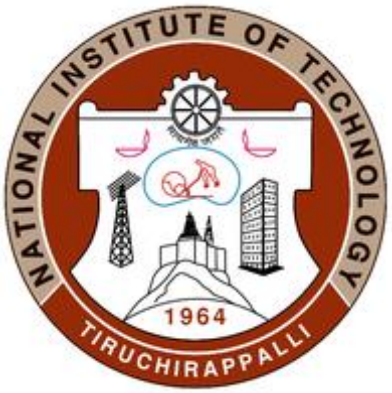
Master of Technology

COMPUTER SCIENCE AND ENGINEERING

CURRICULUM AND SYLLABUS
(2024-25)



DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015, INDIA.

VISION OF THE INSTITUTE

To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry**.**

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

To evolve as an internationally recognised centre of excellence for teaching and research in computer science and engineering with societal and industry relevance.

MISSION OF THE DEPARTMENT

- To offer multidisciplinary and interdisciplinary undergraduate, postgraduate and research programmes with focus on societal research and industrial needs.
- To provide a conducive environment for learning, leading to be efficient employee's and successful entrepreneurs.
- To establish strong and solution oriented industry academia binding for sustainable growth.
- To inculcate ethical values for holistic nation building.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Graduates are prepared to be employed in IT industries and be engaged in continuous learning, understanding, and applying new ideas.
PEO2	Graduates are prepared to take up Masters and Research programmes.
PEO3	Graduates are prepared to be responsible computing professionals in their own area of interest solving societal problems and be successful entrepreneurs

PROGRAMME OUTCOMES (POs)

PO1	Ability to understand the current research topics, identify gaps, propose necessary and relevant solutions for societal problems, and compare the proposed solution with the existing ones.
PO2	Ability to write technical reports of good quality and publish the research findings in refereed journals to enhance the visibility of the proposed solutions.
PO3	Ability to acquire knowledge on a specialized domain by developing the necessary thinking capabilities to carry out meaningful research and enable lifelong learning.

CURRICULUM STRUCTURE

M. Tech. (COMPUTER SCIENCE AND ENGINEERING)

Components	Number of Courses	Credits	Total Credits
Programme Core (PC)	4 in Semester I 2 in Semester II (6 / year)	22	**22**
Programme Elective (PE)*/	2 PE in Semester I 4 PE in Semester II (6 / year)	20	**26**
Open Elective (OE) / Online Course (OC)#@	Based on selection of PE credits	6	
Essential Laboratory Requirements (ELR)	3 / year	6	**6**
Internship/Industrial Training/ Academic Attachment (I/A)	1	2	**2**
Project Phase-I	1	12	**12**
Project Phase-II	1	12	**12**
Total	**20**	**80**	**80**

Note:

OPEN ELECTIVES (OE) / ONLINE COURSE (OC) (Compulsory): Students must complete 6 credits between I and IV semester either through online courses of their choice from NPTEL / Swayam (discipline electives / other electives) or through open electives offered by the PG programmes of the institute other than the progamme specialization.

MICROCREDITS (Compulsory↔/Optional): Students may opt 3 courses of 1 credit (4-week duration) each as microcredits or 2 courses (2 credits (8-week duration) and 1 credit (4-week duration) instead of 1 OE/OC) (↔Depending on selection of credits, either 3 or 4, for PE)

PG CURRICULUM (80 Credits)

SEMESTER I

Course Code	Type	Course name	L	T	P	C
CS601	PC	Mathematical Concepts of Computer Science	3	1	0	4
CS603	PC	Advanced Data Structures and Algorithms	3	0	2	4
CS605	PC	High Performance Computer Architecture	3	0	0	3
CS607	PC	Principles of Machine Learning and Deep Learning	3	0	2	4
E1	PE	Programme Elective I	3	0	2	4
E2	PE	Programme Elective II	3	0	0	3
CS609	ELR	Computer System Design lab	0	0	3	2
Total						24

SEMESTER II

Course Code	Type	Course name	L	T	P	C
CS602	PC	Service Oriented Architecture & Web Security	3	0	0	3
CS604	PC	Advances in Operating Systems	3	1	0	4
E3	PE	Programme Elective III	3	0	2	4
E4	PE	Programme Elective IV	3	0	0	3
E5	PE	Programme Elective V	3	0	0	3
E6	PE	Programme Elective VI	3	0	0	3
CS606	ELR	Data Science and AI Lab	0	0	3	2
CS608	ELR	Web Development Lab	0	0	3	2
						24

SUMMER TERM (evaluation in the III semester)

Code	Course of Study	Credit
CS675	Internship / Industrial Training / Academic Attachment (I/A) (6 weeks to 8 weeks)	2

SEMESTER III

Code	Course of Study	Credit
CS677	Project Work (Phase I)	12
CS704	Online Courses (NPTEL)	6

SEMESTER IV

Code	Course of Study	Credit
CS678	Project Work (Phase II)	12

PROGRAMME ELECTIVES (PE)

S.No	Course Code	Course name	L	T	P	C
1	CS615	Advanced Network Principles and Protocols	3	0	2	4
2	CS616	Cloud Computing Principles	3	0	2	4
3	CS617	Statistical Natural Language Processing	3	0	2	4
4	CS618	Internet of Things	3	0	2	4
5	CS619	Image and Video Analytics	3	0	2	4
6	CS620	Fog and Edge Computing	3	0	2	4
7	CS621	Immersive Technologies	3	0	2	4
8	CS622	Quantum Computing	3	1	0	4
9	CS630	Advanced Databases	3	0	0	3
10	CS631	Advanced Cryptography	3	0	0	3
11	CS632	Network Security	3	0	0	3
12	CS633	Wireless Sensor Networks	3	0	0	3
13	CS634	Software Design Architectures	3	0	0	3
14	CS635	Mobile Network Systems	3	0	0	3
15	CS636	Cloud Security	3	0	0	3
16	CS637	Design and Analysis of Parallel Algorithms	3	0	0	3
17	CS638	Social Network Mining and Analysis	3	0	0	3
18	CS639	Computational Geometry	3	0	0	3
19	CS640	Database Tuning and Administration	3	0	0	3
20	CS641	Big Data Analytics and Mining	3	0	0	3
21	CS642	Models of Computation	3	0	0	3
22	CS643	Cognitive Science	3	0	0	3
23	CS644	Information Visualization	3	0	0	3
24	CS645	Knowledge Management	3	0	0	3
25	CS646	Text Mining	3	0	0	3
26	CS647	Digital & Cyber Forensics	3	0	0	3
27	CS648	Multimedia Presentation and Coding Techniques	3	0	0	3
28	CS649	Principles of Data warehousing and Datamining	3	0	0	3
29	CS650	Hardware Security	3	0	0	3
30	CS651	Advanced Digital Design	3	0	0	3
31	CS652	Real Time Systems	3	0	0	3
32	CS653	Smart Phone Computing	3	0	0	3
33	CS654	Quantum-safe Cryptography	3	0	0	3
34	CS655	Drone Technologies	3	0	0	3
35	CS656	Reinforcement Learning	3	0	0	3
36	CS657	Data Science	3	0	0	3
37	CS658	AI Principles and Practices	3	0	0	3
38	CS659	Advanced Compiler Design	3	0	0	3
39	CS660	Algorithmic Graph Theory	3	0	0	3
40	CS661	Soft Computing Techniques	3	0	0	3
41	CS662	Algorithmic Game Theory	3	0	0	3

OPEN ELECTIVES (OE) (offered to other departments)

S. No	Course Code	Course Name	L	T	P	C
1	CS700	Machine Learning and Deep Learning Techniques	3	0	0	3
2	CS701	Natural Language Processing Techniques	3	0	0	3
3	CS702	Image and Video Analytic Fundamentals	3	0	0	3
4	CS703	Reinforcement Learning Principles	3	0	0	3

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

PROGRAMME CORE (PC)

Course Outcomes: On successful completion of the course, students will be able to:

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS601	Mathematical Concepts for Computer Science	CO1	Comprehend the fundamental methods of logic, number theory, algebra, combinatorics and probability.	3	0	0
		CO2	Conversant with the Mathematical Rigor that is necessary for computer science and be able to come up with rigorous arguments.	3	0	0
		CO3	Define and apply various concepts of combinatorics and probability theory in cryptographic algorithms and randomized algorithms.	3	2	3
		CO4	Comprehend the fundamental concepts of graph theory and apply in real-world situations	3	0	3
CS603	Advanced Data Structures and Algorithms	CO1	Propose algorithmic design strategies such as brute force, greedy, and divide and conquer for solving real world problems.	3	0	2
		CO2	Suggest appropriate data structure for any real world problem	3	1	2
		CO3	Use graph, geometric algorithms for solving real-world problems	3	2	3
		CO4	Propose end to end solution for any problem by proposing an optimal data structure and algorithm	3	3	3

CS605	High-Performance Computer Architecture	CO1	Accustomed to the representation of data, addressing modes, and instruction sets.	3	2	1
		CO2	Understand parallelism both in terms of a single processor and multiple processors.	2	3	1
		CO3	Gain Technical knowledge of parallel hardware constructs to include instruction-level parallelism for multi-core processor design.	2	1	3
		CO4	Analyze the way data is stored in memory.	2	1	3
CS607	Principles of Machine learning and Deep learning	CO1	Ability to implement and apply machine learning algorithms to real-world applications.	3	0	2
		CO2	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains	3	1	2
		CO3	Suggest appropriate Deep learning architectures for solving real-world problems	3	2	3
		CO4	Apply and modify deep learning architectures for new problems.	3	3	3
CS602	Service Oriented Architecture and Web Security	CO1	Apply Security Concepts for Web applications	1	0	0
		CO2	Develop web applications using web services	0	2	0
		CO3	Interpret Web Security Infrastructure	0	0	1
		CO4	Analyze Security requirements and apply appropriate security measures in web service architectures	3	1	2
CS604	Advances in Operating Systems	CO1	Acquire knowledge about advanced concepts in OS	3	2	2
		CO2	Develop OS for distributed systems	3	2	2
		CO3	Develop modules for mobile devices.	2	2	2

		CO4	Design and develop OS for Networking, Cloud and IoT	3	2	2

ESSENTIAL LABORATORY REQUIREMENTS (ELR)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS609	Computer System Design Laboratory	CO1	Build computer systems from components for various specifications.	1	2	0
		CO2	Interface various sensors with single-board computers	1	0	1
		CO3	Program Mbed, Raspberry Pi and Zybo computers to do basic tasks	2	0	2
		CO4	Create basic IoT set up using Scientech IoT kit	3	1	3
CS606	Data Science and AI Lab	CO1	Apply Machine learning algorithms to the real time datasets using Python/R programming languages	3	1	2
		CO2	Design and develop an unstructured database connecting with a Web based GUI	2	1	3
		CO3	Design data intensive applications using data science tools	3	2	3
		CO4	Apply data visualization tools for real time systems	1	2	3
CS608	Web Development Lab	CO1	Design Static Web pages using HTML and style sheets.	1	0	0
		CO2	Build dynamic web pages using Java Script by applying different event handling Mechanisms.	1	0	0

		CO3	Construct web applications incorporating XML and AJAX.	1	2	2
		CO4	Design and deploy Three-Tier Client-Server applications with database connectivity using JSP and PHP and Simple web services using Full Stack Development.	1	2	3

PROGRAMME ELECTIVE (PE)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS615	Advanced Network Principles and Protocols	CO1	Understand the different types of network topologies	3	2	1
		CO2	Understand the different issues related to network layer	3	1	2
		CO3	Understand the working principle of different protocols at different layers	3	2	1
		CO4	Apply networking concepts to real life problems	3	2	3
CS616	Cloud Computing Principles	CO1	Articulate the main concepts, key technologies, strengths, and limitations of cloud computing and the possible applications for state-of-the-art cloud computing	3	2	2
		CO2	Identify the architecture and infrastructure of cloud computing, including saas, paas, iaas, public cloud, private cloud, hybrid cloud	3	1	2
		CO3	Design a cloud with security, privacy, and interoperability	2	2	3

		CO4	Develop proficiency in cloud programming platforms such as Amazon AWS and Microsoft Azure.	2	1	2
CS617	Statistical Natural Language Processing	CO1	Identify the different linguistic components of natural language	3	2	3
		CO2	Design a morphological analyser and tagger for a given natural language	3	3	3
		CO3	Decide on the appropriate parsing techniques necessary for a given language and application	3	3	3
		CO4	Design applications involving natural language	3	1	2
CS618	Internet of Things	CO1	Explain the concept of IoT	3	2	2
		CO2	Analyze various protocols, security and privacy for IoT	3	2	2
		CO3	Design a PoC of an IoT system using Raspberry Pi, Arduino, and PyBoard	2	1	2
		CO4	Apply data analytics and use cloud offerings related to cloud and Analyze applications of IoT in a real-time scenario	3	2	3
CS619	Image and Video Analytics	CO1	Describe the fundamental principles of image analysis	1	0	0
		CO2	Have an idea of various image processing techniques.	2	0	1
		CO3	Apply pattern recognition techniques.	3	1	1
		CO4	Apply image analysis in real world problem	3	3	1
CS620	Fog and Edge Computing	CO1	Understand the key architectures and basic fundamentals of fog computing.	3	2	3
		CO2	Understand the challenges in fog computing.	3	0	3

		CO3	Perform fog and edge computing services.	2	0	2
		CO4	Understand the basic fundamentals of edge computing and Use fog and edge computing services in various applications.	3	2	2
CS621	Immersive Technologies	CO1	Provide an opportunity to explore the research issues in AR, VR & MR.	2	1	3
		CO2	Use advanced stills and immersive technology development tools to conduct closely guided professional research in specific business vertical sectors.	1	3	2
		CO3	Understand the design and implementation of the hardware that enables AR, VR systems to be built	2	1	1
		CO4	Acquire knowledge about the software used in immersive technology and get a better understanding of human-computer interaction.	0	0	1
CS622	Quantum Computing	CO1	interpret the principles of quantum computing and its operations	3	1	2
		CO2	analyze the information theory aspects of quantum computing	3	1	2
		CO3	apply error corrections available for quantum computing	3	2	2
		CO4	describe the principles and some of quantum cryptography	3	3	2
CS630	Advanced Databases	CO1	Write complex queries including full outer joins, self-join, sub queries, and set theoretic queries.	3	1	2
		CO2	Know about the file organization, Query Optimization and Transaction management	3	1	2
		CO3	Work with Main–memory Databases and Data Streams	3	1	2
		CO4	Comprehend emerging and advanced databases	2	1	1

CS631	Advanced Cryptography	CO1	Evaluate the security of a protocol based on security metrics	3	0	3
		CO2	Justify the usage of security principles and digital signatures for any application	3	0	3
		CO3	Ability to break the cryptosystem that is not secure.	3	0	3
		CO4	Design and implementation of provable secure cryptographic protocols	3	2	3
CS632	Network Security	CO1	Be able to determine appropriate mechanisms for protecting the network.	3	1	2
		CO2	Design a security solution for a given application, system with respect to security of the system.	3	2	3
		CO3	Understand the various existing security protocols	3	1	2
		CO4	Understand authentication algorithms and find solution to Security Threats	3	2	3
CS633	Wireless Sensor Networks	CO1	Comprehend the fundamental principles governing wireless communication systems and their diverse applications.	3	2	2
		CO2	Analyze adhoc / sensor network architecture, deployment challenges, and their applications.	3	2	2
		CO3	Acquire knowledge on designing MAC protocols, emphasizing energy efficiency and data transmission reliability.	3	2	2

		CO4	Design scalable, energy-efficient routing protocols with strategies for energy management and QoS to enhance network lifetime and performance.	3	2	2
CS634	Software Design Architectures	CO1	Understand and analyze the abstraction of various architectural styles of a software	3	2	2
		CO2	Analyze the software architectural design models to make design decisions	3	2	2
		CO3	Design, validate and document the software architecture	2	1	2
		CO4	Design and implement algorithm for case studies	1	1	3
CS635	Mobile Network Systems	CO1	Understand the evolution and challenges in mobile communications.	3	2	2
		CO2	Differentiate and apply various MAC and multiplexing schemes	3	2	2
		CO3	Gain knowledge on global mobile telecommunication standards	3	2	2
		CO4	Configure and Implement Mobile IP and optimized protocols for mobile communications.	3	2	2
CS636	Cloud Security	CO1	Understand the principles and concepts underlying cloud computing security.	3	2	2
		CO2	Identify appropriate security measures to mitigate risks associated with network, host, and application layers.	3	3	2

		CO3	Implement suitable data security mechanisms and storage techniques for cloud environments.	3	2	2
		CO4	Develop strategies for managing security risks and compliance, and effectively apply security tools and techniques to protect cloud-based data and infrastructure.	2	3	2
CS637	Design and Analysis of Parallel Algorithms	CO1	Formulate algorithms for array processors	3	0	0
		CO2	Develop searching algorithms for various parallel models.	3	0	3
		CO3	Perform efficient sorting operation on different models	3	0	3
		CO4	Solve linear and nonlinear equations using PRAM models and To Construct graph and find solutions to real world problems	3	3	3
CS638	Social Network Mining and Analysis	CO1	Design a model for semantic web and social network data	2	0	3
		CO2	Model social networks and apply network measures	2	0	3
		CO3	Analyze web social networks and derive useful information	2	1	3
		CO4	Apply general mining algorithms to real-world social media data	2	2	3
CS639	Computational Geometry	CO1	Introduce a variety of algorithmic techniques that apply to geometric problems	3	1	1
		CO2	Aim for diversity at the expense of getting the fastest known algorithms, which are typically obtained with amortized analysis	3	1	3
		CO3	Apply geometric algorithms to solve complex problems in various domains, showcasing an ability to	2	3	3

			adapt and implement these algorithms in practical scenarios.			
		CO4	Ability to analyze and address degenerate cases within geometric algorithms, highlighting an awareness of potential challenges and handle them effectively	1	3	2
CS640	Database Tuning and Administration	CO1	Design and develop an efficient Database Architecture.	2	1	2
		CO2	Maintain and manage user accounts in the Database.	2	1	1
		CO3	Administering the User Security.	2	1	1
		CO4	Explore SQL and Oracle databases to develop a real-time application.	3	2	3
CS641	Big Data Analytics and Mining	CO1	Understand the big data concepts	3	1	2
		CO2	Utilize and apply the Analytical methods, Technology and tools in the industry	3	1	3
		CO3	Explore and apply data streaming techniques	2	1	1
		CO4	Understand the principles and concepts of unstructured data and Understand Hadoop ecosystem and apply to solve real-life problems	2	2	2
CS642	Models of Computation	CO1	Identify the terminology of the theory of computing	0	1	2
		CO2	Predict the major results in computability and complexity theory.	0	2	2
		CO3	Prepare the major models of computations	2	1	2
		CO4	Understand and Explore Machine Learning Based Computation Model	2	2	3

CS643	Cognitive Science	CO1	Know basics of Cognitive Science, Psychology, Nervous system and Brain.	3	1	2
		CO2	Understand major tools and theories from experimental psychology, computer modeling and artificial intelligence, neuroscience, philosophy, linguistics, anthropology, etc. and how they relate to the study of the mind.	2	2	3
		CO3	Understand Brain and sensory motor information, representation of sensory information and how human mind works.	2	2	3
		CO4	Understand the basic cognitive architecture how perception, memory, language, motor control, and so forth come together to produce behavior and implement in artificial systems.	2	3	3
CS644	Information Visualization	CO1	Understand the principles of visual perception	3	0	2
		CO2	Understand time-series analysis and ranking displays	2	0	3
		CO3	Apply core skills for visual analysis and visualization techniques for various data analysis tasks	3	1	2
		CO4	Design information dashboard	3	1	1
CS645	Knowledge Management	CO1	Understand the fundamental concepts in knowledge management and its importance of knowledge sharing.	3	0	1
		CO2	Use the knowledge management	3	1	2

			tools for various applications.			
		CO3	Develop knowledge management applications.	3	2	2
		CO4	Design and develop enterprise knowledge management applications	3	2	2
CS646	Text Mining	CO1	Design clustering techniques for text.	1	3	3
		CO2	Design classification techniques for text	1	3	3
		CO3	Practice visualization methodologies using tools.	3	1	2
		CO4	Practice feature extraction using tools.	3	1	2
CS647	Digital and Cyber Forensics	CO1	Know how to apply forensic analysis tools to recover important evidence for identifying computer crime.	2	2	2
		CO2	Comprehend and use data acquisition methods and tools from various storage formats.	2	2	3
		CO3	Perform network forensic analysis and email investigation.	3	2	3
		CO4	Use correct tool for the particular case and train as next-generation computer crime investigators.	3	2	3
CS648	Multimedia Presentation and Coding Techniques	CO1	Study representation of different multimedia formats.	2	2	2
		CO2	Study the fundamentals of multimedia compression.	2	1	0
		CO3	Develop new algorithms for Lossless Image Coding.	2	0	2
		CO4	Explore the viability to introduce algorithms for multimedia Lossy Image Coding and develop novel techniques for Multimedia Video Compression.	2	2	2

CS649	Principles of Data warehousing and Data Mining	CO1	Technical knowhow of the Data Mining principles and techniques for real time applications.	1	3	2
		CO2	Build the Data warehouse and Mining architectures for real time applications.	1	2	2
		CO3	Apply the knowledge of data classification to classify any real time data.	1	3	1
		CO4	Select and apply proper clustering techniques to build analytical applications and discover the knowledge from the high dimensional mining systems.	1	2	3
CS650	Hardware Security	CO1	Develop algorithms to eliminate side-channel attacks.	3	1	1
		CO2	Design new techniques that will increase PUF response quality.	2	1	1
		CO3	Become aware of various standards in the Information Security System.	3	1	3
		CO4	Illustrate the legal, ethical, and professional issues in information security.	3	1	1
CS651	Advanced Digital Design	CO1	Understand the use standard digital memory devices as components in complex subsystems.	1	1	1
		CO2	Obtain technical knowhow to design simple combinational logic circuits and logic.	1	1	1
		CO3	Acquire skill set to develop the necessary software for basic digital systems.	2	2	3

		CO4	Create their own custom hardware in the FPGA fabric and then control their hardware by writing an application software.	2	2	2
CS652	Real Time Systems	CO1	Understand classifications of Real time systems.	3	2	2
		CO2	Knowledge of Hardware Requirements for Real Time systems.	2	2	3
		CO3	Comprehend Real-time programming environments.	3	2	2
		CO4	Schedule jobs in Real time systems and Develop real time systems.	2	2	3
CS653	Smart phone computing	CO1	Assess and improve services available for mobile social networking.	1	2	2
		CO2	Design secure critical applications on mobile.	0	1	2
		CO3	Develop an algorithm for Gesture Recognition	1	1	3
		CO4	Develop an algorithm for Security in mobile computing	1	1	2
CS654	Quantum-safe Cryptography	CO1	Identify the difference between conventional and Lattice based cryptography protocols.	3	3	3
		CO2	Ability to break the Lattice based Cryptosystem that is not secure.	3	2	3
		CO3	Derive simple provable security proofs for Lattice based schemes and quantum protocols.	3	2	3
		CO4	Design and implement quantum cryptographic protocols and Understand modern quantum	3	2	3

			cryptography – beyond quantum key distribution protocols.			
CS655	Drone Technologies	CO1	Comprehend Hardware components and software programming requirements of drones.	0	0	1
		CO2	Know about a various type of drone technology	2	1	1
		CO3	Select appropriate sensors and actuators for Drones	2	0	1
		CO4	Use navigation and communication systems in UAVs.	2	0	2
CS656	Reinforcement Learning	CO1	Describe and state the key features of Reinforcement learning	3	1	2
		CO2	Suggest appropriate Reinforcement learning strategies for solving real-world problem	3	1	2
		CO3	Implement common RL and Deep RL algorithms	3	2	3
		CO4	Explain the various criteria used for analyzing the RL algorithm by stating the appropriate RL techniques.	3	2	3
CS657	Data Science	CO1	Understand various phases of data science process	2	1	3
		CO2	Apply data science technique for text analytics and classification	3	2	1
		CO3	Apply data science tools for various applications using excel & Python	3	1	2
		CO4	Interpret various tools for data visualization	2	2	3
CS658	Artificial Intelligence	CO1	Devise AI and ML algorithms with explainability aspects	3	2	2
		CO2	Solve real-world problems incorporating the federated learning concepts	2	1	2

	Principles and Practices	CO3	Design AI algorithms by obeying bias, fairness, privacy and robustness	2	2	3
		CO4	Modify algorithms and incorporate generative aspects based on prompt engineering	2	3	3
CS659	Advanced Compiler Design	CO1	Implement stand-alone optimization techniques for some snippet of code	3	0	2
		CO2	Comprehend the differences and similarities in the various approaches to optimizations	3	1	2
		CO3	Design compilers for new languages by incorporating the necessary optimization techniques	3	2	3
		CO4	Propose new algorithms of optimization by modifying the existing approaches	3	2	3
CS660	Algorithmic Graph Theory	CO1	Obtain knowledge in graph fundamentals and properties of different graph families	1	1	2
		CO2	Classify the graph problems based on their computational complexity	3	2	3
		CO3	Implement polynomial time algorithms for special graph classes	3	2	3
		CO4	Develop approximation and parameterized algorithms for graph problems where exact solutions are computationally infeasible.	3	2	3
CS661	Soft Computing Techniques	CO1	Understand the techniques of soft computing and adaptive neuro fuzzy inferencing systems	1	0	3
		CO2	Recognize the feasibility of applying a soft computing	2	0	0

			methodology for a particular problem			
		CO3	Analyse different neural network architectures and the ability to apply the them to simulate and optimize engineering systems	3	0	2
		CO4	Apply and compare the performance of different optimization techniques for engineering problems	3	0	2
CS662	Algorithmic Game Theory	CO1	Understand the basic concepts of game theory with the help of different game scenarios	3	1	2
		CO2	Articulate the knowledge in combinatorial algorithms for market equilibria	3	2	2
		CO3	Evaluate the impact of different equilibria on the overall outcome of the graphical games	3	2	2
		CO4	Quantify the inefficiency of equilibria in games and critically analyze insights from case studies	3	2	2

SEMESTER I

Course Code	**:**	**CS601**
Course Title	**:**	**Mathematical Concepts for Computer Science**
Type of Course	**:**	**PC**
Number of Credit	**:**	**3-1-0-4**

Course Learning Objectives (CLO)

CLO1	Study the fundamental concepts of logic, abstract algebra and linear algebra.
CLO2	To get familiar and understand the fundamental concepts combinatoric and probability theory.
CLO3	To demonstrate the basic concept of probability in randomized algorithm.
CLO4	To understand basic properties of graphs and demonstrate its application in approximation algorithm

Course Content

Unit I Introduction

Functional Logic: Proposition Logic, Resolution Proof system, Predicate logic. Congruences, Fermat's theorem, Euler function, Chinese remainder theorem.

