



THIRD YEAR UG: B.TECH

COMPUTER ENGINEERING

REVISION: FRCRCE-3-26

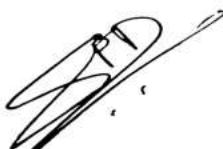
Effective from Academic Year 2026-27

Board of Studies Approval: 04/03/2026

Academic Council Approval: 25/06/2025



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Dean Academics



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INSTITUTE VISION

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

INSTITUTE MISSION

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

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

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

DEPARTMENT VISION

To be a center of excellence in Computer Engineering education that will produce self-motivated and globally competent individuals through holistic development.

DEPRATMENT MISSION

M1: Build state-of-the-art infrastructure that can accommodate cutting-edge technology and is constantly updated in response to the needs.

M2: To emphasize on experiential learning and holistic development in order to pursue academic excellence and inculcate research aptitude through high-quality research publications

M3: Enable the students to foster innovative ideas in pace with the emerging technologies

M4: Encourage faculty members to pursue higher education/research and stay abreast with the latest technology.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1: Apply Computer Science principles and techniques to develop engineering projects in order to achieve client business objectives and/or to conduct fruitful research.

PEO2: Demonstrate excellent interpersonal skills and leadership qualities at their workspace and in the society

PEO3: Successfully work in diverse and multidisciplinary teams, communicate effectively, and find innovative solutions to problems.



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PROGRAMME SPECIFIC OUTCOMES

The student will have the ability to

PSO1: Develop Artificial Intelligence and Machine Learning systems.

PSO2: Apply cyber security mechanisms to ensure the protection of information technology assets.



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

SEM-V												
Course Code	Course Vertical	Sub Vertical	Course Name		Notional Hours	Examination Marks				Credits		
						ISE	MSE	ESE		Total	Points	Total
								Min	Max			
25PCC13CE19	PCPEC	PCC	Cryptography and System Security	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PCC13CE21	PCPEC	PCC	Theory of Computer Science	TH	2	20	30	20	50	100	2	3
				TU	1	50	-	-	-	50	1	
				SS/SL	3							
25PCC13CE22	PCPEC	PCC	Computer Networks	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PCC13CE14	PCPEC	PCC	Data Warehousing and Mining	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25VSE13CE04	SC	VSEC	Cloud Computing Laboratory	PR	4	100	-	-	-	100	2	2
25PEC13CE1X	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PECL13CE1X	PCPEC	PEC	Program Elective Laboratory	PR	2	50	-	-	-	50	1	1
25OE13CE3X	MDC	OE	1. Health, Wellness and Psychology 2. Emotional and Spiritual Intelligence	TH	2	100	-	-	-	100	2	2
				SS/SL	2							
25MDM4X	MDC	MDM	MDM Course-4	TH	2	20	30	20	50	100	2	2
				SS/SL	2							
25DM3X	DM	DM	Double Minor Course	TH	2	20	30	20	50	100	2	4*
				TU	2	50	-	-	-	50	2	
				SS/SL	2							
25HR04	HR	HR	Honors/ with Research	SL	8	-	-	-	-		4	4*
Total					TH:TU:PR:SL 14:01:14:15=44		-	-		1100		22

SEM-VI												
Course Code	Course Vertical	Sub-Vertical	Course Name		Notional Hours	Examination Marks				Total	Credits	
						ISE	MSE	ESE			Points	Total
								Min	Max			
25PCC13CE15	PCPEC	PCC	Distributed Computing	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PCC13CE16	PCPEC	PCC	Software Engineering	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PCC13CE17	PCPEC	PCC	Artificial Intelligence Laboratory	PR	2	50	-	-	-	50	1	1
25PCC13CE18	PCPEC	PCC	Mini Project	PRJ	2	50	-	-	-	50	1	1
25PCC13CE23	PCPEC	PCC	Mobile App Development	PR	2	50	-	-	-	50	1	1
25PCC13CE24	PCPEC	PCC	DevOps: Development and Operations Practices Laboratory	PR	2	50	-	-	-	50	1	1
25PCC13CE25	PCPEC	PCC	Advanced Microprocessors	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PEC13CE2X	PCPEC	PEC	Program Elective Course	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
				SS/SL	2							
25PECL13CE2X	PCPEC	PEC	Program Elective Laboratory	PR	2	50	-	-	-	50	1	1
25PCC13CE20	PCPEC	PCC	Competitive Coding	PR	2	50	-	-	-	50	1	1
25OE13CE4X	MDC	OE	Public Relations and Corporate Communication	TH	2	100	-	-	-	100	2	2
				SS/SL	2							
25MDM5X	MDM	MDM	MDM Course -5	TH	2	100	-	-	-	100	2	2
				SS/SL	2							
25DM4X	DM	DM	Double Minor Course	TH	2	20	30	20	50	100	2	4*
				TU	2	50	-			50	2	
				SS/SL	2						2	
25HR05	HR	HR	Honors/ with Research	SL	8						4	4*
			Total	TH:TU:PR:SL	12:0:20:12=44				-	1100		22



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List of Program Elective Courses (SEM V and SEM VI)

Sem. V-PCE1 (Th+Pr) Credits 3	Sem.VI-PCE2 (Th+Pr) Credits 3
25PEC13CE11: Blockchain Technology	25PEC13CE21: Decentralized Finance
25PEC13CE12: Deep Learning and Reinforcement Learning	25PEC13CE22: Generative AI
25PEC13CE13: Cyber Security	25PEC13CE23: Digital Forensics
25PEC13CE14: Big Data Analytics	25PEC13CE24: Business Intelligence
25PEC13CE15: Computer Graphics	25PEC13CE25: Augmented Reality and Virtual Reality
25PEC13CE16: Human Machine Interface	25PEC13CE26: UX/UI Design
25PEC13CE17: Geographical Information Systems	25PEC13CE27: Quantum Computing
25PEC13CE18: System Programming with Compiler Construction	25PEC13CE28: Advanced Network Communications

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



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FINAL YEAR Computer Engineering Program
Proposed Scheme for BE Computer 2027-2028

SEM-VII/VIII												
Course Code	Course Vertical	Sub-Vertical	Course Name		Contact Hours	Examination Marks					Credits	
						(1 Credit=50 Marks)						
						ISE	MSE	ESE		Total	Points	Total
Min	Max											
25PEC14CE3X	PCPEC	PEC	Program Elective Course1	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25PEC14CE3X	PCPEC	PEC	Program Elective Course2	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25PEC14CE3X	PCPEC	PEC	Program Elective Course3	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25PEC14CE3X	PCPEC	PEC	Program Elective Course4	TH	2	20	30	20	50	100	2	3
				PR	2	50	-	-	-	50	1	
25MDM06X	MDC	MDM	MDM Course-6	TH	2	20	30	20	50	100	2	2
25MDM07X	MDC	MDM	MDM Course-7	TH	2	20	30	20	50	100	2	2
25RMC14CE01	EL	RM	Essentials of Research Methodology	TH	2	20	30	20	50	100	2	2
25RMC14CE02	EL	RM	Intellectual Property Rights	TH	2	20	30	20	50	100	2	2
25PRJ14CE01	EL	PR	Major Project	PRJ	12	300	-	-	-	300	6	6
25SEM14CE01	PCPEC	PEC	Course Seminar		Online		As per Rubrics for Seminar				2	2
25INT14CE01	EL	INT	Semester long Internship	PR	36-40 hrs		As Per Internship Manual				12	12
HXXXCXXX	HMM/DM	HMM/DM	Honors/Minor Degree Course	TH	Online		As Per SWAYAM				8	8*
HXXXCXXX	HMM/DM	HMM/DM	Honors/Minor Degree Lab (Project)	PR							2	2*
Total					TH:TU:PR+PRJ 16:0:8+ 12=36			-		1200	-	40+*10

Sem. VII/VIII-PCE (Th+Pr) Credits 3

25PEC14CE31 : Quantum Computing
25PEC14CE32 : Big Data Analytics
25PEC14CE33 : Soft Computing and Optimization Algorithms
25PEC14CE34: AI for Finance Management
25PEC14CE35: Blockchain Technology
25PEC14CE36 : IT Service Management
25PEC14CE37 : High performance Computing

Course Code	Course Name
25MDM061	Environment Management
25MDM062	Disaster Management
25MDM071	Management Information Systems
25MDM072	Finance 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 courses



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

Pre-requisite Course Codes		25BSC12CE05
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply concepts of modular arithmetic and number theory to classical encryption techniques to achieve system security goals.
	CO2	Apply modern symmetric and asymmetric cryptographic techniques to solve security problems.
	CO3	Analyze cryptographic hash functions and message authentication mechanisms for ensuring data integrity.
	CO4	Analyze digital signature schemes and authentication protocols for secure communication.
	CO5	Analyze network attacks and security protocols to evaluate system vulnerabilities.

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
	3.1	Cryptographic hash functions, Properties of secure hash		



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		function, MD5, SHA-1		
	3.2	MAC, HMAC		
4		Authentication Protocols and Digital Signature Schemes	1,2	4
	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	

Self-Learning:

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

Course Assessment:

Theory:

ISE: Based on Self-Learning / Formative assessment activities will be conducted during the full semester - 20 Marks

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

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

Sr.no	Suggested List of experiments (Any 10)	Ref	COs
1	Design and Implementation of a product cipher using Substitution and Transposition ciphers	1,2	CO1
2	Implementation and analysis of public key cryptography.	1,2	CO1
3	Implementation of Diffie-Hellman Key exchange algorithm.	1,3	CO2
4	For varying message sizes, test integrity of message using MD-5, SHA-1, and analyse the performance of the two protocols.	1,3	CO3
5	Implementation and analysis of Digital signature scheme	1,2	CO4
6	Implementation of Salt and Pepper password protection technique	8	CO3
7	Implement Needham Schroeder authentication protocol.	1,2	CO4
8	Explore the GPG tool of Linux to implement email security	7	CO4



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9	Study and Implement SQL Injection	4	CO5
10	Study and Implement DOS Attacks	4	CO5
11	Using NMAP for ports monitoring.	9	CO5
12	Using open SSL for web server - browser communication.	4	CO5
13	Explorer Kali Linux operating system and explain any one tool of kali Linux	10	CO4, CO5
14	EXPLORING N-STALKER: To download the N-Stalker Vulnerability Assessment Tool and exploring the features.		CO5

Course Assessment: -

Lab:

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

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 Computer Security, Behrouz A. Forouzan & Debdeep Mukhopadhyay, 3rd Edition, McGraw Hill.
- [4] Network Security Bible, Eric Cole, Wiley Publication, Second Edition, 2009
- [5] <https://www.geeksforgeeks.org/computer-networks/zero-knowledge-proof/>
- [6] <https://www.geeksforgeeks.org/computer-networks/what-is-vpn-how-it-works-types-of-vpn/>
- [7] <https://gpgtools.org/>
- [8] <https://share.google/EIr6G6FeqOEffkQaM>
- [9] <https://nmap.org/book/man-port-scanning-techniques.html>
- [10] <https://www.kali.org/> and <https://www.geeksforgeeks.org/linux-unix/kali-linux-tools/>
- [11] <https://share.google/9nQgSgaDdFEaGDOQq>

Video Lectures

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

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	1	3	--	1	2	--	--	2	--	3
CO2	3	3	--	1	2	--	1	2	--	--	2	--	3



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

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

Bloom's Level

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE21	Theory of Computer Science	L	T	P	SL	L	T	P	Total
		2	1	--	2	2	1	--	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20		30		20	50
		Tutorial		50		--		--	50

Pre-requisite Course Codes	25BSC12CE05	
After the successful completion students should be able to:		
Course Outcomes	CO1	Design deterministic and non-deterministic finite automata to recognize formal languages.
	CO2	Construct regular expressions and establish their equivalence with finite automata.
	CO3	Develop context-free grammars for formal languages and convert them into Chomsky and Greibach Normal Forms.
	CO4	Design Pushdown Automata and Turing Machines for language recognition and computation.
	CO5	Analyze computational problems using the concepts of decidability and undecidability.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to Theory of Computation and Finite Automata Fundamental concepts: alphabets, strings, languages, and operations on languages; Deterministic Finite Automata (DFA); Non-Deterministic Finite Automata (NFA); ϵ -NFA and its conversion to DFA; Equivalence of DFA and NFA; Minimization of DFA.	1,2,3	05
	1.2	Finite Automata with Output Moore and Mealy Machines; Equivalence and conversion between Moore and Mealy machines; Applications.	1,2,3	02
2	2.1	Regular Languages Regular Expressions (RE); Conversion between RE and FA; Algebraic laws of regular expressions; Closure properties of Regular Languages (Union, Concatenation, Kleene Star, Complement, Intersection); Pumping Lemma for Regular Languages and its applications.	1,2	03
3	3.1	Grammar Chomsky Hierarchy; Regular Grammars (Right Linear and Left Linear); Conversion between FA and Regular Grammar; Context-Free Grammar (CFG); Derivation trees; Ambiguity in grammars.	1,3	03



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	3.2	Normal Forms Simplification of CFG; Chomsky Normal Form (CNF); Greibach Normal Form (GNF).		
4.	4.1	Push Down Automata (PDA) Formal definition and mathematical model of PDA; Transition functions and state diagrams; Deterministic and Non-Deterministic PDA (DPDA & NPDA); Equivalence of CFG and PDA; Closure properties of Context-Free Languages.	1,2	04
5.	5.1	Turing Machines Formal definition and mathematical model of Turing Machine; Language acceptability; Design and construction of Turing Machines for problem solving.	1,2	02
	5.2	Variants and Advanced Concepts Multitape, Multitrack, Multi-stack, Composite and Iterative Turing Machines; Universal Turing Machine; Church-Turing Thesis.		
6	6.1	Theory of Computability and Undecidability Recursive and Recursively Enumerable Languages; Decidable and Undecidable Problems; Halting Problem; Post Correspondence Problem (PCP); Introduction to Rice's Theorem.	1,2	02
Total				26

Self-Learning:

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Tutorials		
Sr. No.	Tutorial Topics	COs Mapped
1	Design Deterministic Finite Automata (DFA) for given formal languages; DFA minimization using Myhill–Nerode Theorem (State Equivalence Algorithm) and Table-Filling Method.	CO1
2	Design Finite Automata with Output (Moore and Mealy Machines); Conversion between Moore and Mealy Machines; NFA to DFA conversion problems.	CO1
3	Construct Regular Expressions for given languages; Design FA from RE;	CO2



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	Convert FA to RE; Apply Pumping Lemma for Regular Languages.	
4	Construct Context-Free Grammars (CFG); Simplification of CFG; Conversion to Chomsky Normal Form (CNF) and Greibach Normal Form (GNF); Identify ambiguity.	CO3
5	Design and Construct Pushdown Automata (PDA) for given Context-Free Languages	CO4
6	Design Turing Machines to recognize given languages.	CO4
7	Analyze computational problems using Halting Problem and Post Correspondence Problem (PCP); Classify problems as decidable or undecidable.	CO5
Note: Some tutorials may require more than one session due to the analytical and problem-solving complexity involved.		

Course Assessment:

Tutorial:

ISE: Assessment shall be based on five tutorials, with each tutorial carrying 10 marks, evaluated through continuous assessment of analytical thinking, problem-solving skills, and accuracy of solutions.

Recommended Books:

1. K.L.P. Mishra and N. Chandrasekaran, "Theory of Computer Science: Automata, Languages, and Computation", 2nd Edition, PHI Learning.
2. John E. Hopcroft, Rajeev Motwani, and Jeffrey D. Ullman, "Automata Theory, Languages, and Computation", 3rd Edition, Pearson.
3. Vivek Kulkarni, "Theory of Computation", Oxford Higher Education.
4. Michael Sipser, "Introduction to the Theory of Computation", Cengage Learning.
5. Peter Linz, "An Introduction to Formal Languages and Automata", Jones & Bartlett Learning.
6. Daniel A. Cohen, "Introduction to Computer Theory", Wiley Publication.
7. John C. Martin, "Introduction to Languages and the Theory of Computation", McGraw Hill.
8. E.V. Krishnamurthy, "Theory of Computer Science", EWP Publication.

Online Resources:

1. <https://www.youtube.com/playlist?list=PL85CF9F4A047C7BF7>
2. <https://nptel.ac.in/courses/106104028>

Useful Links

1. GATE Official Portal – <https://gate.iitk.ac.in>
2. Sipser Book link: https://cs.brown.edu/courses/csci1810/fall-2023/resources/ch2_readings/Sipser_Introduction.to.the.Theory.of.Computation.3E.pdf
3. NPTEL – https://onlinecourses.nptel.ac.in/no_c26_cs85/preview
<https://nptel.ac.in/courses/106104148>
4. <https://www.geeksforgeeks.org/theory-of-computation/theory-of-computation-toc-for-gate/>
https://cs.brown.edu/courses/csci1810/fall-2023/resources/ch2_readings/Sipser_Introduction.to.the.Theory.of.Computation.3E.pdf



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	2	--	--	--	--	--	--	--	2	2	1
CO2	3	3	2	--	--	--	--	--	--	--	2	2	1
CO3	3	3	2	--	--	--	--	--	--	--	2	2	1
CO4	3	3	3	--	--	--	--	--	--	--	2	2	1
CO5	3	3	--	2	--	--	--	--	--	--	2	2	1

Bloom's Level:

Remember	Understand	Apply ✓	Analyse	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE22	Computer Networks	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PEC13CE28
After the successful completion students should be able to:		
Course Outcomes	CO1	Analyze the impact of transmission media, devices, and switching techniques on computer networks.
	CO2	Apply the knowledge of various functionalities of MAC & LLC sublayer.
	CO3	Classify Functionalities of static & dynamic routing protocol.
	CO4	Analyze Transport layer protocols and its impact on quality of service.
	CO5	Design network architecture using various network protocols in real time environment.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to Computer Networks Components of a computer network: Classification of networks, Network topologies, networking devices (Hub, Switch, Routers, Firewall, Gateway, NIC, Repeater).	1,2,3	2
	1.2	Switching Techniques, Multiplexing, OSI Reference Model, Introduction to TCP/IP Protocol Suite, Comparison between OSI & TCP/IP Protocol Suite.	1,2,3	3
2	2.1	Data Link Layer Introduction To Data Link Layer, Physical Address, Error Detection and Correction (Hamming Code, CRC, Checksum). Elementary Data Link Protocol, Sliding Window Protocol, MAC & LLC Sublayers.	1,2,3	2
	2.2	Channel Allocation, Multiple Access Protocol: Aloha, CSMA/CD, Collision Free Protocol, Ethernet Protocols, 802.X	1,2,3	3
3	3.1	Network Layer Introduction to Network Layer, Design issues of Network layer. Addressing: Logical Address, and Application Specific Address. Introduction to IPV4 Address: Classful Address, Classless Addressing, Special Address, NAT: Address Translation & translation table. Introduction of IPV6.	1,2,3	3
	3.2	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.	1,2,3	3
4	4.1	Transport Layer	1,2,4	3



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		Introduction of Transport layer Services: Port address, Socket primitives. Relationship between transport layer & network layer, Connectionless Transport.		
	4.2	TCP and UDP protocols, TCP congestion control. Multiplexing & Demultiplexing.	1,2,4	2
5	5.1	Application Layer Introduction of Application layer, principal of network application. Web & HTTP, FTP, SMTP, DHCP, DNS: The internet Directory Services	1,2,4	3
	5.2	Peer to Peer Application, Introduction to network security.	1,2,3	2
Total				26

