and Testing in CI/CD Pipelines (CO2)** **Objective:** Implement **Maven and Gradle** for automated builds, integrate **SonarQube** for static code analysis, and configure **unit tests** to run in Jenkins pipelines.	1, 3, 6	2
5	**Integrating Jenkins with Docker for CI/CD** *(CO2/CO3)* **Objective:** Set up **Jenkins to build Docker images**, write a **Jenkinsfile for pipeline automation**, push images to **Docker Hub**, and deploy containerized applications automatically.	1, 2, 5	2
6	**Deploying Jenkins Pipelines with Kubernetes** *(CO3)*	2, 5	2

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	Objective: Create a **Jenkins pipeline** that deploys applications to **Kubernetes clusters**, configure **Kubernetes agents in Jenkins**, and use **Helm charts** for deployment automation.		
7	**Introduction to Docker and Containerization (CO3)** **Objective:** Install **Docker**, create and run containers, write **Dockerfiles**, optimize images, and use **Docker networking and volumes**.	2, 5	2
8	**Docker Compose and Multi-Container Applications (CO3)** **Objective:** Define and deploy **multi-container applications** using **Docker Compose**, explore **networking between containers**, and manage **service dependencies**.	2, 5	2
9	**Kubernetes Basics - Deploying Applications (CO3)** **Objective:** Set up **Minikube/Kubernetes cluster**, create and deploy **Kubernetes pods**, configure **replication controllers**, and expose services.	2, 5	2
10	**Kubernetes Advanced - Services and Scaling(CO3)** **Objective:** Implement **Kubernetes Deployments**, enable **autoscaling**, manage **ConfigMaps and Secrets**, and explore **load balancing** for high availability.	2, 5	2
11	**Infrastructure as Code (IaC) with Terraform(CO4)** **Objective:** Write **Terraform scripts** to provision and manage **AWS/Azure/GCP resources**, automate infrastructure deployment, and ensure **state management**.	7, 8	2
12	**Configuration Management with Ansible(CO4)** **Objective:** Write **Ansible playbooks** to configure **servers and cloud instances**, implement **idempotent configuration management**, and use **Ansible roles**.	7, 8	2
13	**Cloud Automation with AWS/Azure/GCP and Jenkins** *(CO4)* **Objective:** Automate **cloud infrastructure provisioning** using **Terraform and Ansible**, deploy **serverless applications**, configure **IAM roles and security policies**, and integrate with **Jenkins pipelines** for infrastructure automation.	2, 5, 7, 8	2
14	**Implementing Security Best Practices in DevOps(CO5)** **Objective:** Secure **CI/CD pipelines**, scan **Docker images** for vulnerabilities using **Trivy**, implement **least privilege IAM policies**, and secure Kubernetes clusters.	1, 4, 5	2
15	**Monitoring, Logging, and Performance Optimization (CO5)** **Objective:** Set up **Prometheus for real-time monitoring**, configure **Grafana dashboards**, integrate **ELK Stack for log analysis**, and perform **stress testing using Apache JMeter**.	1, 4, 5	2
16	**Mini Project** **Objective:** Integrate **all learned concepts** into an **end-to-end DevOps pipeline**, deploying a **containerized microservices-based application** using DevOps best practices.		

Course Assessment:
Lab
ISE:

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1. ISE-1 will be conducted for five experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

2. ISE-2

a. Four experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.

b. Mini Project -10 marks

Recommended books:

1. Pradeep Chintale – *Modern DevOps Practices: Implement and Secure DevOps in the Public Cloud with Cutting-Edge Tools, Tips, Tricks, and Techniques*, 1st Edition, 2023
2. Justin Domingus, John Arundel – *Cloud Native DevOps with Kubernetes*, 2nd Edition, 2022
3. Michael Kaufmann – *Accelerate DevOps with GitHub: Enhance Software Delivery Performance with GitHub Issues, Projects, Actions, and Advanced Security*, 1st Edition, 2022
4. Robert Benefield – *Lean DevOps: A Practical Guide to On-Demand Service Delivery*, 1st Edition, 2021
5. J. Candel – *Implementing DevSecOps with Docker and Kubernetes: An Experiential Guide to Operate in the DevOps Environment for Securing and Monitoring Container Applications*, 1st Edition, 2022
6. Christopher Cowell, Nicholas Lotz, Chris Timberlake – *Automating DevOps with GitLab CI/CD Pipelines: Build Efficient CI/CD Pipelines to Verify, Secure, and Deploy Your Code Using Real-Life Examples*, 1st Edition, 2022
7. Ankita Patil, Mitesh Soni – *Infrastructure Automation with Terraform: Automate and Orchestrate Your Infrastructure with Terraform Across AWS and Microsoft*, 1st Edition, 2022
8. Sumit Bhatia, Chetan Gabhane – *Reverse Engineering with Terraform: An Introduction to Infrastructure Automation, Integration, and Scalability Using Terraform*, 1st Edition, 2023

Online resources:

1. **CICD – DevOps Automation and DevSecOps – Automation (NPTEL)**
   https://elearn.nptel.ac.in/shop/iit-workshops/completed/cicd-devops-automation-and-devsecops-automation/
2. **Azure DevOps and Microservices & Azure Kubernetes – Deployment Models (NPTEL)**
   https://elearn.nptel.ac.in/shop/iit-workshops/completed/azure-devops-and-micro-services-azure-kubernetes-deployment-models/
3. **DevOps Culture and Mindset (Coursera)**
   https://www.coursera.org/learn/devops-culture-and-mindset
4. **Introduction to Jenkins (edX)**
   https://www.edx.org/course/introduction-to-jenkins
5. **Kubernetes: Getting Started (Pluralsight)**
   https://www.pluralsight.com/courses/kubernetes-getting-started
6. **DevOps Tutorial - GeeksforGeeks**
   https://www.geeksforgeeks.org/devops-tutorial/
7. **DevOps Roadmap for 2025 - GitHub Repository**
   https://github.com/milanm/DevOps-Roadmap
8. **DevOps: Self-Study Materials - EPAM Campus**
   https://campus.epam.com/en/blog/108
9. **DevOps Full Course For 2024 | Simplilearn - YouTube**
   https://www.youtube.com/watch?v=ISqFq7SHPQI
10. **DevOps Tutorial for Beginners - Full Course | Edureka - YouTube**