Unit II Linear Algebra

Groups, homomorphism theorems, cosets and normal subgroups, Lagrange's theorem, Ring. Field. Linear algebra: Vector Space, Basis, Matrices and Linear Transformations, Eigen values, Orthogonality.

Unit III Probability

Counting, Probability, Discrete random variable, Continuous random variable, Moment generating function, Markov's inequality, Chebyshev's inequality, The geometric and binomial distributions, The tail of the binomial distribution.

Unit IV Graph Theory

Graphs, Euler tours, planar graphs, Hamiltonian graphs, Euler's formula, applications of Kuratowski's theorem.

Unit V Graph Applications

Graph colouring, chromatic polynomials, trees, weighted trees, the max-flow min-cut theorem. Matching, halls marriage problem. Independent set, Dominating set, Vertex cover, clique.

Text Books:

1. Kenneth H.Rosen, 'Discrete Mathematics and its Applications', McGraw Hill, Eighth Edition, 2021 (Indian Adaptation by Kamala Krithivasan, IIT Madras).
2. I.N.Herstein, "Topics in Algebra" JOHN Wiley & SONS. 1990.

Reference Books:

1. Sheldon M. Ross, Introduction to Probability Models, Elsevier, 2022.
2. G. Chartrand and P. Zhang, Introduction to Graph Theory, McGraw-Hill Companies.
3. Kenneth Hoffman, Ray Kunze, "Linear Algebra 2nd Edition (Paperback)" by PHI Learning, 2009
4. Behrouz A. Forouzan and Debdeep Mukhopadhyay, Cryptography and Network Security, second edition, Tata McGraw Hill, 2011

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Comprehend the fundamental methods of logic, number theory, algebra, combinatorics and probability.
CO2	Conversant with the Mathematical Rigor that is necessary for computer science and be able to come up with rigorous arguments.
CO3	Define and apply various concepts of combinatorics and probability theory in cryptographic algorithms and randomized algorithms.
CO4	Comprehend the fundamental concepts of graph theory and apply in real-world situations

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS601	**Mathematical**	**CO1**	Comprehend the fundamental methods of logic, number theory, algebra, combinatorics and probability.	3	0	0
		CO2	Conversant with the Mathematical Rigor that is necessary for computer science and be able to come up with rigorous arguments.	3	0	0

	Concepts for Computer Science	**CO3**	Define and apply various concepts of combinatorics and probability theory in cryptographic algorithms and randomized algorithms.	3	2	3
		CO4	Comprehend the fundamental concepts of graph theory and apply in real-world situations	3	0	3

Course Code	:	**CS603**
Course Title	:	**Advanced Data Structures and Algorithms**
Type of Course	:	**PC**
Number of Credit	:	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand the various algorithm design strategies and analysis techniques
CLO2	To explore the different heap and tree data structures
CLO3	To learn about the different graph algorithms
CLO4	To understand the geometric algorithms

Course Content:

Unit I Analysis of Algorithms

Algorithmic design strategies - Review of order of growth of functions, recurrences, probability distributions, Average case analysis of algorithms, Randomized Algorithms – Analysis - NP – Complete and NP – Hard Problems – Amortized Analysis

Lab Component:

Exposure to online coding platforms – Hackerank, SPOJ, LEETCODE

Solving problems with differing time complexity

Unit II Heaps

Min Heap – Min-max Heaps – Deaps – Leftist heaps – Skew leftist heaps – Binomial Heaps – Lazy binomial heaps – Fibonacci Heaps.

Lab Component:

Implementation of all of the Heap data structures

Take a target application and implement using one of the Heap

Unit III Trees

AVL Trees – Red-Black Trees – Splay Trees - B trees – Tries - Point – trees – Quad trees - K-d trees – Segment trees

Lab Component:

Implementation of all of the Balanced Tree Structures

Run a comparative study for any one application by implementing with different Trees

Unit IV Graph Algorithms

Maximum Flow – Flow Networks – Ford-Fulkerson Method – Edmond Karp algorithm - Maximum Bipartite Matching

Lab Component:

Implementation of all of the Graph algorithms

Run applications by implementing one of the graph algorithms

Unit V Geometric Algorithms

Convex Hull – Closest pairs of points – line segment intersection – Map overlay detection – Voronoi diagram

Lab Component:

Implementation of all the geometric algorithms. Case study of the geometric algorithms for any real-world problem

Text Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, Introduction to Algorithms, MIT Press, Fourth Edition, 2022

Reference Books:

1. Mark de Berg, Otfried Cheong, Marc van Kreveld, Mark Overmars, "Computational Geometry Algorithms and Applications", Third Edition, Springer, 2011.
2. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", Second Edition, Universities Press, 2008.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Propose algorithmic design strategies such as brute force, greedy, and divide and conquer for solving real world problems.
CO2	Suggest appropriate data structure for any real world problem
CO3	Use graph, geometric algorithms for solving real-world problems
CO4	Propose end to end solution for any problem by proposing an optimal data structure and algorithm

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course , students will be able to	PO1	PO2	PO3
CS603	Advanced Data Structures and Algorithms	CO1	Propose algorithmic design strategies such as brute force, greedy, and divide and conquer for solving real world problems.	3	0	2

		CO2	Suggest appropriate data structure for any real world problem	3	1	2
		CO3	Use graph, geometric algorithms for solving real-world problems	3	2	3
		CO4	Propose end to end solution for any problem by proposing an optimal data structure and algorithm	3	3	3

Course Code	:	**CS605**
Course Title	:	**High-Performance Computer Architecture**
Type of Course	:	**PC**
Number of Credits	:	**3-0-0-3**

Course Learning Objectives(CLO)

CLO1	To understand the basics of high-performance computer architecture.
CLO2	To understand the concept of parallel execution within computer systems through modern parallel architectures.
CLO3	To assess the communication and computing possibilities of high-performance computing architecture and to predict the performance of parallel applications.
CLO4	To understand the concept of memory allocation and management in high-performance computers.
CLO5	To gain knowledge about the real-world high-performance processors.

Course Content

Unit – I Fundamentals of Computer Design Defining

Computer Architecture – Trends in Technology – Trends in Power in Integrated Circuits– Trends in Cost – Dependability – Measuring, Reporting and Summarising Performance – Quantitative Principles of Computer Design – Basic and Intermediate concepts of pipelining – Pipeline Hazards – Pipelining Implementation issues.

Unit – II Instruction-Level Parallelism and Its Exploitation Instruction-Level Parallelism:

Concepts and Challenges – Basic Compiler Techniques for Exposing ILP – Reducing Branch Costs with Prediction – Overcoming Data Hazards with Dynamic Scheduling – Dynamic Scheduling – Hardware-Based Speculation – Exploiting ILP Using Multiple Issue and Static Scheduling – Exploiting ILP Using Dynamic Scheduling, Multiple Issue and Speculation – Studies of the Limitations of ILP – Limitations on ILP for Realizable Processors – Hardware versus Software Speculation

Unit – III Data-Level and Thread-Level Parallelism

Vector Architecture – SIMD Instruction Set Extensions for Multimedia – Graphics Processing Units – Detecting and Enhancing Loop-Level Parallelism – Centralised Shared-Memory Architectures – Performance of Shared-Memory Multiprocessors – Distributed Shared Memory and Directory-Based Coherence – Basics of Synchronisation – Models of Memory Consistency – Computer Architecture

of Warehouse-Scale Computers – Domain-Specific Architecture – CPUs Versus GPUs Versus DNN Accelerators.

Unit – IV Memory Hierarchy Design Cache

Performance – Six Basic Cache Optimizations – Virtual Memory – Protection and Examples of Virtual Memory – Ten Advanced Optimizations of Cache Performance – Memory Technology and Optimizations – Protection: Virtual Memory and Virtual Machines – The Design of Memory Hierarchies

Unit – V Storage Systems & Case Studies

Advanced Topics in Disk Storage – Definition and Examples of Real Faults and Failures – I/O Performance, Reliability Measures and Benchmarks – Designing and Evaluating an I/O System – The Internet Archive Cluster Case Studies / Lab Exercises: INTEL i3, i5, i7, i9 processor cores, NVIDIA GPUs, AMD, ARM processor cores – Simulators – GEM5, CACTI, SIMICS, Multi2sim and INTEL Software development tools, PARAM Porul.

Text Books

1. David.A.Patterson, John L.Hennessy, "Computer Architecture: A Quantitative approach", Elsevier, 6th Edition 2019.
2. K.Hwang, NareshJotwani, "Advanced Computer Architecture, Parallelism, Scalability, Programmability", Tata McGraw Hill, 2nd Edition 2010.

Reference Books

1. An Introduction to Parallel Programming, Peter S. Pacheco, 2011, 1st Edition, Morgan Kaufmann Publishers, Print Book ISBN:9780123742605 eBook ISBN:9780080921440.
2. An Introduction to General-Purpose GPU Programming, Jason Sanders and Edward Kandrot, 2011, 1stEdition, Addison-Wesley Professional, ISBN-13: 9780131387683.
3. https://paramporul.nitt.edu/info/pdf/PARAM_Porul_User_Guide.pdf

Course Outcomes

Upon completion of this course, the students will be able to:

CO1	Accustomed to the representation of data, addressing modes, and instruction sets.
CO2	Understand parallelism both in terms of a single processor and multiple processors.

CO3	Gain Technical knowledge of parallel hardware constructs to include instruction-level parallelism for multi-core processor design.
CO4	Analyze the way data is stored in memory.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS605	**High-Performance Computer Architecture**	CO1	Accustomed to the representation of data, addressing modes, and instruction sets.	**3**	**2**	**1**
		CO2	Understand parallelism both in terms of a single processor and multiple processors.	**2**	**3**	**1**
		CO3	Gain Technical knowledge of parallel hardware constructs to include instruction-level parallelism for multi-core processor design.	**2**	**1**	**3**
		CO4	Analyze the way data is stored in memory.	**2**	**1**	**3**

Course Code	:	**CS607**
Course Title	:	**Principles of Machine learning and Deep learning**
Type of Course	:	**PC**
Number of Credit	:	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand the basic building blocks and general principles that allow one to design machine learning algorithms
CLO2	To become familiar with specific, widely used machine learning algorithms
CLO3	To introduce building blocks of deep neural network architecture
CLO4	To understand representation and transfer of knowledge using deep learning
CLO5	To learn to use deep learning tools and framework for solving real-life problems

Course Content

UNIT-I Supervised Learning

Types of Machine Learning - Supervised Learning - Classification models - Decision trees - Entropy computation using GINI - Information Gain - Support Vector Machines - non-linear kernels - Ensemble Methods: Bagging - Boosting - Gradient boosting - Linear models for regression - Maximum Likelihood Estimation (MLS) - least squares - regularized least squares - The Bias-Variance Decomposition - Bayesian Linear Regression - Linear models for classification - Discriminant functions - Fisher's linear discriminant

Lab Component:

- Comparison of Decision Trees by varying different computation for Information gain
- SVM's using different kernel and its impact
- Bagging / Boosting
- Regression

UNIT-II Unsupervised Learning

Probabilistic generative models - Probabilistic discriminative models - Bayesian logistic regression - Bayesian learning - Similarity and Distance Measures k-medoids algorithm - Mixture of Gaussians - Expectation maximization for mixture models (EM) - Dimensionality Reduction - Principal Component Analysis (PCA) - Linear Discriminant Analysis (LDA) – Singular Value Decomposition

Lab Component:

- Bayesian Learning algorithms
- EM algorithm by using different probability distribution
- PCA
- LDA

UNIT-III Introduction to Deep Networks

Single layer Networks – Generative – Discriminative classifiers – limitations of fixed basis functions – multilayer networks – deep networks – error functions - gradient descent optimization convergence – back

propagation – regularization – inductive bias – weight decay – learning curves - parameter sharing – residual connections – model averaging

Lab Component:

- Perceptron to evaluate logical operations including XOR
- Implement a Multi-Layer Perceptron and train the model using feed forward algorithm.
- MLP using backpropagation algorithm with gradient decent optimization
- Exercises for under fitting, Overfitting and good fit with MLP and generalize the model

UNIT-IV Convolutional Networks

Computer Vision – Convolutional filters – Visualizing trained CNNs – Object Detection – Image Segmentation – Graphical models – Conditional Independence – Sequence models – Transformers – Attention – language models – multimodal transformers – Graph neural networks – Machine learning on Graphs – Neural message-passing – general graph networks

Lab Component:

- Object Detection, Segmentation using CNNs
- Text analysis using CNN
- Application using Transformers / Attention models
- Graph Neural networks based applications

UNIT-V Deep Learning

RNN - LSTM models – GRU - Generative adversarial networks – Auto Encoders – Diffusion models.

Lab Component:

- RNN / LSTM models for Language processing tasks
- GANs – application
- Auto Encoders – Speech / Language application

Text Books:

1. Ethem Alpaydin, “Introduction to Machine Learning”, PHI, 2005
2. Christopher M Bishop and Hugh Bishop, “Deep learning: foundation and concepts”, Springer, 2023

Reference Books:

1. Tom Mitchell, Machine Learning, McGraw-Hill, 1997
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, The MIT Press, 2016.
3. Francois Chollet, “Deep Learning with Python”, Manning Publications, 2017
4. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems”, O'Reilly Media; 1 edition (April 9, 2017)
5. Josh Patterson, “Deep Learning: A Practitioner's Approach”, O'Reilly Media; 1 edition (August 19, 2017)

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Ability to implement and apply machine learning algorithms to real-world applications.
CO2	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains
CO3	Suggest appropriate Deep learning architectures for solving real-world problems
CO4	Apply and modify deep learning architectures for new problems.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS607	Principles of Machine learning and Deep learning Techniques	CO1	Ability to implement and apply machine learning algorithms to real-world applications.	3	0	2
		CO2	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains	3	1	2
		CO3	Suggest appropriate Deep learning architectures for solving real-world problems	3	2	3
		CO4	Apply and modify deep learning architectures for new problems.	3	3	3

Course Code	:	**CS609**
Course Title	:	**Computer System Design Laboratory**
Type of Course	:	**ELR**
Number of Credit	:	**0 – 0 – 3 – 2**

Course Learning Objectives (CLO)

CLO1	To understand the functionality of the various modules of a computer system.
CLO2	To build computer systems from components.
CLO3	To know how to interface a single board computer with external components
CLO4	To get a basic understanding on working with IoT kits

Course Content:

Exercises:

1. Comparative study of motherboards from INTEL, AMD and ARM with focus on performance.
2. Study of GPUs using NVIDIA boards and study of memory sub systems with focus on performance.
3. Study of Reconfigurable hardware using FPGA boards.
4. Study of display cards, RAM, Sound cards, disk and I/O interfaces
5. Blinking of Onboard LEDs alternatively in Mbed
6. Display 0 to 9 in 7-Segment Display infinitely in Mbed
7. Generate a given waveform using MBed
8. Install Apache and PHP packages in RaspberryPi and host a web page using PHP
9. Controlling onboard LEDs using DIP switches in Zybo
10. Implementing hexadecimal counter in Zybo
11. Read and display temperature and humidity using Scientech IoT Kit
12. Controlling on board LEDs of Scientech IoT depending on room temperature and humidity

Text Books:

1. R. Kelly Campbell, “Introduction to Computer Hardware Lab Manual”, Kendall Hunt, 1st Edition, 2010.
2. Michael Meyers, Lloyd Jeffries, “Mike Meyers' A Guide to PC Hardware”, McGraw Hill Professional, 2004.

Reference Books:

1. Agus Kurniawan, “The Hands-on ARM mbed Development Lab Manual”, PE Press, 1st Edition,

2015.

2. Gareth Halfacree, “The Official Raspberry Pi Beginner's Guide: How to Use Your New Computer”, Raspberry Pi Press, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Build computer systems from components for various specifications.
CO2	Interface various sensors with single-board computers
CO3	Program Mbed, Raspberry Pi and Zybo computers to do basic tasks
CO4	Create basic IoT set up using Scientech IoT kit

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS609	**Computer Systems Design Laboratory**	**CO1**	Build computer systems from components for various specifications.	1	2	0
		CO2	Interface various sensors with single-board computers	1	0	1
		CO3	Program Mbed, Raspberry Pi and Zybo computers to do basic tasks	2	0	2
		CO4	Create basic IoT set up using Scientech IoT kit	3	1	3

SEMESTER II

Course Code	:	**CS602**
Course Title	:	**Service Oriented Architecture and Web Security**
Type of Course	:	**PC**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the basic concepts and the foundations of the Web.
CLO2	To apply the concept of web services in application development.
CLO3	To relate to the cryptography concepts on the web.
CLO4	To illustrate various web security concepts.
CLO5	To introduce Security solutions in XML and Web Services and to introduce Security standards for Web Services

Course Content:

Unit I: Web Service Architecture

Web Service Architecture, XML Technologies, Service Description: WSDL, Service Discovery UDDI, Service Transport, Security Considerations

Unit II: Web Services Technologies

Web Services Technologies - JAX-RPC, JAX-WS. Service Orchestration and Choreography – Composition Standards - Service Oriented Analysis and Design, BPEL

Unit III: Basics of Cryptography

Basics of Cryptography, Symmetric key Encipherment, Asymmetric key Encipherment

Unit IV: Integrity and Authentication

Message Integrity and authentication, Cryptographic hash functions, Digital signature, Entity authentication, Key management

Unit V: Security

Security at the application layer, Transport layer, Network layer, Principles in Practice and System Security

Text Books:

1. Thomas Erl, “Service Oriented Architecture: Concepts, Technology, and Design”, Pearson Education, 2016

2. Cryptography & Network Security, Behrouz A. Forouzan, McGraw-Hill, Inc. New York, NY, USA, 2015.

Reference Books:

1. Web Application Security, By: Bryan Sullivan; Vincent Liu, Publisher: McGraw-Hill, 2011
2. Web Commerce Security Design and Development, By: Hadi Nahari; Ronald L. Krutz Publisher: John Wiley & Sons, 2011.
3. Web Application Security, By: Bryan Sullivan; Vincent Liu, Publisher: McGraw-Hill, 2011

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply Security Concepts for Web applications
CO2	Develop web applications using web services
CO3	Interpret Web Security Infrastructure
CO4	Analyze Security requirements and apply appropriate security measures in web service architectures

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS602	**Service Oriented Architecture and Web Security**	**CO1**	Apply Security Concepts for Web applications	1	0	0
		CO2	Develop web applications using web services	0	2	0
		CO3	Interpret Web Security Infrastructure	0	0	1
		CO4	Analyze Security requirements and apply appropriate security measures in web service architectures	3	1	2

Course Code	:	**CS604**
Course Title	:	**Advances in Operating Systems**
Type of Course	:	**PC**
Number of Credit	:	**3-1-0-4**

Course Learning Objectives (CLO)

CLO1	To study the characteristics of OS for Multiprocessors.
CLO2	To get a comprehensive knowledge of the architecture of distributed systems.
CLO3	To learn the various resource management techniques for distributed systems.
CLO4	To Identify the components and management aspects of Mobile operating Systems.
CLO5	To explore the various OS issues related to Networking, Cloud and IoT.

Course Content:

UNIT-I Multiprocessor Operating Systems

Multiprocessors and Multicores - System Architectures - Structures of OS — OS design issues — Process Scheduling and Allocation - Process synchronization - memory management.

UNIT-II Distributed Operating Systems

Multicomputer- Distributed systems - System Architectures- Design issues — Communication models — clock synchronization — mutual exclusion — election algorithms - Distributed Deadlock detection

UNIT-III Distributed Resource Management

Distributed scheduling - Distributed shared memory - Distributed File system — Multimedia file systems - File placement - Caching

UNIT-IV Mobile Operating Systems

Characteristics of mobile devices - ARM and Intel architectures- Mobile OS Architectures - Underlying OS - Kernel structure and native level programming - Runtime issues - Approaches to power management

UNIT-V OS Issues

OS issues related to Networking, Real Time Systems, Embedded systems, Pervasive computing, Cloud and IoT.

Text Books:

1. M Singhal and NG Shivaratri, “Advanced Concepts in Operating Systems”, Tata McGraw Hill Inc, 2001.

2.Silberschatz, Galvin, Gagne, “Operating System Concepts”, Tenth Edition, John Wiley and Sons, 2018.

Reference Books:

1. M. van Steen and A S Tanenbaum, “Distributed Systems”, CreateSpace, 2017.

2. Source Wikipedia,” Mobile Operating Systems”, General Books LLC, 2010.

Course Outcomes (CO)

At the end of the course students will be able to

CO1	Acquire knowledge about advanced concepts in OS
CO2	Develop OS for distributed systems
CO3	Develop modules for mobile devices.
CO4	Design and develop OS for Networking, Cloud and IoT

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS604	Advances in Operating Systems	CO1	Acquire knowledge about advanced concepts in OS	3	2	2
		CO2	Develop OS for distributed systems	3	2	2
		CO3	Develop modules for mobile devices.	2	2	2
		CO4	Design and develop OS for Networking, Cloud and IoT	3	2	2

Course Code	:	**CS606**
Course Title	:	**Data Science and AI Lab**
Type of Course	:	**ELR**
Number of Credit	:	**0-0-3-2**

Course Learning Objectives (CLO)

CLO1	To explore the features of Data Science tools
CLO2	To implement supervised and unsupervised learning techniques using Python/R programming language
CLO3	To explore hands-on machine learning with excel
CLO4	To build data intensive applications using Pyspark
CLO5	To understand data visualization tools

Course Content:

1. Study of Basic Data Science Libraries in Python/R Programming
2. Working with classification algorithms using Python/R programming
3. Working with clustering techniques using Python/R programming
4. Working with ensemble techniques using Python/R programming
5. Implement Association Mining techniques using Python/R programming
6. Working with Time Series Analysis techniques using Python/R programming
7. Working with unstructured data using MongoDB
8. Working with PySpark
9. Working with VLOOKUP functions and Pivot Table in Excel
10. Demonstration of Data Visualization in Excel.
11. Demonstration of Data Visualization in Python.
12. Create Dashboards and perform data visualization using Tableau
13. Implement a data analytics for the real time data set

Text Books:

1. Julio Cesar Rodriguez Martino, “Hands-on Machine Learning with Microsoft Excel”, Packt Publication, 2019.

2. Jake Vander Plas, “Python Data Science Handbook: Essential Tools for Working with Data” 1st Edition, O'Reilly Media, Inc. 2016.

Reference Books:

1. Tomasz Drabas, Denny Lee, “Learning PySpark: Build data-intensive applications locally and deploy at scale using the combined powers of Python and Spark 2.0” O'Reilly Media, Inc. 2017.
2. Shannon Bradshaw, Eoin Brazil, Kristina Chodorow “MongoDB: The Definitive Guide - Powerful and Scalable Data Storage”, Third Edition (Greyscale Indian Edition), O'Reilly Media, Inc. 2020.
3. Ryan Sleeper, “Practical Tableau” O'Reilly Media, Inc. 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply Machine learning algorithms to the real time datasets using Python/R programming languages
CO2	Design and develop an unstructured database connecting with a Web based GUI
CO3	Design data intensive applications using data science tools
CO4	Apply data visualization tools for real time systems

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS606	Data Science and AI Lab	CO1	Apply Machine learning algorithms to the real time datasets using Python/R programming languages	3	1	2
		CO2	Design and develop an unstructured database connecting with a Web based GUI	2	1	3
		CO3	Design data intensive applications using data science tools	3	2	3
		CO4	Apply data visualization tools for real time systems	1	2	3

Course Code	:	**CS608**
Course Title	:	**Web Development Lab**
Type of Course	:	**ELR**
Number of Credit	:	**0-0-3-2**

Course Learning Objectives (CLO)

CLO1	To understand the basics of Web Designing using HTML and Style Sheets.
CLO2	To learn the basics of Client side scripting and Server side scripting.
CLO3	To be exposed to develop applications using XML, Web Services and AJAX.
CLO4	To learn about the basics of Full Stack development
CLO5	To understand the basics of Socket Programming

Course Content:

1. Design of Static Web pages using HTML and CSS.
2. Design of Dynamic Web pages using various events with Java Script.
3. Design web applications to handle Form processing, Cookies and Session Tracking using JSP and PHP.
4. Design web applications for validating XML documents using DTD and XML Schemas.
5. Design Web applications for translating XML documents into XHTML documents using XSL.
6. Design web applications for dynamic database access using AJAX.
7. Create applications to design and deploy simple web services.
8. Develop Three-tier Client Server architectures for various real time applications with SQL database connectivity using JSP and PHP.
9. Develop various real time chat applications using Socket Programming.
10. Develop applications to ensure security in client server architecture using various cryptography techniques.