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref.	Hrs.
1	Case Study-Classify various types of cabling used in networking	1,2,3	2
2	Illustrate various networking devices using Packet Tracer	1,2,3	2
3	Use CRC/ Hamming code for error detection and correction	2,3	2
4	Analyze various Networking Operations and Troubleshooting using command.	2,3	2
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
7	Illustrate Socket programming using TCP and Remote Login using Telnet/SSH	4	2
8	Illustrate VLAN in network infrastructure	1,2	2
9	Build DHCP Functionality in network infrastructure	4	2
10	Perform Remote login using Telnet server	4	2
11	Mini project-Build Network Architecture for a given problem Statement.		2
	Total		26



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Course Assessment: -

Lab: -

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

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

Useful Links:
1. NPTEL, https://nptel.ac.in/courses/106105081/
2. Stanford University, https://lagunita.stanford.edu/courses/Engineering/Networking-SP/SelfPaced/about
3. www.tutorialspoint.com , https://www.tutorialspoint.com/computer_fundamentals/computer_networking
4. https://www.geeksforgeeks.org/blogs/what-is-5g-wireless-technology-and-how-it-works/

Suggested CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	--	--	--	--	--	--	--	--	--	--	--	1
CO2	3	3	3	--	2	--	--	--	--	2	--	--	1
CO3	3	3	3	--	2	--	--	--	--	3	--	--	1
CO4	3	3	3	3	2	--	--	--	--	3	--	--	1
CO5	3	3	3	3	1	--	--	--	--	3	--	--	1
CO6	3	3	3	3	3	3	--	--	--	3	--	--	1

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

Bloom's level

Remember	Understand	Apply √	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE14	Data Warehousing and Mining	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC12CE08
After the successful completion students should be able to:		
Course Outcomes	CO1	Design and develop appropriate dimensional models for a given real-world case study using tools.
	CO2	Apply and interpret various OLAP operations on multidimensional datasets using tools.
	CO3	Analyze datasets and apply suitable data preprocessing techniques such as cleaning, transformation, reduction, and discretization.
	CO4	Apply classification, clustering, and association rule mining algorithms on real-world datasets.
	CO5	Evaluate classification, clustering, and association algorithms using appropriate performance metrics and validation techniques.
	CO6	Explain Web Mining concepts and techniques, including Web Content, Structure, and Usage Mining.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Data Warehousing Fundamentals Introduction to Data Warehouse, Data warehouse architecture, Data warehouse versus Data Marts, E-R Modelling versus Dimensional Modelling. Introduction to Data Lakehouse, Data Lake vs Data Warehouse	1,2	2
	1.2	Data Warehouse Schemas; Star Schema, Snowflake Schema, Factless Fact Table, Fact Constellation Schema. Major steps in ETL process, OLTP versus OLAP, OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot.		
2	2.1	Data Mining Task Primitives, Architecture, KDD process, Issues in Data Mining, Applications of Data Mining.	1,2	2
	2.2	Data Exploration: Types of Attributes, Statistical Description of Data, Data Visualization	1,2	1
	2.3	Data Preprocessing: Descriptive data summarization, Cleaning, Integration & transformation, Data reduction, Data Discretization and Concept hierarchy generation.	1,2	2
3	3.1	Mining frequent patterns and associations Market Basket Analysis, Frequent Item sets, Closed Item sets, and Association Rule, Frequent Pattern Mining, Apriori	1,2	2



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		Algorithm, Association Rule Generation, Improving the Efficiency of Apriori, Mining Frequent Itemsets without candidate generation.		
	3.2	Introduction to Mining Multilevel Association Rules and Mining Multidimensional Association Rules		
4	4.1	Clustering: Types of data in Cluster Partitioning Methods (k-Means, k-Medoids)	1,2	2
	4.2	Hierarchical Methods (Agglomerative, Divisive).		
5	5.1	Classification: Basic Concepts of Classification, Decision Tree Induction	1,2	2
	5.2	Naïve Bayesian Classification: Accuracy and Error measures, Evaluating the Accuracy of a Classifier: Holdout & Random Subsampling, Cross Validation, Bootstrap.		3
6	6.1	Web Mining: Introduction, Web Content Mining, Data Mining vs Web Mining	1,2,3	2
	6.2	Web Structure Mining: Page Rank, Clever, Web Usage Mining		
Total				26

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref.	Hrs.
1	To Design and build a Data warehouse/Data Mart for given case study 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	To perform various OLAP operations such as slice, dice, drilldown, rollup, pivot using Excel/Python/PostgreSQL	1,2	2
4	Implementation of Data Discretization (any one) & Visualization (any one)	1,2	2
5	To perform data Pre-processing task and Demonstrate performing Classification, Clustering, Association algorithm on data sets using data mining tool (WEKA/R tool)	1,2	2
6	To implementation of Bayesian algorithm	1,2	2



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7	Implementation of Clustering algorithm (K-means/K-medoids)	1,2	2
8	Implementation of Hierarchical clustering	1,2	2
9	Implementation of Association Rule Mining algorithm.	1,2	2
10	Implementation of Page rank/HITS algorithm	1,2	2
11	Implementation of Text Mining	1,2	2
Total			22

Course Assessment: -

Lab: -

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

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.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_cs12/preview
2. <https://www.coursera.org/specializations/data-mining>
3. <https://www.sap.com/resources/data-lake-vs-data-warehouse>

Useful Links

1. <https://learn.microsoft.com/power-bi>
2. <https://www.tableau.com/learn/training>
3. <https://lookerstudio.google.com>
4. <https://help.qlik.com>
5. <https://superset.apache.org>
6. <https://www.metabase.com/learn>
7. <https://www.zoho.com/analytics>
8. <https://grafana.com/tutorials>
9. <https://aws.amazon.com/redshift/>
10. <https://www.databricks.com/discover/data-lakes>



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	3	--	2	1	--	1	1	--	1	2	1
CO2	2	2	--	1	3	--	--	1	--	--	1	2	--
CO3	2	3	--	3	2	1	--	--	--	--	1	3	1
CO4	3	3	2	2	3	1	--	1	--	--	1	3	1
CO5	2	3	1	2	2	1	--	--	1	--	2	3	--
CO6	2	1	--	--	1	1	1	--	2	--	1	1	2

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25VSE13CE04	Cloud Computing Laboratory	--	--	4	--		--	2	2
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		--	--	--	--	--	
		Lab		100	--	--	--	100	

Pre-requisite Course Codes		25PCC12CE010
After the successful completion students should 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	Apply key security mechanisms in the cloud and propose solutions to mitigate associated challenges.
	CO6	Apply the principles of containerization to practical implementations.

	Suggested list of Experiments	Ref.	COs
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	CO1
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	CO2
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 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	3	CO2



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	them like Load balancing, Auto-Scaling, Security etc.		
Services			
4	Title: To study and Implement Infrastructure as a Service using AWS/AZURE/GCP Objective: To demonstrate the steps to create and run virtual machines inside Public cloud platform. This experiment should emphasize on creating and running Linux/Windows Virtual machine inside Amazon EC2 or Microsoft Azure Compute and accessing them using RDP or VNC tools.	1,2,4	CO3
5	Title: To study and Implement Storage as a Service using AWS S3, Glaciers. Objective: To understand the concept of Cloud storage and to demonstrate the different types of storages like object storage, block level storages etc. supported by Cloud Platforms like Own Cloud/ AWS S3, Glaciers.	1,2,4	CO3
6	Title: To study and Implement Database as a Service on SQL/NOSQL databases like AWS RDS, AZURE SQL/ MongoDB Lab/ Firebase. Objective: To know the concept of Database as a Service running on cloud and to demonstrate the CRUD operations on different SQL and NOSQL databases running on cloud like AWS RDS, AZURE SQL/ Mongo Lab/ Firebase.	1,2,4	CO3
SECURITY			
7	Title: To study and Implement Security as a Service on AWS/AZURE/GCP Objective: To understand the Security practices available in public cloud platforms and to demonstrate various Threat detection, Data protection and Infrastructure protection services in AWS and Azure.	1,4	CO5
8	Title: To study and implement Identity and Access Management (IAM) practices on AWS/Azure/GCP Objective: To understand the working of Identity and Access Management IAM in cloud computing and to demonstrate the case study based on Identity and Access Management (IAM) on AWS/Azure cloud platform.	1,2,4	CO5
Serverless and Messaging			
9	Lab Title: Exploring AWS Lambda: Building Serverless Event-Driven Applications Objective: To understand and implement serverless event handling using AWS Lambda, focusing on creating, deploying, and testing event-driven functions integrated with AWS services.	1,4	CO4
10	Lab Title: Implementing Scalable Messaging Systems with AWS SQS and SNS. Lab Objective: To explore and implement cloud messaging services using Amazon SQS and SNS, focusing on building scalable, reliable, and event-driven communication systems.	1,4	CO4
Containerization			
11	Title: To study and Implement Containerization using Docker Objective: To know the basic differences between Virtual machine and Container. It involves demonstration of creating, finding,	6,7	CO6



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	building, installing, and running Linux/Windows application containers inside local machine or cloud platform.		
12	Title: To study and implement container orchestration using Kubernetes Objective: To understand the steps to deploy Kubernetes Cluster on local systems, deploy applications on Kubernetes, creating a Service in Kubernetes, develop Kubernetes configuration files in YAML and creating a deployment in Kubernetes using YAML	6,7	CO6
Mini Project			
13	Design a Web Application hosted on public cloud platform (Suggested list of Mini Project Topics) 1. Deployment of a scalable web application on AWS using EC2, S3, and RDS. 2. Implementing a CI/CD pipeline for a machine learning project using Jenkins and Docker. 3. Building a serverless application using AWS Lambda for real-time data processing. 4. Developing a microservices architecture application deployed on Kubernetes. 5. Setting up and managing a multi-tier application on a private cloud using OpenStack.	UL – 1,2,3	CO1

Course Assessment: -

Lab:-

ISE: Laboratory ISE is divided into two components: 50 marks for performance and submission of experiments and 50 marks for oral/practical evaluation.

Recommended Books:

1. Bernard Golden, “Amazon Web Services for Dummies”, John Wiley & Sons, Inc.
2. Michael Collier, Robin Shahan, “Fundamentals of Azure, Microsoft Azure Essentials”, Microsoft Press.
3. RajkumarBuyya, Christian Vecchiola, S ThamaraiSelvi, “Mastering Cloud Computing”, Tata McGraw-Hill Education.
4. Barrie Sosinsky, “Cloud Computing Bible”, Wiley publishing ,John Paul Mueller, “AWS for Admins for Developers”, John Wiley & Sons, Inc.
6. Ken Cochrane, Jeeva S. Chelladhurai, NeependraKhare , “Docker Cookbook - Second . Edition”, Packt publication
7. Jonathan Baier, “Getting Started with Kubernetes-Second Edition”, Packt Publication

Useful Links (UL):

1. Website links:

Docker Containers and Kubernetes Fundamentals – Full Hands-On Course
<https://www.youtube.com/watch?v=kTp5xUtalw>

Docker and Kubernetes Tutorials Playlist

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



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Docker and Kubernetes Tutorial for Beginners

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

Complete Kubernetes Tutorial for Beginners

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

2.NPTEL links:

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

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

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

3.Certification links:

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

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	3	--	3	3	1	2	1	2	1	2	1
CO2	3	1	1	--	3	--	1	--	1	1	--	1	1
CO3	3	2	3	--	3	3	1	--	1	1	--	2	1
CO4	3	2	3	--	3	3	1	--	1	1	--	2	1
CO5	3	2	3	--	3	3	1	2	1	1	--	1	3
CO6	3	2	3	--	3	3	1	1	1	1	--	2	1

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

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE11	Blockchain Technology	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE19
After the successful completion students should be able to:		
Course Outcomes	CO1	Describe Blockchain concepts in the context of distributed ledger
	CO2	Analyze concepts of cryptocurrencies, consensus algorithms and mining with security of blockchain.
	CO3	Illustrate Ethereum architecture and transaction workflow.
	CO4	Apply the concepts of smart contract using Solidity programming for a given application.
	CO5	Apply Hyperledger Fabric architecture for enterprise blockchain solutions.
	CO6	Design blockchain-based solutions for real-world applications.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to Blockchain Technology: Issues with centralized systems, Distributed Ledger Technology (DLT), Decentralization, What is a blockchain, Origin of blockchain, Foundation of blockchain: Genesis block, Merkle trees, limitations and applications of blockchain. Components of blockchain, Block in blockchain	1,3	3
	1.2	Transactions creation and verification, Mempool, Types of blockchain: Public, Private, and Consortium, Consensus protocols: Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-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	3
	2.2	Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Mist Wallet, Ethereum frameworks		
3	3.1	Programming for Blockchain: Introduction to Smart Contracts, Types of Smart Contracts, Limitations of Smart Contracts	1	2
	3.2	Introduction to Programming: Solidity Programming – Basics, functions, Visibility and Activity Qualifiers, Address and	Useful Link 5	4



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		Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Struct, Mapping, Inheritance, Error handling, Events		
4		Need of Private Blockchain, Consensus Algorithms for Private Blockchain - PAXOS, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT	1	4
5		Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric Hyperledger Fabric Architecture, Components of Hyperledger Fabric, Transaction Flow.	1, Ref.3	4
Total				26

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	References	CO Mapped
1	Construction of Merkle tree and verification of transaction	1,3	CO1
2	MetaMask installation and transfer of ethers	Useful Links: 6	CO3
3	Solidity program: voting application	Useful Links: 5	CO4
4	Solidity program: crowd funding	Useful Links: 5	CO4
5	Solidity program: Transactions using Remix IDE and MetaMask	Useful Links: 5	CO4
6	Implementation of PAXOS/PBFT algorithm	6	CO5
7	Block mining and reward transfer to the account	2	CO2
8	Smart contract execution using Ganache	Useful Links: 5	CO6
9	Genesis block creation using Geth	Useful Links: 8	CO5
10	Hyperledger installation	6 and Useful Links: 7	CO5



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11	Mini project – Development of smart contract for Dapps	-	CO6
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Course Assessment :

Lab:

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

Recommended Books:

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

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



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Suggested CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	--	1	1	--	--	--	--	1	1	2
CO2	3	3	--	1	1	1	1	--	--	--	1	1	2
CO3	3	2	1	1	3	--	--	--	--	--	1	--	2
CO4	3	2	3	2	3	1	1	--	--	--	1	--	2
CO5	2	2	2	1	1	-	1	--	--	--	1	--	2
CO6	3	3	3	2	-	2	1	2	3	--	2	1	2

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE12	Deep Learning Reinforcement Learning	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE		MSE		Min	Max
		Theory		20		30		20	50
		Lab		50		--		--	50

Prerequisite Course Codes	VSE11CE02, PCC12CE09, BSC12CE06	
After the successful completion students should be able to:		
Course Outcomes	CO 1	Explain the fundamental concepts of artificial neural networks.
	CO 2	Apply deep neural network concepts to train and optimize multi-layered feedforward neural networks..
	CO 3	Analyze convolutional neural network (CNN) architectures and autoencoders for feature extraction & data reconstruction.
	CO 4	Apply recurrent neural network architectures to solve complex sequential data problems.
	CO 5	Apply deep reinforcement learning solutions for real-world problems.

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,	2	2



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		Adding noise to input and output		
3	3.1	Convolution Neural Network: Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function,	3,4	4
	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

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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



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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	2
	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 resources	
Total			26	

Course Assessment: -

Lab:

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

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-



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Wesley Data & Analytics Series) 1st Edition by Laura Graesser and Wah Loon Keng
 [8] <https://www.coursera.org/specializations/deep-learning>

Online Resources:

- 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

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/tptn/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. Mastering Atari, Go, Chess, and Shogi by Planning with a Learned Model
<https://arxiv.org/abs/1911.08265>
5. Multi-Armed Bandits & Gradient Bandit Algorithms
<https://medium.com/@numsm2/reinforcement-learning-chapter-2-multi-armed-bandits-part-5-gradient-bandit-algorithms-1af59d4c544c>
6. Attention Is All You Need (Transformers) – <https://arxiv.org/abs/1706.03762>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	--	--	--	--	2	1	--	1	3	--
CO2	3	3	2	1	3	--	1	2	1	--	1	3	--
CO3	3	3	3	2	3	--	1	2	1	--	2	3	--
CO4	3	3	3	3	3	--	1	2	1	--	2	3	--
CO5	3	3	3	3	3	2	1	2	1	2	2	3	1

Bloom's Level:

Remember	Understand	Apply	Analyse ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE13	Cyber Security	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE12, 25PCC13CE13, 25PCC12CE08
After the successful completion students should be able to:		
Course Outcomes	CO1	Describe the fundamentals of cyber security and cyber law.
	CO2	Evaluate database security challenges and recommend effective protection strategies to ensure confidentiality and availability of data.
	CO3	Investigate operating system vulnerabilities, security features, and hardening techniques.
	CO4	Evaluate network and wireless security concepts fundamentals.
	CO5	Analyze web application threats and strategies for implementing secure practices.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Cyber security 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
		Self-Learning: CIA triad with real-life examples, cyber terrorism, insider attacks, Cyber Appellate Tribunal (CAT)		



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		under section 48		
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. SQL Injection: Union-based, Boolean-based, Error-based, exploitation of input vulnerabilities.	1	2
	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
		Self-Learning: Inference attack in Database Security, Different Multilevel Secure Database (MLSDB) models and their principals (Bell-LaPadula , Biba Model)		
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
		Self-Learning: Sandboxing, Cloud OS and its security challenges		
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
		Self-Learning: Network segmentation, Access Control Lists (ACL), Evil Twin attack.		
	5	Web Application Security		
5	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
		Self-Learning: OWASP, Format string attacks		
Total				26



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

Course Assessment:

Theory:

ISE: Based on self-learning /formative assessment - 20 Marks

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

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

Suggested List of Experiments				
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, and simulate attack scenarios.	1, 2, 3	2
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.	2, 3	2



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		Tools Used: Metasploit, LinPEAS, WinPEAS Tasks: Perform privilege escalation, mitigate exploits, automate detection.		
	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, and 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 Tasks: Implement input filtering, create anomaly detection rules, test security.	1, 3	2
6	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
7	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



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8	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, and integrate AI-based monitoring.	1, 2, 3	2

Course Assessment:

Lab:

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

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.
- [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/kbadqkdlcswfjdelrquehwuxcfmijmuixngudufg buubgubfugbububjxcgfvvsbdiibgfGhdfgFHYtyhRtMTk4NzY=>
3. <https://static.pib.gov.in/WriteReadData/specificdocs/documents/2025/nov/doc20251117695301.pdf>
4. <https://csrc.nist.gov/projects/post-quantum-cryptography/post-quantum-cryptography-standardization>
5. <https://www.nist.gov/news-events/news/2025/03/nist-finalizes-guidelines-evaluating-differential-privacy-guarantees-de>

NPTEL:

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

Useful Links



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1.	https://dpdpa.com/ https://dpdpact2023.com/ https://www.nist.gov/pqc
2	https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-226.pdf?utm_source=chatgpt.com https://www.geeksforgeeks.org/dbms/introduction-to-nosql/
3	https://www.ibm.com/think/topics/edr
4	https://www.zscaler.com/resources/security-terms-glossary/what-is-zero-trust-network-access
5	https://owasp.org/Top10/2025/

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	2	--	--	2	--	--	--	3	--	2
CO2	3	2	2	2	2	2	2	--	--	--	3	2	3
CO3	3	2	2	2	2	2	2	--	--	--	3	--	3
CO4	3	3	--	2	2	2	2	--	--	--	2	2	3
CO5	3	3	2	2	2	2	3	--	--	--	2	2	3

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

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

Pre-requisite Course Codes		25PCC12CE08, 25VSE11CE02
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain building blocks of Big Data Analytics.
	CO2	Apply fundamental enabling techniques like Hadoop and MapReduce in solving real world problems.
	CO3	Analyze different NoSQL systems with a given case study
	CO4	Apply advanced techniques for emerging applications like stream analytics.
	CO5	Apply 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	4
	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.		
	1.2	Big Data Analytics Life Cycle, Case Study of Big Data Solution.		
	1.3	Concept of Hadoop, Core Hadoop Components, Hadoop Ecosystem, Hadoop Limitations.		
2		Big Data Storage and Processing	2	4
	2.1	Hadoop Distributed File System (HDFS), Data Processing in Hadoop (MapReduce and Spark).		
	2.2	Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce..		
3		NoSQL	2,3	6
	3.1	Introduction to NoSQL, NoSQL Business Drivers		
	3.2	NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, 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;		



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		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.		
4		Mining Data Streams	1,3	4
	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.		
	4.2	Counting Distinct Elements in a Stream, Count Distinct Problem, Flajolet-Martin Algorithm, The Datar- Gionis-Indyk-Motwani Algorithm		
5		Real-Time Big Data Models	2,5	4
	5.1	A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering		
	5.2	Case Study: Product Recommendation		
6		Data Analytics with R	1,2,6	4
	6.1	Exploring Basic features of R, Exploring R GUI, 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		
	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		
Total				26

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref.	Hrs.
1	Study and Installation of Hadoop.	1,3	2
2	Hands on Hadoop HDFS	2,3	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	2	2



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	Reduce.		
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
7	Create social graphs using NEO4J database.	2,3	2
8	Data stream Algorithm: Implement DGIM Algorithm using Map Reduce.	1,3	2
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
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: -

Lab:

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

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.