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PECL13CE24	**Innovative Product Development Lab (Phase 2)**	--	--	2	--	--	1	1
		Examination Scheme						
		ISE	MSE	ISE	ESE	Total		
		20	-	30	-	50		

Pre-requisite Course Codes	Innovation and Design Thinking, Technology Entrepreneurship	
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Develop functional prototypes and conduct usability testing to refine product design.
	CO2	Analyse legal requirements, business structures, and compliance procedures for startup formation.
	CO3	Design pricing models, financial projections, and branding strategies for product commercialization.
	CO4	Formulate supply chain, vendor management, and distribution strategies for efficient operations.
	CO5	Assess product performance through post-launch analysis, digital marketing, and user feedback.

Exp. No.	Name of the experiment	Ref	Hrs
	Functional Prototype Development		
1)	Activity: i) Develop a functional prototype incorporating key features, materials, and usability considerations in line with the intended product design. ii)Document the development process, materials used, and initial performance observations. Expected Outcome: A Prototype Development and Performance Assessment Report	2	3
	Usability Testing & User Feedback Analysis		
2)	Activity: i) Conduct usability testing by engaging target users through structured surveys, interviews, or focus groups. ii) Observe user interactions, record difficulties faced, and gather feedback on the overall experience. iii) Analyse the test results to identify performance issues, design flaws, and potential enhancements. Expected Outcome: A Report summarizing user interactions, common challenges, and ease of use, suggested improvements, and actionable insights for refining the prototype.	3	2
	Legal Aspects of Starting a Business		
3)	Activity: Study business structures and draft essential legal agreements like MoU and NDA for startup protection. Understand registration procedures and compliance requirements. Outcome: A Drafted MoU and NDA tailored for a startup's needs. A	1	3

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	Business Registration Plan outlining legal entity selection and filing procedures**.**		
Business Entity Formation & Legal Compliance			
4)	Activity: i) Research different business structures (sole proprietorship, partnership, LLP, private limited, etc.) and their legal implications. ii) Draft basic incorporation documents like Memorandum of Association (MoA), Articles of Association (AoA), or partnership deeds. Expected Outcome: i)A Business Structure Selection Report outlining the best legal structure for a chosen business idea. ii)Drafted incorporation documents required for company formation.	**1**	**3**
Startup Registration on Government Portal (Mock Exercise)			
5)	i) Explore different government startup registration portals such as Startup India, MSME Udyam, DPIIT Recognition, etc. ii) Conduct a mock registration process by filling out required details, such as business name, legal entity type, industry sector, and compliance documents. iii) Identify benefits, incentives, and compliance requirements post-registration. Expected Outcomes: i) A detailed report on the startup registration process in India, required documents, and benefits. ii) Screenshots of mock-filled forms and a step-by-step guide for future entrepreneurs.	**1**	**2**
Advanced Pricing Strategies & Financial Modeling			
6)	Activity: Analyze competitor pricing, conduct customer willingness-to-pay surveys, and develop pricing models. Create financial projections, including revenue forecasts and break-even analysis. Expected Outcome: A Pricing Model Report detailing chosen pricing strategies. Projected Financial Statements showing revenue estimations and cost breakdowns.	**4**	**3**
Branding, Packaging & Product Positioning			
7)	Activity: Design a brand identity, including a logo, tagline, and product packaging concept aligned with target customers. Conduct a market positioning analysis to differentiate the product from competitors. Expected Outcome**:** A Branding & Packaging Design with justifications for visual and material choices. A Product Positioning Report defining competitive advantages and branding strategies.	**4**	**2**
Supply Chain & Vendor Management			
8)	Activity: Identify potential suppliers, logistics partners, and key risks in the supply chain. Develop strategies for procurement, inventory control, and supply chain optimization. Expected Outcome**:** A Supply Chain Plan mapping vendor, sourcing strategies, and logistics. A Risk Mitigation Strategy addressing potential disruptions in supply and manufacturing.	**1**	**2**
Digital Marketing & Social Media Growth Hacking			

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9)	Activity: Create and run a small-scale digital marketing campaign using paid ads, influencer partnerships, or social media engagement. Analyze key metrics like click-through rates, conversions, and audience engagement. Expected Outcome: A Social Media Engagement Report detailing campaign effectiveness. A Digital Marketing Strategy suggesting improvements based on performance analysis.	**4**	**2**
User Experience (UX) & A/B Testing			
10)	Activity: Conduct A/B testing on product features, packaging, or marketing strategies to determine user preferences. Collect and analyse test results using survey responses and behavioural analytics. Expected Outcome: An A/B Testing Report comparing variations and their impact. Optimized UX Recommendations based on test findings.	**3**	**2**
Post-Launch Performance Analysis			
11)	Activity: Define key performance indicators (KPIs) for product success and track real-world sales, user feedback, and retention metrics. Identify trends and propose improvements. Expected Outcome: A Performance Analysis Report summarizing launch data and challenges. A Scalability Plan for refining product and market strategy.	**5**	**2**
			26

Course Assessment:

1. ISE-1 will be conducted for five or 50% of experiments/activities. Continuous pre-defined rubrics-based evaluation for 20 marks on reports generated as outcomes of these experiments/activities evaluated on the basis of content accuracy, clarity, analysis, innovation, and presentation.

2. ISE-2 will be conducted for remaining six experiments or 50% of experiments/activities. Continuous pre-defined rubrics-based evaluation for 30 marks on reports generated as outcomes of these experiments/activities evaluated on the basis of content accuracy, clarity, analysis, innovation, and presentation.

Recommended Books:

[1] Eric Ries, The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, 1st Edition, Crown Business, 2011.

[2] Dan Olsen, The Lean Product Playbook: How to Innovate with Minimum Viable Products and Rapid Customer Feedback, 1st Edition, Wiley, 2015.