Text Books:

1. Paul J. Deitel, Harvey M. Deitel, Abbey Deitel, “Internet & World Wide Web How to Program”, Fifth Edition, Deitel Series, 2012.

2. Jason Gilmore, “Beginning PHP and MySQL from Novice to Professional”, Fourth Edition, Apress Publications, 2010.

Reference Books:

1. Brown, Ethan, “Web Development with Node and Express: Leveraging the JavaScript Stack”, O'Reilly Media, 2019.
2. Anthony, Accomazzo, Murray Nathaniel, Lerner Ari, “Fullstack React: The Complete Guide to React JS and Friends”, Fullstack.io, 2017.
3. Robert W. Sebesta, “Programming with World Wide Web”, Fourth Edition, Pearson, 2008.
4. David William Barron, “The World of Scripting Languages”, Wiley Publications, 2000.
5. Dayley B., “Node.js, MongoDB, and AngularJS Web Development”, Addison-Wesley Professional, 2014.
6. Vainikka J., “Full-Stack Web Development using Django REST Framework and React”, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design Static Web pages using HTML and style sheets.
CO2	Build dynamic web pages using Java Script by applying different event handling Mechanisms.
CO3	Construct web applications incorporating XML and AJAX.
CO4	Design and deploy Three-Tier Client-Server applications with database connectivity using JSP and PHP and Simple web services using Full Stack Development.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS608	**Web Development Lab**	**CO1**	Design Static Web pages using HTML and style sheets.	1	0	0
		CO2	Build dynamic web pages using Java Script by applying different event handling Mechanisms.	1	0	0
		CO3	Construct web applications incorporating XML and AJAX.	1	2	2
		CO4	Design and deploy Three-Tier Client-Server applications with database connectivity using JSP and PHP and	1	2	3

			Simple web services using Full Stack Development.			

PROGRAMME ELECTIVES (PE)

Course Code	:	**CS615**
Course Title	:	**Advanced Network Principles and Protocols**
Type of Course	:	**PE**
Number of Credit	:	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand the architecture of the Internet protocols as a layered model
CLO2	To understand the fundamentals of data transmission, encoding and multiplexing
CLO3	To understand how the various components of wide area networks and local area networks work together
CLO4	To understand the concept of application layer

Course Content:

UNIT-I Introduction

Introduction to Networks - Application of Networks - Architecture Topology Switching - SLIP, PPP - ALOHA protocols, CSMA/CD, IEEE 802.3, 802.4, 802.5

Lab component:

1. Create a sample network topology using any network simulator software.

2. Capture the network packets generated by various layer 2 protocols and tabulate all the captured parameters using Wireshark.

UNIT-II Network Layer

Network Layer Issues- Routing, Congestion control- Internetworking - Issues, Address Learning Bridges, Spanning tree, Source routing, Bridges, Routers, Gateway.

Lab Component:

1.Configuration of IP addressing for a given scenario for a given set of topologies.

2.Perform basic router configuration and understand the basic commands.

3.Create a network and understand the basic concepts of Bridges, Routers, and Gateways.

UNIT-III Layer 2 and Layer 3 Protocols

Protocols - IP datagram - hop by hop routing, ARP, RARP, DHCP -Sub net Addressing, Address Masking, ICMP, RIP, RIPV2, OSPF, DNS, LAN and WAN Multicast.

Lab Component:

1.Configure IP routing with RIP using relevant software.

2.Configure IP routing with OSPF using relevant software.

3.Configure Dynamic Host Configuration Protocol (DHCP) using relevant software.

UNIT-IV Transport Layer

Transport Layer- Design issues, Connection Management, Transmission Control Protocol (TCP) User Datagram Protocol (UDP).

Lab Component:

1.Configure Transmission Control Protocol (TCP) using relevant software.

2.Capture the TCP and UDP packets using Wireshark and perform analysis on them.

UNIT-V Application Layer

Application Layer Protocol- Telnet - TFTP - FTP - SMTP - Ping Finger, Bootstrap Network Time Protocol- SNMP.

Lab Component:

1.Configure File Transfer Protocol (FTP) using relevant software.

2.Use Telnet to Login to a remote machine.

3.Connect to a remote machine using Secure Shell (SSH).

4.Configure SMTP using relevant software.

Text Books:

1. Andrew S. Tanenbaum and David J. Wetherall, “Computer Networks”, Pearson, 5th Ed. 2013.

2. William Stallings, "Data and Computer Communications: International Edition”, Pearson Education, 2015

Reference Books:

1. Kevin R. Fall, W Richard Stevens, "TCP/IP Illustrated - Volume I, The protocols", Addison-Wesley, 2012
2. Eiji Oki, Roberto Rojas-Cessa, Mallikarjun Tatipamula, Christian Vogt, “Advanced Internet Protocols, Services and Applications”, John Wiley and Sons Ltd, 2012

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the different types of network topologies
CO2	Understand the different issues related to network layer

CO3	Understand the working principle of different protocols at different layers
CO4	Apply networking concepts to real life problems

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS615	**Advanced Network Principles and Protocols**	CO1	Understand the different types of network topologies	3	2	1
		CO2	Understand the different issues related to network layer	3	1	2
		CO3	Understand the working principle of different protocols at different layers	3	2	1
		CO4	Apply networking concepts to real life problems	3	2	3

Course Code	:	**CS616**
Course Title	:	**Cloud Computing Principles**
Type of Course	:	**PE**
Number of Credit	**:**	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To provide an in-depth and comprehensive knowledge of Cloud Computing fundamental issues, technologies, applications, and implementations
CLO2	To expose the students to the frontier areas of Cloud Computing
CLO3	To motivate students to do programming and experiment with the various cloud computing environments
CLO4	To shed light on the Security issues in Cloud Computing.
CLO5	To introduce about cloud standards.

Course Content:

UNIT – I

History of Centralized and Distributed Computing - Overview of Distributed Computing, Cluster computing, Grid computing. Technologies for Network based systems- SOA – Hardware- MultiCore Systems – GPGPU- Data Storage.

Lab component:

Installation of various hypervisors and instantiation of VMs with image files using open-source hypervisors such as Virtual Box, VMWare Player, Xen, and KVM.

UNIT – II

Cloud issues and challenges - Properties - Characteristics - Service models, Deployment models- Virtualization – Virtual Machines – Hypervisor Types – Resource Virtualization: Server, Storage, Network.

Lab component:

1.Client-server communication between two virtual machine instances, execution of chat application.

2.Find the procedure to run virtual machines of different configurations. Check how many virtual machines can be utilized at a particular time.

3. Find the procedure to attach virtual Block to the virtual machine and check whether it holds the data even after the release of the virtual machine.

UNIT – III

Service models - Infrastructure as a Service (IaaS) - Platform as a Service (PaaS) - Software as a Service (SaaS) - Anything as a service (XaaS) – Service Management

Lab component:

1. Install a C compiler in the virtual machine created using a virtual box and execute Simple Programs.
2. Find a procedure to transfer the files from one virtual machine to another virtual machine.

UNIT – IV

Cloud Access: authentication, authorization and accounting - Cloud Provenance and meta-data - Cloud Reliability and fault-tolerance - Cloud Security, privacy, policy and compliance- Cloud federation, interoperability and standards.

Lab component:

1. Simulate a cloud scenario using CloudSim and run a scheduling algorithm that is not present in CloudSim.
2. Create a data center with two hosts and run two cloudlets on it using CloudSim. The cloudlets run in VMs with different MIPS requirements.

UNIT – V

Cloud Programming and Software Environments –Programming on Amazon AWS and Microsoft Azure – Programming support of Google App Engine – Docker Architecture and Components –Docker Interfaces – Docker Orchestration - Emerging Cloud Software Environment.

Lab component:

1. Install Google App Engine. Create Hello World app and other simple web applications using Python/java.
2. Use the GAE launcher to launch the web applications.
3. Create and execute the First Container using Docker and run a Container from Docker Hub.

Text Books:

1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, “Distributed and cloud computing from Parallel Processing to the Internet of Things”, Morgan Kaufmann, Elsevier, First Edition, 2013.
2. Rajkumar Buyya, James Broberg, Andrzej Goscinski, "Cloud Computing Principles and Paradigms", Wiley, First Edition, 2011.

Reference Books:

1. Barrie Sosinsky, “Cloud Computing Bible”, John Wiley & Sons, First Edition, 2010
2. Tim Mather, Subra Kumaraswamy, and Shahed Latif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance”, O'Reilly, First Edition, 2009

3. James Turnbull , “The Docker Book: Containerization Is the New Virtualization”, e-book, First Edition, 2015.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Articulate the main concepts, key technologies, strengths, and limitations of cloud computing and the possible applications for state-of-the-art cloud computing
CO2	Identify the architecture and infrastructure of cloud computing, including saas, paas, iaas, public cloud, private cloud, hybrid cloud
CO3	Design a cloud with security, privacy, and interoperability
CO4	Develop proficiency in cloud programming platforms such as Amazon AWS and Microsoft Azure.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course, students will be able to**	**PO1**	**PO2**	**PO3**
CS616	Cloud Computing Principles	CO1	Articulate the main concepts, key technologies, strengths, and limitations of cloud computing and the possible applications for state-of-the-art cloud computing	3	2	2
		CO2	Identify the architecture and infrastructure of cloud computing, including saas, paas, iaas, public cloud, private cloud, hybrid cloud	3	1	2
		CO3	Design a cloud with security, privacy, and interoperability	2	2	3
		CO4	Develop proficiency in cloud programming platforms such as Amazon AWS and Microsoft Azure.	2	1	2

Course Code	**:**	**CS617**
Course Title	**:**	**Statistical Natural Language Processing**
Type of Course	**:**	**PE**
Number of Credit:	**:**	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand the need for morphological processing and their representation
CLO2	To know about the various techniques used for speech synthesis and recognition
CLO3	To appreciate the syntax analysis and parsing that is essential for natural language processing
CLO4	To learn about the various representations of semantics and discourse
CLO5	To have knowledge about the applications of natural language processing

Course Content:

UNIT I Morphology and Part-Of-Speech Processing

Introduction –Regular Expressions and Automata-Non-Deterministic FSAs. Transducers –English Morphology -Finite-State Morphological Parsing -Porter Stemmer -Tokenization-Detection and Correction of Spelling Errors. N-grams –Perplexity -Smoothing -Interpolation -Backoff . Part-of-Speech Tagging –English Word Classes -Tagsets -Rule-Based -HMM -Transformation-Based Tagging -Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models

Lab component:

1. Write regular expressions to match various English words or patterns (e.g., email addresses, dates).
2. Implement the Porter Stemming algorithm in a programming language of your choice.
3. Create bigram and trigram models for a sample corpus and compute their perplexity.

UNIT II Speech Processing

Phonetics –Articulatory Phonetics -Phonological Categories -Acoustic Phonetics and Signals -Speech Synthesis –Text Normalization –Phonetic and Acoustic Analysis -Diphone Waveform synthesis –Evaluation-Automatic Speech Recognition –Architecture -Hidden Markov Model to Speech -MFCC vectors -Acoustic Likelihood Computation -Evaluation. Triphones –Discriminative Training -Modeling Variation. Computational PhonologyFinite-State Phonology –Computational Optimality Theory -Syllabification -Learning Phonology and Morphology

Lab component:

1. Record and classify a set of phonemes based on their articulatory properties (place and manner of articulation). Compare these classifications with IPA (International Phonetic Alphabet) symbols.

2. Implement a simple text normalization module that converts raw text into a format suitable for speech synthesis (e.g., converting numbers, dates, and abbreviations into spoken form).

UNIT III Syntax Analysis

Finite-State and Context-Free Grammars -Dependency Grammars. Syntactic Parsing – Ambiguity -Dynamic Programming Parsing Methods –CKY-Earley and Chart Parsing-Partial Parsing-Evaluation. Statistical Parsing – Probabilistic Context-Free Grammars –Probabilistic CKY Parsing of PCFGs – Probabilistic Lexicalized CFGs – Collins Parser – Shallow parsers – Dependency parsing

Lab component:

1. Design a finite-state automaton to recognize a simple language (e.g., valid email addresses or numeric sequences). Implement and test it using a programming language.
2. Implement the CKY (Cocke-Kasami-Younger) algorithm for parsing context-free grammars. Test the parser on a set of sample sentences and evaluate its performance.
3. Create a dependency grammar for a simple language or subset of English. Implement a dependency parser and evaluate its performance on a set of example sentences.

UNIT IV Semantic and Pragmatic Interpretation

Representation of Meaning –Desirable Properties -Computational Semantics -Word Senses -Relations Between Senses –WordNet -Event Participants-Proposition Bank -Frame Net -–Metaphor. Computational Lexical Semantics –Word Sense Disambiguation-Supervised Word Sense Disambiguation -Dictionary and Thesaurus Methods-Word Similarity -Minimally Supervised WSD -Hyponymy and Other Word Relations -Semantic Role Labeling -Unsupervised Sense Disambiguation. Computational Discourse -Discourse Segmentation - Unsupervised Discourse -Segmentation -Text Coherence -Reference Resolution – Phenomena –Features and algorithms -Pronominal Anaphora Resolution

Lab component:

1. Implement a basic semantic representation system for simple sentences. Represent sentences using semantic networks or predicate logic.
2. Implement a system to extract semantic roles from sentences using predefined semantic rolesets (e.g., PropBank). Evaluate the performance on a labeled dataset.
3. Implement a word sense disambiguation (WSD) algorithm using supervised learning methods. Train and test the model on a labeled dataset

UNIT V Applications

Information Extraction –Named Entity Recognition -Relation Detection and Classification –Temporal and Event Processing -Template-Filling -Biomedical Information Extraction. Question Answering and

Summarization - Information Retrieval -Factoid Question Answering -Summarization -Single and Multi-Document Summarization -Focused Summarization -Evaluation. Dialog and Conversational Agents – Properties of Human Conversations -Basic Dialogue Systems- Spam Detection - Sentiment Analysis-building a chatbot - text summarization-NLP in Education and Legal Systems -Document classification-Named Entity Recognition- Semantic Textual Similarity- Prompting Pre-Trained Language Models

Lab component:

1. Implement a Named Entity Recognition (NER) system using an existing library (e.g., spaCy or NLTK). Evaluate its performance on a labeled dataset.
2. Build a factoid question-answering system that can answer factual questions from a given text or knowledge base. Evaluate its performance on a set of questions.
3. Implement a document classification system for educational or legal texts. Train the model on labeled datasets and evaluate its accuracy.
4. Experiment with pre-trained language models (e.g., GPT, BERT) for various NLP tasks. Fine-tune these models on specific tasks and evaluate their performance.

Text Books:

1. Jurafsky and Martin, "Speech and Language Processing", Pearson Prentice Hall, Second Edition, 2008
2. Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.

Reference Books:

1. Stevan Bird, "Natural Language Processing with Python", Shroff, 2009.
2. James Allen, "Natural Language Understanding", Addison Wesley, Second Edition, 2007.
3. Nitin Indurkhya, Fred J. Damerau, "Handbook of Natural Language Processing", (Chapman & Hall/CRC Machine Learning & Pattern Recognition), Second Edition, 2010.
4. Alexander Clark, Chris Fox, Shalom Lappin, "The Handbook of Computational Linguistics and Natural Language Processing", Wiley-Blackwell, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the different linguistic components of natural language
CO2	Design a morphological analyser and tagger for a given natural language
CO3	Decide on the appropriate parsing techniques necessary for a given language and application
CO4	Design applications involving natural language

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS617	Statistical Natural Language Processing	CO1	Identify the different linguistic components of natural language	3	2	3
		CO2	Design a morphological analyser and tagger for a given natural language	3	3	3
		CO3	Decide on the appropriate parsing techniques necessary for a given language and application	3	3	3
		CO4	Design applications involving natural language	3	1	2

Course Code	:	**CS618**
Course Title	:	**Internet of Things**
Course Type	:	**PE**
Number of Credits	:	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand Smart Objects and IoT Architectures
CLO2	To learn about various IOT-related protocols, security, and privacy
CLO3	To build simple IoT system using Raspberry Pi, Arduino, and PyBoard
CLO4	To understand data analytics and cloud in the context of IoT
CLO5	To develop IoT infrastructure for real-time applications

Course Content

UNIT-I Fundamentals and Overview of IoT

Evolution of Internet of Things – Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF), Simplified IoT Architecture and Core IoT Functional Stack – Fog orchestration and Data Management, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, RFID, Video Tracking Applications and Algorithms, Actuators, Smart Objects and Connecting Smart Objects.

Lab component:

1. Understand and implement various IoT architectures.
2. Design and integrate sensors and actuators into an IoT ecosystem.

UNIT-II IoT Protocols, Security, and Privacy

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 1901.2a, LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, SCADA, Application Layer Protocols: CoAP and MQTT, Security and Privacy in IoT: Concepts and Overview, Security Frameworks, Privacy in IoT Network: Fog and Cloud Domain Attacks, Sensing Domain Attacks and their Countermeasures.

Lab component:

1. Explore the optimization of IP for IoT through the implementation of 6LoWPAN and routing techniques over low-power networks.
2. Implement security protocols and frameworks to protect IoT devices within fog and cloud domains, and analyze security risks and countermeasures.

UNIT-III Design and Development

Design Methodology – Embedded computing logic – Microcontroller, System on Chips – IoT system building blocks – Arduino – Board details, IDE programming – Raspberry Pi – Interfaces and Raspberry Pi, Arduino, and PyBoard with Python Programming, IoT Backend design with Python – Flask and Microsoft Azure implementation.

Lab component:

1. Gain practical experience in interfacing Raspberry Pi with different sensors and actuators, utilizing Python programming.
2. Design and implement a backend for IoT applications using Flask and deploy it on Microsoft Azure.

UNIT-IV Data Analytics and Supporting Services

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS for IoT – System Management with NETCONF-YANG, Use of Big Data in Visualization of IoT, Industry 4.0 concepts.

Lab component:

1. Construct a real-time data processing pipeline using Apache Kafka and Apache Spark.
2. Develop a web application using Django to manage and visualize IoT data, deployed in AWS.

UNIT-V Case Studies/Industrial Applications

Cisco IoT system – IBM Watson IoT platform – Manufacturing – Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry – GridBlocks Reference Model – Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control, Cloud of Things: Standards and Architecture, Open-Source E-Health Sensor Platform, Cloud-assisted Cyber-Physical Systems. Introduction to Blockchain in IoT.

Lab component:

1. Explore the capabilities of the IBM Watson IoT platform by building an IoT application for connected manufacturing.

2. Design a layered architecture for smart city applications focusing on smart lighting and smart parking systems.

Text Books:

1. Ammar Rayes, Hafedh Yahmadi, Nabil sahil, Samer Salam ―Internet of Things from Hype to Reality: The Road to Digitization, Springer, 2019.
2. Rajkumar Buyya, Amir Vahid Dastjerdi -Internet of Things Principles and Paradigms, Morgan Kaufman (Elsevier), 2018.

Reference Books

1. Arshdeep Bahga, Vijay Madisetti, ―Internet of Things – A hands-on approach, Universities Press, 2015.

2. Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols, Wiley, 2012

3. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things– Introduction to a New Age of Intelligence", Elsevier, 2014.

4. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), Architecting the Internet of Things, Springer, 2011.

5. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

6. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Explain the concept of IoT
CO2	Analyze various protocols, security and privacy for IoT
CO3	Design a PoC of an IoT system using Raspberry Pi, Arduino, and PyBoard
CO4	Apply data analytics and use cloud offerings related to cloud and analyze applications of IoT in a real time scenario

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS618	**Internet of Things**	**CO1**	Explain the concept of IoT	3	2	2
		CO2	Analyze various protocols, security and privacy for IoT	3	2	2
		CO3	Design a PoC of an IoT system using Raspberry Pi, Arduino, and PyBoard	2	1	2
		CO4	Apply data analytics and use cloud offerings related to cloud and Analyze applications of IoT in a real-time scenario	3	2	3

Course Code	**:**	**CS619**
Course Title	**:**	**Image and Video Analytics**
Type of Course	**:**	**PE**
Number of Credit:	**:**	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of digital image processing
CLO2	To have a knowledge on image and video analysis.
CLO3	To understand the real time use of image and video analytics.
CLO4	To understand the processing of images and videos
CLO5	To demonstrate real time image and video analytics applications.

Course Content:

Unit I Introduction

Digital Image Processing – Characteristics of Digital Image - Basic relationship between pixels Fundamental operations on image - Image sampling and quantization – Image transformations - Color models.

Lab component: Geometric and affine transformations on the image.

Unit II Basic Techniques of Image Processing

Fundamentals of spatial filtering: spatial correlation and convolution-smoothing blurring- sharpening - Basics of filtering in the frequency domain: smoothing-blurring - sharpening-- Histograms and basic statistical models of image.

Lab component: Correlation & Convolution operations on an image, Apply Smoothening & Sharpening filters on the image.

Unit III Transformations and Segmentations

Colour models and Transformations – Image and Video Segmentation-Image and video demonising- Image and Video enhancement- Image and Video compression.

Lab component: Apply segmentation & compression techniques to image & video

Unit IV Detection and Classification

Object detection and recognition in image and Video-Texture models - Image and Video classification models- Object tracking in Video.

Lab component: Perform object detection & tracking

Unit V Applications and Case studies

Industrial- Transportation & Travel- Remote Sensing - Surveillance. IoT Video Analytics Architectures.

Lab component: Develop an application to solve real-time problems.

Text Books:

1. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing", Pearson Education, 4th edition,2018.

2. Wilhelm, Mark J. Burge, "Digital Image Processing An Algorithmic Introduction", Springer; 3rd edition, 2022.

Reference Books:

1.Milan Sonka, Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and MachineVision", 4nd edition, Thomson Learning, 2013.

2.A.K. Jain, "Fundamentals of Digital Image Processing", PHI, New Delhi, 2015.

3.Rick Szelisk, "Computer Vision: Algorithms and Applications", Springer 2011.

Course Outcomes (CO)

At the end of the course, student will be able to

CO1	Describe the fundamental principles of image analysis
CO2	Have an idea of various image processing techniques.
CO3	Apply pattern recognition techniques.
CO4	Apply image analysis in real world problem

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS619	**Image and Video Analytics**	**CO1**	Describe the fundamental principles of image analysis	1	0	0
		CO2	Have an idea of various image processing techniques.	2	0	1
		CO3	Apply pattern recognition techniques.	3	1	1
		CO4	Apply image analysis in real world problem	3	3	1

Course Code		**CS620**
Course Title		**Fog and Edge Computing**
Course Type		**PE**
Number of Credits		**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To introduce Fog Computing technologies and its opportunities.
CLO2	To review underlying technologies, limitations, and challenges along with performance metrics and discuss generic conceptual framework in fog computing.
CLO3	To learn the techniques for storage and computation in fogs, edges, 5G and clouds.
CLO4	To impart the knowledge to log the sensor data and to perform further data analytics.
CLO5	Analyze the performance and issues of the applications developed using fog and edge architecture

Course Content

Unit –I Introduction to Fog Computing

Introduction to Fog Computing, Limitation of Cloud Computing, Differences between Cloud and Fog Computing, Advantages, Business Models, Architecture, Opportunities and Challenges.

Lab component:

1. Experiments using simulation tools to evaluate network performance within cloud data centers, focusing on issues like variable latency and resource exhaustion.
2. Design experiments that run real-time applications in both fog and cloud environments to quantify latency and resource utilization differences.
3. Utilize emulation frameworks to design and simulate various fog computing architectures.

Unit –II Challenges in Fog Resources:

Taxonomy and Characteristics, Resource Management Challenge, Optimization Challenges, Miscellaneous Challenges.

Lab component:

1. Create a simulation environment to evaluate various resource management strategies in fog computing.
2. Conduct experiments focusing on task scheduling strategies within fog nodes.

Unit –III IoT and Fog

Programming Paradigms, Research Challenges and Research Directions, Fog Protocols, Management and Orchestration of Network Slices in 5G, Fog, Edge and Clouds, Data Management and Analysis in Fog Computing, Case Studies.

Lab component:

1. Design and simulate the management and orchestration of network slices in a 5G environment using fog computing principles.
2. Develop a data management framework tailored for fog computing environments to handle IoT data flow efficiently.

Unit –IV Introduction to Edge Computing

Origins of Edge, Edge Helping Low-End IoT Nodes, Architecture, Edge Helping Higher-Capability.

Lab component:

1. Understand and implement the architecture of edge computing systems.
2. Implement and analyze edge computing solutions for high-capability devices.

Unit –V Applications of Fog and Edge Computing

Mobile Offloading, Edge Helping the Cloud, Edge for Augmented Reality, Data Processing on the Edge, Dispersed Learning with Edge/Fog Computing, Video Analytics on the Edge, Edge Computing Applications.