Useful Links

- [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>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	--	--	--	--	--	--	--	1	--	--
CO2	3	3	2	2	3	--	--	--	--	--	2	--	--
CO3	2	3	1	1	2	--	--	--	--	--	1	1	2
CO4	2	3	2	2	3	--	--	--	--	--	2	2	--



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CO5	2	2	2	1	2	2	1	--	--	--	2	1	2
CO6	2	2	1	3	3	--	--	--	--	--	1	1	--

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

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
25PEC13CE15	Computer Graphics	L	T	P	SL	L	T	Total
		2	--	2	2	2	--	3
		Examination Scheme						
		ESE						
		ISE		MSE		Min	Max	Total
		Theory	20	30		20	50	100
		Lab	50	--		--	--	50

Pre-requisite Course Codes	ESC11CE03, BSC11CE01, BSC11CE03	
After the successful completion students should be able to:		
Course Outcomes	CO1	Describe the basic concepts of Computer Graphics.
	CO2	Apply various algorithms for basic graphics primitives.
	CO3	Apply 2-D geometric transformations on graphical objects.
	CO4	Analyze and implement 2-D Viewing and Clipping techniques for graphical objects.
	CO5	Apply 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:	T1,2	2
	1.1	Definition and Representative uses of computer graphics, Overview of coordinate system, Definition of scan conversion, rasterization and rendering.		
	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



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	3.1	Basic transformations: Translation, Scaling, Rotation	T1,2	
	3.2	Matrix representation and Homogeneous Coordinates	T1,2	
	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

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 10 Marks

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

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



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Exp. No.	Suggested List of Experiments	Ref	Hrs
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
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
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	1, 2	2



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	rendering of objects within a given view area.		
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)		
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. 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	1,2,3	



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	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.		

Course Assessment:-

Lab: -

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

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:

- 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>

Useful Links

1. <https://learnopengl.com>
2. <https://docs.blender.org/manual>
3. <https://learn.unity.com>
4. <https://threejs.org/docs>
5. <https://processing.org/tutorials>
6. <https://docs.gimp.org>
7. <https://www.shadertoy.com/howto>

Online Resources for Lab:

1. Blender Tutorials: <https://www.blender.org/>



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2. Computer Graphics Lab:
<https://www.cse.chalmers.se/edu/course/TDA362/tutorials/index.html>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcome (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	1	--	--	--	--	--	--	--	--	--	--	--
CO2	2	3	--	--	2	--	--	--	--	--	--	1	--
CO3	2	2	3	--	3	--	--	--	--	--	--	1	--
CO4	1	3	2	--	2	--	--	1	--	--	--	1	--
CO5	2	2	3	--	2	2	1	1	2	2	1	--	--
CO6	3	--	--	--	1	--	--	--	--	--	--	--	--

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE16	Human Machine Interface	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes	BSE12CE03, 25PCC13CE16	
After the successful completion students should be able to:		
Course Outcomes	CO1	Identify User Interface (UI) design principles.
	CO2	Analyse effective user friendly interfaces for real world application.
	CO3	Apply Interactive Design process to analyse and improve user interface design.
	CO4	Evaluate user interface design based on standard usability principles.
	CO5	Create real world applications using UI design concepts

Module No.	Unit No.	Topics	Ref	Hrs
1		FOUNDATIONS OF HMI:	1,2, 8,9	4
	1.1	The Human: History of User Interface Designing, I/O channels, Hardware, Software and Operating environments, The Psychopathology of everyday Things, Psychology of everyday actions, Reasoning and problem solving.		
	1.2	The computer: Devices, Memory, processing and networks.		
	1.3	Interaction: Models, frameworks, Ergonomics, styles, elements, interactivity, Paradigms.		
2		DESIGN & SOFTWARE PROCESS:	4.7	4
	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.		
	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:	1,2, 8,9	4
	3.1	The graphical User Interface: Popularity of graphics, the concept of direct manipulation, graphical systems, Characteristics.		



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	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:	5	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.		
5		INTERFACE DESIGN FOR MOBILE DEVICES:	6	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:	7,8	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	

Self-Learning:-

1. Self-learning hours include MOOCs, spoken tutorials, online resources, and extended study hours to enhance independent learning and better understanding of each module of the course content.
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Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Module No.	Sr.No	Suggested List of Experiments	Ref.	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	1,2	2



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		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		
1	2	Know the user/client Developing an interface for an application for Physically or visually challenged people	3,4,5,22,23	2
2	3	Requirement Gathering Technique Design story boards from any two scenarios for any software system.	5,6,8	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.	8,16	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	3,8,22,23	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 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.	23	2
5	7	Icon designing Choose a unique domain, design a few icons and show how it can be accommodated on an interface	22,23	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)	11,22	2
6	9	Redesigning interface To calculate screen complexity of existing Graphical User Interface and redesign the interface to minimize the screen complexity. (New)	22,23,25	2
6	10	Study of Technical papers and writing a review of it.		2



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		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 than one industry and present case study and report on the same		
Total				26

Course Assessment: -

Lab:-

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

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.

Useful Links:

Sr. No	Title	Link
1	History of HMI	https://www.youtube.com/watch?v=LJ0sIHi-Owo
2	Norman's Doors	https://www.youtube.com/watch?v=yY96hTb8WgI
3	Gulf of Evaluation	https://www.youtube.com/watch?v=bg4UwyPPZ6U
4	Usability Heuristics	https://www.youtube.com/watch?v=B56Bz3T_aEw
5	Contextual Inquiry	https://nptel.ac.in/courses/106106177/4
6	Gestalt Principles	https://www.interaction-design.org/literature/topics/gestalt-principles



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7	Low Fidelity and High Fidelity Prototyping	https://nptel.ac.in/courses/106106177/13
8	Human Computer Interaction – Introduction	https://nptel.ac.in/courses/106106220
9	Seven Stages of Action Model	https://www.youtube.com/watch?v=iz4YcJ8Cw7Q
10	Shneiderman's 8 Golden Rules	https://www.youtube.com/watch?v=Q2gV5YJb8hM
11	Fitts' Law Explained	https://www.youtube.com/watch?v=YxKjS6YxG5A
12	Hick's Law in UI Design	https://www.youtube.com/watch?v=6YqQ8g6n0kA
13	Mental Models in UX Design	https://www.youtube.com/watch?v=9uOMectkCCs
14	Task Analysis in HCI	https://nptel.ac.in/courses/106106220/18
15	Persona Creation in UX	https://www.youtube.com/watch?v=7Q8mKQvL0yI
16	Think-Aloud Usability Testing	https://www.youtube.com/watch?v=2m6nGyfXrV8
17	System Usability Scale (SUS)	https://www.youtube.com/watch?v=HhWk0gF3W0k
18	Accessibility & WCAG Guidelines	https://www.w3.org/WAI/standards-guidelines/wcag/
19	AR/VR Interfaces in HCI	https://www.youtube.com/watch?v=K4iJkR9VnW0
20	Voice User Interface (VUI) Design	https://www.youtube.com/watch?v=5wR1G9J0Yq8
21	Wizard of Oz Prototyping Method	https://www.youtube.com/watch?v=3Q9gYz3lM8M
22	User Centered Design Process	https://www.youtube.com/watch?v=F9e1JQp1J6I
23	Interaction Styles in HCI	https://nptel.ac.in/courses/106106220/10
24	Cognitive Load Theory in Design	https://www.youtube.com/watch?v=Z7x9W6Yx9eA
25	Error Prevention & Recovery in UI	https://www.youtube.com/watch?v=8cJ3vY9Wm9Y



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	1	--	--	--	--	--	--	--	--	--	2	1
CO2	2	3	--	--	2	--	--	--	--	--	--	2	1
CO3	2	2	3	--	3	--	--	--	--	--	--	2	2
CO4	1	3	2	--	2	--	--	1	--	--	--	2	1
CO5	2	2	3	--	3	2	1	1	2	2	1	3	2

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

Bloom's level

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE17	Geographical Information Systems	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE		MSE	Min	Max	Total
		Theory		20		30	20	50	100
		Lab		50		--	--	--	50

Pre-requisite Course Codes	BSC11CE03, BSC12CE06, PCC12CE06, PCC12CE08, PCC12CE07	
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the fundamental concepts, components, and applications of GIS.
	CO2	Apply 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

Self-Learning:

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Sr. No.	Suggested List of Experiments	Ref	COs Mapped
1	Introduction to GIS software (QGIS, ArcGIS)	1,3	CO1
2	Geo referencing and projection of toposheet, Digitization of map/ Toposheet.	1	CO1
3	Spatial Data Analysis	1,6	CO3
4	Preparation of Non-Spatial Data, Linking Spatial and Non-Spatial data.	1	CO3
5	Google earth integrations in GIS.	1	CO3
6	Spatial and Non spatial Query and Analysis	1	CO4
7	Vector data analysis	1,6	CO4
8	Watershed Analysis	1,6	CO4
9	Terrain Analysis	1,5	CO5
10	Network Analysis	1,5	CO5



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

Online Resources:

5. Esri Training course
6. IRS-ISRO course on GIS
7. NPTEL course on GIS

Course Assessment: -

Lab: -

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

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	--	--	--	--	--	--	--	--	--	1	2	--
CO2	3	2	--	--	2	--	--	--	--	--	1	2	--
CO3	2	2	--	1	--	1	1	--	--	--	1	2	1
CO4	2	3	1	2	2	1	1	--	--	--	1	2	1
CO5	2	2	2	1	2	2	1	--	--	--	1	2	--

Bloom's Level

Remember	Understand	Apply ✓	Analyse	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13CE18	System Programming and Compiler Construction	2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Practical		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE12 and 25PCC12CE010	
After the successful completion students should be able to:			
Course Outcomes	CO1	Apply the design concepts of single-pass and two-pass assemblers using appropriate data structures.	
	CO2	Design single-pass and two-pass macro processors with suitable data structures.	
	CO3	Compare and justify different loader and linker schemes for program relocation and linking.	
	CO4	Design and analyze the lexical, syntax, and semantic phases of a compiler using finite automata, parsing techniques, and syntax-directed definitions.	
	CO5	Apply techniques of intermediate code generation, code optimization, and basic code generation for compiler design.	

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Introduction to System Software Concept of System Software, Goals of system software, system program and system programming, Introduction to various system programs such as Assembler, Macro processor, Loader, Linker, Compiler, Interpreter, Device Drivers, Operating system, Editors, Debuggers.	1,3	2
2	2.1	Assemblers Elements of Assembly Language programming, Assembly scheme, pass structure of assembler, Assembler Design: Two pass assembler Design and single pass Assembler Design for X86 processor, data structures used.	1,3	4
4	4.1	Loaders and Linkers Introduction, Functions of loaders, Relocation and Linking concept, Different loading schemes: Relocating loader, Direct Linking Loader, Dynamic linking and loading.	1,3	3



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5	5.1	Compilers: Analysis Phase Introduction to compilers, Phases of compilers: Lexical Analysis- Role of Finite State Automata in Lexical Analysis, Design of Lexical analyzer, data structures used. Syntax Analysis- Role of Context Free Grammar in Syntax analysis, Types of Parsers: Top down parser- Recursive descent Parser, Predictive Parser, LL(1), Bottom up parser- SR Parser, Operator precedence parser, SLR, LALR, CLR. Semantic Analysis , Syntax directed definitions.	1,2,3,4	7
6	6.1	Compilers: Synthesis phase Intermediate Code Generation: Types of Intermediate codes: Syntax tree, Postfix notation, three address codes: Triples and Quadruples, indirect triple. Code Optimization: Need and sources of optimization, Code optimization techniques: Machine Dependent and Machine Independent. Code Generation: Issues in the design of code generator, code generation algorithms. Basic block and flow graph.	1,2,3,4	6
Total				26

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
Sr. No.	Topic	Ref	CO Mapped
1	Implementations of two pass Assembler.	1,3	CO1
2	Implementation of Two pass Macro Processor.	1	CO2
3	Implementation of Lexical Analyzer.	3	CO4
4	Implementation of Parser (Any one).	5	CO4
5	Implementation of Intermediate code generation phase of compiler.	5	CO5
6	Implementation of code generation phase of compiler.	5,6	CO5
7	Study and implement experiments on LEX, YACC.	4	CO4

Course Assessment: -



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Lab

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

Recommended Books:

1. D. M Dhamdhare: Systems programming and Operating Systems, Tata McGraw Hill, Revised Second Edition
2. A. V. Aho, R. Shethi, Monica Lam, J.D. Ulman: Compilers Principles, Techniques and Tools, Pearson Education, Second Edition.
3. J. J. Donovan: Systems Programming Tata McGraw Hill, Edition 1991
4. John R. Levine, Tony Mason & Doug Brown, Lex & YACC, O 'Reilly publication, second Edition
5. D, M. Dhamdhare, Compiler construction 2e, Macmillan publication, second edition.
6. Kenneth C. Loudon, Compiler construction: principles and practices, Cengage Learning
7. Leland L. Beck, System software: An introduction to system programming, Pearson publication, Third Edition
8. Dragon Book
9. Linux Docs

Useful Links for E-resources:

1. <http://www.nptelvideos.in/2012/11/compiler-design.html>
2. <https://www.coursera.org/lecture/nand2tetris2/unit-4-1-syntax-analysis-5pC2Z>

SUGGESTED CO - PO articulation Matrix

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyse	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	SL	T	P	Total
25PECL13CE11	Image Processing Laboratory	--	--	2	--	--	1	1
		Examination Scheme						
		ISE		MSE		ESE		Total
		50		--		--		50

Pre-requisite Course Codes	25BSC11CE01 , 25ESC11CE03	
After 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.	Suggested List of Experiments	Ref	Cos Mapped
1	Write a program to read and display images using a library (e.g., OpenCV/Matplotlib).	1, 2	CO1
2.	Perform basic operations: grayscale conversion, cropping, resizing, and flipping images.	1, 2	CO1
3	Implement histogram equalization for image enhancement.	1, 2	CO2
4	Apply spatial filters: smoothing (average filter) and sharpening (Laplacian filter).	1, 2	CO2
5	Perform Fourier Transform to enhance images in the frequency domain.	1, 2	CO2
6	Implement edge detection algorithms: Sobel, Prewitt, and Canny.	1, 2	CO3
7	Apply thresholding techniques for image segmentation (global and adaptive thresholding).	1, 2	CO3
8	Perform morphological operations: erosion, dilation, opening, and closing.	1, 2	CO4
9	Write a program to compress an image using a standard technique (e.g., Run-Length Encoding).	1, 2	CO3
10.	Perform color image processing: separate and manipulate RGB channels.	1, 2	CO1
11	Extract features from an image using edge and corner detection methods.	1, 2	CO4
12	Design and implement an application (e.g., license plate detection or face recognition).	1, 2	CO2, CO4, CO5
Mini Project: (Suggested list of Mini Project Topics)			



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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	CO5
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Course Assessment:

Lab:

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

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/>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	3	--	2	--	--	--	--	--	2	2	2
CO2	3	3	2	--	3	--	--	--	--	--	2	2	2
CO3	3	3	2	--	3	1	--	--	--	--	3	3	2
CO4	3	3	3	--	3	2	--	--	--	--	2	2	2
CO5	3	3	3	--	3	2	2	1	2	--	2	2	2

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

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	SL	T	P	Total
25PECL13CE12	Natural Language Processing Laboratory	--	--	2	--	--	1	1
		Examination Scheme						
		ISE		MSE		ESE		Total
		50		--		--		50

Pre-requisite Course Codes	25PCC12CE09, 25BSC12CE06	
After successful completion of the course learner will be able to		
Course Outcomes	CO1	Apply appropriate data preprocessing techniques to prepare unstructured text data for NLP applications.
	CO2	Apply word representation techniques to extract meaningful features for machine learning models.
	CO3	Perform Part-of-Speech (POS) tagging and Named Entity Recognition (NER) using rule-based and statistical methods
	CO4	Apply text classification techniques to effectively analyze and categorize textual data for practical applications.
	CO5	Implement scalable NLP applications leveraging Large Language Models (LLMs) for real-world use cases

Suggested List of Experiments		Ref.	COs
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 stopwords 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	CO1
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	1,2,5	CO2



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	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.		
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 taggi	1,2,4	CO3
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. 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).	1,2,5	CO3



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	Fine-tune a pre-trained model using Hugging Face's Transformers library.		
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 stopwords 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	CO4
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 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.	3,4	CO5
	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.	5	CO5



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	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		
	Total		26

Course Assessment: -

Lab:-

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

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



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- [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>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	2	--	2	--	--	--	1	--	2	2	--
CO2	3	2	2	--	2	--	--	--	1	--	2	2	--
CO3	3	2	2	--	3	--	--	--	1	--	3	3	--
CO4	3	3	3	2	3	--	--	2	3	--	3	3	1
CO5	3	3	3	2	3	--	--	2	3	--	3	3	1

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
26PECL13CE13	Industrial IoT Laboratory	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		25PCC12CE05
After the successful completion students should be able to:		
Course Outcomes	CO1	Implement industrial sensor networks for data acquisition in IIoT applications.
	CO2	Configure and compare IIoT communication protocols to enable reliable industrial data exchange.
	CO3	Apply AI and Edge Computing for Industrial Automation
	CO4	Integrate IIoT devices with cloud platforms to process and visualize industrial big data.
	CO5	Implement and test security mechanisms to ensure data integrity in IIoT systems.