[3] David Bland & Alex Osterwalder, Testing Business Ideas: A Field Guide for Rapid Experimentation, 1st Edition, Wiley, 2019.

[4] Philip Kotler, Kevin Lane Keller, Alexander Chernev, Marketing Management, 16th Edition, Pearson, 2022.

[5] W. Chan Kim & Renée Mauborgne, Blue Ocean Strategy: How to Create Uncontested Market Space and Make the Competition Irrelevant, Expanded Edition, Harvard Business Review Press, 2015.

Online Resources:

1) Stanford d.school – Design Thinking & Prototyping
2) Indian Startup Registration (Startup India) – https://www.startupindia.gov.in
3) Ministry of Corporate Affairs (Company Registration) – https://www.mca.gov.in
4) Intellectual Property India (Patent & Trademark Filing) – https://ipindia.gov.in
5) Harvard Business Review on Pricing Strategy – https://hbr.org/topic/pricing

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6)   Neil Patel's Marketing Blog – https://neilpatel.com/blog

7)   A/B Testing Guide by Optimizely – https://www.optimizely.com/optimization-glossary/ab-testing

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
25PECL13CE25	**Explainable AI lab**	**Examination Scheme**						
		ISE	MSE	ISE	ESE	Total		
		20	--	30	--	50		

Pre-requisite Course Codes		C programming, Artificial Intelligence
		On successful completion of the course learner will be able to
Course Outcomes	CO1	Differentiate between black-box models and interpretable models.
	CO2	Apply and compare various explain-ability methods such as LIME, SHAP, and counterfactuals.
	CO3	Implement and evaluate different XAI techniques using open-source libraries.
	CO4	Analyze the trade-offs between model accuracy, interpretability, and user trust in AI applications.
	CO5	Assess ethical concerns such as bias, fairness, and privacy in XAI models.
	CO6	Explore emerging explain-ability techniques and their impact on AI decision-making and regulatory compliance.

Exp. No.	Name of the experiment	Ref	Hrs
Module and concepts: 1. Introduction to Explainable AI			
1	Differentiate and describe the Black Box Problem in AI Objective: Demonstrate the lack of interpretability in deep learning models by training a black-box model and analyzing its outputs.	1, 2	
2.	Exploring the Need for Explainability Objective: Compare the trust and transparency of a simple decision tree model vs. a deep learning model on the same dataset.	1, 2	
2. Taxonomy of Explainable AI Methods			
3	Implementing LIME (Local Interpretable Model-Agnostic Explanations). Objective: Use LIME to explain predictions of a machine learning model on structured/tabular data.	1, 2	
4	SHAP (SHapley Additive Explanations) for Feature Importance Objective: Apply SHAP to a random forest classifier and analyze feature contributions to predictions.	1, 2	
5	Counterfactual Explanations in AI Models Objective: Generate counterfactual examples for a neural network classifier to explain decision boundaries.	1, 2	

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6	Visualization-Based Explanations for AI Models Objective: Use Grad-CAM (Gradient-weighted Class Activation Mapping) to interpret CNN models on image data.	1, 2	
3. Implementation and Evaluation of XAI Techniques			
7	Comparing Model Performance and Explainability Trade-offs Objective: Evaluate different models (e.g., decision trees, neural networks) in terms of accuracy vs. interpretability.	1, 3	
8	Explainability Metrics and Their Evaluation Objective: Implement and analyze quantitative explainability metrics such as fidelity, consistency, and comprehensibility.	1, 3	
9	Case Study: Applying XAI to a Real-World Problem Objective: Use an XAI method to analyze a real dataset (e.g., medical, finance) and derive actionable insights.	1, 3	
4. Ethical and Societal Implications of XAI			
10	Identifying and Mitigating Algorithmic Bias Using XAI Detect bias in AI models using explainability tools and propose strategies to mitigate it.	3, 4	
11	Exploring Regulatory Frameworks and XAI Compliance Objective: Analyze GDPR, AI Ethics guidelines, and interpret their implications on AI development.	3, 4	
5. Future Directions and Open Challenges in XAI			
12	Explainability in Reinforcement Learning Objective: Implement explainable reinforcement learning techniques (e.g., decision trees for policy explanation).	2, 5	
6. Innovative Experiment in Research for Explainable AI			

13	Human-Centered Evaluation of AI Explanations
	Objective: Investigate how human users interpret and trust AI explanations by conducting a user study.
	    i. Select an AI model (e.g., a deep learning classifier for medical diagnosis).
	    ii. Generate different explanations using LIME, SHAP, and counterfactual reasoning.
	    iii. Design a user study where participants interact with AI-generated explanations and rate their trust, understanding, and usefulness.
	    iv. Analyze the results to determine which explanation method improves human trust and decision-making.
	Innovation: This experiment integrates psychology and AI, studying how humans perceive explainability in real-world scenarios.
		2, 3, 4	

Lab:
ISE:
1. ISE-1 will be conducted on 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
2. ISE-2
a. Remaining 50% of experiments. Continuous pre-defined rubrics-based evaluation for 20 marks.
b. Miniproject/Innovative experiment for 10 marks

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Recommended Text / Reference Books:
1. Explainable AI: Interpreting, Explaining, and Visualizing Deep Learning, W. Samek, G. Montavon, A. Vedaldi, L. K. Hansen & K.-R. Müller, Springer, 2019.
2. Interpretable Machine Learning: A Guide for Making Black Box Models Explainable, C. Molnar, (Independently published), 2020.
3. Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2, S. Raschka & V. Mirjalili, Packt Publishing, 2019.
4. Fairness and Transparency in Machine Learning, S. Barocas, M. Hardt & A. Narayanan, Now Publishers Inc., 2019.
5. Explainable and Interpretable Models in Computer Vision and Machine Learning, H. J. Escalante, S. Escalera, I. Guyon, X. Baro, Y. Gucluturk, U. Guclu & M. A. J. van Gerven, Springer, 2018.