Lab component:

1. Design a real-time video analytics system utilizing edge computing for efficient data processing.
2. Case Study: Edge-Based Video Analytics for Smart Cities or for any other real time applications.

Text Books

1. Buyya, Rajkumar, and Satish Narayana Srirama, Fog and Edge computing: Principles and Paradigms, 2019, 1st edition, John Wiley & Sons, USA.
2. Wei Change and Jie Wu, Fog/Edge Computing for Security, Privacy and Applications, Springer, 2021.

Reference Books

1. Bahga, Arshdeep, and Vijay Madisetti, Cloud computing: A hands-on approach, 2014, 2ndedition, CreateSpace Independent Publishing Platform, USA.
2. OvidiuVermesan, Peter Friess, "Internet of Things –From Research and Innovation to Market Deployment", 2014, 1st edition, River Publishers, India.

Course Outcomes

At the end of the course, the student will be able to

CO1	Understand the key architectures and basic fundamentals of fog computing.
CO2	Understand the challenges in fog computing.
CO3	Perform fog and edge computing services.

CO4	Understand the basic fundamentals of edge computing and Use fog and edge computing services in various applications.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course students will be able to**	**PO1**	**PO2**	**PO3**
CS620	**Fog and Edge Computing**	CO1	Understand the key architectures and basic fundamentals of fog computing.	3	2	3
		CO2	Understand the challenges in fog computing.	3	0	3
		CO3	Perform fog and edge computing services.	2	0	2
		CO4	Understand the basic fundamentals of edge computing and Use fog and edge computing services in various applications.	3	2	2

Course Code	:	**CS621**
Course Title	**:**	**Immersive Technologies**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-2-4**

Course Learning Objectives (CLO)

CLO1	To understand the historical and modern overviews and perspectives on virtual reality
CLO2	To understand visual computation in computer graphics
CLO3	To understand the interaction between system and computer
CLO4	To know the fundamentals of sensation, perception, technical and engineering aspects of AR, VR & MR.
CLO5	To know the applications of Immersive Technology

Course Content

Unit I Introduction to Immersive Technologies

Types: VR, AR, MR, XR, Immersing web and mobile apps, Components of VR, Multiple Models of Input and Output Interface in Virtual Reality, Current trends and state of the art in immersive technologies.

Lab component: Calibration in Google Cardboard

Unit II Interactive Techniques in Virtual Reality

Hand Gesture - 3D Manus - Object Grasp, Tracker – Position, Motion, Full body, Navigation/Manipulation Interfaces - Navigation and controllers, Tracker Performance Parameters.

Lab component: Making a room on unity and creating assets in blender.

Unit III Visual Computation in Virtual Reality

Basics of Computer Vision & Computer Graphics - Software and Hardware Technology on Stereoscopic Display - Advanced Techniques in Computer Graphics, Management of Large Scale Environments & Real-Time Rendering.

Lab component: Apply transformations on 3D object and render it.

Unit IV Augmented and Mixed Reality

Technology and features of AR - visualization techniques for augmented reality - wireless displays in educational augmented reality applications - mobile projection interfaces - marker-less tracking for augmented reality - enhancing interactivity in AR environments - evaluating AR systems.

Lab component: Develop an AR application.

Unit V Development Tools and Frameworks in Virtual Reality

Frameworks of Software Development Tools in VR. X3D Standard; Vega - Virtools. 3D Rendering toolkit: Intel oneAPI Rendering Tool, OpenGL; Animation – Blender, Unity & Unreal Engine.

Application of VR in Digital Entertainment, Film & TV Production, Healthcare & Physical Exercises – VR in Industrial Applications & Digital Twin creation.

Lab component: Develop an application to solve real-world problems on immersive technologies.

Text Books:

1. Routhier Pierre ," Immersive Technologies", Blurb, 2019.
2. Burdea, G. C., P. Coffet.,"Virtual Reality Technology", Second Edition, Wiley, 2016.

Reference Books:

1. Alan Craig, William Sherman, Jeffrey Will, "Developing Virtual Reality Applications, Foundations of Effective Design", Morgan Kaufmann, 2009.
2. Steven M. LaValle, "Virtual Reality", Cambridge University Press, 2016.
3. William R Sherman and Alan B Craig, "Understanding Virtual Reality: Interface, Application and Design (The Morgan Kaufmann Series in Computer Graphics)", Morgan Kaufmann Publishers, San Francisco, CA, 2002.
4. Alan B. Craig,"Understanding Augmented Reality, Concepts and Applications", Morgan Kaufmann, 2013.

Course Outcomes (CO)

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

CO1	Provide an opportunity to explore the research issues in AR, VR & MR.
CO2	Use advanced stills and immersive technology development tools to conduct closely guided professional research in specific business vertical sectors.
CO3	Understand the design and implementation of the hardware that enables AR, VR systems to be built
CO4	Acquire knowledge about the software used in immersive technology and get a better understanding of human-computer interaction.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS621		**CO1**	Provide an opportunity to explore the research issues in AR, VR & MR.	2	1	3

	Immersive Technologies	**CO2**	Use advanced stills and immersive technology development tools to conduct closely guided professional research in specific business vertical sectors.	1	3	2
		CO3	Understand the design and implementation of the hardware that enables AR, VR systems to be built	2	1	1
		CO4	Acquire knowledge about the software used in immersive technology and get a better understanding of human-computer interaction.	0	0	1

Course Code	**:**	**CS622**
Course Title	**:**	**Quantum Computing**
Course Type	**:**	**PE**
Credit	**:**	**3-1-0-4**

Course Learning Objectives (CLO)

CLO1	To understand the principles of quantum computing and its operations
CLO2	To study the information theory aspects of quantum computing
CLO3	To explore the various error corrections available for quantum computing
CLO4	To comprehend the applications of quantum computing to information theory and cryptography

Course Content:

UNIT I Introduction to Quantum Computation

Review of Linear Algebra: Vector Space, Hilbert Space, Bases, Matrices, Eigenvalues and Eigenvectors, Hermitian matrices, and Unitary matrices.

Introduction to Quantum Computing. Dirac Notation, Qubits, Bloch Sphere, Postulates of Quantum Mechanics, Classical Computation Vs Quantum Computation. Quantum algorithms summarized - Quantum information - Postulates of quantum mechanics - Application: superdense coding - Density operator - Schmidt decomposition and purifications - EPR and the Bell inequality

UNIT II Quantum Computing Operations

Measurements: Composite system, reduced state, mixed state. Single Qubit gates – two-qubit gates – Multiple Qubits gates, Universal gates, Quantum circuit model of computation, Quantum computational complexity - no-cloning theorem. Applications: order-finding and factoring - General applications of the quantum Fourier - Quantum search algorithms - Quantum search as a quantum simulation, Quantum counting - Speeding up the solution of NP-complete problems

UNIT III Quantum Information

Quantum computers: physical realization - Guiding principles - Conditions for quantum computation- Harmonic oscillator quantum computer - Quantum information - Quantum noise and quantum operations - Classical noise and Markov processes, Quantum operations Examples of quantum noise and quantum operations - Applications of quantum operations - Limitations of the quantum operations formalism

UNIT IV Quantum Error Correction

Distance measures for quantum information - Distance measures for classical information- the closeness of two quantum states –Quantum error-correction- Three qubit bit flip code - Shor code, Theory of quantum error-correction- Constructing quantum codes - Classical linear codes - Stabilizer codes - Stabilizer formalism - Fault-tolerance: the big picture- Fault-tolerant quantum logic- Fault-tolerant measurement- Elements of resilient quantum computation

UNIT V Quantum cryptography

Introduction to classical cryptography vs. quantum cryptography, Quantum key distribution. Comparison Between Classical and Quantum Information Theory, Applications of Quantum Information. Classical error correction codes, Quantum error correction codes, Three and nine qubit quantum codes. Fault-tolerant quantum computation.

Text Books

1. Nielsen, M., & Chuang, I. In Quantum Computation and Quantum Information: 10th Anniversary Edition, Cambridge: Cambridge University Press, 2010.
2. Rieffel, Eleanor G., and Wolfgang H. Polak. "Quantum computing: A gentle introduction (scientific and engineering computation)." The MIT Press 10 (2014): 1973124.

Reference Books

1. John Gribbin, Computing with Quantum Cats: From Colossus to Qubits, Prometheus Books, 2014
2. B.N. Murdin Quantum Computing from the Ground Up, by Riley Tipton Perry, Contemporary Physics, 2013
3. Tannor, David J. Introduction to quantum mechanics: a time-dependent perspective. 2007.

Course Outcomes (CO)

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

CO1	interpret the principles of quantum computing and its operations
CO2	analyze the information theory aspects of quantum computing
CO3	apply error corrections available for quantum computing
CO4	describe the principles and some of quantum cryptography

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS622	**Quantum Computing**	CO1	interpret the principles of quantum computing and its operations	3	1	2
		CO2	analyze the information theory aspects of quantum computing	3	1	2
		CO3	apply error corrections available for quantum computing	3	2	2
		CO4	describe the principles and some of quantum cryptography	3	3	2

Course Code	:	**CS630**
Course Title	:	**Advanced Databases**
Course Type	:	**PE**
Number of Credits	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the basic concepts and terminology related to DBMS and Relational Database Design
CLO2	To the design and implement Distributed Databases.
CLO3	To understand advanced DBMS techniques like parallel and Main-memory databases
CLO4	To understand the concept of transaction management in the database
CLO5	To understand the query optimization techniques

Course Content

Unit I Introduction

Query Processing - Evaluation of relational algebra expressions, query equivalence, join strategies,Query Optimization, Rule-Based Query Optimization - Formal review of relational database and FDs Implication, Closure, its correctness

Unit II Locking and Concurrency Control

Correctness of interleaved execution, Locking and management of locks, Two Phase Locking, deadlockd, multiple level granularity, Concurrency Control on B+ trees, Optimistic Concurrency Control

Unit III Recovery System and XML

Failure classification, recovery algorithm, XML and relational databases- Structure of XML Data, XML Document Schema, Querying and Transformation, Application Program Interfaces to XML, Storage of XML Data, XML Applications

Unit IV Parallel and Distributed Databases

I/O Parallelism- Interquery Parallelism, Intraquery Parallelism, Intraoperation Parallelism, Design of Parallel Systems -Homogeneous and Heterogeneous Databases -Distributed Data - Distributed Transaction, Concurrency Control in Distributed Databases -Distributed Query Processing- Cloud-Based Databases.
Unit V NoSQL Databases

Introduction to NoSQL databases - Need for NoSQL – Characteristics of NoSQL - Key-value database - Columnar databases – Document databases -Graph databases - MongoDB - CRUD operations with MongoDB – Query Operators, MongoDB Aggregations-MongoDB Node.js Database Interaction - Database Sharding -Sharding architectures and types.

Text Books:

1. R. Elmasri and S. B. Navathe, "Fundamentals of Database Systems", Seventh Edition, Pearson Education / Addison Wesley, 2021.

2. R. Ramakrishnan, J. Gehrke, Database Management Systems, McGraw Hill, January 2007

3. A. Silberschatz, Henry F. Korth, and S. Sudharshan, "Database System Concepts", 6th Ed., McGraw Hill,March 2019.

Reference Books:

1. Garcia-Molina, Ullman, and Widom, Database Systems: The Complete Book, 2nd Edition, Prentice Hall, 2008

2. Philip A. Bernstein, Vassos Hadzilacos, Nathan Goodman, Concurrency Control and Recovery in Database Systems, Addison-Wesley Online at https://www.microsoft.com/en-us/research/people/philbe/book/

3. Patrick Valduriez M. Tamer Ozsu, Principles of Distributed Database Systems, 2020

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Write complex queries including full outer joins, self-join, sub queries, and set theoretic queries.
CO2	Know about the file organization, Query Optimization and Transaction management
CO3	Work with Main–memory Databases and Data Streams
CO4	Comprehend emerging and advanced databases

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS630	**Advanced Databases**	**CO1**	Write complex queries including full outer joins, self-join, sub queries, and set theoretic queries.	3	1	2
		CO2	Know about the file organization, Query Optimization and Transaction management	3	1	2
		CO3	Work with Main–memory Databases and Data Streams	3	1	2
		CO4	Comprehend emerging and advanced databases	2	1	1

Course Code	:	**CS631**
Course Title	**:**	**Advanced Cryptography**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To gain knowledge about the mathematics of the cryptographic algorithms
CLO2	To study the concepts of applied cryptography such as commitment, zero knowledge proof etc.
CLO3	To understand the application of cryptographic techniques in real world applications.
CLO4	To comprehend the notion of provable security and its implication with improved security guarantees.

Course Content:

UNIT-I Number Theory

Review of number theory, group, ring and finite fields, quadratic residues, Legendre symbol, Jacobi symbol, Probability, Probability, Discrete random variable, Continuous random variable, Markov's inequality, Chebyshev's inequality, normal distribution, the geometric and binomial distributions.

UNIT-II Formal Notions of Attacks

Formal Notions of Attacks: Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Attacks under Message Non-malleability: NM-CPA and NM-CCA2, Inter-relations among the attack model.

UNIT-III Public Key Cryptography

Public key cryptography, probabilistic encryption, homomorphic encryption, Elliptic curve cryptosystems, Cryptographic hash functions.

UNIT-IV Digital Signatures

Digital signatures and the notion of existential unforgability under chosen message attacks. Schnorr signature scheme. Zero Knowledge Proofs and Protocols,

UNIT-V Blockchain Technology

Blockchain technology, Consensus algorithm, Incentives and proof of work, Smart contract, Bitcoin. **Text Books:**

1. W. Mao, “Modern Cryptography: Theory & Practice”, Pearson Education, 2014

2. Jonathan Katz and Yehuda Lindell, “Introduction to Modern Cryptography” (3rd edition): CRC Press, 2020.

Reference Books:

1. Koblitz, N. Course on Number Theory and Cryptography, Springer Verlag, 1986 4.

2. Menezes, A, et.al. Handbook of Applied Cryptography, CRC Press, 1996.

3. Thomas Koshy, Elementary Number Theory with applications, Elsevier India, 2005.

4. Arvind Narayanan, Joseph Bonneau, Edward Felten , Andrew Miller and Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies”, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Evaluate the security of a protocol based on security metrics
CO2	Justify the usage of security principles and digital signatures for any application
CO3	Ability to break the cryptosystem that is not secure.
CO4	Design and implementation of provable secure cryptographic protocols

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS631	Advanced Cryptography	CO1	Evaluate the security of a protocol based on security metrics	3	0	3
		CO2	Justify the usage of security principles and digital signatures for any application	3	0	3
		CO3	Ability to break the cryptosystem that is not secure.	3	0	3
		CO4	Design and implementation of provable secure cryptographic protocols	3	2	3

Course Code	:	**CS632**
Course Title	:	**Network Security**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the network security, services, attacks, mechanisms, types of attacks on TCP/IP protocol suite.
CLO2	To comprehend and apply authentication services, authentication algorithms
CLO3	To comprehend and apply network layer security protocols, Transport layer security protocols, Web security protocols.
CLO4	To understand the wireless network security threats.

Course Content:

UNIT –I Overview of Network Security

Overview of Network Security, Security services, attacks, Security Issues in TCP/IP Suite-Sniffing, spoofing, buffer overflow, ARP poisoning, ICMP Exploits, IP address spoofing, IP fragment attack, routing exploits, UDP exploits, TCP exploits.

UNIT-II Authentication Protocol

Authentication requirements, Authentication functions - Message Authentication Codes - Hash Functions - Security of Hash Functions and MACs - MD5 message Digest algorithm - Secure Hash Algorithm - RIPEMD - HMAC Digital Signatures, Authentication Protocols-Kerberos, X.509.

UNIT-III Security

IP Security-AH and ESP, SSL/TLS, SSH, Web Security-HTTPS, DNS Security, Electronic Mail Security (PGP, S/MIME).

UNIT-IV Viruses/Malwares and Attacks

Intruders, Viruses, Worms, Trojan horses, Distributed Denial-Of-Service (DDoS), Firewalls, IDS, Honey nets, Honey pots.

UNIT-V Introduction to wireless Network Security

Introduction to wireless network security, Risks and Threats of Wireless networks, Wireless LAN Security (WEP, WPA).

Text Books:

1. Yang Xiao and Yi Pan, “Security in Distributed and Networking Systems Series in Computer and Network Security – Vol. 1” World Scientific, 2007.

2. W. Stallings, “Cryptography and Network Security: Principles and Practice”, 7/E, Pearson Education, 2016.

Reference Books:

1. Aaron E. Earle, “Wireless Security Handbook”, Auerbach publications, Taylor & Francis Group, 2005.

2. Atul Kahate, “Cryptography and Network Security”, 4/E, McGraw Hill Education, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Be able to determine appropriate mechanisms for protecting the network.
CO2	Design a security solution for a given application, system with respect to security of the system.
CO3	Understand the various existing security protocols
CO4	Understand authentication algorithms and find solution to Security Threats

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS632	**Network Security**	**CO1**	Be able to determine appropriate mechanisms for protecting the network.	3	1	2
		CO2	Design a security solution for a given application, system with respect to security of the system.	3	2	3
		CO3	Understand the various existing security protocols	3	1	2
		CO4	Understand authentication algorithms and find solution to Security Threats	3	2	3

Course Code	:	**CS633**
Course Title	:	**Wireless Sensor Networks**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	Understand the fundamentals of wireless communication technology, various modulation and multiple access techniques.
CLO2	Comprehend the principles, structure, and design factors of ad hoc and sensor networks along with their unique constraints, challenges, and applications.
CLO3	Understand the functioning of MAC protocols with an emphasis on optimizing efficiency, ensuring reliability, and QoS.
CLO4	Examine and assess different routing protocols and comprehending their underlying design principles, benefits, and drawbacks.
CLO5	Understand the principles of QoS and energy management including strategies for power conservation and efficient resource utilization.

Course Content:

Unit I Introduction

Introduction: Fundamentals of wireless communication technology, the electromagnetic spectrum radio propagation, characteristics of wireless channels, modulation techniques, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet.

Unit II Introduction to Adhoc/sensor networks

Introduction to adhoc/sensor networks: Key definitions of adhoc/ sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, driving applications, issues in adhoc wireless networks, issues in design of sensor network, sensor network architecture, data dissemination and gathering.

Unit III MAC Protocols

MAC Protocols : Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC, IEEE 802.15.4.

Unit IV Routing Protocols

Routing Protocols: Issues in designing a routing protocol, classification of routing protocols, table-driven, on- demand, hybrid, flooding, hierarchical, and power aware routing protocols

Unit V QoS and Energy Management

QoS and Energy Management: Issues and Challenges in providing QoS, classifications, MAC, network layer solutions, QoS frameworks, need for energy management, classification, battery, transmission power, and system power management schemes.

Text Books:

1. Dr. Manish Gupta, Mr Deepak Sharma, Ms Neha Gupta, Dr. Naresh Kumar, “A Complete guide to Wireless sensor networks”, Notion Press 2021.

2. C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education – 2008.

Reference Books:

1.Shashikant V. Athawale, Ad-Hoc and Wireless Sensor network, Pearson, 2022.

2.Feng Zhao and Leonides Guibas, "Wireless sensor networks ", Elsevier publication – 2005

3.William Stallings, "Wireless Communications and Networks ", Pearson Education – 2013

Course Outcomes (CO) - At the end of the course student will be able to

CO1	Comprehend the fundamental principles governing wireless communication systems and their diverse applications.
CO2	Analyze adhoc / sensor network architecture, deployment challenges, and their applications.
CO3	Acquire knowledge on designing MAC protocols, emphasizing energy efficiency and data transmission reliability.
CO4	Design scalable, energy-efficient routing protocols with strategies for energy management and QoS to enhance network lifetime and performance.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS633	**Wireless Sensor Networks**	**CO1**	Comprehend the fundamental principles governing wireless communication systems and their diverse applications.	3	2	2
		CO2	Analyze adhoc / sensor network architecture, deployment challenges, and their applications.	3	2	2
		CO3	Acquire knowledge on designing MAC	3	2	2

			protocols, emphasizing energy efficiency and data transmission reliability.			
		CO4	Design scalable, energy-efficient routing protocols with strategies for energy management and QoS to enhance network lifetime and performance.	3	2	2

Course Code	**:**	**CS634**
Course Title	**:**	**Software Design Architecture**
Course Type	**:**	**PE**
Number of Credits	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	Understand the basics of software architectural design
CLO2	Analyze the software architectural models
CLO3	Design UML for software architecture
CLO4	Explore the software modelling tools
CLO5	Design algorithms and apply for case studies

Course Content

UNIT-I Software Architecture

Introduction-Software Architecture -The Role of the Architect-Architectural Styles-Quality Attributes, Why Is Software Architecture Important, Contexts of Software Architecture: Architecture in a Technical Context-Architecture in a Project Life-Cycle Context-Architecture in a Business Context-Architecture in a Professional Context- Stakeholders- How Is Architecture Influenced - What Do Architectures Influence?

UNIT-II : Architectural Design

Design in General, Design in Software Architecture-Architectural Design-Element Interaction Design-Element Internals Design- Why Is Architectural Design So Important? Architectural Drivers-Design Purpose-Quality Attributes-Primary Functionality- Architectural Concerns- Constraints, Design Concepts: The Building Blocks for Creating Structures-Reference Architectures-Architectural Design Patterns-Deployment Patterns- Tactics- Externally Developed Components, Architecture Design Decisions

UNIT-III Design Space for Architecture and models

Software Architecture Design Guidelines, Software Architecture Design Space: Types of software structures- software elements-software connectors-An Agile Approach to software Design, Models of software architecture: overview, UML for software architecture, Architecture View models, Architecture Description Languages

UNIT-IV Software Architecture Process and Documentation

Software Architecture Process: Process Outline, Architecture Design, Validation, Documenting a Software Architecture: Uses and Audiences for Architecture Documentation, Notations for Architecture Documentation, Views, Choosing the Views, Combining Views, Building the Documentation Package. Documenting Behaviour, Architecture Documentation and Quality Attributes, Documenting Architecture in an Agile Development Project

UNIT-V Modeling Tools and Case studies

UML, SysML, AADL, Case studies-FCAPS systems, Big data systems, Banking system

Text Books

1.Humberto Cervantes, Rick Kazman," Designing Software Architectures: A Practical Approach", PearsonEducation 2016.

2.Kai Qian, Xiang Fu, Lixin Tao, Chong-wei Xu, "Software Architecture and Design Illuminated", Jones &Bartlett Learning; 1 edition, 2009

Reference Books

1.Len Bass, Paul Clements, Rick Kazman," Software Architecture in Practice", 3rdedition, Pearson Education, 2013

2.Ian Gorton," Essential Software Architecture", Springer-Verlag Berlin, Heidelberg, 2006

3.Paul Clements, Felix Bachmann, Len Bass, David Garlan, James Ivers, Reed Little, Paulo Merson, Robert Nord, Judith Stafford," Documenting Software Architectures: Views and Beyond", 2nd edition, Pearson Education, 2011

4.Hofmeister, Christine, Robert Nord, and Dilip Soni. Applied software architecture. Addison-Wesley Professional, 2000.

Course Outcomes (CO) - At the end of the course student will be able to

CO1	Understand and analyze the abstraction of various architectural styles of a software
CO2	Analyze the software architectural design models to make design decisions
CO3	Design, validate and document the software architecture
CO4	Design and implement algorithm for case studies

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS634	**Software Design Architectures**	**CO1**	Understand and analyze the abstraction of various architectural styles of a software	3	2	2
		CO2	Analyze the software architectural design models to make design decisions	3	2	2
		CO3	Design, validate and document the software architecture	2	1	2
		CO4	Design and implement algorithm for case studies	1	1	3

Course Code	:	**CS 635**
Course Title	:	**Mobile Network Systems**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	Introduce basics of mobile communication systems, wireless transmissions and interference management
CLO2	Learn MAC protocols and multiplexing schemes in detail.
CLO3	Explore mobile telecommunication standards and satellite systems
CLO4	Understand Mobile IP and network layer protocols
CLO5	Study mobile transport protocols and their optimizations

Course Content:

Unit I Introduction

Introduction to wireless, mobile and cellular mobile systems- cellular mobile telephone systems, analog and digital cellular systems- frequency reuse, co-channel interference. Wireless transmission- Signal Propagation, Spread Spectrum Techniques.

Unit II MAC

MAC - Medium access control - MAC, SDMA, FDMA, TDMA, CDMA, Hand offs and dropped calls-initiation of handoff, power difference, mobile assisted cell-site and Intersystem handoff.

Unit III Wireless Network

Communication Systems - Mobile Telecommunication standards, GSM, DECT, TETRA, IMT 2000, CTEO, satellite systems – GEO, LEO and MEO, and broadcast systems –Digital audio and video broadcasting, IEEE 802.11, HIPERLAN, Bluetooth, Wireless ATM, WATM services.

Unit IV Mobile Network Layer

Mobile Network Layer - Network support for mobile systems – Mobile IP- IP packet delivery-Agent discovery- tunneling and encapsulation, reverse tunneling, IPV6, DHCP.

Unit V Mobile Transport Layer

Mobile Transport Layer - Mobile transport and application layer protocol - Review of traditional TCP, fast retransmit/fast recovery, transmission/timeout freezing, file systems, WWW, WAP.