Suggested List of Experiments			
		Ref	Hrs
1.	8051 Programming & Embedded Systems	[8],[9]	2
	Objective: Introduce students to microcontroller architecture and basic embedded C programming concepts. Experiments Introduction to 8051 Microcontroller and Embedded C Environment - Study of 8051 architecture - Installation of Keil IDE - Writing and compiling a simple embedded C program - LED blinking using Port pins Digital Input and Output Interfacing - Interfacing push button switches - LED control using conditional statements - Understanding port operations and bit manipulation Timer Programming in 8051 - Generate time delays using Timer-0 - Square wave generation using Timer-1 - Use timers for periodic events Interrupt Programming - External interrupt for switch input - Timer interrupt based LED blinking		



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	5. Real Time Programming using FreeRTOS - Task Management - Semaphore Management - Event /Queue Management		
2	Sensors and Actuators Interfacing	[8]	2
	Objective: Introduce students to sensor data acquisition and actuator control ,. Experiments Temperature Sensor Interfacing - Interfacing LM35 with microcontroller - Reading analog sensor data - Displaying data on LCD/serial monitor Gas Sensor / Environmental Sensor Interfacing - Interfacing gas or humidity sensors - Threshold detection and alert generation Actuator Control - Interfacing relay or buzzer - DC Motor Control Basic Data Logging - Send sensor data to PC through serial communication		
3	Basic IoT System Implementation	[4]	2
	Objective: Introduction to basic IoT Concepts. ESP32 / Raspberry Pi Introduction - Programming ESP32 using Arduino IDE - Basic GPIO control Sensor Data Transmission using WiFi - Read sensor data from ESP32 - Send data to a web server or dashboard MQTT Communication - Publish sensor data using MQTT - Subscribe and visualize data Cloud Data Visualization - Send sensor data to IoT cloud platforms - Create real-time dashboards2		
	Topics wise List of Experiments relevant to Industrial IoT	Ref.	Hrs
4	Interfacing Industrial-Grade Sensors via LoRaWAN - Connect temperature, humidity, vibration, and gas sensors over LoRaWAN - Transmit & receive sensor data over long distances (1-10 km)	[1], [2], [6], [7]	2
5	5G-Enabled Industrial Data Transmission for Smart Factories - Set up ESP32/Raspberry Pi with a 5G modem - Test real-time high-speed, low-latency IIoT communication	[1], [5], [7]	2
6	AI-Based Visual Inspection with Edge AI Cameras - Use OpenCV & AI cameras (Raspberry Pi + Coral Edge TPU) - Detect faulty industrial parts using image processing & deep learning	[1], [5]	4
7	Secure IIoT Communication with LoRaWAN & MQTT-TLS	[1], [6],	4



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	a) Implement encrypted sensor data transfer over LoRa & MQTT	[7]	
8	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]	4
9	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	[6], [7]	4
10	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 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	[1], [5], [6]	4
11	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.	[1], [5], [6]	4
Total			26

Course Assessment: -

Lab:-

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

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 Madiseti "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



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7. David Hanes, Gonzalo Salgueiro, Rob Barton,” IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things” Released June 2017 Publisher(s): Cisco Press ISBN: 978013430709
8. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C, 2nd ed. Upper Saddle River, NJ, USA: Pearson Education, 2006.
9. J. J. Labrosse, MicroC/OS-II: The Real-Time Kernel, 2nd ed. Boca Raton, FL, USA: CRC Press, 2002.
10. <https://nptel.ac.in/courses/106105195>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	2	1	3	2	--	2	2	--	2	--	--
CO2	3	3	2	1	3	2	--	2	2	--	2	--	2
CO3	3	3	3	1	3	2	--	2	2	--	2	3	--
CO4	3	2	3	1	3	2	--	2	2	--	2	2	2
CO5	3	3	1	1	3	2	3	2	2	--	2	--	3

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

Bloom's level

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PECL13CE14	Innovative Product Development Laboratory -Phase1 (Start-up)	L	T	P	SL	L	T	P	Total
		--	--	2	--	-	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		25PCC11CE01
After the successful completion students should be able to:		
Course Outcomes	CO1	Implement a functional product prototype based on validated requirements.
	CO2	Evaluate product performance and usability through testing and iteration.
	CO3	Analyse eligibility and benefits of DPIIT recognition for a given product
	CO4	Pitch a product's incubation or funding readiness using appropriate documentation and pitching techniques.

	Suggested List of Experiments	Ref.	COs
1	Generating and Refining Innovative Product Ideas Using Design Thinking 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	1
2	Market Research & Customer Discovery - i) Analyse competitors' products and marketing strategies to identify market gaps and opportunities. ii) Conduct surveys to gather insights into customer preferences, behaviours, and pain points. Expected Outcome: Create a Market Segmentation Report that includes customer personas with demographic, psychographic, behavioural, and pain point details. The report should analyse market segmentation based on key 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.	2	1
3	Concept Development & Validation i) Create initial product concepts in the form of wireframes, sketches, or low-fidelity prototypes. ii) present these concepts to stakeholders, including potential users,	3	2



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	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.		
4	Prototyping & MVP Definition Develop a prototype of the selected product concept to visualize core functionality and user interaction using simple prototyping techniques. Identify and define the Minimum Viable Product (MVP) by selecting essential features required to address the primary user problem. Validate the prototype through basic user or stakeholder feedback and refine the concept accordingly. Expected Outcome: A Prototype and MVP Definition Document including prototype visuals, a clearly defined set of MVP features, and a summary of feedback received with proposed refinements.	2	2
5	Introduction to IPR & Patent Search Conduct a basic patent search using online databases such as Google Patents, WIPO, or the Indian Patent Office to identify existing solutions related to the selected product idea. Analyze prior art to understand novelty and avoid duplication. Expected Outcome: A Patent Search Summary Report documenting the searched keywords, relevant existing patents, and a brief analysis of similarities and differences with the proposed product idea. The report should highlight preliminary novelty assessment and awareness of intellectual property considerations.	6	3
6	Business Model Development Using the Lean Canvas Approach 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
7	Product Cost Estimation & Pricing Basics Estimate the approximate cost of developing the proposed product by identifying major cost components such as materials, development effort, tools, and operational expenses. Explore basic pricing approaches including cost-based and value-based pricing to suggest a suitable price range. Expected Outcome: A Cost Estimation and Pricing Report detailing the identified cost components, assumptions made, and justification for the chosen pricing approach. The report should demonstrate understanding of cost-price relationships and basic financial feasibility.	2	3
8	Designing a Go-to-Market Strategy Design a basic Go-to-Market (GTM) strategy for launching the product by defining target customers, value positioning, marketing channels,	5	4



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	distribution approach, and potential challenges in market entry. Expected Outcome: A Go-to-Market Strategy Document describing the target market, customer acquisition approach, positioning strategy, and high-level execution plan for introducing the product to the market.		
9	Pitching & Storytelling for Product Ideas Prepare and deliver a concise product pitch highlighting the problem, proposed solution, target users, value proposition, business rationale, and go-to-market strategy. The pitch may be presented live or recorded as a short video. Expected Outcome: An Evaluated Product Pitch Presentation or Video , assessed on clarity of problem articulation, coherence of solution, storytelling effectiveness, and overall communication of the product concept.	4	4
	Total		20

Course Assessment: -

Lab:-

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

Recommended Books:

- [1] Tim Brown, “Change by Design: How Design Thinking Creates New Alternatives for Business and Society”, Revised edition, Harper Business, 2019.
- [2] Eric Ries, “The Lean Startup: How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses”, 1st edition, Crown Business, 2011.
- [3] Jake Knapp, John Zeratsky, and Braden Kowitz, “Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days”, 1st edition, Simon & Schuster, 2016.
- [4] Alexander Osterwalder and Yves Pigneur, “Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers”, 1st edition, John Wiley & Sons, 2010.
- [5] Geoffrey A. Moore, “Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers”, 3rd edition, Harper Business, 2014.

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	3	--	2	2	--	2	--	--	1	1	--
CO2	2	3	2	3	2	2	--	2	--	--	1	1	--
CO3	1	3	--	--	--	2	2	--	--	--	2	1	--
CO4	1	1	2	--	--	--	--	2	3	--	2	1	--

Bloom's level

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25PECL13CE22	Ethical Hacking	L	T	P	L	T	P	Total
		--	--	2	--	--	1	1
		Examination Scheme						
			ISE	MSE	ESE	Total		
		Theory	--	--	--	--		
		Lab	50	--	--	50		

Pre-requisite Course Codes	25PCC12CE08, 25PCC12CE010, 25VSE12CE03, 25PCC13CE22	
After the successful completion students should be able to:		
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 List of Experiments			
Sr. No.	Labs	Ref.	COs
1	Enumeration – Performing network enumeration to extract system details, user information, and shared resources. 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	CO1
2	Vulnerability Analysis – Identifying security weaknesses in networks, systems, and applications using automated tools and manual analysis. 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	CO1
3	Vulnerability Analysis – Identifying security weaknesses in networks, systems, and applications using automated tools and manual analysis. Objectives: Perform vulnerability scans using automated tools.	1, 4	CO1



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	- 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. 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	CO2
5	Malware Threats – Analyzing and detecting different types of malware to understand their behavior and mitigation techniques. 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	CO5
6	Sniffing – Capturing and analyzing network traffic to extract sensitive information and detect vulnerabilities. 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	CO3
7	Social Engineering – Simulating phishing and credential harvesting attacks to exploit human vulnerabilities. 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	CO3
8	Denial-of-Service (DoS) – Launching DoS and DDoS attacks to analyze their impact on network availability. 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	CO3
9	Evading IDS, Firewalls, and Honeypots – Bypassing security monitoring systems and avoiding detection. Objectives: - Perform IDS evasion using obfuscation techniques. - Bypass firewall rules using tunneling methods. - Detect and evade honeypots in a network.	3, 4	CO4



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	Tools/Technology Required: Metasploit, Nmap, Snort, Tcpdump, SEED Labs.		
10	Hacking Web Servers and Applications – Exploiting web application vulnerabilities to gain unauthorized access. 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	CO3
11	Session Hijacking Prevention – Implementing security measures to prevent unauthorized session hijacking. 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	CO5
12	Hacking Wireless Networks – Analyzing and exploiting wireless security flaws to test for vulnerabilities. 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	CO3
13	Hacking Mobile Platforms – Testing mobile application security to identify and exploit vulnerabilities. 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	CO3, CO5
14	IoT Hacking – Identifying security weaknesses in IoT devices and exploiting misconfigurations. 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	CO3, CO5
15	Cloud Computing Security – Analyzing cloud security risks and implementing security controls. Objectives: • Analyze cloud misconfigurations and security gaps. • Perform privilege escalation in cloud environments. • Secure cloud storage and IAM configurations. Tools/Technology Required: AWS CLI, Azure Security Tools, CloudGoat, ScoutSuite.	1, 4	LO5
16	Cryptography and Encryption Attacks – Testing encryption mechanisms for weaknesses and cryptographic vulnerabilities.	1, 4	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.		
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. <i>Note: students can also choose real life CTF/ Bug bounty challenges for completion of this activity</i> 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 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:		



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	○ SQL Injection ○ Cross-Site Scripting (XSS) ○ Insecure Direct Object References (IDOR) ○ Broken Authentication & Session Management ○ 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). ○ Red Team tasks: • Perform reconnaissance using OSINT techniques. • Exploit web, network, and system vulnerabilities. • Maintain persistence and evade detection. ○ 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.		
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Course Assessment:-

Lab:-

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

Recommended Books:

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.



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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>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	3	--	2	3	--	2	--	--	--	1	2	3
CO2	2	3	--	2	3	--	2	--	--	--	1	2	3
CO3	2	3	1	3	3	2	2	--	--	--	1	2	3
CO4	2	3	--	2	3	--	2	--	--	--	1	2	3
CO5	2	2	3	2	3	1	2	--	--	--	1	2	3

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25OE13CE3X	Health, Wellness and Psychology	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
		ISE		MSE	ESE		Total	
		Theory		100	--		100	
		Lab		--	--		--	

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

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Introduction to Psychology, Health and Wellness		
	1.1	Understanding holistic health- Meaning, components of holistic health- components of wellbeing, Psychology of overall health enhancing behaviors component, Types of health compromising behaviors, Illness Management and wellness enhancement.	1	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)	2	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.	2,3	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.	2	4



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	2.3	Eudaimonic Wellness: Meaning and characteristics; concept of defensive coping.	1,4	2
3		Positive Approach and The Psychology of Living in The Present		
	3.1	The Psychology of Living in the Present: meaning, self-registering to the flow of positive thoughts and actions; addressing positive and negative emotions; Eliminating daily hassles, creating happiness. Responding to overthinking: Sociocultural factors and self-realization.	1,2,4	4
	3.2	Resilience: Meaning and Nature; How to build resilience; Self communication and self-care, reframe thoughts; channelize gratitude; practice resilience building: physical and mental exercises.	3,4	4
	Total			26

Self Learning: -

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

Course Assessment:

ISE: Based on self-learning / formative assessment - 100 Marks

Health and Wellness: Introduce Group Happiness Project. Group work: Meet, exchange, contact, collect info, talk about why you chose this topic, brainstorm ideas, and present people's opinions in your designed PPT. 60 marks

Psychology of wellness or happiness: Case Study or movie review presentation:
 Example: Chris Gardener in the Pursuit of Happyness (Group-specific interpretation)
 :40 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.



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	1	2	--	--	--	2	--	1	--	1	--	--	--
CO2	--	2	2	--	--	2	--	2	3	2	2	--	--
CO3	--	3	2	1	--	3	1	2	3	2	2	--	--

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
25OE13CE3X	Emotional and Spiritual Intelligence	L	T	P	L	T	P	Total
		2	--	--	2	--	--	2
		Examination Scheme						
			ISE	MSE	ESE	Total		
		Theory	100	--	--	100		
		Lab	--	--	--	--		

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

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Fundamentals of Emotional Intelligence		
	1.1	Emotion- Meaning, characteristics of emotion, components of emotion- cognitive component, physiological component, Behavioural component. Types of emotions, exposing the myths about emotion, physiological or bodily changes accompanying emotions, how emotions affect our thinking and actions	1	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	2	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	2	3
	2.2	Social Awareness: Others' Perspectives, Empathy and Compassion Relationship Management: Effective communication, Collaboration, Teamwork, and Conflict management (professional impact)	2	3
	2.3	Strategies to develop and enhance emotional intelligence and using them effectively in professional life	1	2



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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	6,8	3
		Yoga of Action and Spirituality: Professionalism		
	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.	5, 7	3
4		Opposite Polarity in SI and Overall Impact on Personality	8	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.		
5	5.1	Spiritual Ecology and Environmental Grassroots Activism	4	2
		- Spiritual Stewardship and Ecology: Case studies based on making a difference in ecology through environmental - grassroots activism		
			Total	26

Self Learning:-

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

Course Assessment: -

ISE:

Activities, Quiz, Assignments- 50 marks

Emotional Intelligence: Identifying emotions and applying it to personal and professional situations - 20 marks

Spiritual Intelligence: Performing solutions based on given problems - 30 Marks



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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.

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	1	2	--	--	--	2	--	1	--	1	--	1	--
CO2	--	2	2	--	--	2	--	2	3	2	2	1	--
CO3	--	3	2	1	--	3	3	3	2	2	1	1	--

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE15	Distributed Computing	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE13
After the successful completion students should be able to:		
Course Outcomes	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.
	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.		
	1.3	Modern Middleware: Containerization (Docker), Kubernetes, API Gateways.		
		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.		
		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		



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		Based Algorithms and Non-Token based Algorithms, Performance measures.		
		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.		
		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.		
		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.		
Total				26

Self-Learning: -

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref.	Hrs
1	Implement a multithreaded Server with clients	1,4	2
2	Implement an RPC client and server	1,4	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
5	To implement Election Algorithm.	1,2	2
6	To implement Mutual Exclusion/Clock synchronization algorithms.	1,2	2
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	2,3	2



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	distributed processing		
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		
11	Load Balancing in Cloud Computing	2,3	2
12	SAP HANA Multiple-Host System	1,2,5	4
	Total		26

Course Assessment: -

Lab:

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

Recommended Books:

- [1] Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, 4th edition, Pearson Education, 2023.
- [2] Mukesh Singhal, Niranjana 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.

Useful Links

- [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] <https://nptel.ac.in/courses/106104182>
- [5] <https://link.springer.com/article/10.1007/s42044-024-00183-y>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	3	3	2	2	--	--	--	--	--	--	--
CO2	3	3	2	3	--	3	--	--	--	--	--	--	1
CO3	3	2	3	2	2	2	--	--	--	--	--	--	1
CO4	3	2	3	3	--	3	2	--	--	--	2	--	1



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CO5	3	3	3	3	2	3	2	--	--	--	--	--	1
CO6	3	2	2	2	--	3	2	--	1	1	2	--	2

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE16	Software Engineering	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	30	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25ESC11CE03, 25PCC12CE07
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply appropriate software process models for software project development.
	CO2	Analyse software requirements and document them using standard specification techniques.
	CO3	Apply estimation, scheduling, and tracking techniques to plan software projects.
	CO4	Apply software design principles, patterns, and architectural styles in system design.
	CO5	Analyse risks and quality issues in software projects and propose suitable controls.
	CO6	Apply software testing strategies and maintenance concepts to software systems.