Online Resources (Courses & Tutorials):
1. Interpretable Machine Learning Course by Christoph Molnar:
https://christophm.github.io/interpretable-ml-book/
2. MIT OpenCourseWare - Explainable AI (XAI): https://ocw.mit.edu/ (Search for "Explainable AI")
3. IBM AI Explainability 360 Toolkit: https://research.ibm.com/blog/ai-explainability-360

Further Reading (Research Papers & Articles):
1. A Survey of Explainable AI Methods: https://arxiv.org/abs/2003.07631
2. Google AI Blog on Explainability: https://cloud.google.com/vertex-ai/docs/explainable-ai/overview
3. Facebook AI on XAI Research: https://research.facebook.com/publications/xair-a-framework-of-explainable-ai-in-augmented-reality/

Open-Source Tools & Repositories:
1. LIME (Local Interpretable Model-Agnostic Explanations): https://github.com/marcotcr/lime
2. SHAP (SHapley Additive Explanations): https://github.com/slundberg/shap

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25PECC13CE20	Competitive Coding	--	--	2	--	--	1	1
		Examination Scheme						
			ISE1	MSE	ISE2	ESE	Total	
		Lab	20	--	30	--	50	

Pre-requisite Course Codes	PCC12CE07 (Java), PCC12CE09 (AoA)
	Coding should be done in C/C++/JAVA

Course Outcomes	CO1	Solve advanced array and string problems using efficient techniques like the sliding window and two-pointer approach.
	CO2	Develop expertise in utilizing linked lists, stacks, and queues to efficiently solve complex computational problems.
	CO3	Apply graph and tree algorithms to solve complex problems, enhancing data analysis and optimization efficiency.
	CO4	Implement efficient pattern-matching algorithms, optimizing performance through detailed complexity analysis.
	CO5	Apply bit manipulation, number theory, and modular arithmetic techniques to effectively solve real-world computational problems.

Exp. No.	Topics
1	**Complexity Classes & Algorithm Comparison:** Revise and compare algorithms based on the following time complexities: • **$O(1)$:** Constant time - e.g., accessing an array element • **$O(\log n)$:** Logarithmic time - e.g., binary search • **$O(\sqrt{n})$:** Square root time - e.g., algorithms involving geometric operations • **$O(n)$:** Linear time - e.g., linear search • **$O(n \log n)$:** Linearithmic time - e.g., merge sort, quick sort, heap sort • **$O(n^2)$:** Quadratic time - e.g., bubble sort, insertion sort • **$O(n^3)$:** Cubic time - e.g., 3D matrix operations • **$O(2^n)$:** Exponential time - e.g., brute-force for the Traveling Salesman Problem • **$O(n!)$:** Factorial time - e.g., generating all permutations
2	**Advanced Standard Library Data Structures** Deepen your understanding of dynamic arrays, sets, maps, iterators, and range operations with real-world applications and optimization challenges: • **Dynamic Arrays:** Implement efficient resizing and compare performance across insertions and deletions. • **Sets & Maps:** Solve problems with custom comparisons, such as finding the top K elements or first unique character in a stream. • **Iterators & Range Operations:** Use iterators for merging sorted arrays or sliding window algorithms with range queries. • **Optimized Data Structures:** Implement custom map/set from scratch, optimizing for time and memory complexity. **Lab Exercise:**

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	• Build an LRU cache with std::map for fast lookups.
	• Find the top K elements dynamically with maps and sets.
	• Solve the sliding window maximum problem with efficient complexity using range-based operations.
3	**Advanced Arrays and Strings:** Learn and apply techniques like the sliding window, two-pointer approach, and binary search to solve complex problems in arrays and strings. **Lab Exercises:** • Find the maximum sum sub-array of size K using the sliding window technique. • Find the longest substring without repeating characters. • Find a pair with a given sum in a sorted array using the two-pointer technique. • Search for an element in a rotated sorted array using binary search. • Check if there is a pair in an array with a given sum X using hashing. • Find the first missing positive integer in an unsorted array. • Solve the "Sort Colors" problem (0s, 1s, 2s problem) using the Dutch National Flag algorithm. • Solve two medium-level array problems on a competitive programming platform like LeetCode or Codeforces. • Find the maximum product of two integers in an array. • Find the longest increasing subsequence in an unsorted array. • Move all zeroes in an array to the end while maintaining the relative order of non-zero elements. **Advanced Learner Challenges:** • Count all palindromic substrings in a given string. • Find the minimum number of swaps required to make a string palindrome. • Solve the "Longest Palindromic Substring" problem using Manacher's algorithm. • Sort an array and count the number of inversions. • Find the median of two sorted arrays using binary search. • Solve the "Kth Largest Element in an Array" using the quick-select algorithm. • Find all unique triplets in an array that sum to zero. • Solve the "Container With Most Water" problem using the two-pointer approach. • Implement a solution for the "3Sum" problem using sorting and two-pointer technique. • Solve the "Maximum Subarray Sum" problem using dynamic programming (Kadane's algorithm).
4	**Linked List:** Study the fundamental operations and advanced techniques involving linked lists, including reversing, detecting loops, and rearranging nodes. **Lab Exercises:** • Reverse a linked list in groups of K. • Detect and remove a loop in a linked list. • Reorder a linked list, rearranging nodes in the pattern L1 → Ln → L2 → Ln-1 → L3 → Ln-2 → .... • Implement basic operations like insertion, deletion, and traversal in a singly linked list. • Find the middle element of a linked list using two pointers. • Merge two sorted linked lists into one sorted list. • Reverse a singly linked list using an iterative and recursive approach. • Detect if a linked list is a palindrome using two-pointer technique.

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- Find the intersection point of two linked lists using hash sets or two-pointer technique.
- Rotate a linked list by k positions.

Advanced Learner Challenges:
- Flatten a multilevel doubly linked list (where each node may have a next and child pointer).
- Find the intersection point of two linked lists using optimized space (no additional data structures).
- Merge k sorted linked lists using a priority queue.
- Detect and handle cycle in a linked list using the Floyd's cycle-finding algorithm (Tortoise and Hare).
- Implement an LRU cache using doubly linked list and hash map.
- Implement a doubly linked list and perform operations like insertion, deletion, and traversal.