Text Books:

1. Jochen Schiller, "Mobile Communications ", Pearson Education India, 2020**.**

2. Theodore S. Rappaport, “Wireless Communications: Principles and Practice”, Updated 2/e, Pearson Education, 2024

Reference Books:

1. William C.Y Lee, "Mobile Cellular Telecommunications ", McGraw Hill International Editions, 2e, 2017.
2. William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004.
3. Cory Beard, William Stallings, “Wireless Communication Networks and Systems”, Global Edition, Pearson Education, 2016

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the evolution and challenges in mobile communications.
CO2	Differentiate and apply various MAC and multiplexing schemes
CO3	Gain knowledge on global mobile telecommunication standards
CO4	Configure and Implement Mobile IP and optimized protocols for mobile communications

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS 635	**Mobile Network Systems**	CO1	Understand the evolution and challenges in mobile communications.	3	2	2
		CO2	Differentiate and apply various MAC and multiplexing schemes	3	2	2
		CO3	Gain knowledge on global mobile telecommunication standards	3	2	2
		CO4	Configure and Implement Mobile IP and optimized protocols for mobile communications.	3	2	2

Course Code	:	**CS636**
Course Title	:	**Cloud Security**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To provide an in-depth and comprehensive knowledge of cloud computing security concepts.
CLO2	To understand the techniques and protocols used to secure network, host, and application layers.
CLO3	To explore data security and storage mechanisms in cloud environments.
CLO4	To understand the availability management strategies for different service models (SaaS, PaaS, IaaS).
CLO5	To understand security tools and techniques for cloud environments.

Course Content:

UNIT – I Introduction

Introduction to cloud computing, Modular arithmetic background, concepts of security, how to assess security of a system, information theoretic security v/s computational security, key drivers to adopting the cloud, Barries to cloud computing adoption in the enterprise.

UNIT – II Infrastructure security

Network level - Ensuring Data Confidentiality, Integrity and Proper Access Control, Mitigation, Host level – SaaS, PaaS and IaaS Host Security, Virtualization Software Security, Application level - Security Threats, SaaS, PaaS and IaaS Application Security. Privacy and Compliance Risks, Threats to Infrastructure, Data, and Access Control. Case study: Amazon's EC2 infrastructure.

UNIT – III Data Security and storage

Data security and storage in cloud, data dispersal techniques, High-availability and integrity layer for cloud storage, Encryption and key management in the cloud, Cloud forensics, Data location and availability.

UNIT – IV Security Management in the cloud

Security Management standards, Security Management in the cloud, Availability management, SaaS availability management, Pass availability management, Iaas availability management.

UNIT – V Cloud Security Tools

Security tools and techniques for the cloud, Data distribution and information dispersal techniques Data encryption/decryption methodologies, Trustworthy cloud infrastructures, Cloud related regulatory and compliance issues

Text Books:

1. Mather, T., Kumaraswamy S., and Latif, S. "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance", O'Reilly, First Edition, 2009.
2. William Stallings, "Cryptography and Network Security: Principles and Practice", Pearson, Global Edition, Eighth Edition, 2022.

Reference Books:

1. Menezes, A., Oorschot, P., Vanstone, S, "Handbook of Applied Cryptography", CRC Press, First Edition, 1996
2.Krutz, Ronald L., and Russell Dean Vines, "Cloud security: A comprehensive guide to secure cloud computing", Wiley Publisher, First Edition, 2010
3.Rittinghouse, John W., and James F. Ransome, "Cloud computing: implementation, management, and security", CRC press, First Edition, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the principles and concepts underlying cloud computing security.
CO2	Identify appropriate security measures to mitigate risks associated with network, host, and application layers.
CO3	Implement suitable data security mechanisms and storage techniques for cloud environments.
CO4	Develop strategies for managing security risks and compliance, and effectively apply security tools and techniques to protect cloud-based data and infrastructure.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS636	**Cloud Security**	**CO1**	Understand the principles and concepts underlying cloud computing security.	3	2	2
		CO2	Identify appropriate security measures to mitigate risks associated with network, host, and application layers.	3	3	2
		CO3	Implement suitable data security mechanisms and storage techniques for cloud environments.	3	2	2

		CO4	Develop strategies for managing security risks and compliance, and effectively apply security tools and techniques to protect cloud-based data and infrastructure.	2	3	2

Course Code	:	**CS637**
Course Title	:	**Design and Analysis of Parallel Algorithms**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand different array processors and parallel algorithms for multiprocessors.
CLO2	To Perform the various operation on the PRAM Model
CLO3	To perform merging and sorting operations on different models
CLO4	To solve linear equations using parallel algorithms for basic problems.
CLO5	To study graph Algorithms

Course Content:

UNIT I

Structures and algorithms for array processors: SIMD Array Processors, Interconnection networks, Parallel algorithms for Array processors. Multiprocessor architecture-and Interconnection networks-multiprocessor control algorithms- parallel algorithms for multiprocessors.

UNIT II

Selection – broadcast- all sums- parallel selection. Searching a random sequence, sorted sequence on PRAM models, Tree and Mesh.

UNIT III

Merging – A network for merging – merging on PRAM models. Sorting on a linear array, EREW, CREW and CRCW SIMD models, MIMD Enumeration sort.

UNIT IV

Matrix operations- Transposition, Matrix by matrix multiplication, matrix by vector multiplication. Numerical problems- solving systems of linear equations, finding roots of nonlinear equations on PRAM models.

UNIT V

Graphs – Connected components- dense graphs- sparse graphs. Minimum spanning tree- Solli's algorithm, Biconnected components, Ear decomposition, Directed graphs

Text Books:

1.S. G. Akl, "Design and Analysis of Parallel Algorithms", Prentice Hall Inc., 1992.

2.Selim G. Akl "Parallel Sorting Algorithms", Academic Press, 1985.

Reference Books:

1. Kai Wang and Briggs, “Computer Architecture and Parallel Processing”, McGraw Hill, 1985.
2. Joseph Jaja, “An Introduction to parallel Algorithms”, Addison Wesley, 1992.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Formulate algorithms for array processors
CO2	Develop searching algorithms for various parallel models.
CO3	Perform efficient sorting operation on different models.
CO4	Solve linear and nonlinear equations using PRAM models and To Construct graph and find solutions to real world problems

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS637	**Design and Analysis of Parallel Algorithms**	**CO1**	Formulate algorithms for array processors	3	0	0
		CO2	Develop searching algorithms for various parallel models.	3	0	3
		CO3	Perform efficient sorting operation on different models	3	0	3
		CO4	Solve linear and nonlinear equations using PRAM models and To Construct graph and find solutions to real world problems	3	3	3

Course Code	:	**CS638**
Course Title	:	**Social Network Mining and Analysis**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To design modeling, aggregating and knowledge representation of semantic web
CLO2	To summarize knowledge on network measures and network growth models
CLO3	To study about extracting and analyzing web social networks
CLO4	To understand mining of common social network websites

Course Content:

UNIT-I Introduction

Introduction to Semantic Web: Limitations of current Web — Development of Semantic Web — Emergence of the Social Web. Social Network analysis: Development of Social Network Analysis — Key concepts and measures in network analysis

UNIT-II Modelling, Aggregating and Knowledge Representation:

Ontology and their role in the Semantic Web: Ontology-based knowledge Representation — Ontology languages for the Semantic Web: Resource Description Framework — Web Ontology Language — Modelling and aggregating social network data: State-of-the-art in network data representation — Ontological representation of social individuals and social relationships — Aggregating and reasoning with social network data — Advanced representations.

UNIT-III Network Measures and Growth Models:

Network basics, local node-level measures, Node centrality, Assortativity, Transitivity, Reciprocity, Similarity, Degeneracy, Random network model, ring lattice network model, Watts-Strogatz model, preferential attachment model, Price's model, local-world network model, network model with accelerating growth, Link analysis, community structure in networks

UNIT-IV Extracting and Analyzing Web Social Networks:

Group-level measures, subgroups and community detection, inferential statistics for complete networks, exponential random graph models, directed networks, stochastic actor-oriented models, Link prediction, Social Tie analysis and Social Influence Analysis, User behaviour Modeling and Prediction, community analysis.

UNIT-V Mining the Social Web

Mining Twitter – examining tweets and their patterns, Mining Facebook – analyzing social graph

connections, Mining LinkedIn – exploring LinkedIn API, Mining Web pages – scraping, parsing and crawling the web, Mining Git Hub – property graphs and interest graphs, Mining mail boxes – getting and analyzing Enron corpus.

Text Books:

1. Tanmoy Chakraborty, "Social Network Analysis", Wiley, First edition, 2021.
2. Borgatti, Stephen P., Martin G. Everett, Jeffrey C. Johnson, and Filip Agneessens, "Analyzing social networks", Third edition, SAGE Publications Limited, 2024.

Reference Books:

1. Guandong Xu,Yanchun Zhang, and Lin Li, "Web Mining and Social Networking Techniques and Applications", Springer, 2010.
2. Jie Tung, Juanzi Li, "Semantic Mining of Social Networks", Morgan and Claypool Publishers,2015.
3. Peter Mika, "Social networks and the Semantic Web", Springer, 1st edition, 2007.
4. Matthew A. Russell, Mikhail Klassen, "Mining the Social Web", 3rd Edition, O-Reilly Media, 2019.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design a model for semantic web and social network data
CO2	Model social networks and apply network measures
CO3	Analyze web social networks and derive useful information
CO4	Apply general mining algorithms to real-world social media data

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	Course outcomes - at the end of the course students will be able to	PO1	PO2	PO3
CS638	**Social Network Mining and Analysis**	CO1	Design a model for semantic web and social network data	2	0	3
		CO2	Model social networks and apply network measures	2	0	3
		CO3	Analyze web social networks and derive useful information	2	1	3
		CO4	Apply general mining algorithms to real-world social media data	2	2	3

Course Code	:	**CS639**
Course Title	:	**Computational Geometry**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CO1	To introduce geometric algorithms and related research issues.
CO2	To exposure algorithms and data structures for geometric problems.
CO3	To exposure to randomization as a tool for developing geometric algorithms.
CO4	To develop an understanding of the applications of computational geometry in solving real-world problems of interdisciplinary domains .

Course Content:

UNIT - I Convex hulls

Convex hulls: construction in 2d and 3d, lower bounds; Triangulations: polygon triangulations,representations, point-set triangulations, planar graphs; Voronoi diagrams: construction and applications, variants.

UNIT - II Delaunay triangulations

Delaunay triangulations: divide-and-conquer, flip and incremental algorithms, duality of Voronoi diagrams, min-max angle properties.

UNIT - III Geometric searching

Geometric searching: point location, fractional cascading, linear programming with prune and search, finger trees, concatenable queues, segment trees, interval trees; Visibility: algorithms for weak and strong visibility, visibility with reflections, art-gallery problems; Arrangements of lines: arrangements of hyperplanes, zone theorems, many-faces complexity and algorithms.

UNIT - IV Combinatorial geometry

Combinatorial geometry: Ham-sandwich cuts, Helly's theorems, k-sets, polytopes and hierarchies, polytopes and linear programming in d-dimensions, complexity of the union of convex sets, simply connected sets and visible regions.

UNIT - V Sweep techniques

Sweep techniques: plane sweep for segment intersections, Fortune's sweep for Voronoi diagrams, topological sweep for line arrangements; Randomization in computational geometry: algorithms, techniques for counting; Robust geometric computing; Applications of computational geometry.

Text Books:

1. Mark de Berg, Otfried Schwarzkopf, Marc van Kreveld and Mark Overmars, Computational Geometry: Algorithms and Applications, Springer, Third Edition, 2011.

2. Laszlo Michael , Computational Geometry and Computer Graphics in C++, Pearson, 1st Edition, 2017

Reference Books:

1. F. P. Preparata and Michael I. Shamos, Computational Geometry: An Introduction, Springer, 1985.
2. Joseph O' Rourke, Computational Geometry in C (Cambridge Tracts in Theoretical Computer Science), Cambridge University Press, 1998.
3. K. Mulmuley, Computational Geometry: An Introduction Through Randomized Algorithms, Prentice Hall, 1994.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Introduce a variety of algorithmic techniques that apply to geometric problems
CO2	Aim for diversity at the expense of getting the fastest known algorithms, which are typically obtained with amortized analysis
CO3	Apply geometric algorithms to solve complex problems in various domains, showcasing an ability to adapt and implement these algorithms in practical scenarios.
CO4	Ability to analyze and address degenerate cases within geometric algorithms, highlighting an awareness of potential challenges and handle them effectively

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS639	**Computational Geometry**	**CO1**	Introduce a variety of algorithmic techniques that apply to geometric problems	3	1	1
		CO2	Aim for diversity at the expense of getting the fastest known algorithms, which are typically obtained with amortized analysis	3	1	3
		CO3	Apply geometric algorithms to solve complex problems in various domains, showcasing an ability to adapt and implement these algorithms in practical scenarios.	2	3	3
		CO4	Ability to analyze and address degenerate cases within geometric algorithms, highlighting an awareness of potential challenges and handle them effectively	1	3	2

Course Code	**:**	**CS640**
Course Title	**:**	**Database Tuning and Administration**
Course Type	**:**	**PE**
Number of Credits	**:**	**3-0-0-3**

Course Objectives

CLO1	rn various types of File Systems and Database Architectures
CLO2	derstand the internal storage structures in a physical DB design.
CLO3	ow the fundamental concepts of transaction processing techniques.
CLO4	derstand the concept of ASM Instance.
CLO5	ow the manipulation of SQL Queries for transaction and concurrency control.

Course Content

UNIT– I File Systems and Databases

Data, information, databases, database management systems, data redundancy, database systems, DBMS functions, and connecting a client to the Oracle DBMS, Data models, Hands on: Installing and connecting to a database management system, Modeling and Normalization Performance Tuning, Security, Administration, and Ethical Issues, Transactions, Distributed, Clustered, Tiered and Mobile Databases Object-Oriented and Object-Relational Databases, Introduction and applications to Data warehousing and Data Mining.

UNIT–II Exploring the Oracle Database Architecture

Introduction Exploring the Oracle Database Architecture, connecting to a server, Oracle Database Server Architecture Instance: Database Configurations, Memory structures, Managing the Database instance.

UNIT – III Managing the ASM Instance

ASM introduction, benefits instance processes and parameters, Interaction between database instances and ASM, ASM instance dynamic performance views, system privileges, disk groups, disks, Allocation units and managing files in ASM files. Creating Oracle Net Service aliases, Configuring connect- time failover, Controlling the Oracle Net Listener, Oracle - Managed Files (OMF), Enlarging the database, Managing Data Concurrency.

UNIT– IV Administering User Security

Create and manage database user accounts, Create and manage roles, Predefined roles, Create and manage profiles, Supplied password verification Function, Assigning quotas to users, Principle of least privilege, Protect privileged Accounts Managing Undo Data: DML and undo data generation, Monitor and administer undo data, Configuring undo retention, Undo retention guarantee, Undo Advisor, Implementing Oracle Database Auditing

UNIT–V Database Maintenance

Database Maintenance, Performance Management, Configuring recoverability, Backing Up the Control File to a Trace File, Performing Database Recovery: Opening a Database, Keeping a Database Open, Data Recovery Advisor, Loss of Control file/Redo Log file/data file /noncritical data file system, critical data file, Data failure examples, Data recovery advisor, Recovery.

Text books

1. Elmasri, R. and Navathe, S.B., Fundamentals of Database Systems, 7th ed, Pearson, 2016.
2. Freeman, Robert G., and Arup Nanda. Oracle Database 11g: New Features. 1st ed. McGraw-Hill/Oracle Press, 2008.

Reference Books

1. Lightstone, Sam S., Toby J. Teorey, and Tom Nadeau. Physical Database Design: the database professional's guide to exploiting indexes, views, storage, and more. Morgan Kaufmann, 2010.
2. Sciore, Edward. Database design and implementation. John Wiley & Sons, 2009.
3. Bernstein, Hadzilacos, Goodman "Concurrency Control and Recovery in Database Systems", 11th ed. Addison- Wesley, 1987.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design and develop an efficient Database Architecture.
CO2	Maintain and manage user accounts in the Database.
CO3	Administering the User Security.
CO4	Explore SQL and Oracle databases to develop a real-time application.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS640	Database Tuning and Administration	CO1	Design and develop an efficient Database Architecture.	2	1	2
		CO2	Maintain and manage user accounts in the Database.	2	1	1
		CO3	Administering the User Security.	2	1	1
		CO4	Explore SQL and Oracle databases to develop a real-time application.	3	2	3

Course Code	**:**	**CS641**
Course Title	**:**	**Big Data Analytics and Mining**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand big data and data analytics lifecycle
CLO2	To specialize in data streaming and visualization using R
CLO3	To get a knowledge on advanced analytical methods, technology and tools
CLO4	To learn time-series analysis and text analytics techniques
CLO5	To learn Hadoop ecosystem and NoSQL databases

Course Content

UNIT-I Big data overiew

State of the practice in Analytics-Key roles for new big data ecosystem, Big Data Architecture – Big data characteristics –Volume – Veracity – Velocity- Data Analytics Lifecycle overview- Discovery- Data Preparation-Model Planning-Model Building-Communicate Results- operationalize.

UNIT-II Introduction to Stream Computing

Introduction to Streams- Concepts – Stream data model and architecture Stream Computing, Sampling data in a stream – Filtering streams – Counting distinct elements in a stream – Estimating moments – Counting oneness in a window – Decaying window - Exploratory Data Analytics and Visualization Using R-Programming.

UNIT-III Clustering and Association Rule Mining

Overview of Clustering-K-means - Decision Trees-Naïve Bayes-Diagnostics of Classifiers-Additional classification methods- Association Rules-Overview-Apriori Algorithm-Evaluation of candidate rules-An Example: Transactions in grocery Store-Validation and Testing-Diagnostics, Regression-Linear Regression—Multiple Regression, Logistic Regression Models

UNIT-IV Time Series Analysis and Text Analysis

Time series Analysis- Overview of Time series analysis- Moving Averages, Exponential smoothing, Auto Regression, ARIMA Model-RNN and LSTM. Text Analysis-Text analysis steps-A text analysis Example-Collecting raw Text-Representing Text-Term Frequency—Inverse document frequency (TF-IDF)-Glove-Categorizing documents by Topics-Determining Sentiments-Gaining insights

UNIT-V Hadoop Ecosystem

The Hadoop Ecosystem - Design of HDFS – HDFS Concepts-HBase – data model and implementations – HBase clients – HBase examples – Hive – data types and file formats – HiveQL data definition – HiveQL

data manipulation – HiveQL queries - APACHE Spark – Components of Spark- Resilient Distributed Datasets -Data Sharing using RDD.

Text Books:

1. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley publishers, 2015.
2. Simon Walkowiak, "Big Data Analytics with R" PackT Publishers, 2016.

Reference Books

1. Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2015.
2. Jure Leskovec, Anand Rajaraman, Jeff Ullman, "Mining of Massive Datasets", 3rd edition, Cambridge University Press, 2020.
3. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, Second Edition, Dec 2014.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the big data concepts
CO2	Utilize and apply the Analytical methods, Technology and tools in the industry
CO3	Explore and apply data streaming techniques
CO4	Understand the principles and concepts of unstructured data
CO5	Understand Hadoop ecosystem and apply to solve real-life problems

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS641	Big Data Analytics and Mining	CO1	Understand the big data concepts	3	1	2
		CO2	Utilize and apply the Analytical methods, Technology and tools in the industry	3	1	3
		CO3	Explore and apply data streaming techniques	2	1	1
		CO4	Understand the principles and concepts of unstructured data and Understand Hadoop ecosystem and apply to solve real-life problems	2	2	2

Course Code	**:**	**CS642**
Course Title	**:**	**Models of Computation**
Course Type	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Objectives

CO1	To understand computation and computability concepts
CO2	To study different approaches to facilitate computing
CO3	To learn the abstractions of computation and their implementations
CO4	To learn the fundamental aspects of Quantum Computing
CO5	To study various algorithms in Nature Inspired Computing

Course Content

UNIT I Turing Machine Models

Turing Machines, Logic, Proofs, Computability, Halting Problem, Undecidability, Introduction to recursive function theory.

UNIT II Quantum Computation

Quantum Computing History, Postulates of Quantum Theory, Dirac Notation, the Quantum Circuit Model, Simple Quantum Pro Teleportation, Superdense Coding, Foundation Algorithms

UNIT III Nature Inspired Computing

Nature-Inspired Computing Optimization and Decision Support Techniques, Evolutionary Algorithms, Swarm Intelligence Benchmarks and Testing

UNIT IV Machine Learning Models

Supervised Learning: Learning a Class, Vapnik-Chervonenkis Dimension, Probably Approximately Correct Learning, Regression, Model Selection and Generalization, Multilayer Perceptrons, Kernel Machines, Markov Models and Hidden Markov Models

UNIT V Evolutionary Computing

Evolutionary Computing Introduction to Genetic Algorithms, Genetic Operators and Parameters, Genetic Algorithms in P Solving, Theoretical Foundations of Genetic Algorithms, Implementation Issues.

Text books

1. Alpaydin, E., Machine learning, 4th ed., MIT Press, 2021.
2. Michael A. Nielsen & Isaac L. Chuang, “Quantum Computation and Quantum Information”, 10th, Cambridge University 2010.

Reference Books

1. John E. Savage, “Models of Computation - Exploring the Power of Computing”, Addison-Wesley, 2008.

2. Margaret M. Fleck, “Building Blocks for Theoretical Computer Science”, University of Illinois, Urbana-Champaign, 2013.

3. G.Rozenberg, T.Back, J.Kok, Editors, “Handbook of Natural Computing”, Springer Verlag, 2012.

4. Tom Mitchell, Machine Learning, McGraw Hill, 1997.

5. Hopcroft, J.E Motwani, R. and Ullman, J.D.Introduction to automata theory, languages, and computation. 2nd ed. Addison-Wesley Longman, 2014.

6. M. Mitchell, “An Introduction to Genetic Algorithms”, Prentice-Hall, 1996.

7. Sastry, K., Goldberg, D. and Kendall, G. Genetic algorithms. Search methodologies: Introductory tutorials in optimization and decision support techniques, 2005.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the terminology of the theory of computing.
CO2	Predict the major results in computability and complexity theory.
CO3	Prepare the major models of computation.
CO4	Understand and explore Machine Learning based computation model.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS642	Models of Computation	CO1	Identify the terminology of the theory of computing	0	1	2
		CO2	Predict the major results in computability and complexity theory.	0	2	2
		CO3	Prepare the major models of computations	2	1	2
		CO4	Understand and Explore Machine Learning Based Computation Model	2	2	3

Course Code	:	**CS643**
Course Title	:	**Cognitive Science**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To know concepts, approaches and issues in the field of cognitive science.
CLO2	To understand questions raised in the disciplines of computer science, linguistics, philosophy and psychology and focus on the interaction of these disciplines in approaching the study of the mind.
CLO3	To make specialization on topics central to cognitive science such as the nature of mental representation, reasoning, perception, language use.
CLO4	To learn other cognitive processes of humans and other intelligent systems.

Course Content:

UNIT - I Introduction

Introduction to the study of cognitive sciences. A brief history of cognitive science. Methodological concerns in philosophy, artificial intelligence and psychology. Structure and constituents of the brain; Brief history of neuroscience; Mathematical models; Looking at brain signals; Processing of sensory information in the brain.

UNIT - II Neural Network Models

Neural Network Models; Processing of sensory information in the brain; motor and sensory areas; Brain Imaging, fMRI, MEG, PET, EEG; Multisensory integration in cortex; information fusion; from sensation to cognition, cybernetics; From physics to meaning; Analog vs. Digital: Code duality.

UNIT - III Linguistic Knowledge

What is language?; Linguistic knowledge: Syntax, semantics, (and pragmatics); Generative linguistics; Brain and language; Language disorders; Lateralization; The great past tense debate; Cognitivist and emergent standpoints ; A robotic perspective.

UNIT - IV Affordance, Perception and Attention

Affordances, direct perception, Ecological Psychology, affordance learning in robotics; Development, child and robotic development; Attention and related concepts; Human visual attention; Computational models of attention; Applications of computational models of attention.

UNIT - V Learning, Memory and Cognition

Categories and concepts; Concept learning; Logic; Machine learning; Constructing memories; Explicit vs. implicit memory; Information processing (three-boxes) model of memory; Sensory memory; Short term

memory; Long term memory; Rationality; Bounded rationality; Prospect theory; Heuristics and biases; Reasoning in computers; Key points in social cognition; Context and social judgment; Schemas; Social signals.

Text Books:

1. Jay Freidenberg and Gordon Silverman, Cognitive Science: An Introduction to the Study of Mind, SAGE, 2016.

2. José Luis Bermúdez, Cognitive Science: An Introduction to the Science of the Mind, Cambridge University Press, Second Edition, 2014.

Reference Books:

1. Robert Wilson and Frank Keil (editors). The MIT Encyclopedia of the Cognitive Sciences . MIT Press, 1999 .

2. Dana S. Dunn (Editor), Positive Psychology: Established and Emerging Issues (Frontiers of Social Psychology), Frontiers of Social Psychology, 2017.