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, CMM, Waterfall model, Incremental & Iterative Process Models, Evolutionary Process Models: Spiral, Prototyping	1,2	3
	1.3	Agile process model: Agile Principles, Scrum, Kanban, Extreme Programming (XP) DevOps Process Model: Need for DevOps, DevOps lifecycle, CI/CD concepts, DevOps practices and benefits.	1,2,6,7	2
2	2.1	Software Requirements Analysis: Types of requirements – functional and non-functional requirements, system and user requirements, requirement elicitation techniques, requirement engineering process.	1,2	2
	2.2	Requirement Modelling: Scenario-based models (use cases), behavioral models Agile Requirements: User stories, acceptance criteria, requirement prioritization (MoSCoW), concept of requirement traceability.	1,4	2
3	3.1	Project Estimation, Scheduling and Tracking Project Estimation: Concept of software project estimation;	1,6	2



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		Project estimation techniques – LOC and Function Point estimation (concept and limitations); COCOMO II model.		
	3.2	Project Scheduling and Tracking: Defining a task set for the software project; Gantt Chart; Program Evaluation and Review Technique (PERT); tracking the schedule.	1,6	1
	3.3	Agile Project Planning: Overview of Agile project planning; concepts of story points, velocity, sprint planning, re-estimation and use of buffers in project schedules	1,6	1
4	4.1	Design Engineering: Software Design Fundamentals -Design concepts: abstraction, modularity, encapsulation; design quality attributes: cohesion and coupling	1,3,6	2
	4.2	Design Patterns Creational patterns: Singleton, Factory; Structural patterns: Adapter, Decorator; Behavioural patterns: Observer, Strategy.	1,3,6	2
	4.3	Architectural Styles: Layered architecture, Model–View–Controller (MVC); Monolithic vs Microservices architecture (conceptual comparison)	1,6	1
5	5.1	Software Risk & Quality Management Software Risk, Types of Risk, Risk Identification, Risk Assessment, Risk Projection, RMMM Plan.	1,2	1
	5.2	Software Quality Assurance Task, SCM process, change and version control, Formal Technical Review (FTR), Walkthrough.	1,5,6	2
6	6.1	Software Testing Fundamentals: Purpose of software testing; levels of testing – unit testing, integration testing, validation testing, system testing	1,2	2
	6.2	Software Testing Techniques: White-box testing – basis path testing, control structure testing; Black-box testing – equivalence partitioning, boundary value analysis	1,2	2
	6.3	Software Maintenance and Evolution: Types of software maintenance; software re-engineering; reverse engineering; importance of maintenance in software life cycle.	1,2	1
Total				26

Self-Learning:

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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



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Suggested List of Experiments			
	Topics	Ref.	Hrs.
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	Gather requirements for a sample software system using requirement elicitation methods and document them in IEEE format. (SRS document)	1,2, 4	2
3	Develop UML diagrams (use case, activity, sequence, DFD etc) for a selected case study.	1,2, 4	2
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	2
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	2
10	Create a component level design of a chosen software system.	1,4	2
11	Conduct a risk assessment for a software project and create a Risk Mitigation and Management Plan (RMMM).	1,2	2
Total			22

Course Assessment: -

Lab:-

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

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 Behfroz and Fredeick J. Hudson, "Software Engineering Fundamentals", Oxford University Press, 1997
- [4] Grady Booch, James Rumbaugh, 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



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Useful Links

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://ieeexplore.ieee.org/document/720574>
7. <https://martinfowler.com/> and <https://refactoring.guru/design-patterns/solid>
8. GitHub / GitLab – <https://docs.github.com/>
 - Jira – <https://www.atlassian.com/software/jira>
 - SonarQube – <https://docs.sonarsource.com/>
 - Swagger / OpenAPI – <https://swagger.io/docs/>
 - Postman – <https://learning.postman.com/>
 - JUnit – <https://junit.org/junit5/>
 - Pytest – <https://docs.pytest.org/>
 - Jenkins – <https://www.jenkins.io/doc/>
 - GitHub Actions – <https://docs.github.com/actions>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	--	--	2	--	--	--	--	2	--	2	--
CO2	2	2	--	--	2	--	--	--	2	-	--	2	--
CO3	2	3	3	--	3	--	--	--	--	3	--	2	--
CO4	2	3	3	--	2	--	--	--	--	2	--	2	--
CO5	1	3	--	--	2	--	1	--	--	2	--	2	1
CO6	2	--	2	--	3	--	--	--	--	--	--	2	--

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

Bloom's Level:

Remember	Understand	Apply	Analyse ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	SL	T	P	Total
25PCC13CE17	Artificial Intelligence Laboratory	--	--	2	--	--	1	1
		Examination Scheme						
		ISE		MSE		ESE		Total
		50		--		--		50

Pre-requisite Course Codes	25VSE11CE02		
After the successful completion students should be able to:			
Course Outcomes	CO1	Analyze given problem environment and develop intelligent agents capable of solving it effectively.	
	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.	Suggested List of Experiments	Ref	COs Mapped
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	CO1, CO3
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	CO1, CO2
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	CO1, CO2
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	1, 2	CO1, CO2



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	devised using A* Algorithm.		
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	CO2
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	CO3, CO4
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	CO3
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	CO1, CO2
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	CO1, CO2
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	CO3, CO4
11.	Aim: To construct a Bayesian Network for a given problem to draw inference. Objective: For any dataset construct a Bayesian Network for the same. Draw the inference about possibility of event happening in future. Observe the changes in probabilities as the network is built.		CO3
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		CO1, CO2, CO3, CO4



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

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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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	3	--	2	1	--	--	2	--	2	3	--
CO2	3	3	2	--	3	1	--	--	2	--	2	3	--
CO3	3	3	2	2	3	1	--	--	3	--	3	3	--
CO4	3	3	3	2	3	2	2	1	2	--	2	3	--

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

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE18	Mini Project	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
			ISE		MSE		ESE	Total	
		Theory	--		--		--	--	
		Lab	50		--		--	50	

Pre-requisite Course Codes		--
After the successful completion students should 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	Evaluate the impact of solutions using test cases, benchmark data, theoretical inferences, experiments, or simulations.
	CO4	Apply standard engineering practices and project management principles 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	Demonstrate communication and teamwork skills through technical report writing, presentations, and collaborative group work.

Guidelines:

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

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

- Project orientation should be given at the end of fifth semester.
- Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
- 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.
- 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:

- 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.
- Types of Mini Projects:



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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. Sustainable solutions
10. Any others
 - Technology Used: Use of latest technology or modern tools can be encouraged.
 - The project should be mapped to the sustainable development goals (SDGs)
 - Students should not repeat work done previously (work done in the last three years).
 - Project work must be carried out by the group of at least 2 students and max. 4.
 - The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
 - The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
 - Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
 - Guide allocation should be done and students have to submit weekly progress report to the internal guide.
 - 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.
 - 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 of Existing system or research gap
- Problem Statement and Objective
- SDG mapping
- 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
- Results and Discussion



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- 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 competitions.
- write minimum one technical paper & publish in good journal.
- participate in national / international conference

Course Assessment: -

Lab:-

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

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	3	1	2	1	1	--	--	1	--	2	2	2
CO2	3	3	3	2	3	1	--	1	--	1	2	2	2
CO3	2	3	2	3	3	1	--	--	1	--	1	1	--
CO4	2	2	2	1	2	3	3	2	1	2	2	2	2
CO5	2	1	1	1	2	--	--	1	1	1	3	2	2
CO6	--	--	--	--	--	--	1	3	3	2	1	1	--

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

Bloom's Level:

Remember	Understand	Apply	Analyze	Evaluate	Create √
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PCC13CE23	Mobile Application Development	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		--
After the successful completion students should be able to:		
Course Outcomes	CO1	Demonstrate installation and configuration of mobile application development framework
	CO2	Develop responsive and user-friendly interfaces using the framework
	CO3	Design simple mobile applications using the framework
	CO4	Create secure mobile applications on real-life scenarios

	Suggested List of Experiments	Ref.	COs Mapped
1	Installation and configuration of Flutter Dart	Useful Link 3	CO1
2	Responsive and user-friendly interfaces development using Flutter widgets, layouts, and Material/Cupertino design principles	Useful Link 1	CO2
3	Development of basic calculator using Flutter	1-5	CO2, 3
4	Development of gaming application using Flutter:	1-5	CO2, 3
5	Development of chatting app using Flutter.	Useful Link 2	CO2, 3
6	Creating pop-up messages using Flutter.	1-5	CO2, 3
7	Creating menu and purchasing an item for e-commerce app using flutter	Useful Link 2	CO2, 3
8	Development of travel guide for Mumbai city (area wise).	Useful Link 2	CO2, 3
9	Development of unit converter app	Useful Link 2	CO2, 3
10	Mini project on real life scenarios	Useful Link 2	CO2, 3, 4

Course Assessment: -

Lab:-

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

Recommended Books:

- [1] "Flutter for Beginners: An Introductory Guide to Building Cross-Platform Mobile Applications with Flutter and Dart 2" by Alessandro Biessek, Packt Publishing, 2019.



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- [2] "Beginning Flutter: A Hands-On Guide to App Development" by Marco L. Napoli, Wiley, 2019
- [3] "Flutter Projects: A practical, project-based guide to building real-world cross-platform mobile applications and games" by Simone Alessandria, Packt Publishing, 2020
- [4] "Flutter Cookbook: Over 100 Proven Techniques and Solutions for Mobile Developers" by Simone Alessandria and Brian Kayfitz, Packt Publishing, 2021
- [5] Mark L Murphy, "Beginning Android", Wiley India Pvt Ltd

Useful Links:

- [1] <https://flutter.dev/>
- [2] <https://firebase.flutter.dev/docs/overview/>
- [3] <https://docs.flutter.dev/get-started/install>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	1	--	2	3	3	--	--	1	--	--	1	--	--
CO2	3	--	2	3	3	--	--	1	--	--	1	2	--
CO3	3	--	2	3	3	--	--	1	--	--	1	2	--
CO4	3	1	2	3	3	--	--	1	2	2	2	2	3

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned		
		L	T	P	T	P	Total
25PCC13CE24	DevOps: Development and Operations Practices Laboratory	--	--	2	--	1	1
		Examination Scheme					
		ISE		MSE	ESE	Total	
		50		--	--	50	

Pre-requisite Course Codes	25PCC13CE22, 25PCC12CE010, 25PCC12CE08, 25VSE12CE03		
After the successful completion students should 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	Analyze monitoring, logging, security, and performance optimization to enhance system reliability.	

Exp. No.	Suggested List of Experiments	Ref	CO Mapped
1	Introduction to DevOps and Setting Up the Lab Environment 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	CO1
2	Git and Version Control Best Practices 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	CO2
3	Jenkins Installation and Initial Configuration Objective: Install Jenkins, configure user authentication and security settings, set up Jenkins plugins, and connect Jenkins with GitHub/GitLab repositories.	1, 3, 6	CO2
4	Automating Builds and Testing in CI/CD Pipelines 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	CO2
5	Integrating Jenkins with Docker for CI/CD 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	CO2/ CO3
6	Deploying Jenkins Pipelines with Kubernetes Objective: Create a Jenkins pipeline that deploys applications to Kubernetes clusters, configure Kubernetes agents in Jenkins, and use Helm charts for deployment automation.	2, 5	CO3



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7	Introduction to Docker and Containerization Objective: Install Docker, create and run containers, write Dockerfiles, optimize images, and use Docker networking and volumes.	2, 5	CO3
8	Docker Compose and Multi-Container Applications Objective: Define and deploy multi-container applications using Docker Compose, explore networking between containers, and manage service dependencies.	2, 5	CO3
9	Kubernetes Basics - Deploying Applications Objective: Set up Minikube/Kubernetes cluster, create and deploy Kubernetes pods, configure replication controllers, and expose services.	2, 5	CO3
10	Kubernetes Advanced - Services and Scaling Objective: Implement Kubernetes Deployments, enable autoscaling, manage ConfigMaps and Secrets, and explore load balancing for high availability.	2, 5	CO3
11	Infrastructure as Code (IaC) with Terraform Objective: Write Terraform scripts to provision and manage AWS/Azure/GCP resources, automate infrastructure deployment, and ensure state management.	7, 8	CO4
12	Configuration Management with Ansible Objective: Write Ansible playbooks to configure servers and cloud instances, implement idempotent configuration management, and use Ansible roles.	7, 8	CO4
13	Cloud Automation with AWS/Azure/GCP and Jenkins 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	CO4
14	Implementing Security Best Practices in DevOps Objective: Secure CI/CD pipelines, scan Docker images for vulnerabilities using Trivy, implement least privilege IAM policies, and secure Kubernetes clusters.	1, 4, 5	CO5
15	Monitoring, Logging, and Performance Optimization 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	CO5
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: Laboratory ISE is divided into two components: 25 marks for performance and submission of experiments and 25 marks for oral/practical evaluation.



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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**
<https://www.youtube.com/watch?v=hQcFE0RD0cQ>



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	--	--	--	3	--	--	1	--	--	1	1	--
CO2	2	1	1	--	3	--	--	2	--	2	1	1	1
CO3	2	1	3	--	3	--	--	2	--	--	1	1	2
CO4	2	2	3	--	3	--	1	1	--	2	1	2	3
CO5	2	2	2	--	3	--	--	--	--	1	1	2	2

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
26PCC13CE21	Advanced Microprocessors	L	T	P	SL	L	T	P	Total
		2	--	2	1	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC12CE05
After the successful completion students should be able to:		
Course Outcomes	CO1	Describe 80386DX Architecture and register organization
	CO2	Explain the fundamental concepts of RISC architecture and analyze its design principles in comparison with CISC architecture.
	CO3	Apply the knowledge of ARM processor architecture to develop and optimize embedded system applications.
	CO4	Demonstrate the ability to design and implement efficient interrupt handling mechanisms for advanced microprocessor systems
	CO5	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	1,3	5
	1.1	Compare CISC and RISC 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 CISC and RISC Processors, Design Issues of RSIC Processors, Performance Issues in Pipelined Systems.		
2		The Intel Microprocessors 80386DX	1,3	6
	1.1	Enhancement of 8086 in 80186, 80286, 80386, Architecture of 80386 microprocessor, 80386 Programmer's Model.		
	1.2	Modes of Operation in the Intel 80386		
3		Pentium Processor	2,3	5
	2.1	Introduction and enhancement in Pentium processor		
	2.2	Superscalar Operation		
	2.3	Branch Prediction Logic, Cache Organization and MESI protocol		
4.		ARM Processor Fundamentals	4,5,6	4
	4.1	ARM Processor Families: Features and comparison of ARM		



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		processor series.		
	4.2	ARM Registers, Current Program Status Registers, ARM Pipeline, Exceptions, Interrupt and vector table		
5		ARM Exception and Interrupt Handling	7,8,9,10	6
	5.1	Exception Handling: Types and priorities of exceptions, Interrupt Handling Schemes: Interrupt latency and context switching.		
	5.2	Memory Protection units: Protected Regions, Initialization of MPU, Use of Caches and write buffer.		
	5.3	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				26

Self-Learning:

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

Course Assessment:

Theory:

ISE: should be based on self-learning / Formative assessment- 10 Marks

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

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

Suggested List of Experiments

1. Write ALP to display the contents of the flag register.(80386)
2. Write ALP to display a message in different colours with blinking (80386)
3. Program using ARM LPC 21XX to blink LEDs connected on I/O ports.
4. Program to transmit a string using the serial port of the LPC 21XX.
5. Program to generate a square wave of pulse width 100 ms using the timer of LPC 21XX.
6. program the ARM LPC 2138 RTC to display current time and date on LCD.
7. Timer Configuration and Delay Generation
 - Write a program to configure timers for generating specific time delays.
 - Implement a program to toggle an LED based on a timer interrupt.
 - Measure the time elapsed between two events using timers.
8. UART Communication
 - Configure UART for sending and receiving data.
 - Write a program to send "Hello, World!" over UART and display it on a terminal.



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- Create a program to echo received data back to the terminal.

Course Assessment: -

Lab

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

Recommended Books:

- [1] The 80386, 80486, and Pentium Processors: Hardware, Software, and Interfacing, Walter Triebel and Avtar Singh, Prentice Hall, 2nd edition, 1999. 5.
- [2] Pentium Processor System Architecture, Tom Shanley and Don Anderson, Addison-Wesley Publications, 3rd edition, 1995.
- [3] K. M. Bhurchandani and A. K. Ray, "Advanced Microprocessors and Peripherals", McGraw Hill
- [4] ARM Architecture Reference Manual" by David Seal.
- [5] The Definitive Guide to ARM Cortex-A Series" by Joseph Yiu -
- [6] ARM System Developer's Guide: Designing and Optimizing System Software" by Andrew N. Sloss, Dominic Symes, and Chris Wright –
- [7] ARM Assembly Language: Fundamentals and Techniques" by William Hohl -
- [8] "Computer Organization and Design: The Hardware/Software Interface – ARM Edition" Authors: David A. Patterson, John L. Hennessy
- [9] Modern Operating Systems" Author: Andrew S. Tanenbaum, Herbert Bos
- [10] "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers" Author: Jonathan W. Valvano

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	--	1	--	--	--	1	--	1	2	1
CO2	3	3	2	1	--	--	--	--	1	--	2	2	1
CO3	3	2	3	2	2	1	--	1	1	2	2	2	1
CO4	3	3	3	2	2	1	--	1	1	2	2	2	1
CO5	3	3	2	2	2	1	--	--	1	--	2	2	1

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

Bloom's Level:

Remember	Understand	Apply	Analyze √	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE21	Decentralized Finance	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PEC13CE11
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the fundamental concepts of Decentralized Finance (DeFi).
	CO2	Analyze the core components of DeFi, including its underlying primitives, financial building blocks, and performance metrics.
	CO3	Examine the architecture, ecosystem, and major protocols of DeFi, and critically evaluate the associated risks and challenges.
	CO4	Demonstrate the process of token exchange and liquidity provision using DeFi protocols.
	CO5	Apply knowledge of DeFi to identify real-world applications and related security concerns.

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	5
	1.2	Fungible and non-fungible tokens (NFT), ERC20 and ERC721 tokens, their comparison, Initial Coin Offering (ICO), Security Token Offering (STO)		
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	6
	2.2	DeFi key metrics: Total Value Locked, Daily Active Users, Market Cap		
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	5
	3.2	DeFi EcoSystem and Protocols: On-chain Asset Exchange, Loanable Fund Markets on-chain assets, Stablecoins, Portfolio Management, Derivatives, Privacy-preserving mixers		
	3.3	DeFi Risk and Challenges: Security Risks, Liquidity Risks, Regulation Risk, smart contract		



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		risk, scaling risk		
4	4.1	Maker DAO: Maker Protocol: Dai Stablecoins, Maker Vaults, Maker Protocol Auctions Maker Actors: Keepers, Price Oracles, Emergency Oracles, DAO Teams, Dai Savings Rate	1, 2, Link6, Link7, Link8	5
	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	2
	5.2	Criminalities in DeFi space, DeFi security practices		
6	6.1	Decentralized Insurance, Decentralized Exchanges, Decentralized Synthetix		3
Total				26

Self-Learning:

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref.	Hrs.
1	Create a Simple ERC20 Token Using OpenZeppelin	Useful Link -9	2
2	Implement Deploy and Test ERC721 (Basic NFT)	Useful Link -9	2
3	Implementation of Decentralized Application (DApp)	3, Useful Link -10	3
4	Implement Mini Decentralized Exchange (Fixed Price Swap)	Useful Link -11	3
5	Implementation of Blockchain Applications for Central Bank Digital Currencies (CBDC)	Useful Link -12	2
6	Implement Simple Lending Contract (Without Interest)	Useful Link -13	2



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7	Implement KYC Verification Smart Contract	Useful Link -14	2
8	Implementation of DApp for insurance	Useful Link -14	2
9	Implement DAO Governance Contract	Useful Link -14	2
10	Case study of Fintech industry /AAVE protocol	1,2, 3	3
11	Case study of Compound/Yearn Finance	1,2,3	3
Total			26

Course Assessment: -

Lab:-

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

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:

1. <https://www.binance.com/en/research/analysis/real-world-assets>
2. <https://research.binance.com/static/pdf/navigating-defi-derivatives-.pdf>
3. <https://docs.soliditylang.org/>
4. <https://ethereum.org/en/developers/docs/standards/tokens/erc-20/>
5. <https://ethereum.org/en/developers/docs/standards/tokens/erc-721/>
6. <https://makerdao.com/da/whitepaper/>
7. <https://uniswap.org/>
8. <https://wbtc.network/assets/wrapped-tokens-whitepaper.pdf>
9. <https://docs.openzeppelin.com/contracts/>
<https://docs.openzeppelin.com/contracts/4.x/erc20>
<https://remix.ethereum.org/>
<https://ethereum.org/en/developers/docs/standards/tokens/erc-20/>
10. <https://ethereum.org/en/developers/docs/dapps/>
<https://hardhat.org/docs>
<https://docs.metamask.io/>
<https://docs.ethers.org/>
11. <https://uniswap.org/whitepaper-v2.pdf>
<https://docs.uniswap.org/>
<https://docs.soliditylang.org/>
12. <https://www.bis.org/publ/othp33.htm>
<https://ethereum.org/en/developers/docs/>



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- <https://www.rbi.org.in/> (for Indian CBDC reference)
<https://docs.hyperledger.org/>
13 <https://docs.aave.com/>
<https://ethereum.org/en/developers/docs/smart-contracts/>
<https://docs.soliditylang.org/>
14. <https://ethereum.org/en/developers/docs/smart-contracts/>
<https://docs.soliditylang.org/>
<https://docs.openzeppelin.com/contracts/4.x/access-control>

Suggested CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	2	--	--	1	--	--	1	--	--	--	--	1
CO2	3	3	--	2	1	--	--	1	--	--	--	--	1
CO3	3	3	1	2	1	2	--	2	--	--	--	--	2
CO4	3	3	3	2	3	1	--	1	1	--	--	--	2
CO5	3	2	1	2	1	3	1	3	1	--	--	--	3

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

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE22	Generative AI	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		20	30	50	100		
		Lab		50	--	--	50		

Pre-requisite Course Codes		PCC12CE09, BSC12CE06, 26PEC13CE12
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply foundational concepts of Neural Networks and Deep Learning to implement basic Generative AI models.
	CO2	Apply Transformer-based architectures for text generation and NLP tasks.
	CO3	Apply Generative AI frameworks for model training and deployment tasks.
	CO4	Develop Generative AI applications for image, video, and multimodal content generation.
	CO5	Analyse ethical issues, bias, and adversarial risks in real-world Generative AI applications and propose mitigation strategies.
	CO6	Apply emerging Generative AI techniques to address real-world problem scenarios.