5	**Stack and Queue:** Study the fundamental operations of stacks and queues, including their applications and efficient implementations. **Lab Exercises:** • Sort a stack using recursion. • Check for balanced parentheses using a stack. • Implement a circular queue using arrays or linked lists. • Generate binary numbers from 1 to N using a queue. • Implement a queue using two stacks. • Reverse a stack using recursion. • Implement a stack using linked list and perform basic operations. • Implement a queue using two stacks and perform enqueue and dequeue operations. • Solve the "Next Greater Element" problem using a stack. • Implement a queue that supports fast access to both the front and back elements. • Implement a priority queue using a heap data structure. **Advanced Learner Challenges:** • Implement a stack that supports retrieving the minimum element in O(1) time. • Evaluate Reverse Polish Notation (RPN) using a stack. • Design and implement an LRU (Least Recently Used) Cache with O(1) operations for both get and put. • Solve the "Sliding Window Maximum" problem using deque. • Implement a stack that supports O(1) time for both push and pop operations in a multi-threaded environment. • Design a queue that supports O(1) time complexity for enqueue and dequeue operations using a doubly linked list.
4	**Graphs:** Study essential graph algorithms including Topological Sorting, Maximum Flow, Maximum Bipartite Matching, Strongly Connected Components, and Cycle Detection using Union-Find. **Lab Exercises:** • Detect a cycle in a graph using Depth-First Search (DFS). • Find all connected components in an undirected graph using DFS/BFS. • Implement the Shortest Path algorithm in an unweighted graph. • Perform Topological Sorting on a Directed Acyclic Graph (DAG). • Solve the Word Ladder problem using BFS. • Check if a graph is bipartite using BFS/DFS.

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	• Implement Dijkstra's algorithm for the shortest path in a weighted graph. • Find the shortest path in a graph using Bellman-Ford Algorithm. • Solve the Hamiltonian Path problem using backtracking. • Find the Articulation Points and Bridges in a graph. **Advanced Learner Challenges:** • Find all Strongly Connected Components (SCCs) in a directed graph using Tarjan's Algorithm. • Solve the Maximum Bipartite Matching problem using augmenting paths or Hopcroft-Karp algorithm. • Implement the Ford-Fulkerson Algorithm for Maximum Flow and use Edmonds-Karp for efficient implementation. • Solve graph colouring problems with greedy or backtracking algorithms. • Apply the Hungarian Algorithm to solve the assignment problem. • Implement Minimum Spanning Tree using Kruskal's or Prim's Algorithm.
5	**Trees: -** Study essential tree structures such as Binary Search Trees (BST), B-Trees, AVL Trees, Red-Black Trees, Segment Trees, and Binary Index Trees, with a focus on their construction, operations, and applications. • Binary Search Tree (BST): Insert a key into a Binary Search Tree (BST), search for a key, delete a node while maintaining properties, perform inorder, preorder, and postorder traversals, find the height, check if a binary tree is a valid BST, and find the Lowest Common Ancestor (LCA) of two nodes. • B-Trees and B+ Trees: Insert keys into a B-Tree while maintaining balance, delete keys ensuring validity, and traverse all keys in sorted order in a B+ Tree. • AVL Tree: Insert a node into an AVL Tree with rotations (LL, RR, LR, RL) and check if a binary tree is height-balanced. • Red-Black Tree: Insert a key into a Red-Black Tree while maintaining properties and check if a tree satisfies Red-Black Tree rules. • Segment Trees: Construct a segment tree for range sum queries, query the sum of a range [l, r], and update an index in the array with reflected changes in the segment tree. • Binary Index Tree (BIT): Build a Binary Index Tree for prefix sum queries, query the prefix sum up to a given index, and update an element reflecting changes in the BIT. Advanced Learner: (Fenwick Tree, LCA with Binary Lifting, Heavy Light decomposition). • Find the Maximum Value in a Range After K Range Updates (Lazy Propagation). • Dynamic Range Sum Queries Using Fenwick Tree. • LCA of Two Nodes Using Binary Lifting. • Path Queries in a Tree Using Heavy-Light Decomposition.
6	**Greedy Algorithms:** Study advanced interval scheduling problems and complex optimization problems using greedy techniques. **Lab Exercises:** • Implement Huffman coding for data compression. • Solve the Activity Selection Problem to choose the maximum number of compatible activities. • Find the minimum number of coins required to make a given amount (Coin Change Problem).

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- Solve the Gas Station Problem to determine the starting point for a circular route with fuel constraints.
- Solve the Fractional Knapsack Problem to maximize the total value of items in a knapsack.
- Solve the Jump Game problem to determine if it's possible to reach the last index of an array.
- Find the minimum number of platforms required for trains, given their arrival and departure times.
- Solve the Job Sequencing Problem to schedule jobs with deadlines and maximize profit.
- Maximize the sum of selected intervals by finding non-overlapping intervals.
- Solve the interval covering problem to select the smallest number of intervals covering a given range.

Advanced Learner Challenges:
- Use Prim's Algorithm to find the minimum cost to connect all points in a graph (Minimum Spanning Tree).
- Split an array into M subarrays to minimize the largest sum using binary search and greedy methods.
- Construct the Lexicographically smallest string after K swaps.
- Maximize the number of non-overlapping subarrays with a given sum using greedy algorithms.
- Solve the Min-Cost to Connect All Points problem using a greedy approach and MST.
- Solve the Minimum Cost to Hire K Workers problem with constraints.
- Maximize the total weight of intervals in an interval scheduling problem with additional constraints.