3. Shettleworth, S.J. (2010). Cognition, Evolution, and Behavior. Oxford: OUP.

4. Benjafield, J. G., Smilek, D., & Kingstone, A. (2010). Cognition, 4th edition. New York: Oxford University Press.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Know basics of Cognitive Science, Psychology, Nervous system and Brain.
CO2	Understand major tools and theories from experimental psychology, computer modeling and artificial intelligence, neuroscience, philosophy, linguistics, anthropology, etc. and how they relate to the study of the mind.
CO3	Understand Brain and sensory motor information, representation of sensory information and how human mind works.
CO4	Understand the basic cognitive architecture how perception, memory, language, motor control, and so forth come together to produce behavior and implement in artificial systems.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS643	**Cognitive Science**	**CO1**	Know basics of Cognitive Science, Psychology, Nervous system and Brain.	3	1	2

		CO2	Understand major tools and theories from experimental psychology, computer modeling and artificial intelligence, neuroscience, philosophy, linguistics, anthropology, etc. and how they relate to the study of the mind.	2	2	3
		CO3	Understand Brain and sensory motor information, representation of sensory information and how human mind works.	2	2	3
		CO4	Understand the basic cognitive architecture how perception, memory, language, motor control, and so forth come together to produce behavior and implement in artificial systems.	2	3	3

Course Code	**:**	**CS644**
Course Title	**:**	**Information Visualization**
Course Type	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To introduce visual perception and core skills for visual analysis
CLO2	To understand visualization for time-series analysis
CLO3	To understand visualization for ranking analysis AND deviation analysis
CLO4	To understand visualization for distribution analysis, correlation analysis and multivariate analysis
CLO5	To understand issues and best practices in information dashboard design.

Course Content

UNIT I Introduction

Information visualization – effective data analysis – traits of meaningful data – visual perception – making abstract data visible – building blocks of information visualization – analytical interaction – analytical navigation – optimal quantitative scales – reference lines and regions – trellises and crosstabs – multiple concurrent views – focus and context – details on demand – over-plotting reduction – analytical patterns – pattern examples.

UNIT II Time Analysis and Ranking Pattern

Time-series analysis – time-series patterns – time-series displays – time-series best practices – part-to-whole and ranking patterns – part-to-whole and ranking displays – best practices – deviation analysis – deviation analysis displays – deviation analysis best practices.

UNIT III Distribution and Correlation Analysis

Distribution analysis – describing distributions – distribution patterns – distribution displays – distribution analysis best practices – correlation analysis – describing correlations – correlation patterns – correlation displays – correlation analysis techniques and best practices – multivariate analysis – multivariate patterns – multivariate displays – multivariate analysis techniques and best practices.

UNIT IV Introduction to Dashboard

Information dashboard – categorizing dashboards – typical dashboard data – dashboard design issues and best practices – visual perception – limits of short-term memory – visually encoding data – Gestalt principles – principles of visual perception for dashboard design.

UNIT V Analysis and Designing of Dashboard

Characteristics of dashboards – key goals in the visual design process – dashboard display media – designing

dashboards for usability – meaningful organization – maintaining consistency – aesthetics of dashboards – testing for usability – case studies: sales dashboard, CIO dashboard, Telesales dashboard, marketing analysis dashboard.

Text Books

1.Sosulski, Kristen. Data visualization made simple: insights into becoming visual. Routledge, 2018.

2.Stephen Few, "Now you see it: Simple Visualization techniques for quantitative analysis", Analytics Press,2009.

Reference Books

1.Stephen Few, "Information dashboard design: The effective visual communication of data", O'Reilly, 2006.

2.Edward R. Tufte, "The visual display of quantitative information", Second Edition, Graphics Press, 2001.

3.Nathan Yau, "Data Points: Visualization that means something", Wiley, 2013.

4.Ben Fry, "Visualizing data: Exploring and explaining data with the processing environment", O'Reilly,2008.

5.Gert H. N. Laursen and Jesper Thorlund, "Business Analytics for Managers: Taking business intelligence beyond reporting", Wiley, 2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the principles of visual perception
CO2	Understand time-series analysis and ranking displays
CO3	Apply core skills for visual analysis and visualization techniques for various data analysis tasks
CO4	Design information dashboard

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS644	**Information Visualization**	**CO1**	Understand the principles of visual perception	3	0	2
		CO2	Understand time-series analysis and ranking displays	2	0	3
		CO3	Apply core skills for visual analysis and visualization techniques for various data analysis tasks	3	1	2
		CO4	Design information dashboard	3	1	1

Course Code	**:**	**CS645**
Course Title	**:**	**Knowledge Management**
Course Type	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To give an overview of Knowledge management, its evolution, and its challenges.
CLO2	To acquire knowledge about building the learning organization and how knowledge markets aremanaged.
CLO3	To know the use of Knowledge management tools.
CLO4	To learn in-depth details about various knowledge management applications.
CLO5	To expose the future trends and challenges in knowledge management.

Course Content

Unit I Introduction

An Introduction to Knowledge Management - The foundations of knowledge management- including cultural issues- technology applications organizational concepts and processes- management aspects- and decisionsupport systems. The Evolution of Knowledge Management**:** From Information Management to Knowledge Management - Key Challenges Facing the Evolution of Knowledge Management - Ethics for Knowledge Management

Unit II Organization and Knowledge Management

Organization and Knowledge Management - Building the Learning Organization. Knowledge Markets: Cooperation among Distributed Technical Specialists – Tacit Knowledge and Quality Assurance.

Unit III Telecommunications and Networks In Knowledge Management

Telecommunications and Networks in Knowledge Management - Internet Search Engines and Knowledge Management - Information Technology in Support of Knowledge Management -Knowledge Management and Vocabulary Control - Information Mapping in Information Retrieval -Information Coding in the Internet Environment - Repackaging Information.

Unit IV Components of a Knowledge Strategy

Components of a Knowledge Strategy - Case Studies (From Library to Knowledge Center, Knowledge Management in the Health Sciences, Knowledge Management in Developing Countries).

Unit V Advanced Topics and Case Studies in Knowledge Management

Advanced topics and case studies in knowledge management - Development of a knowledge management map/plan that is integrated with an organization's strategic and business plan - A case study on Corporate Memories for supporting various aspects in the process life -cycles of an organization.

Text Books

1.Dalkir, Kimiz. Knowledge management in theory and practice. Fourth Edition, MIT Press, 2023

2.Srikantaiah.T. K., Koenig, M., "Knowledge Management for the Information Professional ", First Edition, InformationToday, Inc., 2000.

Reference Books

1.Nonaka, I., Takeuchi, H., "The Knowledge-Creating Company: How Japanese Companies Create theDynamics of Innovation", Oxford University Press, 1995

2.Donald Hislop," Knowledge Management in Organizations -A critical introduction", Fourth Edition, OxfordUniversity Press, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the fundamental concepts in knowledge management and its importance of knowledge sharing.
CO2	Use the knowledge management tools for various applications.
CO3	Develop knowledge management applications.
CO4	Design and develop enterprise knowledge management applications

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS645	**Knowledge Management**	**CO1**	Understand the fundamental concepts in knowledge management and its importance of knowledge sharing.	3	0	1
		CO2	Use the knowledge management tools for various applications.	3	1	2
		CO3	Develop knowledge management applications.	3	2	2
		CO4	Design and develop enterprise knowledge management applications	3	2	2

Course Code		**:**	**CS646**
Course Title		**:**	**Text Mining**
Course Type		**:**	**PE**
Number of Credits		**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	Describe text extraction techniques.
CLO2	Differentiate various clustering techniques on text.
CLO3	Distinguish various classification techniques on text.
CLO4	Analyze visualization methodologies.
CLO5	Illustrate about Feature extraction and Semantic embedding.

Course Content

Unit-I: Text Extraction

Text Extraction: Introduction, Rapid automatic keyword extraction: candidate keywords, keyword scores, adjoining keywords, extracted keywords, Benchmark evaluation: precision and recall, efficiency, stoplist generation, Evaluation on new articles.

Unit-II Clustering

Clustering: Multilingual document clustering: Multilingual LSA, Tucker1 method, PARAFAC2 method, LSA with term alignments, LMSA, LMSA with term alignments

Unit-III: Classification

Classification: Content-based spam email classification using machine-learning algorithms, Utilizing nonnegative matrix factorization for email classification problems, Constrained clustering with k-means type algorithms.

Unit-IV Anomaly and trend detection

Anomaly and trend detection: Text Visualization techniques such as tag clouds, authorship and change tracking, Data Exploration and the search for noval patterns, sentiment tracking, visual analytics and FutureLens, scenario discovery, adaptive threshold settting for novelty mining.

Unit-V: Text streams

Text streams: Introduction, Text streams, Feature extraction and data reduction, Event detection, Trend detection, Event and trend descriptions, Embedding semantics in LDA topic models: Introduction, vector space modeling, latent semantic analysis, probabilistic latent semantic analysis, Latent Dirichlet allocation, embedding external semantics from Wikipedia, data-driven semantic embedding.

Text Books

1.Michael W. Berry & Jacob Kogan ,"Text Mining Applications and Theory", Wiley publications, 2010.

2.Aggarwal, Charu C., and ChengXiang Zhai, eds. Mining text data. Springer Science & Business Media, 2012.

Reference Books

1.Miner, Gary, et al. Practical text mining and statistical analysis for non-structured text data applications. Academic Press, 2012.

2.Srivastava, Ashok N., and Mehran Sahami. Text mining: Classification, clustering, and applications. Chapman and Hall/CRC, 2009.

3.Buitelaar, Paul, Philipp Cimiano, and Bernardo Magnini, eds. Ontology learning from text: methods, evaluation and applications. Vol. 123. IOS press, 2005.

4.Jiawei Han, Micheline Kamber and Jian Pei, “Data Mining Concepts and Techniques”, Third Edition, Elsevier, 2011.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design clustering techniques for text.
CO2	Design classification techniques for text
CO3	Practice visualization methodologies using tools .
CO4	Practice feature extraction using tools.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	Course outcomes - at the end of the course students will be able to	PO1	PO2	PO3
CS646	**Text Mining**	**CO1**	Design clustering techniques for text.	1	3	3
		CO2	Design classification techniques for text	1	3	3
		CO3	Practice visualization methodologies using tools.	3	1	2
		CO4	Practice feature extraction using tools.	3	1	2

Course Code	:	**CS647**
Course Title	**:**	**Digital and Cyber Forensics**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CO1	To understand the basic digital forensics and techniques for conducting the forensic examination on different digital devices.
CO2	To understand how to examine digital evidences such as the data acquisition, identification analysis.
CO3	To understand the basics of mobile phone forensics.
CO4	To understand the network based cyber security intrusion detection.
CO5	To know the various forensics tool.

Course Content:

UNIT- I Introduction

Overview of Digital Forensics, preparing for digital investigations, maintaining professional conduct, preparing a digital forensics investigation, procedures for private-sector high-tech investigations, understanding data recovery workstations and software, conducting an investigation.

UNIT-II Data Acquisition

Data acquisition - understanding storage formats for digital evidence, determining the best acquisition method, using acquisition tools, validating data acquisitions, performing RAID data acquisitions, using remote network acquisition tools, using other forensics acquisitions tools.

UNIT-III Network Forensics

Evidence acquisition, packet analysis, Wireless: Network Forensics Unplugged, Network Intrusion Detection and Analysis, Reconstructing web browsing, email activity, and windows registry changes, intrusion detection, tracking offenders. E-mail and social media investigations- investigating E-mail crime and violations, understanding E-mail servers, specialized E-mail forensics tool, application to social media.

UNIT-IV Mobile Device and Cloud Forensic

Mobile device forensics - understanding mobile device forensics, understanding acquisition procedures for mobile devices, Cloud forensics - An overview of cloud computing, legal challenges, technical challenges, acquisitions in the cloud, conducting a cloud investigation, tools for cloud forensics

UNIT-V Processing Crime

Identifying digital evidence, collecting evidence in private-sector, processing law enforcement crime scene, preparing for search, securing computer incident, seizing digital evidence, storing digital evidence, obtaining digital hash, reviewing case, Current computer forensics tools – software and hardware tools, validating and testing forensic software

Text Books:

1. Bill Nelson, Amelia Phillips, Chris Steuart, "*Guide to Computer Forensics and Investigations: Processing Digital Evidence*", Cengage Learning, 5th edition, 2016.

2. Sherri Davidoff, Jonathan Ham, "*Network Forensics: Tracking Hackers Through Cyberspace*", Prentice Hall, 2012.

Reference Books:

1. Garrison, Clint P., "*Digital Forensics for Network, Internet, and Cloud Computing: A Forensics Evidence Guide for Moving Targets and Data*", Syngress, 2010.

2. Iosif I. Androulidakis, "*Mobile phone security and forensics: A practical approach*", Springer publications, 2012.

3. Vacca, J, "*Computer Forensics, Computer Crime Scene Investigation*", Charles River Media, 2nd Edition, 2005

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Know how to apply forensic analysis tools to recover important evidence for identifying computer crime.
CO2	Comprehend and use data acquisition methods and tools from various storage formats.
CO3	Perform network forensic analysis and email investigation.
CO4	Use correct tool for the particular case and Train as next-generation computer crime investigators.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS647	**Digital and Cyber Forensics**	**CO1**	Know how to apply forensic analysis tools to recover important evidence for identifying computer crime.	2	2	2

		CO2	Comprehend and use data acquisition methods and tools from various storage formats.	2	2	3
		CO3	Perform network forensic analysis and email investigation.	3	2	3
		CO4	Use correct tool for the particular case and train as next-generation computer crime investigators.	3	2	3

Course Code		**CS648**
Course Title		**Multimedia Presentation and Coding Techniques**
Course Type		**PE**
Number of Credits		**3-0-0-3**

Course Learning Objectives

CLO1	To Understand how Text, Audio, Image and Video information can be represented digitally in computer.
CLO2	To Learn the basic audio coding techniques.
CLO3	To Understand the bi-level Image lossless coding techniques, grayscale and colour image coding techniques.
CLO4	To Understand lossy Image, video Coding techniques

Course Content

UNIT -I Multimedia Representation

Multimedia Representation - Text, Audio, Image and Video Representation - -Human Vision and Audio Systems and their Limitations - Sampling, Quantization, Coding, Companding. Multimedia Communication Systems – Database Systems – Synchronization issues – Presentation requirements – Applications – Video conferencing – Virtual reality – Interactive Video – Media on Demand.

UNIT- II Coding Techniques

Basic Coding Techniques-Introduction to Data Compression - Information Theory -Statistical Coding - Dictionary Based Coding – Audio Coding.

UNIT-III Lossless Image Coding

Lossless Image Coding-Bi-Level -Reflected Gray Codes - Predictive Coding –GIF-Lossless JPEG

UNIT- IV Lossy Image Coding

Lossy Image Coding-Distortion Measures -Transform Coding -JPEG -Wavelet Coding -Sub-Band Coding - JPEG2000 - Progressive Image Coding.

UNIT- V Video Coding

Video Coding (Lossy)-Video Coding Concepts - The Hybrid DPCM/DCT Algorithm-Motion Compensated Prediction- Motion Estimation-Standards: H.261, MPEG-1,2,4,7.

Text Books

1. Ze-Nian Li & Mark Drew, “Fundamentals of Multimedia”, Second Edition, springer,2014.

2. Yun Q. Shi, Huifang Sun, “Image and Video Compression for Multimedia Engineering: Fundamentals,

Algorithms, and Standards", CRC Press, Second edition, 2008

Reference Books

1. B.Prabhakaran, "Multimedia Database Management Systems", Springer International Edition,2007.
2. Tay Vaughan, "Multimedia: Making it Work", McGraw Hill Publication, Eighth Edition, 2010.

Course Outcomes

At the end of the course, the student will be able to

CO1	Study representation of different multimedia formats.
CO2	Study the fundamentals of multimedia compression.
CO3	Develop new algorithms for Lossless Image Coding.
CO4	Explore the viability to introduce algorithms for multimedia Lossy Image Coding and develop novel techniques for Multimedia Video Compression.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS648	**Multimedia Presentation And Coding Techniques**	CO1	Study representation of different multimedia formats.	2	2	2
		CO2	Study the fundamentals of multimedia compression.	2	1	0
		CO3	Develop new algorithms for Lossless Image Coding.	2	0	2
		CO4	Explore the viability to introduce algorithms for multimedia Lossy Image Coding and develop novel techniques for Multimedia Video Compression.	2	2	2

Course Code	:	**CS649**
Course Title	:	**Principles of Data warehousing and Data Mining**
Number of Credits	:	**3-0-0-3**
Prerequisites (Course code)	:	**__**
Course Type	:	**PE**

Course Learning Objectives

CLO 1	Understand the principles of Data warehousing and Data Mining.
CLO 2	Comprehend the Data warehouse and Data Mining system architectures.
CLO 3	Understand the various Data Pre-processing Methods.
CLO 4	Compare various classification and clustering techniques
CLO 5	Know about various advanced mining techniques.

Course Content

UNIT-I Data Warehousing

Data Warehousing and Business Analysis: - Data Warehousing Components –Building a Data warehouse –Data Warehouse Architecture – DBMS Schemas for Decision Support – Data Extraction, Cleanup, and Transformation Tools –Metadata – reporting – Query tools and Applications – Online Analytical Processing (OLAP) – OLAP and Multidimensional Data Analysis.

UNIT-II Data Mining

Data Mining Functionalities – Data Pre-processing – Data Cleaning – Data Integration and Transformation – Data Reduction – Data Discretization and Concept Hierarchy Generation- Architecture Of A Typical Data Mining Systems- Classification Of Data Mining Systems. Association Rule Mining: - Efficient and Scalable Frequent Item set Mining Methods – Mining Various Kinds of Association Rules – Association Mining to Correlation Analysis – Constraint-Based Association Mining.

UNIT-III Classification and Prediction

Issues Regarding Classification and Prediction – Classification by Decision Tree Introduction – Bayesian Classification – Rule Based Classification – Classification by Back propagation – Support Vector Machines – Associative Classification – Lazy Learners – Other Classification Methods – Prediction – Accuracy and Error Measures – Evaluating the Accuracy of a Classifier or Predictor – Ensemble Methods – Model Section.

UNIT-IV Cluster Analysis

Types of Data in Cluster Analysis – Categorization of Major Clustering Methods – Partitioning Methods

– Hierarchical methods – Density-Based Methods – Grid-Based Methods – Model Based Clustering Methods – Clustering High-Dimensional Data – Constraint-Based Cluster Analysis – Outlier Analysis.

UNIT-V Advanced Mining Techniques

Mining Object, Spatial, Multimedia, Text and Web Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects – Spatial Data Mining – Multimedia Data Mining – Text Mining – Mining the World Wide Web Introduction to big data, big data analytics, NoSQL systems, Hadoop, PIG and HIVE.

Text Books

1.Jiawei Han, Micheline Kamber and Jian Pei, "Data Mining Concepts and Techniques",Third Edition, Elsevier, 2011.

2.Edward Capriolo, Dean Wampler, Jason Rutherglen "Programming Hive: Data Warehouse and Query Language for Hadoop" 1st Edition, O'reilly, 2012.

Reference Books

1. Pramod J. Sadalage, Martin Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", first edition, Addison-Wesley Professional, 2012.

2. Alex Berson and Stephen J. Smith "Data Warehousing, Data Mining & OLAP", Tata McGraw Hill Edition, Tenth Reprint 2007.

3. .P. Soman, Shyam Diwakar and V. Ajay "Insight into Data Mining Theory and Practice", Easter Economy Edition, Prentice Hall of India, 2006.

4. K. Gupta "Introduction to Data Mining with Case Studies", Easter Economy Edition, Prentice Hall Of India, 2006.

5. Jure Leskovec, Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Third Edition, Cambridge University Press, 2020.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Technical knowhow of the Data Mining principles and techniques for real time applications.
CO2	Build the Data warehouse and Mining architectures for real time applications.
CO3	Apply the knowledge of data classification to classify any real time data.
CO4	Select and apply proper clustering techniques to build analytical applications and Discover the knowledge from the high dimensional mining systems.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	Course outcomes - at the end of the course students will be able to	PO1	PO2	PO3
CS649	Principles of Data warehousing and Data Mining	CO1	Technical knowhow of the Data Mining principles and techniques for real time applications.	1	3	2
		CO2	Build the Data warehouse and Mining architectures for real time applications.	1	2	2
		CO3	Apply the knowledge of data classification to classify any real time data.	1	3	1
		CO4	Select and apply proper clustering techniques to build analytical applications and discover the knowledge from the high dimensional mining systems.	1	2	3

Course Code	**:**	**CS650**
Course Title	**:**	**Hardware Security**
Course Type	**:**	**PE**
Number of Credits	**:**	**3-0-0-3**

Course Learning Objectives(CLO)

CLO1	To understand the different issues in hardware security
CLO2	Learn about the possible attacks on the cyber-physical systems in detail.
CLO3	To introduce the side-channel attacks and countermeasures to avoid it.
CLO4	To study on the detection and prevention of Hardware Trojans.
CLO5	To know the impact of Hardware Security Compromise on Public Infrastructure

Course Content

UNIT – I Preliminaries

Algebra of Finite Fields, Basics of the Mathematical Theory of Public Key Cryptography, Basics of Digital Design on Field-programmable Gate Array (FPGA), Classification using Support Vector Machines (SVMs). Useful Hardware Security Primitives: Cryptographic Hardware and their Implementation, Optimization of Cryptographic Hardware on FPGA, Physically Unclonable Functions (PUFs), PUF Implementations, PUF Quality Evaluation, Design Techniques to Increase PUF Response Quality.

UNIT- II Side-channel Attacks on Cryptographic Hardware

Basic Idea, Current-measurement based Side-channel Attacks (Case Study: Kochers Attack on DES), Design Techniques to Prevent Side-channel Attacks, Improved Side-channel Attack Algorithms (Template Attack, etc.), Cache Attacks

UNIT – III Testability and Verification of Cryptographic Hardware

Fault-tolerance of Cryptographic Hardware, Fault Attacks, Verification of Finite-field Arithmetic Circuits. Modern IC Design and Manufacturing Practices and Their Implications: Hardware Intellectual Property (IP) Piracy and IC Piracy, Design Techniques to Prevent IP and IC Piracy, Using PUFs to prevent Hardware Piracy, Model Building Attacks on PUFs (Case Study: SVM Modeling of Arbiter PUFs, Genetic Programming based Modeling of Ring Oscillator PUF)

UNIT – IV Hardware Trojans and Their Detection

Hardware Trojan Nomenclature and Operating Modes, Countermeasures Such as Design and Manufacturing Techniques to Prevent/Detect Hardware Trojans, Logic Testing and Side-channel Analysis based Techniques for Trojan Detection, Techniques to Increase Testing Sensitivity.

UNIT – V Infrastructure Security

Impact of Hardware Security Compromise on Public Infrastructure, Defense Techniques (Case Study: Smart- Grid Security).

Text Books

1. DebdeepMukhopadhyay and RajatSubhra Chakraborty: Hardware Security: Design, Threats and Safeguards, CRC Press, 2014

2. Tehranipoor, Mark, N. Nalla Anandakumar, and Farimah Farahmandi: Hardware Security Training, Hands-on, 2023.

Reference Books

1. Ted Huffmire et al: Handbook of FPGA Design Security, Springer,2010.

2. Mangard, Elisabeth Oswald, Thomas Popp: Power analysis attacks - revealing the secrets of smart cards, Springer, 2010.

3. Mark Joye and Michael Tunstall: Fault Analysis in Cryptography, Springer, 2012.

4. Abijit Das and C. E. VeniMadhavan: Public-Key Cryptography: Theory and Practice, Pearson Education Asia, 2009.

Course Outcomes:

At the end of the course student will be able to

CO1	Develop algorithms to eliminate side-channel attacks.
CO2	Design new techniques that will increase PUF response quality.
CO3	Become aware of various standards in the Information Security System.
CO4	Illustrate the legal, ethical, and professional issues in information security.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO-PO	At the end of the course students will be able	PO1	PO2	PO3
CS650	**Hardware Security**	CO1	Develop algorithms to eliminate side-channel attacks.	3	1	1
		CO2	Design new techniques that will increase PUF response quality.	2	1	1
		CO3	Become aware of various standards in the Information Security System.	3	1	3
		CO4	Illustrate the legal, ethical, and professional issues in information security.	3	1	1

Course Code	:	**CS651**
Course Title	:	**Advanced Digital Design**
Course Type	:	**PE**
Number of Credits	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the basic building blocks, logic gates, adders, multipliers, shifters and other digital devices
CLO2	To apply logic minimization techniques, including Karnaugh Maps
CLO3	To learn techniques and tools for programmable logic design
CLO4	To be able to create custom hardware in the FPGA fabric
CLO5	To develop software to control the custom hardware

Course Content

UNIT-I Combinational and Sequential logic design

Review of Combinational and Sequential logic design – Structural models of combinational logic- Propagation delay – Behavioral Modeling – Boolean equation based behavioral models of combinational logic – Cyclic behavioral model of flip-flop and latches – A comparison of styles for behavioral modeling – Design documentation with functions and tasks

UNIT-II Synthesis of Combinational and Sequential logic

Synthesis of Combinational and Sequential logic – Introduction to synthesis – Synthesis of combinational logic - Synthesis of sequential logic with latches – Synthesis of three-state devices and bus interfaces – Synthesis of sequential logic with flip-flops – Registered logic – State encoding – Synthesis of gated clocks and clock enables – Anticipating the results of synthesis – Resets – Synthesis of loops – Design traps to avoid – Divide and Conquer: partitioning a design.