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 Text Generation: Chatbots, Summarization, Code Generation, Image & Video Generation: DeepFakes, Style Transfer, Art Generation, Audio & Speech: Voice Cloning, Music Composition,	5,8	5



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		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
			1,4	3
Total				26

Self-Learning:-

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

Course Assessment: -

Theory:

ISE: Based on self-learning / formative assessment - 10 Marks

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

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

		Suggested list of Experiments		
Module No.	Sr. No	Topics	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 LSTM		2
	11	Develop a Financial News Summarization Tool		1



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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

Course Assessment: -

Lab:-

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

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/>



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5. MIT AI Ethics & Adversarial AI Security Course
<https://www.media.mit.edu/projects/ai-ethics/overview/>

Useful Links

1	1. https://arxiv.org/abs/2310.19736 Evaluating Large Language Models: A Comprehensive Survey 2. https://www.superannotate.com/blog/llm-evaluation-guide 3. A Deep Dive on LLM Evaluation by Hamel Husain https://www.youtube.com/watch?v=IsZVCnViwhk 4. LLM Evaluation metrics explained with maths and examples Data Science in your pocket https://www.youtube.com/watch?v=Vb-ua--mzRk 5. How to Benchmark Large Language Models with Galileo Metrics - with Demo Voicebot + Synthedia https://www.youtube.com/watch?v=P9tGTr2Z6t4
2	1. Prompt Engineering Tutorial – Master ChatGPT and LLM Responses freeCodeCamp.org https://www.youtube.com/watch?v=_ZvnD73m40o 2. Why Your AI Prompts Fail-A Taxonomy of LLM Prompting and Defect Strategies by Prompt Optimizer https://www.youtube.com/watch?v=W0409dpOQh0 3. Prompt Engineering Guide - From Beginner to Advanced by Matthew Berman https://www.youtube.com/watch?v=uDIW34h8cmM 4. How LLMs Work & Why Prompt Engineering Matters by ByteMonk https://www.youtube.com/watch?v=8RWfE9eDWXI 5. Prompt engineering essentials: Getting better results from LLMs Tutorial by GitHub https://www.youtube.com/watch?v=LAF-lACf2QY
3	1. What Is RAG? Retrieval-Augmented Generation Explained Simply by Redis https://www.youtube.com/watch?v=xPMQ2cVbUTI 2. Understanding RAG Agents with Pinecone and LangChain by COMMAND https://www.youtube.com/watch?v=bsVrSenBmn0 3. RAG Explained For Beginners by KodeKloud https://www.youtube.com/watch?v=swvzKSOEluc 4. LangChain Agents in 2025 Full Tutorial for v0.3 by James Briggs https://www.youtube.com/watch?v=Gi7nqB37WEY 5. OpenAI Function Calling - Full Beginner Tutorial by Dave Ebbelaar https://www.youtube.com/watch?v=aqdWSYWC_LI
4	1. Large Language Models Meet Energy Systems: Opportunities, Challenges, and Future Perspectives https://www.sciencedirect.com/science/article/abs/pii/S0306261925018069 2. https://arxiv.org/html/2501.11006v1 GREEN-CODE: Optimizing Energy Efficiency in Large Language Models for Code Generation 3. https://arxiv.org/abs/2509.08867 Benchmarking Energy Efficiency of Large Language Models Using vLLM 4. https://aclanthology.org/2025.acl-long.1563/ Energy Considerations of Large Language Model Inference and Efficiency Optimizations

SUGGESTED CO - PO articulation Matrix



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Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	3	--	--	--	--	--	--	--	2	3	1
CO2	3	3	3	--	3	--	--	--	--	--	2	3	1
CO3	3	3	3	--	3	--	--	--	--	--	2	3	1
CO4	3	3	3	2	3	2	--	--	--	--	2	3	1
CO5	2	3	3	2	--	3	3	--	--	--	2	3	1
CO6	3	3	3	2	3	2	--	--	--	--	3	3	1

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

Bloom's Level:

Remember	Understand	Apply	Analyze √	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13CE23	Digital Forensics	2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE		MSE		Min	Max
		Theory		20		30		20	50
		Lab		50		--		--	50

Pre-requisite Course Codes		25PCC13CE11, 25PCC13CE11
After the successful completion students should be able to:		
Course Outcomes	CO1	Analyse the nature of cybercrime, and computer crime, and summarize key steps in digital forensic lifecycle.
	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	Investigate and document comprehensive forensic findings by correlating evidence across multiple domains.

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 Memory Image, Volatility framework, Extracting Information		



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	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	4	6
	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	5,6	4
	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	4
	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	

Self-Learning:-

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

Course Assessment:

Theory:

ISE: Based on self-learning / formative assessment - 20 Marks

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

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



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Serial No.	Lab	Ref.	COs Mapped
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: - Install Ubuntu Linux and configure forensic tools (Autopsy, Sleuth Kit) - Use Guymager and dd to create disk images. - Verify image integrity with hash values (MD5/SHA-256). Document the process with timestamps and chain-of-custody details.	2, 5	CO2
2	File System Forensics Objective: Analyze and recover data from different file systems. Tools: Autopsy, Sleuth Kit. Activities: Explore NTFS, FAT32, and EXT4 file systems. Recover deleted files and analyze metadata.	2,5	CO2
3	Windows Forensics Objective: Investigate forensic artifacts in Windows systems. Tools: RegRipper, FTK Imager Lite. Activities: Extract and analyze the Windows Registry. Investigate event logs and user activity traces.	2,5	CO3
4	Linux Forensics Objective: Conduct forensic investigations on Linux systems. Tools: Sleuth Kit, grep. Activities: Analyze log files (e.g., /var/log). Recover deleted files from an EXT4 file system.	2,5	CO3
5	Memory Forensics Objective: Analyze volatile memory dumps for forensic evidence. Tools: Volatility Framework. Activities: Extract memory dumps using memdump. Identify processes, hidden artifacts, and malware.	3,7	CO4
6	Network Forensics Objective: Capture and analyze network traffic to reconstruct events. Tools: Wireshark, NetworkMiner. Activities: Capture live traffic and analyze packets. Reconstruct network sessions to identify suspicious activities	2,6	CO4
7	Mobile Device Forensics Objective: Extract and analyze data from mobile devices. Tools: Andriller, Autopsy (mobile modules).	4,6	CO5



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	Activities: i. 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: i. Extract and analyze email headers and metadata. Recover deleted emails and attachments.	2,5	CO5
9	Browser Forensics Objective: Investigate web browsing history and cached data. Tools: Browser History Capturer, NirSoft Tools. Activities: i. Recover browsing history, cookies, and cached files. Analyze artifacts to determine user activity.	2,5	CO5
10	Malware Analysis Objective: Analyze malware behavior using static and dynamic methods. Tools: REMnux, Cuckoo Sandbox. Activities: i. Perform static analysis on malware samples. Use Cuckoo Sandbox for dynamic analysis of malware behavior.	1,6	CO3
11	Cloud Forensics Objective: Investigate forensic artifacts in cloud environments. Tools: AWS CloudTrail, Google Cloud Audit Logs. Activities: i. Analyze logs from cloud platforms. Investigate user activity and data breaches in the cloud.	2,6	CO3
12	Steganography and Data Hiding • Objective: Detect and analyze hidden data in digital files. • Tools: StegExpose, Stegdetect. • Activities: i. Use steganalysis tools to uncover hidden data in images and ii. audio files. Extract and analyze steganographic content.	2,6	CO3
13	Disk Encryption and Decryption Objective: Analyze encrypted disks and decrypt data for forensic analysis. Tools: VeraCrypt, Autopsy. Activities: i. Encrypt and decrypt data using VeraCrypt. Analyze encrypted disks and extract evidence.	2,5	CO3
14	Incident Response and Log Analysis Objective: Investigate a simulated security incident by analyzing logs. Tools: Graylog, ELK Stack (Elasticsearch, Logstash, Kibana). Activities: i. Analyze system logs to identify suspicious activity. Generate and document a forensic incident report.	2,6	CO6



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15	Legal and Ethical Aspects of Forensics Objective: Prepare a forensic report while understanding legal and ethical implications. Tools: Case studies and reporting templates. Activities: i. Review forensic cases and identify legal challenges. Prepare comprehensive reports following ethical standards.	5,6	CO6
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Course Assessment:-

Lab:-

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

Recommended Books:

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
6. Cloud Security: Attacks, Techniques, Tools and Challenges, Emmanuel S Pilli, Preeti Mishra, and R. C. Joshi, CRC Press, 2021
7. 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)

4. <https://tools.kali.org/>
5. <https://www.sleuthkit.org/autopsy/>
6. <https://accessdata.com/product-download/ftk-imager-version-4-3-0>
7. <https://www.pearsonitcertification.com/articles/article.aspx?p=462199&seqNu=2>



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Online Resources (Practical)

1. <https://www.cfreds.nist.gov/>
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/>

Useful Links:

1	https://dpdpa.com/ https://dpdpact2023.com/ https://www.geeksforgeeks.org/ethical-hacking/information-technology-act-2000-india/
2	https://www.geeksforgeeks.org/ethical-hacking/anti-forensics/
3	https://cybersectools.com/tools/dshell

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	--	2	--	--	2	--	--	--	3	--	2
CO2	3	2	2	2	2	2	2	--	--	--	3	--	3
CO3	3	2	2	2	2	2	2	--	--	--	3	--	3
CO4	3	3	--	2	2	2	2	--	--	--	2	--	3
CO5	3	3	2	2	2	2	3	--	--	--	2	--	3
CO6	3	3	--	--	--	--	3	--	--	--	--	--	3

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

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE24	Business Intelligence	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE14
After the successful completion students should be able to:		
Course Outcomes	CO1	Explain the concepts of Business Intelligence, decision-making processes, mathematical models, and decision support systems in organizational Contexts.
	CO2	Apply ETL processes using appropriate tools and technologies.
	CO3	Apply BI tools to develop dashboards, perform KPI analysis, and generate reports for effective business performance monitoring.
	CO4	Apply BI models for data-driven decision-making in marketing, logistics, Production and revenue management.
	CO5	Apply cloud-based and real-time BI solutions using streaming analytics Frameworks for industry.

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Introduction to Business Intelligence		
	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.		
2		Business Intelligence and Analytics		
	2.1	Business Intelligence vs Analytics, Data Preparation for BI Analysis, Data Modelling for BI Analysis, Categories of `BI Analysis: Descriptive, Diagnostic, Predictive, Prescriptive, Steps to create a BI Strategy.	[2][3]	2
	2.2	Self Service BI: Importance, User Roles and Data Democratization, Challenges and Best Practices for implementation, Analytics and BI Platforms- Superset, Metabase, Integration of BI with Big Data: architecture and usecase, Emerging Trends in BI & Analytics.		
3		BI Tools & Technologies		
	3.1	Introduction to BI Tools: Microsoft Power BI, Tableau,	[1]	2



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		QlikView.		
	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
4		Business Intelligence Applications		
	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
5		Advanced BI & Cloud Integration		
	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

Self-Learning:

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

Course Assessment: -

Theory: -

ISE: Based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref	Hrs
1	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
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	[2]	2



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	analysis.		
5	Perform visualization of business data and create interactive dashboards using Power BI.	[1]	2
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
7	Implement Real-Time Data Analytics Using Apache Kafka.	[1]	2
8	Create data visualizations and story-driven dashboards using Tableau.	[1]	2
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		
11	Decision Support System for Supply Chain Optimization	[1]	3
12	Customer Segmentation and Market Analysis	[2]	3
	Total		26

Course Assessment: -

Lab:-

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

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.

Useful Links

- [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>

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	3	2	--	--	1	2	1	--	--	--	1	2
CO2	3	3	2	2	3	3	--	--	--	--	--	1	2
CO3	2	2	2	1	3	3	--	--	--	1	--	1	2
CO4	2	3	3	2	3	2	2	--	--	--	--	1	2
CO5	3	2	3	2	3	2	3	2	1	1	1	2	2

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



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Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
5PEC13CE25	Augmented Reality and Virtual Reality	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
			ISE	MSE	ESE	Total			
		Theory	20	30	50	100			
	Lab	50	--	--	50				

Pre-requisite Course codes		25ESC11CE03, 25PEC13CE15	
Course Outcomes	CO1	Identify the fundamental concepts of Augmented Reality (AR) including terminology, marker detection, camera calibration, and pose estimation.	
	CO2	Apply AR development concepts to design basic AR interfaces and applications.	
	CO3	Identify the principles and components of Virtual Reality (VR) systems and interaction methods.	
	CO4	Apply geometric transformations and motion concepts in virtual world environments.	
	CO5	Analyze VR application areas and emerging trends for real-world problem solving.	

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 detection, How to select a marker type, Marker design, General marker detection application.	4,5,7	
2		AR Development & Applications		2
	2.1	User interfaces, Avoiding physical contacts, Practical experiences	4,5,	



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		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	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

Self-Learning: -

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Course Assessment: -

Theory: -

ISE: Based on self-learning / formative assessment- 20 Marks

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

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Exp. No.	Suggested List of Experiments	Ref	Hrs
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
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)			
13	Mini Project to perform using Unity or any other tool (2/3 students per group). For possible ideas refer the following list. 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.	7,8	

Course Assessment: –

Lab: -



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

Recommended Textbooks:

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

Useful Links:-

1	https://help.figma.com / https://helpx.adobe.com/xd
2	https://learn.unity.com
3	https://m3.material.io / https://developer.apple.com/design/human-interface-guidelines
4	https://docs.blender.org/manual
5	https://clarity.microsoft.com / https://analytics.google.com/analytics/academy



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	--	1	--	--	--	--	--	--	2	2	1
CO2	2	3	--	2	2	--	--	--	--	--	2	2	1
CO3	2	2	1	1	--	--	--	--	--	--	2	2	1
CO4	2	2	3	2	2	--	--	--	--	--	2	3	2
CO5	2	3	2	2	2	--	--	--	--	--	2	3	2

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

Bloom's level

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE26	UI/UX Design	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE		MSE		Min	Max
		Theory		20		30		20	50
		Lab		50		--		--	50

Pre-requisite Course Codes	PCC11CE01	
After the successful completion students should be able to:		
Course Outcomes	CO1	Identify the iterative, user-centric design process for creating graphical user interfaces.
	CO2	Apply the user Interfaces to different devices and requirements.
	CO3	Design and develop a functional UI/UX prototype for a given design problem.
	CO4	Apply typography and colour theory in UI/UX design, including font selection, readability, contrast, and colour usage guidelines.
	CO5	Apply simulation, prototyping, and usability testing techniques to design user-centric 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.		
		UI/UX Design Essentials: Colour 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



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	3.2	Colour Harmonies, Creating Contrast with Colour, Guidelines for Proper Colour Usage.		
		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

Self-Learning : -

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

Course Assessment: -

Theory: -

ISE: based on self-learning /formative assessment - 20 Marks.