7	**Dynamic Programming:** Explore foundational and advanced concepts, including the Travelling Salesman Problem (TSP), Longest Arithmetic Subsequence, and various Matrix DP problems. **Lab Exercises:** - Solve the Fibonacci sequence using recursion and dynamic programming. - Implement Matrix Chain Multiplication to minimize multiplication costs. - Find the Longest Increasing Subsequence in a given array. - Solve the 0/1 Knapsack Problem using DP. - Determine if an array can be partitioned into two subsets with equal sums (Partition Equal Subset Sum). - Find the number of unique paths in an m x n grid (robot grid path problem). - Solve the Longest Common Subsequence (LCS) problem for two strings. - Compute the Edit Distance (minimum operations to convert one string to another). - Solve the Coin Change problem to find the minimum number of coins needed to make a sum. **Advanced Learner Challenges:** - Compute the Maximum Path Sum in a Binary Tree using dynamic programming. - Solve the Travelling Salesman Problem (TSP) using bit masking and DP. - Find the minimum number of insertions to make a string a palindrome. - Count the number of ways to partition a set into K subsets using Stirling Numbers. - Solve the Maximum Rectangle in a Binary Matrix problem. - Find the minimum cost path in a weighted grid using DP.

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	• Implement Word Break Problem using a dictionary and DP.
8	**Bit Manipulation:** Master the use of bitwise operators and their applications, including subset generation, XOR tricks, subset sum with bit masking, and counting set bits. **Lab Exercises:** • Find the only non-repeating number in an array using XOR. • Compute the maximum XOR of two numbers in an array. • Count the number of set bits (1s) in an integer using bitwise operations. • Generate all subsets of a set using bit masking. • Solve the problem of checking if a number is a power of two using bit manipulation. **Advanced Learner Challenges:** • Reverse the bits of a given number. • Check if a number is a power of two using bitwise tricks. • Find the number of ways to partition a set using XOR. • Solve the Travelling Salesman Problem (TSP) using bit masking and dynamic programming.
9	**Strings and Pattern Matching:** Explore key algorithms for string matching, including Rabin-Karp, Z-Algorithm, and Knuth-Morris-Pratt (KMP). **Lab Exercises:** • Find the longest palindromic substring in a given string. • Implement the KMP pattern matching algorithm to search for a pattern in a text. • Find all occurrences of a pattern in a text using the Rabin-Karp algorithm. • Find the smallest window in a string that contains all characters of another string. **Advanced Learner Challenges:** • Compute the Longest Prefix which is also a Suffix (LPS Array) for a string. • Find the shortest string that contains all permutations of another string. • Generate all palindromic substrings of a string efficiently. • Implement the Z-Algorithm for pattern matching in a string.
10	**Mathematics and Number Theory:** Explore fundamental concepts in number theory, including the Chinese Remainder Theorem, tiling problems, modular arithmetic, and key algorithms such as GCD, LCM, prime factorization, and combinatorics. **Lab Exercises:** • Find the number of ways to tile a floor of size NxM using 1xM tiles. • Find the Kth smallest number in lexicographical order. • Count the number of distinct subsequences of a string using modular arithmetic. • Solve modular arithmetic problems using basic number theory operations (GCD, LCM). **Advanced Learner Challenges:** • Use the Sieve of Eratosthenes to find all prime numbers less than N and explore its variants. • Apply the Chinese Remainder Theorem to solve modular congruence and related problems.

Course Assessment:

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- **ISE-1:** Evaluates 40-50% of the experiments, with continuous rubric-based assessment (15 marks).
- **ISE-2:** Evaluates the remaining experiments, with continuous rubric-based assessment (15 marks).
- **Final Assessment:** A 3-hour coding contest with three problems of varying difficulty levels, conducted on any online platform (20 marks).

Recommended Books:
1. The Algorithm Design Manual by Steven S. Skiena
2. Competitive Programmer's Handbook by Antti Laaksonen
3. Elements of Programming Interviews by Adnan Aziz (for interview-focused problem-solving)

Online Practice Platforms:
- Video tutorials on competitive programming (YouTube channels like Abdul Bari, CodeChef)
- GitHub - Competitive Programming
- **Codeforces**: For high-level algorithmic challenges
- **LeetCode**: For interview-specific questions
- **HackerRank**: For implementation-heavy challenges
- **TopCoder**: For advanced contests and problems
- **CodeChef**: For practicing competitive programming problems and contests
- **AtCoder**: For practicing algorithmic problems with increasing difficulty
- **SPOJ**: For a wide variety of algorithmic challenges

Online Certification Courses:
- *Udemy - The Bible of Competitive Programming & Coding Interviews*
- *Coursera - Data Structures and Algorithm Specialization by UC San Diego*

Additional Practice:
- **Linked Lists**: Problems on LeetCode (Linked List), GeeksforGeeks (Linked List Practice)
- **Stacks**: Problems on GeeksforGeeks (Stacks), HackerRank (Stacks)
- **Queues**: Practice on HackerRank (Queues), LeetCode (Queue Problems)
- **Trees**: Explore Binary Tree problems on LeetCode, GeeksforGeeks (Binary Trees)
- **Graphs**: Problems on Codeforces (Graphs), LeetCode (Graph Problems), GeeksforGeeks (Graph Algorithms)

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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25MDM41	**Health, Wellness and Psychology**	2	--	--	2	--	--	2
			Examination Scheme					
			ISE-I	MSE	ISE-II	ESE	Total	
		Theory	50	---	50	---	100	
		Lab	---	---	---	---	---	

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

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Introduction to Psychology, Health and Wellness**		
	1.1	Understanding holistic health- Meaning, components of holistic health- components of wellbeing, Psychology of overall health-enhancing behaviors component, Types of health-compromising behaviors, Illness Management and wellness enhancement.	R1	4
	1.2	Nature and source of stress, personal and professional triggers of stress, Effects of stress, coping with stress (minimalistic yet effective exercise habits)	R2	4
2		**Promoting Personal and Professional Wellness: Human Strengths & Life-Enhancement**		
	2.1	Strength: Definition, meaning; Realizing strength; Maximizing Unrealized strength Weakness: Definition, meaning; Identifying and overcoming weakness; Developing hope and optimistic approach.	R2 & R3	4
	2.2	Recovery and Goal Setting: analyzing trends in personality, Approaching Individual differences; Meaning of Goal setting, Types and effectiveness of Goal Setting. Motivation: Meaning, Theory of Needs, 4A's of coping with stress during or after goal setting.	R2	4
	2.3	Eudaimonic Wellness: Meaning and characteristics; concept of defensive coping.	R1, & R4	2
3		**Positive Approach and The Psychology of Living in The Present**		