UNIT-III Design and Synthesis of Datapath Controllers

Design and Synthesis of Datapath Controllers – Partitioned sequential machines– Design example: Binary counter – Design and synthesis of a RISC stored-program machine – Processor, ALU, Controller, Instruction Set, Controller Design and Program Execution – UART – Operation, Transmitter, Receiver.

UNIT-IV Programmable devices

Programmable logic devices – Storage devices – Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Programmability of PLDs – Complex PLDs – Introduction to Altera and Xilinx FPGAs – Algorithms – Nested loop programs and data flow graphs – Design Example of Pipelined Adder,

Pipelined FIR Filter – Circular buffers – FIFOs and Synchronization across clock domains – Functional units for addition, subtraction, multiplication and division – Multiplication of signed binary numbers and fractions.

UNIT-V Post Synthesis Design Validation

Post Synthesis Design Validation – Post Synthesis Timing Verification – Dynamically Sensitized Paths – System Tasks for Timing Verification –Hands-on exercises using Xilinx tools.

Text Book

1.Michael D. Ciletti, "Advanced Digital Design with the VERILOG HDL", Pearson Education, 2nd Edition, 2010.

2.Snider, Ross K., "Advanced Digital System Design using SoC FPGAs: An Integrated Hardware/Software Approach", Springer Nature, 1st edition, 2023.

Reference Books

1.Samir Palnitkar "Verilog HDL", Pearson Education,2nd Edition, 2003.

2.Stephen Brown, "Fundamentals of Digital Logic with Verilog", McGraw Hill Higher Education, 3rd edition, 2013.

Course Outcome

At the end of the course student will be able to

CO1	Understand the use standard digital memory devices as components in complex subsystems
CO2	Obtain technical knowhow to design simple combinational logic circuits and logic
CO3	Acquire skill set to develop the necessary software for basic digital systems
CO4	Create their own custom hardware in the FPGA fabric and then control their hardware by writing an application software.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course students will be able**	**PO1**	**PO2**	**PO3**
CS651	**Advanced Digital Design**	**CO1**	Understand the use standard digital memory devices as components in complex subsystems.	1	1	1

		CO2	Obtain technical knowhow to design simple combinational logic circuits and logic.	1	1	1
		CO3	Acquire skill set to develop the necessary software for basic digital systems.	2	2	3
		CO4	Create their own custom hardware in the FPGA fabric and then control their hardware by writing an application software.	2	2	2

Course Code	**:**	**CS652**
Course Title	**:**	**Real Time Systems**
Type of Course	**:**	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To study issues related to the design and analysis of systems with real-time constraints.
CLO2	To learn the features of Real time OS.
CLO3	To learn about computer control and hardware requirements for Real time systems.
CLO4	To study the methods of developing Real time applications and also
CLO5	To study the difference between different Real time system development methodologies.

Course Content:

UNIT-I Introduction to real–time computing

Elements of Control System – Structure of a real–time system – Classification of Real-time Systems, Time Constraints, Classification of Programs, Concepts of Computer Control: Introduction, Sequence Control, Loop Control, Supervisory Control, Centralized Computer Control, Hierarchical Systems.

UNIT-II Hardware Requirements for Real-Time Applications

Introduction – General Purpose Computer – Single Chip Microcomputers and Microcontrollers – Specialized Processors – Process-Related Interfaces – Data Transfer Techniques – Communications – Standard Interface.

UNIT-III Languages for Real-Time Applications

Introduction – Syntax Layout and Readability – Declaration and Initialization of Variables and Constants –Modularity and Variables – Compilation of Modular Programs – Data types – Control Structures – Exception Handling – Low-level facilities – Co–routines – Interrupts and Device Handling – Concurrency –Real-Time Support – Overview of Real-Time Languages.

UNIT-IV Real Time Operating Systems

Introduction – Real-Time Multi-Tasking OS – Scheduling Strategies – Priority Structures – Task Management –Scheduler and Real-Time Clock Interrupt Handler – Memory Management – Code Sharing – Resource Control– Task Co-Operation and Communication – Mutual Exclusion.

UNIT-V RTS Development Methodologies

Introduction – Yourdon Methodology – Ward and Mellor Method – Hately and Pirbhai Method.

Text Books:

1. Stuart Bennet, "Real–Time Computer Control", 2nd Edn., Pearson Education, 2009.

2. Rajib Mall, "Real–Time Systems: Theory and Practice", 1st edition, Pearson Education, 2016.

Reference Books:

1. Rob Williams ,"Real-Time Systems Development" , Butterworth-Heinemann Ltd,2005.
2. Qing Li and Caroline Yao ,"Real-Time Concepts for Embedded Systems" ,CRC Press ,1st Edition,2003.
3. Albert M. K. Cheng, "Real-time Systems: Scheduling, Analysis, and Verification", Wiley, 1st edition ,2010.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand classifications of Real time systems.
CO2	Knowledge of Hardware Requirements for Real Time systems.
CO3	Comprehend Real-time programming environments.
CO4	Schedule jobs in Real time systems and Develop real time systems.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS652	**Real Time Systems**	**CO1**	Understand classifications of Real time systems.	**3**	**2**	**2**
		CO2	Knowledge of Hardware Requirements for Real Time systems.	**2**	**2**	**3**
		CO3	Comprehend Real-time programming environments.	**3**	**2**	**2**
		CO4	Schedule jobs in Real time systems and Develop real time systems.	**2**	**2**	**3**

Course Code	:	**CS653**
Course Title	:	**Smart phone computing**
Course Type	:	**PE**
Number of Credits	:	**3-0-0-3**

Course Learning Objectives(CLO)

CO1	Recognize the different challenges in mobile computing
CO2	Estimate the measurement and management of energy for wireless devices
CO3	Categorize about the different interface design issues
CO4	Identify Gesture Recognition
CO5	Privacy and Security in mobile computing

Course Content

UNIT-I Introduction & Programming platforms:

Introduction: Challenges in mobile computing, convergence of sensing, computing, and communications, Introduction to smartphones, tablet, PDA, or other digital mobile devices, Introduction to smartphone system architecture.

Programming platforms: Overview of different mobile programming environments, Difference with the classical programming practices, Introduction to mobile operating systems, iOS, Android, Windows, Mobile application development.

UNIT-II Wireless Energy Management & Localization

Wireless Energy Management: Measurement of energy consumption, WiFi Power Save Mode (PSM), Constant Awake Mode (CAM), Different Sleep States, WiFi Energy management. **Localization:** User location and tracking system, Cell tower localization, Spot localization, Logical location, Ambience fingerprinting, War-driving, Localization without war-driving, Indoor localization, Crowd sourcing for localization.

UNIT-III Location Privacy & Context Sensing

Location Privacy: Different approaches, K-anonymity, Clique Cloak, Location Privacy, Applications with location proof.

Context Sensing: Context-Aware system, Automatic Image Tagging, Safety critical applications (case study: determining driver phone use), Energy-efficient Context Sensing, Contextual Ads and Mobile Apps. **Lab Component:** (if applicable)

UNIT-IV Activity and Gesture Recognition

Activity and Gesture Recognition: Machine Recognition of Human Activities, Mobile Phones to Write in Air, Personalized Gesture Recognition, Content Rating, Recognizing Human without Face Recognition, Phone-to- Phone Action Games, Interface design issues, Touchscreen, Gesture-based Input.

UNIT-V Mobility & Privacy and Security

Mobility: Overview of Mobility models, Automatic Transit Tracking, Mapping, Arrival Time Prediction, Augmenting Mobile 3G with Wi-Fi, Vehicular Wi-Fi Hotspots, Code Offload .

Privacy and Security: Authentication on Mobile Phones, Activity based Password, Finger Taps usage as Fingerprints **Miscellany:** Cloud-based services, Peer-to-peer applications, Delay-tolerance, Mobile social networking.

Text Books

1. Zheng, Pei, and Lionel Ni. Smart phone and next generation mobile computing, 1st ed. Elsevier, 2010.
2. Hansmann, LotharMerk, Martin Niclous, Stober, Principles of Mobile Computing, 2ed, 2006.

Reference Books

1. Tomasz Imielinski, Mobile Computing, Springer, 1996
2. Mayes, Keith E., and Konstantinos Markantonakis, eds. Smart cards, tokens, security and applications. Vol. New York: Springer, 2008.
3. Bolt, Richard A. “Put-that-there”: Voice and gesture at the graphics interface. Vol. 14. ACM,1980.
4. Kazmierski, Tom J., and Steve Beeby. Energy harvesting systems. New York: Springer, 2014.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Assess and improve services available for mobile social networking.
CO2	Design secure critical applications on mobile.
CO3	Develop an algorithm for Gesture Recognition
CO4	Develop an algorithm for Security in mobile computing

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS653	Smart phone computing	CO1	Assess and improve services available for mobile social networking.	1	2	2
		CO2	Design secure critical applications on mobile.	0	1	2
		CO3	Develop an algorithm for Gesture Recognition	1	1	3
		CO4	Develop an algorithm for Security in mobile computing	1	1	2

Course Code	:	**CS654**
Course Title	:	**Quantum-safe Cryptography**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To provide basic concepts of Lattice based Cryptography
CLO2	To explain the impact of quantum computers on modern cryptography
CLO3	To introduce quantum cryptographic tools and protocols, and their cryptanalysis
CLO4	To comprehend the notion of provable security and its implication with improved security guarantees
CLO5	To provide basic concepts of Lattice based Cryptography

Course Content:

UNIT I

Review of public key cryptography. Subset-sum problems and knapsack cryptosystems, Lattices: Basic definitions and properties, short vectors in lattices, Babai's algorithm, Cryptosystems based on hard lattice problems, The GGH public key cryptosystem

UNIT –II

Convolution polynomial rings, The NTRU public key cryptosystem, NTRU as a lattice cryptosystem. Lattice reduction algorithms, LLL algorithm. Applications of LLL to cryptanalysis.

UNIT III

Useful Lattice Problems: Learning with Errors (LWE), Short Integer Solution (SIS), Short Integer Solution (ISIS), Ring-LWE.

Public key cryptography from LWE, Public key cryptography from Ring-LWE, IND-CPA and IND-CCA security in lattice-based cryptography, Crystals – Kyber algorithm, Lattice based identity based cryptosystem.

Unit IV

Lattice based hash function, Lattice based digital signature, CRYSTALS-Dilithium, and FALCON, Lattice based commitment scheme, Lattice based Zero Knowledge Proof.

Unit V

Review of quantum computers, Quantum key distribution protocols: The BB84, E91. Quantum key agreement protocols, Quantum one time pad, Quantum public key encryption, Quantum oblivious transfer, Quantum money.

Text Books

1. Thomas Vidick, Stephanie Wehner, "Introduction to Quantum Cryptography", September 2023.
2. Jiang Zhang, Zhenfeng Zhang, "Lattice-Based Cryptosystems A Design Perspective" Springer, 2020.

Reference Books:

1. Lecture notes on Lattice-based Cryptography by Daniele Micciancio & Oded Regev .
2. Lecture notes by Chris Peikert on "A Decade of Lattice Cryptography".
3. NPTEL course on "Quantum Algorithms and Cryptography" by Prof. Shweta Agarwal, IIT Madras.
4. Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman, "An Introduction to Mathematical ryptography", Springer ,2008, ISBN: 978-0-387-77993-5.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the difference between conventional and Lattice based cryptography protocols.
CO2	Ability to break the Lattice based Cryptosystem that is not secure.
CO3	Derive simple provable security proofs for Lattice based schemes and quantum protocols.
CO4	Design and implement quantum cryptographic protocols and understand modern quantum cryptography – beyond quantum key distribution protocols

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS654	**Quantum-safe Cryptography**	**CO1**	Identify the difference between conventional and Lattice based cryptography protocols.	3	3	3
		CO2	Ability to break the Lattice based Cryptosystem that is not secure.	3	2	3
		CO3	Derive simple provable security proofs for Lattice based schemes and quantum protocols.	3	2	3
		CO4	Design and implement quantum cryptographic protocols and Understand modern quantum cryptography – beyond quantum key distribution protocols.	3	2	3

Course Code	:	**CS655**
Course Title	:	**Drone Technologies**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the basics of drone concepts
CLO2	To learn and understand the fundaments of design, fabrication and programming of drone
CLO3	To impart the knowledge of flying and operation of the drone
CLO4	To know about the various applications of drone
CLO5	To understand the safety risks and guidelines of flying

Course Content:

Unit I Introduction & Modelling

Introduction to Drones and Basic components – Aerodynamic and Flight dynamics – Drone Design - Calculations and Assumptions – Propulsion and Energy Management – Anti-vibration and Noise reduction in UAV – Multi Copter Flight Control Models.

Unit II Perception

Introduction to Autonomous Navigation – Sensor Perception on UAV – Artificial Intelligence and Machine Learning – Localization and Mapping.

Unit III Mission Decision–Making

Obstacle detection and Avoidance – Mission Planning and Path Planning – Wireless Communication on UAV – Multi UAV Systems.

Unit IV Drone Building Activities

Drone Building Activities: Configuring and Calibrating Drone Components – Thrust stands and Motor/Propeller performance testing – ROS.

Unit IV Regulations & Applications

Regulations & Applications: Safety risks - Guidelines to fly safely- specific aviation regulation and standardisation - Drone license. Design of drones for applications such as medical and agriculture.

Text Books:

1. Daniel Tal and John Altschuld, “Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation”, John Wiley & Sons, Inc., 2021.

2. Terry Kilby and Belinda Kilby, “Make: Getting Started with Drones “Maker Media, Inc, 2016.

Reference Books:

1. Zavrsnik, “Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance”, Springer, 2018.
2. Armand J. Chaput, “Design of Unmanned Air Vehicle Systems”, Lockheed Martin Aeronautics Company, 2001.
3. Reg Austin “Unmanned aircraft systems UAV design, development and deployment”, Wiley, 2010.
4. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

Course Outcomes (CO)

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

CO1	Comprehend Hardware components and software programming requirements of drones.
CO2	Know about a various type of drone technology
CO3	Select appropriate sensors and actuators for Drones
CO4	Use navigation and communication systems in UAVs.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS655	**Drone Technologies**	**CO1**	Comprehend Hardware components and software programming requirements of drones.	0	0	1
		CO2	Know about a various type of drone technology	2	1	1
		CO3	Select appropriate sensors and actuators for Drones	2	0	1
		CO4	Use navigation and communication systems in UAVs.	2	0	2

Course Code	**:**	**CS656**
Course Title	**:**	**Reinforcement learning**
Type of course	**:**	**PE**
Number of Credits	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To explore the various approaches to reinforcement learning
CLO2	To understand the policy and evaluation strategies of reinforcement learning approaches
CLO3	To learn about the Temporal difference and approximated learning approaches
CLO4	To introduce Deep Reinforcement learning approaches

Course Content

UNIT-I Introduction

Reinforcement learning – Elements of Reinforcement learning – limitations and scope – Example Tic-tac-toe – Tabular solution methods – multi-armed bandits – k-armed bandit problem – action-value methods – 10-armed testbed – incremental implementation – tracking a non-stationary problem – optimistic initial values – Upper-confidence bound action section – gradient bandit algorithm – associative search - finite markov decision processes – agent environment interface – goals and rewards – returns and episodes – unified notation for episodic and continuing tasks – policies and value functions – optimal policies and optimal value functions – optimality and approximation

Unit II – Dynamic Programming and Monte Carlo methods

Policy evaluation – improvement – iteration – value iteration – Asynchronous dynamic programming – generalized policy iteration – Efficiency of DP – Monte carlo prediction – monte carlo estimation of action values – monte carlo control – without exploring starts – off-policy monte carlo control – discounting aware importance sampling – per-decision importance sampling

Unit III – Temporal difference learning and Bootstrapping

TD prediction – Advantages – Optimality of TD Sarsa: On policy TD control – Q-learning off-policy TD control – Expected Sarsa – Maximization Bias and double learning – Games, Afterstates and Special cases – n-step TD prediction – n-step Sarsa – n-step Off-policy learning – per-decision methods with control variates – off-policy learning without importance sampling – n-step tree backup algorithm – A unifying algorithm – n-step Q(σ) – Planning and learning with tabular methods – models and planning – prioritized sweeping – trajectory sampling – planning at decision time - rollout algorithms – monte carlo tree search

Unit IV Approximate solution methods

On-policy prediction with approximation – value-function approximation – prediction objective – stochastic gradient, semi-gradient methods – linear methods – Feature construction – Nonlinear function approximation Least squares TD – Memory based function approximation – kernel based approximation – on-policy control – Episodic semi-gradient control – Semi-gradient n-step sarsa – differential semi-gradient n-step sarsa – off-policy methods – semi-gradient methods – examples – deadly triad – Bellman error – Gradient, Emphatic TD methods – Eligibility Traces – The λ return – TD (λ) – Online λ return algorithm – Sarsa (λ) – Variable λ and γ – Watkins Q(λ) and tree-backup (λ).

Unit V Policy Gradient and Deep Reinforcement learning

Reinforce – Monte carlo policy gradient – with baseline – actor-critic methods – Deep Q-Networks – Learning the Q-function – Action Selection – DQN algorithm – Double DQN algorithm

Text Books:

1. Richard S Sutton and Andrew G Barto, " Reinforcement learning –2nd Edition", MIT Press, 2nd Edition, 2023
2. Laura Gresser and Loon Keng, "Foundations of Deep Reinforcement Learning: Theory and Practice in Python:, Addison and Wesley, 1st Edition, 2022.

Reference Books:

1. Marco Wiering and Martjin Van Otterlo, " Reinforcement learning State of the Art", Springer Verlag, 2012
2. Phil Winder, " Reinforcement learning: Industrial Applications of Intelligent agents", Shroff/O-Reilly, 1st Edition, 2020

Course Outcomes (CO)

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

CO1	Describe and state the key features of Reinforcement learning
CO2	Suggest appropriate Reinforcement learning strategies for solving real-world problem
CO3	Implement common RL and Deep RL algorithms
CO4	Explain the various criteria used for analyzing the RL algorithm by stating the appropriate RL techniques.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS656	**Reinforcement Learning**	**CO1**	Describe and state the key features of Reinforcement learning	3	1	2
		CO2	Suggest appropriate Reinforcement learning strategies for solving real-world problem	3	1	2
		CO3	Implement common RL and Deep RL algorithms	3	2	3
		CO4	Explain the various criteria used for analyzing the RL algorithm by stating the appropriate RL techniques.	3	2	3

Course Code	:	**CS657**
Course Title	:	**Data Science**
Type of Course	:	**PE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the concept of Real Time data representations.
CLO2	To learn data science process and analysis
CLO3	To understand various data science techniques.
CLO4	To learn the various Excel Function to solve Data Science Problems
CLO5	To gain knowledge in data science Tools for data visualization.

Course Content:

UNIT I INTRODUCTION TO DATA SCIENCE

Introduction to Data Science – History of Data Science – Relationship between Data Warehouse – Big Data and Data Science –Scope of Data Science – Data Science with other fields – Relationship between Data Science and Information Science. Data: Data Types-Structured Vs. Unstructured data –Quantitative vs. Qualitative data-The Four Levels of Data-Data Collection-Data Pre-Processing- Roles and Responsibilities of a data scientist- Data Science concerns

UNIT II DATA SCIENCE PROCESS AND DATA ANALYSIS

Data Science Process: Prior Knowledge - Data Preparation - Modeling - Application - Knowledge

Data Collections: Open Data-Social Media Data-Multimodal data- Data storage and Presentation-Data Preprocessing: Data Cleaning-Data Integration-Data Transformation-Data Reduction-Data Discretization-Data Analysis and Data Analytics: Descriptive analysis- Diagnostic Analytics- Predictive Analytics-Prescriptive analysis-Exploratory analysis-Mechanistic analysis

UNIT III DATA SCIENCE TECHNIQUES

Text Analytics-Traditional Feature Engineering Models - bag of words model - bag of N-Grams model - TF - IDF Model - Text Classification -Linear regression, SVM, Naïve Bayes- Ensemble Models - Random Forest - Gradient Boosting Machines Time series Forecasting - Time series Decomposition - Smoothing based Methods - Regression based Methods - Machine Learning Methods - Anomaly Detection - Distance based outlier Detection - Density based outlier Detection - Local outlier factor -Feature Selection - Principal Component Analysis - Information theory based filtering - chi-square based filtering - Wrapper-type feature selection.

UNIT IV DATA SCIENCE IN SPREADSHEET

Introduction to Basic functions of Spreadsheet– Data Collection and Preparation – Importing Data into Spreadsheet from Different Data Sources –Data Cleaning and Preliminary Data Analysis – Correlation and importance of variables technical requirements- Data Visualization in Spreadsheet – Pivot Tables and Charts-VLOOKUP-Dashboard in Spreadsheet

UNIT IV DATA VISUALIZATION

Data Exploration - Objectives of data Exploration - Datasets - Descriptive Statistics - Data Visualization - Roadmap for data exploration -Data Visualization Tools-Tools for Data Science-

Importing Matplotlib – Line plots – Scatter plots – visualizing errors – density and contour plots – Histograms – legends – colors – subplots – text and annotation – customization – three dimensional plotting – Geographic Data with Basemap – Visualization with Seaborn and Tableau.

Text Books:

1. Sinan Ozdemir, "Principles of Data Science", Packt Publication, 2016.

2. Chirag Shah, "A Hands-on Introduction to Data Science", Cambridge University Press, 2020.

3. Vijay Kotu, Bala Deshpande, "Data Science: Concepts and Practice", Second Edition, Elsevier Publications, 2019.

4. Cathy O'Neil and Rachel Schutt. "Doing Data Science, Straight Talk from The Frontline" O'Reilly Media, Inc. 2013.

5. Julio Cesar Rodriguez Martino, "Hands-on Machine Learning with Microsoft Excel", Packt Publication, 2019.

6. Jake Vander Plas, "Python Data Science Handbook: Essential Tools for Working with Data" 1st Edition, O'Reilly Media, Inc. 2016.

Reference Books:

1. Hector Guerrero, "Excel Data Analysis: Modelling and Simulation", Springer International Publishing, 2nd Edition, 2019.

2. Steven S Skiena, "Data Science Design Manual", Spring International Publication, 2017.

3. Rajendra Akekar, Priti Srinivas Sajja, "Intelligence Techniques for Data Science", Spring International Publication, 2016.

4. Longbing Cao, "Data Science Thinking: The Next Scientific, Technological and Economic Revolution", Spring International Publication, 2018.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand various phases of data science process
CO2	Apply data science technique for text analytics and classification
CO3	Apply data science tools for various applications using excel & Python
CO4	Interpret various tools for data visualization

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course students will be able**	**PO1**	**PO2**	**PO3**
CS657	**Data Science**	**CO1**	Understand various phases of data science process	2	1	3
		CO2	Apply data science technique for text analytics and classification	3	2	1
		CO3	Apply data science tools for various applications using excel & Python	3	1	2
		CO4	Interpret various tools for data visualization	2	2	3

Course Code	**:**	**CS658**
Course Title	**:**	**Artificial Intelligence Principles and Practices**
Number of Credits	**:**	**3-0-0-3**
Course Type	**:**	**PE**

Course Learning Objectives (CLO)

CLO1	To understand the general principles of AI
CLO2	To learn about the explainability and federated learning principles of AI
CLO3	To explore the Ethical and Responsible practices of AI
CLO4	To know about the developments in Generative AI
CLO5	To develop algorithms using all the principles of AI

Course Content

Unit I Introduction

Definition of AI, Significance and Types of AI – Narrow vs General Intelligence – Key concepts – Algorithms and Models used in AI – Data preprocessing and feature engineering – AI in Healthcare, Finance, Transportation, Customer Service, Education and Legal – Three Branches of AI – Explainable machine learning – importance and challenges of Explainability – Feature importance based explanation methods – instance – based explanation methods – counterfactual-based explanation methods – concept activation vector-based explanation methods – model-agnostic explanation methods

Unit II Causal Reasoning and Federated learning

Correlation and causation – causal graphical models – causal discovery – causal inference – causal ML – Causal Reinforcement learning – Federated learning - importance of privacy protection - concept and framework of federated learning - vertical and horizontal federated learning – homomorphic encryption – secure multi-party computation – applications of FL in Privacy protection

Unit III Responsible AI

Importance of Responsible AI – Ethics in the Age of AI: The call for responsibility – mitigating bias and discrimination – Ethics in AI governances – Bias and Fairness – Understanding Bias in Data and Models – Techniques to Detect and Mitigate Bias – Implementing bias detection and fairness - transparency and explainability – Importance of Transparency and Explainability in AI Models – Methods for Achieving Explainable AI – Tools, Frameworks and Implementation of Transparency and Explainability – Challenges and Solutions in Achieving Transparency and Explainability

Unit IV Ethical Aspects of AI

Privacy and security- Privacy concerns in AI – Security Concerns in AI - robustness and reliability – Challenges in Achieving Robustness – Challenges in Achieving Reliability

Unit V Generative AI

Introduction to Generative AI – Machine learning for Language models – Exploring ChatGPT – Art of Prompt engineering – Designing Effective Prompts – Programming LLMs – Introduction to RAG

Text Books

1.Hua Chao, "Decoding AI - A Deep Dive into the Principles and Applications of Artificial Intelligence: Unveiling the Secrets of AI: Making Artificial Intelligence Accessible to Everyone", kindle Edition, 2024.