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

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

Module No.	Sr.no	Suggested List of experiments	Ref.	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



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	6	To evaluate Good and Bad Design of UI elements for IRCTC's Next Generation eTicketing System website.	2, 3	2
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:–

Lab: -

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

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:

- [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/>

Useful Links:



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1	https://m3.material.io
2	https://developer.apple.com/design/human-interface-guidelines
3	https://carbondesignsystem.com

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	--	2	-	--	--	--	--	--	2	1	--
CO2	2	2	3	--	2	--	--	--	--	--	2	1	--
CO3	2	2	3	2	2	--	--	--	--	--	2	1	--
CO4	2	2	2	2	2	--	--	--	--	--	2	1	--
CO5	2	3	3	3	2	--	--	--	--	--	2	1	--

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

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PEC13CE27	Quantum Computing	L	T	P	SL	L	T	P	Total
		2	--	2	2	2	--	1	3
		Examination Scheme							
				ISE	MSE	ESE		Total	
						Min	Max		
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE19
After the successful completion students should be able to:		
Course Outcomes	CO1	Differentiate between classical and quantum computing paradigms.
	CO2	Design and analyze quantum circuits using quantum logic gates.
	CO3	Implement different fundamental quantum algorithms.
	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.
1.		Introduction to Quantum Computing & Industry Trends	1,2,3	4
	1.1	Classical vs. Quantum Computing, Qubits, Entanglement, Superposition and interferences,		
	1.2	Industry Applications: Cybersecurity, AI, Finance, Drug Discovery		
	1.3	Current Quantum Hardware: IBM, Google, Intel, Rigetti, D-Wave		
2		Mathematical Foundations	1,2	4
	2.1	Linear Algebra for Quantum Computing, Probability in Quantum Mechanics		
	2.2	Dirac Notation & State Vectors		
	2.3	Tensor Products and Unitary Transformations, Tensor Products of Matrices		
3		Quantum Gates & Circuits	1,2,3	5
	3.1	Pauli Gates (X, Y, Z), Hadamard (H), Phase (S, T)		
	3.2	Controlled and Multi-Qubit Gates (CNOT, Toffoli, Fredkin)		
	3.3	Quantum Circuit Design for Optimization & AI, Reversible Computing & its Role in Low-Power Design		
4		Quantum Algorithms	2,3	5
	4.1	Shor's Algorithm (Breaking RSA Cryptography)		
	4.2	Grover's Algorithm (Search Optimization)		
	4.3	Variational Quantum Eigensolver (VQE) for AI/ML		
5		Quantum Cryptography & Security	1,2,4	4
	5.1	Quantum Key Distribution (BB84, E91)		



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	5.2	Post-Quantum Cryptography (NIST Standards)		
	5.3	Quantum Secure Cloud Computing, Quantum-Resistant Blockchain Technologies		
6		Quantum Hardware & Programming	4	4
	6.1	Superconducting Qubits vs. Trapped Ions vs. Photonic Qubits		
	6.2	Cloud-Based Quantum Platforms: IBM Quantum, Google Quantum AI		
	6.3	Programming with Qiskit, Cirq, and Braket, Challenges in Scaling Quantum Computers		
Total			26	

Self-Learning:

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

Course Assessment:

Theory:

ISE: should be based on self-learning / formative assessment - 20 Marks

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

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

Suggested List of Experiments			
	Topics	Ref.	Hrs.
1	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
	Total		22

Course Assessment: -

Lab

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



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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
- [5] Post-Quantum Cryptography” — by Daniel J. Bernstein, Johannes Buchmann, and Erik Dahmen
- [6] Quantum Machine Learning: An Applied Approach” — by Santanu Ganguly

Online Resources:

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

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	--	--	--	--	--	--	--	--	2	3	--
CO2	3	3	2	--	2	--	--	--	--	--	2	3	2
CO3	3	3	3	2	2	--	--	--	--	--	2	3	2
CO4	3	3	3	2	2	3	--	--	--	--	2	3	2
CO5	3	3	3	2	3	--	--	--	--	--	2	3	3
CO6	3	3	3	3	3	2	--	--	--	--	2	3	3

Legends:- High: 3, Medium: 02, Low: 1, No Mapping: -

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PEC13CE28	Advanced Network Communications	2	--	2	2	2	--	1	3
		Examination Scheme							
						ESE			
				ISE	MSE	Min	Max	Total	
		Theory		20	30	20	50	100	
		Lab		50	--	--	--	50	

Pre-requisite Course Codes		25PCC13CE22
After the successful completion students should be able to:		
Course Outcomes	CO1	Analyze the packet structure of IPv4 and IPv6 including subnetting, supernetting, and address mapping mechanisms.
	CO2	Configure Static and Dynamic Routing Protocols using network simulators.
	CO3	Illustrate and analyze functions of Transport layer protocols.
	CO4	Implement and analyze of Application layer protocols in a network environment.
	CO5	Analyze and work with modern wireless networking technologies.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	Unit - I Internet Architecture and Network Layer Overview of Internet and Intranet architecture. Role and functions of Internet Service Providers (ISPs) and the Internet Corporation for Assigned Names and Numbers (ICANN). Detailed study of IPv4 and IPv6 header formats. Concepts of subnetting, subnet addressing, address masking, and supernetting.	1,4,5	2
	1.2	Address mapping mechanisms including Address Resolution Protocol (ARP) for logical-to-physical address mapping and Reverse Address Resolution Protocol (RARP) for physical-to-logical address mapping, along with their working principles and message formats.	1,4,5	2
2	2.1	Unit - II Routing Protocols Router architecture, routing tables, queuing mechanisms, and packet switching techniques. Routing protocols with emphasis on intra-domain routing using Distance Vector Routing, including the creation, initialization, sharing, and updating of routing tables. Study of Routing Information Protocol (RIPv2). Link State Routing using Open Shortest Path First (OSPF), including types of links and graphical representation. Inter-domain routing through Path Vector Routing and Border Gateway Protocol (BGPv4).	1,3,6	3
	2.2	Internet Control Message Protocol (ICMP): message types, message formats, and error reporting mechanisms.	1,4,5	2
3	3.1	Unit - III Transport Layer Protocols Process-to-process delivery and client-server communication model. Multiplexing and demultiplexing techniques. Comparison of	1,2,3	3



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		connectionless and connection-oriented services. User Datagram Protocol (UDP): port numbers, well-known ports, UDP header format, features, and applications.		
	3.2	Transmission Control Protocol (TCP): services and features, TCP segment structure, three-way handshake, flow control, error control, and congestion control techniques (open-loop and closed-loop). Transport Layer Security (TLS): working principles and applications. Stream Control Transmission Protocol (SCTP): services and features.	1,2,3	3
4	4.1	Unit - IV Application Layer Protocols Domain Name System (DNS): architecture, domain types, DNS namespace, domain name resolution, and mapping to physical addresses. Electronic mail systems: Message Transfer Agent using Simple Mail Transfer Protocol (SMTP), its components and working; Message Access Agents including Post Office Protocol (POP) and Internet Message Access Protocol (IMAP). File Transfer Protocol (FTP) and Anonymous FTP.	1,3, 6	3
	4.2	Remote logging using Telnet and Remote Desktop. World Wide Web (WWW) and Hypertext Transfer Protocol (HTTP): architecture, types of web documents, and HTTP transactions. Pretty Good Privacy (PGP): security parameters, services, overview of PGP algorithms, key rings, and PGP certificates.	1,3, 6	2
5	5.1	Unit - V Wireless Network Technologies Wireless communication technologies including 3G, 4G, and 5G systems. Software Defined Networking (SDN): architecture, working principles, and applications.	1, 7,5,8	3
	5.2	Edge Computing and Edge Networking-Definition, Components, Challenges, Applications. Multimedia Wireless Networks – Streaming Audio and Video, Voice Over Internet Protocol (VoIP), Protocols – Realtime Transport Protocol (RTP), Real-Time Streaming Protocol (RTSP). Network Functions Virtualization (NFV): architecture, benefits, and applications. Edge Computing and Edge Networking: definition, components, challenges, and applications. Multimedia wireless networks including streaming audio and video, Voice over Internet Protocol (VoIP), and associated protocols such as Real-Time Transport Protocol (RTP) and Real-Time Streaming Protocol (RTSP).	1,6,8	3
Total				26

Self-Learning:-

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

Course Assessment: -



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Theory: -

ISE: based on self-learning and formative assessment - 20 Marks.

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

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

Suggested List of Experiments			
	Topics	Ref.	COs
1	a) Identify IP allocations and Internet Service Providers for a student network Using WHOIS. b) Set up IP addresses and subnet masks on given network devices	1,4,5 Useful link 3	1
2	Identify and resolve network issues using network diagnostic tools like ping, tracert, show, debug commands.	1,2 Useful link 3	2
3	Configure basic routing protocols using any relevant software/virtual lab.	2,3,6 Useful link 3	2
4	Capture and Analyze ICMPv4 Packets using appropriate tool	2 Useful link 5,7	4
5	Configure, diagnose and troubleshoot TCP and UDP connection issues using diagnostic tools like netstat, Wireshark, iperf	1,2	3
6	Configure DNS using relevant software.	1,3,6	4
7	Configure FTP using relevant software	1,3,6	4
8	Monitor network traffic using browser developer tools	1,3,6	2
9	Design a simple network for SDN using Mininet	7	5
10	Using Ping and Latency Tools i) Measure latency and packet loss over time using any suitable tool e.g. PingPlotter ii) Analyze network packets to detect performance bottlenecks using any suitable tool e.g. Wireshark	1,3 Useful link 5,7	2
11	Multimedia traffic analysis i) Capture and analyze HTTP video streaming traffic using any suitable tool e.g. Wireshark ii) Monitor RTP (Real-time Transport Protocol) packets from a multimedia stream using any suitable tool e.g. Wireshark	1,3,8 Useful link 5,7	4
12	Mini Project based on given problem statement		1-5

Course Assessment: -

Lab:

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

Recommended Books:



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- [1] Data Communication and Networking 5E, Forouzan Behrouz A., Universities Press. McGraw Hill Education (India), New Delhi, 2005, ISBN-13:978-1-25- 906475-3
- [2] Internetworking with TCP/IP, Comer Douglas E. Volume I, Fourth Edition. Prentice Hall of India Private Limited, New Delhi- 11001 ISBN- 81-23-2065-4
- [3] TCP/IP Protocol Suite, Forouzan Behrouz A. Tata McGraw-Hill Edition, New Delhi ISBN-0-07-043474-3
- [4] Computer Networks, Sixth Edition, Tanenbaum Andrew S., Nick Feamster, David J. Wetherall Pearson ISBN-13: 978136764052
- [5] Advanced Computer Network, B.M. Harwani & DT Editorial Services Dreamtech ISBN 978-93-5004-13-3
- [6] Computer Networks Principles, Technologies and Protocols for Network Design Natalia Olifer, Victor Olifer Wiley ISBN
- [7] SDN: Software Defined Networks, Thomas D. Nadeau, Ken Gray, O'Reilly Media, Inc. ISBN: 9781449342302
- [8] Computer Networking, 8th Edition Kurose Pearson Education, ISBN-10 9356061319

Useful Links:

1. **Coursera – Computer Networks Courses**
<https://www.coursera.org/courses?query=computer%20networks>
2. **Cisco Networking Academy (NetAcad)**
<https://www.netacad.com/>
3. **JavaTpoint – Computer Network Tutorial**
<https://www.javatpoint.com/computer-network-tutorial>
4. **NPTEL – Computer Networks (Online Course)**
https://onlinecourses.nptel.ac.in/noc23_cs35/preview
5. **JavaTpoint – Software Defined Networking (SDN): Benefits and Challenges of Network Virtualization**
<https://www.javatpoint.com/software-defined-networking-sdn-benefits-and-challenges-of-network-virtualization>
6. **TutorialsPoint – 5G: Future of Wireless Networks**
<https://www.tutorialspoint.com/5g-future-of-wireless-networks>

Suggested CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	2	--	1	--	2	--	--	--	1	--	2
CO2	2	2	2	--	2	--	1	--	--	--	1	--	2
CO3	2	2	2	--	2	--	1	--	--	--	1	--	2
CO4	2	2	2	--	2	--	1	--	--	--	1	--	2
CO5	2	2	2	--	1	--	1	--	--	--	1	--	2

Legends:- High: 3, Medium: 02, Low: 1, No Mapping: -

Bloom's Level:



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Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PECL13CE21	Social Media Analytics Laboratory	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		25PEC13CE14, 25PECL13CE12
After the successful completion students should be able to:		
Course Outcomes	CO1	Describe engagement metrics at multiple levels to evaluate user interaction and overall content performance.
	CO2	Analyze social media data by utilizing appropriate analytics tools and programming libraries to extract meaningful patterns and insights.
	CO3	Perform social network analysis by computing network measures and generating visualizations to interpret user relationships and influence patterns.
	CO4	Design and evaluate a basic recommendation or social information filtering system using appropriate performance metrics.
	CO5	Design dashboards to monitor KPIs, engagement metrics, and campaign performance for business or public sector applications.

Suggested List of Experiments			
	Topics	Ref.	CO
1	Analyse 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	1	CO1
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	CO2
3	Data Cleaning and Storage- Preprocess, filter and store social media data for business (Using Python, MongoDB, R, etc).	1,2	CO2
4	Exploratory Data Analysis and visualization of Social Media Data for business.	3	CO3
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)	3	CO2
6	Develop Structure based social media analytics model for any business. (e.g. Structure Based Models -community detection, influence analysis)	3,4	CO2
7	Develop a dashboard and reporting tool based on real time social media data.	3,4	CO5



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8	Implement Content-Based Filtering and Collaborative Filtering algorithms for personalized recommendation systems using appropriate similarity measures and evaluation metrics.	4	CO4
9	Analyze competitor activities using social media data.	4	CO1
10	Develop social media text analytics models for improving existing product/ service by analysing customer 's reviews/comments	4,5	CO5

Course Assessment: -

Lab:-

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

Recommended Books:

- [1]. Social Media Analytics [215], Techniques and Insights for Extracting Business Value Out of social media, Matthew Ganis, Avinash Kohirkar, IBM Press
- [2]. Social Media Analytics Strategy_ Using Data to Optimize Business Performance, Alex Gonçalves, A Press Business Team
- [3]. Social Media Data Mining and Analytics, Szabo, G., G. Polatkan, O. Boykin & A. Chalki Opoulus (219), Wiley, ISBN 978-1-118-82485-6
- [4]. Social Media Mining: An Introduction, Reza Zafarani, Mohammad Ali Abbasi, Huan Liu, Cambridge University Press
- [5]. Social Media Analytics: Effective Tools for Building, Interpreting, and Using Metrics, Marshall Sponder, McGraw-Hill Education

SUGGESTED CO - PO articulation Matrix

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

Legends: - High: 3, Medium: 02, Low: 1, No Mapping: -

Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned		
		L	T	P	L	T	P	Total
25PECL13CE15	Open-Source Intelligence and Threat Intelligence Laboratory	--	--	2	--	--	1	1
		Examination Scheme						
		ISE		MSE		ESE		Total
		50		--		--		50

Pre-requisite Course Codes	25VSE11CE02	
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	Evaluate security risks by correlating multi-source OSINT and Threat Intelligence data.
	CO4	Investigate complex scenarios involving ransomware, dark web intelligence, IoT vulnerabilities, and geospatial analysis.
	CO5	Analyze investigation findings to derive evidence-based conclusions and actionable cybersecurity recommendations.

Exp.No.	Suggested Experiments	Ref	COs Mapped
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. Self-Study: - VM/Isolation: VirtualBox / VMware, Windows Sandbox - Browser OSINT: Firefox profiles, Multi-Account Containers, uBlock Origin, Privacy Badger - OSINT Suites: Maltego CE, SpiderFoot, theHarvester - Recon basics (safe use): Amass, Subfinder	1	CO1
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.	1	CO1



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	- Analyze connections with Gephi and perform sentiment/content analysis. - Investigate usernames with Sherlock, analyze emails with EmailRep, and check breaches using haveibeenpwned API. Tools: Gephi, Sherlock, EmailRep, haveibeenpwned API, platform-specific OSINT tools. Self-Study: - Username pivoting: Sherlock / Maigret - Account footprinting: Social Searcher, Namechk / KnowEm style services - Graphing/Link analysis: Gephi, Maltego graphs - Email reputation / breach exposure (awareness): HaveIBeenPwned (public check), EmailRep		
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. Self-Study: - Video/Image verification: InVID WeVerify plugin - Reverse image: Google Lens, TinEye, Yandex Images - Metadata: ExifTool, Metadata2Go (web) - Image forensics: FotoForensics (ELA), Forensically - Claim verification support: Wayback Machine, archive.today	1	CO 1
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). Self-Study: - Site intelligence: BuiltWith, Wappalyzer - Domain/hosting: WHOIS / RDAP lookup, SecurityTrails (if available), DNSlytics - URL behavior: urlscan.io (public), redirect checkers - Brand abuse tracking: Google Alerts, Visualping (site change monitoring)	1	CO2
5	Geospatial Intelligence Objective: Utilize geospatial tools to analyze location-based intelligence and extract geotagged data.	1	CO4



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	Activities: Use Google Earth Pro for geospatial analysis; extract image metadata using ExifTool. Tools: Google Earth Pro, OpenStreetMap, ExifTool. Self-Study: - Core GEOINT: Google Earth Pro, Google Maps - GIS: QGIS (free), ArcGIS Online (free tier options), Sentinel Hub EO Browser - Sun/shadow: SunCalc, Sun Seeker (mobile) - Terrain/Elevation: OpenTopoMap, NASA SRTM sources (viewers) - Coordinate conversion: GPS Visualizer, EPSG.io		
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. Self-Study: - URL reputation: VirusTotal URL, urlscan.io, Google Safe Browsing transparency checks - Phish reporting: PhishTank - Email header analysis: Google Admin Toolbox Messageheader, MXToolbox header analyzer - Domain/email checks: MXToolbox, SPF/DKIM/DMARC checkers - Sandbox awareness: ANY.RUN (view reports), Joe Sandbox Cloud	3	CO2
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. Self-Study: - Trend/News mapping: Google Trends, GDELT (global events DB) - Narrative monitoring: CrowdTangle alternatives, social listening tools. - Geo-context overlays: Google Earth Pro historical imagery, Relief/Terrain layers - Data sources: World Bank Data, UNData, Data.gov style portals.	1	CO2
8	Automated OSINT Data Aggregation Objective: Build an automated pipeline to aggregate OSINT data from various sources. Activities:	1	CO3



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	- 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). Self-Study: - Python: Requests, BeautifulSoup, Scrapy (basics), Pandas - Workflow automation: cron / Task Scheduler - APIs: VirusTotal API (free tier), Shodan API (limited), AbuseIPDB API - Storage/Sharing: SQLite, MongoDB (optional), JSON/CSV pipelines		
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. Self-Study: - Document analysis: pdftinfo (poppler), strings, file, olevba - Hashing: sha256sum / certutil, HashMyFiles - IOC extraction helpers: CyberChef	1	CO2
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. Self-Study Tools/Tech - Feed enrichment: ThreatFox, URLhaus - Standards awareness: STIX/TAXII (OpenCTI optional if you want a second platform) - Visualization: MISP Galaxy / tags/taxonomies	2	CO3
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	CO2



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	Self-Study: - Threat reporting sources: vendor blogs, CERT advisories, CISA advisories - Actor profiling aids: MISP Galaxy, ATT&CK group pages - Graphing: Maltego / Gephi for relationships		
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. Self-Study Tools/Tech - Online intelligence: MalwareBazaar - Static triage: Detect It Easy (DIE), PESTudio - Dynamic (safe lab VM): Procmon, Process Explorer, Wireshark - Basic sandbox reports: ANY.RUN public reports	3	CO2
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. Self-Study: - Family identification: ID Ransomware (public) - IOC/Intel: VirusTotal, vendor decryptor notes - Crypto wallet visibility: Blockchain.com explorer / Blockchair	2	CO4
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. Self-Study: - Recon: Masscan - Packet/log view: Wireshark, Zeek - Internet exposure intel: Shodan - DNS: dig/nslookup, SecurityTrails-style DNS history tools	2	CO2
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	2	CO4



	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. Self-Study: • Leak indexing (open sources): HaveIBeenPwned, breach directories • Monitoring: keyword alerting + RSS aggregators		
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. Self-Study: • Vuln intel: CIRCL CVE search • IoT exposure: Shodan / Censys (read-only learning) • Firmware awareness: Binwalk (intro), Firmware Analysis Toolkit • Protocol awareness: MQTT tools, basic Modbus/CoAP viewers	3	CO4
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. Self-Study: • SIEM-like stack: Elastic (basic), Security Onion • IOC queries: Sigma rules, YARA rules • Timeline: Timesketch	3	CO2
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). Self-Study: • Scanner: Greenbone • Web app checks: OWASP ZAP • CVE context: NVD, vendor advisories • Reporting helpers: CVSS calculators, remediation mapping	3	CO2
19	Cyber Threat Attribution Objective: Use open-source tools to attribute cyber threats to specific	1	CO2



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	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.		
	Self-Study: • Actor Intel: public threat reports, MISP Galaxy clusters • Similarity analysis: Jaccard/overlap tooling, graph relationship tools. • Timeline correlation: simple time-series in Pandas		
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

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

Course Assessment: -

Lab:-

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

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.