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	3.1	The Psychology of Living in the Present: meaning, self-registering to the flow of positive thoughts and actions; addressing positive and negative emotions; Eliminating daily hassles, creating happiness. Responding to overthinking: Sociocultural factors and self- realization.	R1,R2, &R4	4
	3.2	Resilience: Meaning and Nature; How to build resilience; Self-communication	R3 & R4	4
		and self-care, reframe thoughts; channelize gratitude; practice resilience building: physical and mental exercises.		
	Total			26

Course Assessment:

ISE-1:
Certification: 50 marks
NPTEL/ Swayam/any other authentic portal certification
https://archive.nptel.ac.in/courses/109/103/109103182/
https://onlinecourses.nptel.ac.in/noc23_hs06/preview

ISE-2:
Health and Wellness: Introduce Group Happiness Project. Group work: Meet, exchange, contact, collect info, talk about why you chose this topic, brainstorm ideas, and present people's opinions in your designed PPT. 30 marks
Psychology of wellness or happiness: Case Study and Brief Report on : Chris Gardener in the Pursuit of Happyness (Group-specific interpretation) 20 Marks

Recommended Books:

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

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
		2	0	0	2	0	0	2
25MDM42	**Emotional and Spiritual Intelligence**		Examination Scheme					
		Theory	ISE-I	MSE		ISE-II	ESE	Total
		Theory	50	---		50	---	100
		Lab	---	---		---	---	---

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

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Fundamentals of Emotional Intelligence**		
	1.1	Emotion- Meaning, characteristics of emotion, components of emotion- cognitive component, physiological component, Behavioural component. Types of emotions, exposing the myths about emotion, physiological or bodily changes accompanying emotions, how emotions affect our thinking and actions	R1	3
	1.2	Nature and Significance of EI, Models of emotional intelligence: Ability, Trait and Mixed, Building blocks of emotional intelligence: self-awareness, self- management, social awareness, and relationship management	R2	3
2		**Personal and Social Competence**		
	2.1	Self-Awareness: Observing and recognizing one's own feelings, Knowing one's strengths and areas of development Self-Management: Managing emotions, anxiety, fear, and anger	R2	3
	2.2	Social Awareness: Others' Perspectives, Empathy and Compassion Relationship Management: Effective communication,Collaboration, Teamwork, and Conflict management (professional impact)	R2	3
	2.3	Strategies to develop and enhance emotional intelligence and using them effectively in professional life	R1	2
3		**Background and Approach: Spiritual Intelligence and Karma Yoga**		

	3.1	• Spiritual Intelligence- Definition, need, state of presence, psychological element, Intuitive intelligence. • Foundation of Spiritual Intelligence • Types of spiritual actions • Models- SQ and SI-Growth model • Yoga of Action and Spirituality: Professionalism	R6,R8	3
	3.2	• Types of spiritual actions • Models- SQ and SI-Growth model • Readiness for spiritual intelligence: self-leadership, synthesize high performance, spiritual awareness, neuropsychology, and state of conscious identity.	R5, R7	3
4		**Opposite Polarity in SI and Overall Impact on Personality**		4
	4.1	• Twin poles of attention- subject and the object pole • Benefits of Spiritual Intelligence- personal, social and corporate • Dimensions of Spiritual Intelligence- SI and Self Esteem, SI and Restoration of confidence SI and clarity of thoughts and speech, Personality moulding and SI.	R8	
5	5.1	**Spiritual Ecology and Environmental Grassroots Activism**		
		• Spiritual Stewardship and Ecology: Case studies based on making a difference in ecology through environmental grassroots activism	R4	2
Total				**26**

Course Assessment:

ISE-1:
Certification: 50 marks
NPTEL/ Swayam/ Farmer space Certification
https://onlinecourses.swayam2.ac.in/aic22_ge23/preview
https://www.framerspace.com/course/-Mx9gV_of5-self-directed-emotional-learning-for-empathy-and-kindness-short-course?cid=64815e6241de0ce10ee9c717

ISE-2:
1.Emotional Intelligence: Identifying emotions and applying it to personal and professional situations 20 marks
2. Spiritual Intelligence: Performing solutions based on given problems 30 Marks

Recommended Books:

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

5.Vivekananda, S. (2015). The Complete Book of Yoga. Solar Books.

6.Yogananda, P. (1946). Autobiography of a Yogi. Thomas Press Ltd.

7.Krishnaswami, O. (2006). Karma Yoga: Yoga of Action. Dev Publishers.

8.Buzan, T. (2001). Power of Spiritual Intelligence: 10 Ways to Tap into Your Spiritual Genius. Thorsons.

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25MDM05	**Public Relations and Corporate Communication**	2	--	--	2	--	--	2
		Examination Scheme						
		ISE1		ISE2		ESE		Total
		50		50		----		100

Pre-requisite Course Codes		SLRW Skills
Course Outcomes	CO1	Develop professional communication skills through training and practice
	CO2	Draft professional documents with precision
	CO3	Develop effective communication strategies for diverse, cultural and global business environment

Module No.	Unit No.	Topics	Ref.	Hrs.
1		**Professional Communication Skills**	R-1,3	8
	1.1	Resume Writing & Cover Letter for Employment		
	1.2	Group Discussion		
	1.3	Formal dressing		
	1.4	Communication – language and articulation		
	1.5	Interview Techniques		
	1.6	Formal email writing		
2		**Synergy Communication**	R-4	6
	2.1	Presentation Skills – creating and delivering presentations		
	2.2	Report Writing- Importance, Objective, type – versioning and storage		
	2.3	Meetings and Documentation: Notice, Agenda, Minutes		
	2.4	Phone and video communication		
3		**Cross-Cultural Communication**	R-2,4	6
	3.1	Cultural awareness		
	3.2	Language barriers		
	3.3	Global communication strategies		
	3.4	Corporate etiquettes		
4		**Corporate Identity and Branding**	R-5	6
	4.1	Corporate image and reputation		
	4.2	Branding strategies		
	4.3	Visual identity		
	4.4	Messaging and tone		
	4/5	Cultural context of branding		
			Total	26