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- [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/>
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>

SUGGESTED CO - PO articulation Matrix

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

Bloom's Level:

Remember	Understand	Apply	Analyze √	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PECL13CE23	Advanced Java Laboratory	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		25PCC12CE07
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply Java Swing components and event-handling mechanisms to build event-driven graphical applications.
	CO2	Apply Java Database Connectivity (JDBC) to access databases through Java Programs
	CO3	Build dynamic web pages, using Servlets and JSP.
	CO4	Illustrate remote methods in an application using Remote Method Invocation (RMI)
	CO5	Demonstrate Enterprise Java beans for the construction of enterprise software
	CO6	Apply RESTful web service concepts to setup and configure distributed applications.

Suggested List of Experiments		Ref.	COs
Module 1	Swing- Difference between AWT and Swing, Swing Components, MVC Architecture: Lab Exercise: • Develop an application demonstrating use of AWT and Swing Components.	1,2,3	CO1
Module 2	JDBC- JDBC architecture, JDBC drivers, Establishing database connections, Connection pooling, Prepared Statement and Callable Statement. Lab Exercise: • Develop JDBC Application that use the JDBC API to connect to a database	1,2,3	CO1
Module 3	Servlets Servlet life cycle, Servlet containers, Initialization parameters, Context parameters, GET and POST methods, HTML forms and servlets. Lab Exercises: • Create a Java Web Application using Servlet.	1,2,3	CO1
Module	Java Server Pages- JSP life cycle, JSP expressions and declarations,	1,2,3	CO2



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4	Page directives, JSP actions and implicit objects, Standard and Custom Tag Libraries, Expression Language (EL), session management Lab Exercises: ● Create a Java Web Application using JSP using session management		
Module 5	Remote interface, Passing objects, RMI Process: Server Side, Client side. Lab Exercises: ● Develop RMI Java application.	1,2,3	CO2
Module 6	Enterprise Java Beans- Introduction to EJB, Session beans, entity beans, and message-driven beans, EJB container Lab Exercises: ● Develop component-based development model using EJB.	1,2,3	CO3
Module 7	Spring Framework- Dependency Injection (DI) and Inversion of Control (IoC), Spring AOP (Aspect-Oriented Programming), Configuring Spring MVC, Handling web requests Lab Exercises: ● Develop RESTful web service using Spring.	1,2,3	CO3
Module 8	Hibernate Framework- Introduction to Hibernate, Object-Relational Mapping (ORM), Hibernate architecture, Mapping Java classes to database tables, HQL (Hibernate Query Language) Lab Exercises: ● Develop Web Content with Hibernate MVC.	1,2,3	CO4
Module 9	Mini Project	1,2,3	CO4
Total			26

Course Assessment: -

Lab:-

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

Recommended Books:

1. Herbert Schildt, "The Complete Reference: Java", McGraw Hill Education.
2. Jim Keogh, "The Complete Reference: J2EE", McGraw Hill Education.
3. Stephanie Bodoff et al, "The J2EE Tutorial", 2nd Edition, Pearson Education, 2004.

Online Practice Platforms:

1. Herbert Schildt, "The Complete Reference: Java", McGraw Hill Education.
2. Jim Keogh, "The Complete Reference: J2EE", McGraw Hill Education.
3. Stephanie Bodoff et al, "The J2EE Tutorial", 2nd Edition, Pearson Education, 2004.

SUGGESTED CO - PO articulation Matrix



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Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2
CO1	3	2	3	1	3	--	--	--	1	2	--	1	--
CO2	3	3	3	2	3	--	--	--	1	2	1	--	1
CO3	3	3	3	2	3	1	--	--	2	3	1	--	1
CO4	3	3	2	3	3	1	--	--	2	2	1	--	--
CO5	3	2	3	2	3	1	--	--	2	2	2	1	--
CO6	3	2	3	2	3	1	--	--	2	2	2	--	1

Legends:- High: 3, Medium: 02, Low: 1, No Mapping: -

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PECL13CE14	Innovative Product Development Laboratory -II	L	T	P	SL	L	T	P	Total
		--	--	2	--		--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		25PECL13CE14
After the successful completion students should be able to:		
Course Outcomes	CO1	Implement a functional product prototype based on validated requirements.
	CO2	Evaluate product performance and usability through testing and iteration.
	CO3	Analyse eligibility and benefits of DPIIT recognition for a given product
	CO4	Pitch a product's incubation or funding readiness using appropriate documentation and pitching techniques.

To be Taught in laboratory			
	Topics wise List of Experiments with relevant topic	Ref.	COs
1	Requirement Finalization & System Architecture Design Refine functional and non-functional requirements based on IPD Level 1 outcomes and design the system architecture including components, data flow, and interfaces. Expected Outcome: A System Requirement and Architecture Document with finalized requirements and architecture diagrams.	1	1
2	Functional / High-Fidelity Prototype Development Develop a functional prototype of the product using appropriate software, hardware, or platform tools to implement core features. Expected Outcome: A Working Product Prototype demonstrating core functionality aligned with defined requirements.	2	1
3	Product Testing, Validation & Iteration Conduct functional and usability testing of the prototype and refine the product based on user and stakeholder feedback. Expected Outcome: A Testing and Validation Report documenting test cases, observations, and implemented improvements.	1,2	2
4	Technology & Market Readiness Assessment (TRL & MRL) Assess the maturity of the product using Technology Readiness Level (TRL) and Market Readiness Level (MRL) frameworks as adopted on the YUKTI national innovation platform. Justify the current readiness levels and identify steps required to progress to the next level. Expected Outcome: A Readiness Level Assessment Document indicating current TRL and MRL levels with justification and a brief roadmap for advancement.	3	2,4
5	Startup Ecosystem in India: DPIIT & Startup India Process	3	3



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	Study the startup lifecycle in India, including Startup India, DPIIT recognition, role of incubators, and overview of startup registration processes. Expected Outcome: A Startup Ecosystem Awareness Report explaining the process, platforms, eligibility criteria, and benefits.		
6	Government Innovation & Startup Support Programs Explore relevant government schemes such as Startup India Seed Fund, AICTE/DST/MeitY/MSME schemes, and map suitable programs to the developed product. Expected Outcome: A Government Scheme Mapping Document linking the product idea to applicable innovation and startup support programs.	4	3
7	IPR Strategy & Incubation Readiness Define an IPR approach for the product and prepare an incubation-readiness checklist covering documentation, team readiness, and next steps. Expected Outcome: An IPR and Incubation Readiness Note outlining protection strategy and preparedness for incubation.	6	3,4
8	Product Demonstration & Incubation Pitch Demonstrate the functional product and deliver a structured pitch aligned to incubation or startup evaluation criteria. Expected Outcome: An Evaluated Product Demonstration and Pitch , suitable for presentation to IIC, incubators, or startup forums.	5,4	4
Total			26

Course Assessment: -

Lab:-

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

Recommended Books:

- [1] Don Norman, “The Design of Everyday Things”, Revised edition, Basic Books, 213
- [2] Jake Knapp, John Zeratsky and Braden Kowitz, “Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days”, 1st edition, Simon & Schuster, 216
- [3] Eric Ries, “The Lean Startup: How Today’s Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses”, 1st edition, Crown Business, 211
- [4] Alexander Osterwalder and Yves Pigneur, “Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers”, 1st edition, John Wiley & Sons, 210
- [5] Geoffrey A. Moore, “Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers”, 3rd edition, Harper Business, 214
- [6] David Pressman, “Patent It Yourself”, 18th edition, Nolo Publications, 218



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SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	3	--	2	2	--	2	--	--	1	2	2
CO2	2	3	2	3	2	2	--	2	--	--	1	2	2
CO3	1	3	--	--	--	2	2	--	--	--	2	2	2
CO4	1	1	2	--	--	--	--	2	3	--	2	2	2

Bloom's Level:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
25PECL13CE25	Explainable AI Laboratory	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		25ESC11CE3, 25PCC13CE17
After the successful completion students should 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	Evaluate ethical, fairness, bias, and privacy implications in AI systems using explainability techniques.
	CO5	Assess ethical concerns such as bias, fairness, and privacy in XAI models.
	CO6	Analyze emerging explainable AI techniques with respect to user trust, decision making and regulatory compliance in real world AI systems.

	Suggested List of Experiments	Ref.	COs
1	Introduction to Explainable AI 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. 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	CO1
2	Taxonomy of Explainable AI Methods Implementing LIME (Local Interpretable Model-Agnostic Explanations). Objective: Use LIME to explain predictions of a machine learning model on structured/tabular data SHAP (SHapley Additive Explanations) for Feature Importance Objective: Apply SHAP to a random forest classifier and analyze feature contributions to predictions. Counterfactual Explanations in AI Models Objective: Generate counterfactual examples for a neural network classifier to explain decision boundaries. Visualization-Based Explanations for AI Models Objective: Use Grad-CAM (Gradient-weighted Class Activation Mapping) to interpret CNN models on image data.	1, 2	CO2
3	Implementation and Evaluation of XAI Techniques	1, 3	CO3



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	Comparing Model Performance and Explainability Trade-offs Objective: Evaluate different models (e.g., decision trees, neural networks) in terms of accuracy vs. interpretability. Explainability Metrics and Their Evaluation Objective: Implement and analyze quantitative explainability metrics such as fidelity, consistency, and comprehensibility. 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.		
4	Ethical and Societal Implications of XAI Identifying and Mitigating Algorithmic Bias Using XAI Detect bias in AI models using explainability tools and propose strategies to mitigate it. Exploring Regulatory Frameworks and XAI Compliance Objective: Analyze GDPR, AI Ethics guidelines, and interpret their implications on AI development.	3, 4	CO4
5	Future Directions and Open Challenges in XAI Explainability in Reinforcement Learning Objective: Implement explainable reinforcement learning techniques (e.g., decision trees for policy explanation).	2, 5	CO5
6	Innovative Experiment in Research for Explainable AI 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	CO6
	Total		26

Course Assessment: -

Lab:-

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

Recommended Books:

1. Explainable AI: Interpreting, Explaining, and Visualizing Deep Learning, W. Samek, G. Montavon, A. Vedaldi, L. K. Hansen & K.-R. Müller, Springer, 219.
2. Interpretable Machine Learning: A Guide for Making Black Box Models Explainable, C. Molnar, (Independently published), 2020.



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3. Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2, S. Raschka & V. Mirjalili, Packt Publishing, 219.
4. Fairness and Transparency in Machine Learning, S. Barocas, M. Hardt & A. Narayanan, Now Publishers Inc., 219.
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, 218.

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”)

Further Reading (Research Papers & Articles):

1. A Survey of Explainable AI Methods: <https://arxiv.org/abs/203.07631>
2. Google AI Blog on Explainability: <https://cloud.google.com/vertex-ai/docs/explainableai/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 Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	2	--	1	1	--	--	--	--	--	1	3	--
CO2	2	3	2	2	3	--	--	--	--	--	2	3	--
CO3	2	2	3	3	3	--	--	1	--	--	2	3	--
CO4	2	3	2	3	2	1	--	--	--	--	2	3	--
CO5	1	2	--	2	1	2	3	--	--	--	2	3	--
CO6	1	2	--	2	1	2	2	1	1	--	3	3	--

Legends: High: 3, Medium: 02, Low: 1, No Mapping: -

Bloom's Level:

Remember	Understand	Apply	Analyze √	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
		L	T	P	SL	L	T	P	Total
25PECL13CE26	Software Testing and Quality Assurance Laboratory	--	--	2	--		--	1	1
		Examination Scheme							
				ISE		MSE		ESE	Total
		Theory		--		--		--	--
		Lab		50		--		--	50

Pre-requisite Course Codes		BSE11CE02, 25PCC13CE16
After the successful completion students should be able to:		
Course Outcomes	CO1	Apply software testing fundamentals and test case design techniques to analyze functional requirements.
	CO2	Apply manual and automated testing to identify, report, and manage software defects.
	CO3	Analyze software quality using performance, API, and security testing techniques.
	CO4	Evaluate software quality through test documentation, reports, and presentations.

	Suggested List of Experiments	Ref.	COs
1	Introduction to Software Testing & STLC Software testing fundamentals, objectives of testing, SDLC vs STLC, levels and types of testing, and role of quality assurance in software development.	1,2	1
2	Test Case Design Techniques Equivalence Partitioning, Boundary Value Analysis, and Decision Table testing with manual design of test cases for a given problem statement.	1,2	1
3	Manual Test Execution & Defect Reporting Execution of test cases, identification of defects, defect lifecycle, and defect reporting using tools such as JIRA or Bugzilla.	2	2
4	Test Management & Documentation Preparation of test plans, test summary reports, and basic usage of test management tools (TestLink) for organizing test cases and test execution.	2	2,4
5	Test Automation using Selenium Selenium WebDriver architecture, element identification techniques, creation of basic automation scripts, and execution of automated test cases.	3	2
6	Performance Testing using JMeter Introduction to performance testing concepts, creation of basic load and stress test plans using JMeter, and analysis of performance metrics.	4	3
7	API Testing Understanding REST APIs, sending requests and validating responses using tools such as SOAPUI or Postman, and basic API test case design.	4	3
8	Security Testing using OWASP ZAP Introduction to application security testing, vulnerability scanning using OWASP ZAP, identification of common security issues, and interpretation	5	3



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	of scan results.		
9	Mini Project – End-to-End Testing Application of the complete software testing lifecycle including test planning, test case design, manual testing, automation of selected test cases, defect reporting, and preparation of a final test report.	1-5	4
	Total		26

Course Assessment: -

Lab:-

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

Recommended Books:

- [1] Glenford J. Myers, Corey Sandler and Tom Badgett, “The Art of Software Testing”, 3rd edition, Wiley, 211
- [2] Srinivasan Desikan and Gopalaswamy Ramesh, “Software Testing: Principles and Practices”, Pearson Education, 2006
- [3] Alan Richardson, “Automated Testing with Selenium”, Packt Publishing, 216
- [4] Mark Utting and Bruno Legeard, “Practical Model-Based Testing”, Morgan Kaufmann, 2007
- [5] OWASP Foundation, “OWASP Testing Guide”, Latest Edition

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Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	2	3	2	--	--	--	--	--	--	--	1	--	--
CO2	2	2	3	2	3	--	--	2	--	--	1	2	2
CO3	1	3	--	3	3	2	2	--	--	--	1	2	2
CO4	1	1	2	--	--	--	--	2	3	2	2	--	--

Bloom's Level:

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Course Code	Course Name	Teaching Scheme (Hrs/week)				Credits Assigned			
26PCC13CE22	Competitive Coding	L	T	P	SL	L	T	P	Total
		--	--	2	--	--	--	1	1
		Examination Scheme							
				ISE	MSE	ESE	Total		
		Theory		--	--	--	--		
		Lab		50	--	--	50		

Pre-requisite Course Codes		PCC12CE07, PCC12CE09
After the successful completion students should be able to:		
Course Outcomes	CO1	Solve advanced array and string problems using efficient techniques like the sliding window and two-pointer approach.
	CO2	Implement solutions for complex computational problems using linked lists, stacks, and queues.
	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.

Suggested List of Experiments		Ref	COs
Module 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	1,2	CO1
Module 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.	1,2	CO1



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	Lab Exercise: ● 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 rangedbased operations.		
Module 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).	1,2	CO1
Module 4	Linked List: Study the fundamental operations and advanced techniques involving linked lists, including reversing, detecting loops, and rearranging	1,2	CO2



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	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 $L1 \rightarrow L_n \rightarrow L2 \rightarrow L_{n-1} \rightarrow L3 \rightarrow L_{n-2} \rightarrow \dots$ ● 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. ● 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 a doubly linked list and perform operations like insertion, deletion, and traversal.		
Module 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. ● Generate binary numbers from 1 to N using a queue. ● Reverse a stack using recursion. ● Implement a stack/queue using linked list and perform basic 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. ● Solve the "Sliding Window Maximum" problem using deque. ● Implement a stack that supports O(1) time for both push and pop operations in a multithreaded environment.	1,2	CO2



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	Design a queue that supports $O(1)$ time complexity for enqueue and dequeue operations using a doubly linked list.		
Module 6	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. - 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 HopcroftKarp 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.	1,2	CO3
Module 7	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. Lab Exercises: - 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.	1,2	CO3



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	● 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.		
Module 8	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) ● 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.	1,2	CO4



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	• 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.		
Module 9	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.	1,2	CO4
Module 10	Strings and Pattern Matching: Explore key algorithms for string matching, including Rabin-Karp, Z-Algorithm, and KnuthMorris-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.	1,2	CO4



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	- 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.		
	Total		26

Course Assessment: -

Lab:-

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

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 problemsolving)

Online Practice Platforms:

1. Video tutorials on competitive programming (YouTube channels like Abdul Bari, CodeChef)
2. GitHub - Competitive Programming
3. Codeforces: For high-level algorithmic challenges
4. LeetCode: For interview-specific questions
5. HackerRank: For implementation-heavy challenges
6. TopCoder: For advanced contests and problems
7. CodeChef: For practicing competitive programming problems and contests
8. AtCoder: For practicing algorithmic problems with increasing difficulty
9. SPOJ: For a wide variety of algorithmic challenges

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes* (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3	2	1	2	--	--	--	1	--	3	2	--
CO2	3	3	2	1	2	--	--	--	1	--	3	2	--
CO3	3	3	3	2	2	--	--	--	1	--	3	2	--
CO4	3	3	2	2	2	--	--	--	1	--	3	2	--

Legends:- High: 3, Medium: 02, Low: 1, No Mapping: -



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Bloom's Level:

Remember	Understand	Apply	Analyze ✓	Evaluate	Create
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Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
25OE13CE4X	Public Relations and Corporate Communication	2	--	--	2	--	--	2
		Examination Scheme						
		ISE		MSE	ESE		Total	
		100		--	--		100	

Pre-requisite Course Codes		---
After the successful completion students should be able to:		
Course Outcomes	CO1	Develop employable communication skills through practical usage
	CO2	Draft professional documents with precision
	CO3	Develop effective communication strategies for diverse, cultural and global business environment

Module No.	Unit No.	Topics	Ref.	Hrs.
1		Career Advancement Skills	1,3,	5
	1.1	Resume Writing & Cover Letter for Employment		
	1.2	Group Discussion		
	1.3	Impressive Grooming		
	1.4	Communication Simulation		
	1.5	Interview Techniques		
2		Synergy Communication	4	4
	2.1	Presentation Skills		
	2.2	Report Writing- Importance, Objective, types...		
	2.3	Meetings and Documentation: Notice, Agenda, Minutes		
3		Cross-Cultural Communication	2,4	2
	3.1	Cultural awareness		
	3.2	Language barriers		
	3.3	Global communication strategies		
4		Corporate Identity and Branding	5	2
	4.1	Corporate image and reputation		
	4.2	Branding strategies		
	4.3	Visual identity		
	4.4	Messaging and tone		
Total				13

Self-Learning:

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



Society of St. Francis Xavier, Pilar's
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Course Assessment: -

Theory:

ISE: Based on self-learning / formative assessment - 100 Marks

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

Recommended Textbooks:

- 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

SUGGESTED CO - PO articulation Matrix

Course Outcomes	Programme Outcomes (POs)											Programme Specific Outcomes (PSOs)	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	--	--	--	--	--	1	--	1	--	1	--	1	--
CO2	--	1	2	--	--	1	--	2	3	2	2	1	--
CO3	--	2	2	--	--	--	2	3	2	2	1	1	--

Legends: - High: 3, Medium: 02, Low: 1, No Mapping: -

Bloom's Levels:

Remember	Understand	Apply ✓	Analyze	Evaluate	Create
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