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Assessment:

Sr. No.	List of Written and Oral Assignments	ISE	Marks
1	Resume/ Cover Letter	ISE1	10
2	GD Practices		10
3	Mock Interview HR Question		10
4	Team Building Activity		10
5	Notice & Agenda and Minutes of the Meeting		10
6	Formal presentation	ISE2	10
7	GD Practices		20
8	Mock Interview HR Question		20
	Total (Average)		100

ISE-1:
Certification: 50 marks
NPTEL/ Swayam/ Farmer space Certification
https://onlinecourses.swayam2.ac.in/aic22_ge23/preview

https://www.framerspace.com/course/-Mx9gV_of5-self-directed-emotional-
learning-for-empathy-and-kindness-short-course?cid=64815e6241de0ce10ee9c717

ISE-2:
1.Emotional Intelligence: Identifying emotions and applying it to personal
and professional situations 20 marks
2. Spiritual Intelligence: Performing solutions based on given problems 30 Marks

Recommended Books:
1. Bar-On, R., & Parker, J.D.A.(Eds.) (2000). The handbook of emotional intelligence, San Francisco, California: Jossey Bros.
2. Goleman, D. (2005). Emotional Intelligence. New York: Bantam Book.
3. Sternberg, R. J. (Ed.). (2000). Handbook of intelligence. Cambridge University Press.
4. Thich Nhat Hanh, V. S. (2016). *Spiritual Ecology: The Cry of the Earth.* Golden Sufi Center.
5. Vivekananda, S. (2015). *The Complete Book of Yoga.* Solar Books.
6. Yogananda, P. (1946). *Autobiography of a Yogi.* Thomas Press Ltd.
7. Krishnaswami, O. (2006). *Karma Yoga: Yoga of Action.* Dev Publishers. Buzan, T. (2001). *Power of Spiritual Intelligence: 10 Ways to Tap into Your Spiritual Genius.* Thorsons.

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

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	L	T	P	Total
25PCC13CE18	Mini Project	0	0	2	0	0	1	1
		Examination Scheme						
		ISE1	MSE		ISE2	ESE		Total
		20	--		30	--		50

Pre-requisite Course Codes		
	On successful completion of the course learner will be able to	
Course Outcomes	CO1	Identify and analyze problems related to society, research, innovation, and entrepreneurship through a comprehensive literature survey.
	CO2	Formulate and apply appropriate methodologies using engineering knowledge and skills to develop effective solutions.
	CO3	Validate, verify, and evaluate the impact of solutions using test cases, benchmark data, theoretical inferences, experiments, or simulations.
	CO4	Adopt standard engineering practices and project management principles while ensuring sustainability and ethical considerations.
	CO5	Develop technical competency and lifelong learning through self-directed learning, participation in competitions, hackathons, and exposure to industry trends.
	CO6	Enhance communication and teamwork skills through technical report writing, presentations, and collaborative group work.

Guidelines:

1. Project Topic Selection and Allocation (end of sem 5):

    A. Project topic selection Process to be defined and followed:

        o Project orientation can be given at the end of fifth semester.
        o Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
        o Student's should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
        o Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer DigitalIndia portal, SIH portal or any other hackathon portal for problem selection.
    B. Topics can be finalized with respect to following criterion:

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o Topic Selection: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.

o Types of Mini Projects:

Mini projects can be undertaken in various forms, including but not limited to:

1. Software and Application Development
2. Machine Learning & Data Science
3. Embedded Systems & IoT
4. Cybersecurity & Blockchain
5. Simulation & Algorithm Development
6. Cloud Computing & DevOps
7. Augmented Reality (AR) & Virtual Reality (VR)
8. Social Impact & Community-Based Projects
9. Any others

o Technology Used: Use of latest technology or modern tools can be encouraged.

o Students should not repeat work done previously (work done in the last three years).

o Project work must be carried out by the group of at least 2 students and max. 4.

o The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)

o The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.

o Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.

o Guide allocation should be done and students have to submit weekly progress report to the internal guide.

o Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.

o In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels.

2. Project Report Format:

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the Department.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
- Analysis/Framework/ Algorithm
- Design details
- Methodology (your approach to solve the problem) Proposed System
- Experimental Set up
- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Set up

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- Results and Discussion
- Conclusion and Future Work
- References
- Appendix – List of Publications/certificates/patents/competitions participated etc.

3. Desirable: Students should be encouraged –
- to participate in various project competition.
- to write minimum one technical paper & publish in good journal.
- to participate in national / international conference

4. Course Assessment : Distribution of marks for the ISEs shall be done based on following:

ISE-1 (20 marks)
- Project Idea Evaluation (10 marks)
- Mid-term presentation 1 will be carried out and evaluation is based on rubrics decided by the department. (10 marks)

ISE-2 (30 marks)
- Mid-term presentation 2 will be carried out and evaluation is based on rubrics decided by the department. (10 marks)
- Full project demonstration will be carried out at the end of the semester in front of the panel of the department. (10 marks)
- Report writing and Weekly Log Report (10 marks)

The final certification and acceptance of project ensures the satisfactory performance on the above aspects.

Project Idea Evaluation Metrics:
Literature Survey and Gaps Identified, Problem Statement Defined, Scope of Project, Objectives Defined, Mapped to SDG (Sustainable Development Goals), Presentation Skills, Individual Team Contribution and Professional Ethics.

Mid Term Presentation Metrics:
Design & Methodology Used, Technologies Used, Implementation, Presentation, Individual Contribution, Professional Ethics.

Full Project Demonstration:
Literature Survey, Design & Methodology Used, Implementation & Functionality, Presentation, Report Quality, Individual Team Contribution and Professional Ethics, Competitions & Hackathons Participation