2.Avinash Manure, shaleen Bengani, Saravanan S, "Introduction to Responsible AI: Implement Ethical AI using Python", First Edition, A press, 2023

Reference Books

1.Altaf Rehmani, "Generative AI for everyone: Understanding the essentials and applications of this breakthrough technology", Kindle Edition, 2024

2. Melanny Castilla, "The principles of AI – A comprehensive Guide to Understanding, AI", Kindle Edition, 2024

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Devise AI and ML algorithms with explainability aspects
CO2	Solve real-world problems incorporating the federated learning concepts
CO3	Design AI algorithms by obeying bias, fairness, privacy and robustness
CO4	Modify algorithms and incorporate generative aspects based on prompt engineering

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS658	Artificial Intelligence Principles and Practices	CO1	Devise AI and ML algorithms with explainability aspects	3	2	2
		CO2	Solve real-world problems incorporating the federated learning concepts	2	1	2
		CO3	Design AI algorithms by obeying bias, fairness, privacy and robustness	2	2	3
		CO4	Modify algorithms and incorporate generative aspects based on prompt engineering	2	3	3

Course Code		**CS659**
Course Title		**Advanced Compiler Design**
Course Type		**PE**
Number of Credits		**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the need for optimizations in a compiler
CLO2	To explore and optimize the flow analysis
CLO3	To study the need and methods of dependence analysis
CLO4	To exploit the different optimizations in loops, procedures
CLO5	To understand the need for register allocation and memory optimizations

Course Content

UNIT-I Introduction

Phases of the compiler – Intermediate Representations – Symbol Tables – Procedure abstraction – Name Spaces – Managing memory – Storage locations – Storing and accessing arrays – Character Strings – Structure References – Control-flow constructs – Procedure calls – Introduction to optimization – Scope of Optimizations – Value numbering over regions larger than basic blocks – Global Redundancy elimination – Cloning – inline substitution

UNIT-II Control and Data flow analysis

Control flow analysis - Approaches – DFS, Preorder, Postorder and BFS – Dominators and postdominators – Loops and strongly connected components – reducibility – interval analysis and control trees – structural analysis – Data flow analysis – Taxonomy of dataflow problems and solutions – iterative data-flow analysis – lattices of flow functions – control tree based analysis - structural analysis – interval analysis – SSA form – Data flow analysers

UNIT-III Dependence analysis and early optimizations

Dependence relations – DAGs – Dependence in loops, testing, dynamically allocated objects – Aliases in Programming languages – aliases gatherer – alias propagator - Optimizations – Flow sensitivity early optimizations – Constant folding – scalar replacements – value numbering – cop propagations – redundancy elimination – partial-redundancy elimination – code hoisting

UNIT-IV Loop and Procedure Optimization

Induction-variable elimination – unnecessary bounds-check elimination – Tail-call optimization and tail recursion elimination – procedure integration – in-line expansion - leaf-routine optimization and shrink wrapping – If simplifications – Branch prediction – Branch optimization

UNIT-V Register and Memory optimization

Memory vs Registers – Allocation vs assignment – register classes – local register allocation and assignment - global register allocation and assignment – Impact of data and instruction cache – instruction-cache optimization – Data-cache optimization -

Text Books:

1. Cooper, K., Torczon, L., Engineering a Compiler, Morgan Kaufmann, 2004
2. Muchnick, S., Advanced Compiler Design and Implementation, Morgan Kaufmann, 1997.

Reference Books:

1. Uday P. Khedker, Amitabha Sanyal, and Bageshri Karkare, Data Flow Analysis: Theory and Practice, CRC Press, 2013
2. Appel, A., Modern Compiler Implementation in Java (or ML, or C), Cambridge University Press, 2002.
3. Aho, A., Lam, M., Sethi, R., Ullman, J., Compilers: Principles, Techniques, & Tools, Addison Wesley, 2007.
4. Y. N. Srikant, Priti Shankar, The Compiler Design Handbook: Optimizations and Machine Code Generation, CRC Press, 2008
5. Randy Allen, Ken Kennedy, Optimizing Compilers for Modern Architectures: A Dependence-based Approach, Morgan Kaufmann, 2001

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Implement stand-alone optimization techniques for some snippet of code
CO2	Comprehend the differences and similarities in the various approaches to optimizations
CO3	Design compilers for new languages by incorporating the necessary optimization techniques
CO4	Propose new algorithms of optimization by modifying the existing approaches

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able to	PO1	PO2	PO3
CS659		**CO1**	Implement stand-alone	3	0	2

	Advanced Compiler Design		optimization techniques for some snippet of code			
		CO2	Comprehend the differences and similarities in the various approaches to optimizations	3	1	2
		CO3	Design compilers for new languages by incorporating the necessary optimization techniques	3	2	3
		CO4	Propose new algorithms of optimization by modifying the existing approaches	3	2	3

Course Code	**:**	**CS660**
Course Title	**:**	**Algorithmic Graph Theory**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the fundamental concepts and properties of different graph families
CLO2	To study the computational complexity classes for different graph problems
CLO3	To devise polynomial time solutions for graph problems in special graph classes
CLO4	To explore the concepts of parameterized algorithms and approximation algorithms

Course Content:

Unit I: Graph Theory Concepts

Fundamental Graph Concepts, Operations on Graphs, Graph Products, Planar Graphs, Isomorphism, Connectivity, Trees, Coloring, Nordhaus-Gaddum Result, Graph Classes-Bipartite subclasses, Chordal Subclasses, Random Graphs, Perfect Graphs

Unit II: Computational Complexity

P, NP, NP-Hard, NP-Complete classes. NP-complete Proofs of graph problems: Vertex Cover, Clique, Domination, Secure Domination, Connected Domination, and other placement problems. Other Computational Complexity Classes

Unit III: Polynomial-time Algorithms

Polynomial-time solutions for the Graph Problems in special graph classes namely Interval graphs, Proper Interval Graphs, Threshold Graphs, Strongly Chordal Graphs, Convex Bipartite Graphs, Bipartite chain Graphs, Trees, Block Graphs

Unit IV: Parameterized Algorithms

Introduction, Kernelization, Bounded Search Trees, Iterative Compression, Randomized Methods in Parameterized Algorithms, Fixed-parameter Intractability

Unit V: Approximation Algorithms and Case Study:

Introduction to Approximation Algorithms, Approximation Hardness, Lower and Upper Bounds on Approximation Ratio

Case Study: Parameterized Algorithms for Graph Burning Problem, Feedback Set Problems, and for Generalized Domination. Approximation Algorithms for Domination and its variants.

Text Books:

1. Garey, Michael R., and David S. Johnson. Computers and intractability. Vol. 174. San Francisco: freeman, 1979.
2. West, Douglas Brent. Introduction to graph theory. Vol. 2. Upper Saddle River: Prentice hall, 2001.
3. Golumbic, Martin Charles. Algorithmic graph theory and perfect graphs. Elsevier, 2004.

Reference Books:

1. Cygan, Marek, Fedor V. Fomin, Łukasz Kowalik, Daniel Lokshtanov, Dániel Marx, Marcin Pilipczuk, Michał Pilipczuk, and Saket Saurabh. Parameterized algorithms. Vol. 5, no. 4. Cham: Springer, 2015.Vazirani, Vijay V. Approximation algorithms. Vol. 1. Berlin: springer, 2001.
2. Haynes, Teresa W., Stephen Hedetniemi, and Peter Slater. Fundamentals of domination in graphs. CRC press, 2013.
3. Haynes, Teresa W., Stephen T. Hedetniemi, and Michael A. Henning. Domination in graphs: Core concepts.Cham: Springer, 2023.

Course Outcomes (CO)

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

CO1	Obtain knowledge in graph fundamentals and properties of different graph families
CO2	Classify the graph problems based on their computational complexity
CO3	Implement polynomial time algorithms for special graph classes
CO4	Develop approximation and parameterized algorithms for graph problems where exact solutions are computationally infeasible.

Course outcome and Programme outcome mapping:

Course Code	**Course Title**	**CO**	**At the end of the course, students will be able to**	**PO1**	**PO2**	**PO3**
CS660	Algorithmic Graph Theory	CO1	Obtain knowledge in graph fundamentals and properties of different graph families	1	1	2
		CO2	Classify the graph problems based on their computational complexity	3	2	3
		CO3	Implement polynomial time algorithms for special graph classes	3	2	3

		CO4	Develop approximation and parameterized algorithms for graph problems where exact solutions are computationally infeasible.	3	2	3

Course Code		**CS661**
Course Title		**Soft computing Techniques**
Course Type		**PE**
Number of Credits		**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand soft computing concepts and techniques and foster their abilities in designing and implementing soft computing-based solutions for real-world and engineering problems.
CLO2	To introduce fuzzy systems, fuzzy logic and its applications from an engineering perspective
CLO3	To explain about Artificial Neural Networks and various categories of ANN.
CLO4	To explore Genetic algorithms and their role in solving problems

Course Content

Unit-I Introduction to Soft Computing

Concept of a computing system, “Soft" computing versus "Hard" computing, Characteristics of Soft computing, Some applications of Soft computing techniques

Unit-II Fuzzy logic

Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Fuzzy relations, rules, propositions, implications and inferences, Defuzzification techniques, Fuzzy logic controller design, Some applications of Fuzzy logic.

Unit-III Genetic Algorithms

Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques, Basic GA framework and different GA architectures, GA operators: Encoding, Crossover, Selection, Mutation, etc., Solving single-objective optimization problems using GAs.

Unit-IV Multi-objective Optimization Problem Solving

Concept of multi-objective optimization problems (MOOPs) and issues of solving them, Multi-Objective Evolutionary Algorithm (MOEA), Non-Pareto approaches to solve MOOPs, Pareto-based approaches to solve MOOPs, Some applications with MOEAs.

Unit-V Artificial Neural Networks

Biological neurons and its working, Simulation of biological neurons to problem solving, Different ANNs architectures, Training techniques for ANNs, Applications of ANNs to solve some real-life problems.

Text Books

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley Publications, 3rd Edition, March 2010

2. Rajasekaran, S., Pai, G. A. Vijayalakshmi, Neural Networks, Fuzzy Systems and Evolutionary Algorithms: Synthesis and Applications, Phi Learning, Second Edition, Twentieth Reprint (2/E), 2018.

3. S.N.Sivanandam, S.N.Deepa, Principles of Soft Computing, Wiley Publications, Third Edition, 2019

Reference Books

1. David E. Goldberg, "Genetic Algorithms", Pearson Education India, 2013

2. Simon O. Haykin, "Neural Networks and Learning Machines", 3/E, Prentice Hall, 2011

3. Randy L. Haupt and sue Ellen Haupt, Practical Genetic Algorithms, John Willey & Sons, 2002.

4. J.-S. R. Jang, C.-T. Sun, and E. Mizutani, Neuro-Fuzzy and soft Computing, PHI Learning, 2009.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the techniques of soft computing and adaptive neuro fuzzy inferencing systems
CO2	Recognize the feasibility of applying a soft computing methodology for a particular problem
CO3	Analyse different neural network architectures and the ability to apply the them to simulate and optimize engineering systems
CO4	Apply and compare the performance of different optimization techniques for engineering problems

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course students will be able to**	**PO1**	**PO2**	**PO3**
CS661	**Soft Computing Techniques**	**CO1**	Understand the techniques of soft computing and adaptive neuro fuzzy inferencing systems	1	0	3
		CO2	Recognize the feasibility of applying a soft computing methodology for a particular problem	2	0	0
		CO3	Analyse different neural network architectures and the	3	0	2

			ability to apply the them to simulate and optimize engineering systems			
		CO4	Apply and compare the performance of different optimization techniques for engineering problems	3	0	2

Course Code	**:**	**CS662**
Course Title	**:**	**Algorithmic Game Theory**
Type of Course	**:**	**PE**
Number of Credit	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To study basic solution concepts of game theory
CLO2	To learn the combinatorial algorithms for market equilibria
CLO3	To explore graphical games
CLO4	To determine the inefficiency of equilibria in games and Case studies

Course Content:

Unit I: Introduction to Game Theory

Basic Solution Concepts and Computational Issues, The Complexity of Finding Nash Equilibrium, Equilibrium Computation for Two-Player Games in Strategic and Extensive Form, The Lemke–Howson Algorithm

Unit II: Combinatorial Algorithms for Market Equilibria

Algorithm for Single-Source Multiple-Sink Markets, An Auction-Based Algorithm, Computation of Market Equilibria by Convex Programming and its Limitations

Unit III: Graphical Games

Computing Nash Equilibria in Tree Graphical Games, Graphical Games and Correlated Equilibria, Graphical Exchange Economies, Cryptographic Influences on Game Theory, Game Theoretic Influences on Cryptography

Unit IV: Quantifying the Inefficiency of Equilibria

Introduction to the Inefficiency of Equilibria, The Price of Anarchy of Selfish Routing, Reducing the Price of Anarchy, Network Formation Games and the Potential Function Method, Pure Equilibria for Identical Machines and Uniformly Related Machines, Mixed Equilibria on Identical Machines and Uniformly Related Machines

Unit V: Case Study

Mechanism Design with Money and without Money, Solving Load Balancing Problems using Game Theory. Solving Combinatorial Problems using Game Theory-especially Graph Problems that are NP-complete.

Text Books

1. Nisan, Noam, Tardos, Eva, Roughgarden, Tim and Vazirani, Vijay. "Algorithmic Game Theory." (2007).
2. Osborne, Martin J. *An introduction to game theory*. Vol. 3. No. 3. New York: Oxford university press,

2004.

Reference Books

1. Chalkiadakis, Georgios, Edith Elkind, and Michael Wooldridge. *Computational aspects of cooperative game theory*. Springer Nature, 2022.
2. Kolokoltsov, Vasily N., and Oleg A. Malafeyev. *Understanding game theory: introduction to the analysis of many agent systems with competition and cooperation*. World scientific, 2020.
3. Siegel, Aaron N. *Combinatorial game theory*. Vol. 146. American Mathematical Society, 2023.

Course Outcomes (CO)

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

CO1	Understand the basic concepts of game theory with the help of different game scenarios
CO2	Articulate the knowledge in combinatorial algorithms for market equilibria
CO3	Evaluate the impact of different equilibria on the overall outcome of the graphical games
CO4	Quantify the inefficiency of equilibria in games and critically analyze insights from case studies

Course Outcome and Programme Outcome Mapping:

Course Code	**Course Title**	**CO**	**At the end of the course, students will be able to**	**PO1**	**PO2**	**PO3**
CS662	Algorithmic Game Theory	CO1	Understand the basic concepts of game theory with the help of different game scenarios	3	1	2
		CO2	Articulate the knowledge in combinatorial algorithms for market equilibria	3	2	2
		CO3	Evaluate the impact of different equilibria on the overall outcome of the graphical games	3	2	2
		CO4	Quantify the inefficiency of equilibria in games and critically analyze insights from case studies	3	2	2

OPEN ELECTIVES (OE) (offered to other departments)

Course Code	:	**CS700**
Course Title	:	**Machine Learning and Deep Learning Techniques**
Type of Course	:	**OE**
Number of Credit	:	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the basic building blocks and general principles that allow one to design machine learning algorithms
CLO2	To become familiar with specific, widely used machine learning algorithms
CLO3	To introduce building blocks of deep neural network architecture
CLO4	To understand representation and transfer of knowledge using deep learning
CLO5	To learn to use deep learning tools and framework for solving real-life problems

Course Content

UNIT-I Supervised Learning

Types of Machine Learning - Supervised Learning - Classification models - Decision trees - Entropy computation using GINI - Information Gain - Support Vector Machines - non-linear kernels - Ensemble Methods: Bagging - Boosting - Gradient boosting - Linear models for regression - Maximum Likelihood Estimation (MLS) - least squares - regularized least squares - The Bias-Variance Decomposition - Bayesian Linear Regression - Linear models for classification - Discriminant functions - Fisher's linear discriminant

UNIT-II Unsupervised Learning

Probabilistic generative models - Probabilistic discriminative models - Bayesian logistic regression - Bayesian learning - Similarity and Distance Measures k-medoids algorithm - Mixture of Gaussians - Expectation maximization for mixture models (EM) - Dimensionality Reduction - Principal Component Analysis (PCA) - Linear Discriminant Analysis (LDA) – Singular Value Decomposition

UNIT-III Introduction to Deep Networks

Single layer Networks – Generative – Discriminative classifiers – limitations of fixed basis functions – multilayer networks – deep networks – error functions - gradient descent optimization convergence – back propagation – regularization – inductive bias – weight decay – learning curves - parameter sharing – residual connections – model averaging

UNIT-IV Convolutional Networks

Computer Vision – Convolutional filters – Visualizing trained CNNs – Object Detection – Image Segmentation – Graphical models – Conditional Independence – Sequence models – Transformers – Attention – language models – multimodal transformers – Graph neural networks – Machine learning on Graphs – Neural message-passing – general graph networks

UNIT-V Deep Learning

RNN - LSTM models – GRU - Generative adversarial networks – Auto Encoders – Diffusion models.

Text Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", PHI, 2005
2. Christopher M Bishop and Hugh Bishop, "Deep learning: foundation and concepts", Springer, 2023

Reference Books:

1. Tom Mitchell, Machine Learning, McGraw-Hill, 1997
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", The MIT Press, 2016.
3. Francois Chollet, "Deep Learning with Python", Manning Publications, 2017
4. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", O'Reilly Media; 1 edition (April 9, 2017)
5. Josh Patterson, "Deep Learning: A Practitioner's Approach", O'Reilly Media; 1 edition (August 19, 2017)

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Ability to implement and apply machine learning algorithms to real-world applications.
CO2	Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains
CO3	Suggest appropriate Deep learning architectures for solving real-world problems
CO4	Apply and modify deep learning architectures for new problems.

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING

Course Code	Course Title	CO	At the end of the course, students will be able to	PO1	PO2	PO3
CS700	Machine Learning and Deep Learning Techniques	CO1	Ability to implement and apply machine learning algorithms to real-world applications.	3	0	2
		CO2	Identify the deep learning algorithms which are more	3	1	2

			appropriate for various types of learning tasks in various domains			
		CO3	Suggest appropriate Deep learning architectures for solving real-world problems	3	2	3
		CO4	Apply and modify deep learning architectures for new problems.	3	3	3

Course Code	**:**	**CS701**
Course Title	**:**	**Natural Language Processing Techniques**
Type of Course	**:**	**OE**
Number of Credit:	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the need for morphological processing and their representation
CLO2	To know about the various techniques used for speech synthesis and recognition
CLO3	To appreciate the syntax analysis and parsing that is essential for natural language processing
CLO4	To learn about the various representations of semantics and discourse
CLO5	To have knowledge about the applications of natural language processing

Course Content:

UNIT I Morphology and Part-Of-Speech Processing

Introduction –Regular Expressions and Automata-Non-Deterministic FSAs. Transducers –English Morphology -Finite-State Morphological Parsing -Porter Stemmer -Tokenization-Detection and Correction of Spelling Errors. N-grams –Perplexity -Smoothing -Interpolation -Backoff . Part-of-Speech Tagging – English Word Classes -Tagsets -Rule-Based -HMM -Transformation-Based Tagging -Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models

UNIT II Speech Processing

Phonetics –Articulatory Phonetics -Phonological Categories -Acoustic Phonetics and Signals -Speech Synthesis –Text Normalization –Phonetic and Acoustic Analysis -Diphone Waveform synthesis – Evaluation-Automatic Speech Recognition –Architecture -Hidden Markov Model to Speech -MFCC vectors -Acoustic Likelihood Computation -Evaluation. Triphones –Discriminative Training -Modeling Variation. Computational PhonologyFinite-State Phonology –Computational Optimality Theory - Syllabification -Learning Phonology and Morphology

UNIT III Syntax Analysis

Finite-State and Context-Free Grammars -Dependency Grammars. Syntactic Parsing – Ambiguity - Dynamic Programming Parsing Methods –CKY-Earley and Chart Parsing-Partial Parsing-Evaluation. Statistical Parsing – Probabilistic Context-Free Grammars –Probabilistic CKY Parsing of PCFGs – Probabilistic Lexicalized CFGs – Collins Parser – Shallow parsers – Dependency parsing

UNIT IV Semantic and Pragmatic Interpretation

Representation of Meaning –Desirable Properties -Computational Semantics -Word Senses -Relations Between Senses –WordNet -Event Participants-Proposition Bank -Frame Net -–Metaphor. Computational Lexical Semantics –Word Sense Disambiguation-Supervised Word Sense Disambiguation -Dictionary and Thesaurus Methods-Word Similarity -Minimally Supervised WSD -Hyponymy and Other Word Relations -Semantic Role Labeling -Unsupervised Sense Disambiguation. Computational Discourse -Discourse Segmentation - Unsupervised Discourse -Segmentation -Text Coherence -Reference Resolution – Phenomena –Features and algorithms -Pronominal Anaphora Resolution

UNIT V Applications

Information Extraction –Named Entity Recognition -Relation Detection and Classification –Temporal and Event Processing -Template-Filling -Biomedical Information Extraction. Question Answering and Summarization - Information Retrieval -Factoid Question Answering -Summarization -Single and Multi-Document Summarization -Focused Summarization -Evaluation. Dialog and Conversational Agents – Properties of Human Conversations -Basic Dialogue Systems- Spam Detection - Sentiment Analysis-building a chatbot - text summarization-NLP in Education and Legal Systems -Document classification-Named Entity Recognition- Semantic Textual Similarity- Prompting Pre-Trained Language Models

Text Books:

1. Jurafsky and Martin, “Speech and Language Processing”, Pearson Prentice Hall, Second Edition, 2008
2. Christopher D. Manning and Hinrich Schütze, “Foundations of Statistical Natural Language Processing”, MIT Press, 1999.

Reference Books:

1. Stevan Bird, “Natural Language Processing with Python”, Shroff, 2009.
2. James Allen, “Natural Language Understanding”, Addison Wesley, Second Edition, 2007.
3. Nitin Indurkhya, Fred J. Damerau, “Handbook of Natural Language Processing”, (Chapman & Hall/CRC Machine Learning & Pattern Recognition), Second Edition, 2010.
4. Alexander Clark, Chris Fox, Shalom Lappin, “The Handbook of Computational Linguistics and Natural Language Processing”, Wiley-Blackwell, 2012.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the different linguistic components of natural language
CO2	Design a morphological analyser and tagger for a given natural language
CO3	Decide on the appropriate parsing techniques necessary for a given language and application

CO4	Design applications involving natural language

COURSE OUTCOME AND PROGFRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course students will be able to**	**PO1**	**PO2**	**PO3**
CS701	Natural Language Processing Techniques	CO1	Identify the different linguistic components of natural language	3	2	3
		CO2	Design a morphological analyser and tagger for a given natural language	3	3	3
		CO3	Decide on the appropriate parsing techniques necessary for a given language and application	3	3	3
		CO4	Design applications involving natural language	3	1	2

Course Code	**:**	**CS702**
Course Title	**:**	**Image and Video Analytic Fundamentals**
Type of Course	**:**	**OE**
Number of Credit:	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of digital image processing
CLO2	To have a knowledge on image and video analysis.
CLO3	To understand the real time use of image and video analytics.
CLO4	To understand the processing of images and videos
CLO5	To demonstrate real time image and video analytics applications.

Course Content:

Unit I Introduction

Digital Image Processing – Characteristics of Digital Image - Basic relationship between pixels Fundamental operations on image - Image sampling and quantization – Image transformations - Color models.

Unit II Basic Techniques of Image Processing

Fundamentals of spatial filtering: spatial correlation and convolution-smoothing blurring- sharpening - Basics of filtering in the frequency domain: smoothing-blurring - sharpening-- Histograms and basic statistical models of image.

Unit III Transformations and Segmentations

Colour models and Transformations – Image and Video Segmentation-Image and video demonising- Image and Video enhancement- Image and Video compression.

Unit IV Detection and Classification

Object detection and recognition in image and Video-Texture models - Image and Video classification models- Object tracking in Video.

Unit V Applications and Case studies

Industrial- Transportation & Travel- Remote Sensing - Surveillance. IoT Video Analytics Architectures.

Text Books:

1. Rafael C Gonzalez, Richard E Woods, "Digital Image Processing", Pearson Education, 4th edition,2018.

2. Wilhelm, Mark J. Burge, "Digital Image Processing An Algorithmic Introduction", Springer; 3rd edition, 2022.

Reference Books:

1.Milan Sonka, Vaclav Hlavac, Roger Boyle, “Image Processing, Analysis, and MachineVision”, 4nd edition, Thomson Learning, 2013.

2.A.K. Jain, “Fundamentals of Digital Image Processing”, PHI, New Delhi, 2015.

3.Rick Szelisk, “Computer Vision: Algorithms and Applications”, Springer 2011.

Course Outcomes (CO)

At the end of the course, student will be able to

CO1	Describe the fundamental principles of image analysis
CO2	Have an idea of various image processing techniques.
CO3	Apply pattern recognition techniques.
CO4	Apply image analysis in real world problem

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	**Course Title**	**CO**	**At the end of the course, students will be able to**	**PO1**	**PO2**	**PO3**
CS702	**Image and Video Analytic Fundamentals**	**CO1**	Describe the fundamental principles of image analysis	1	0	0
		CO2	Have an idea of various image processing techniques.	2	0	1
		CO3	Apply pattern recognition techniques.	3	1	1
		CO4	Apply image analysis in real world problem	3	3	1

Course Code	**:**	**CS703**
Course Title	**:**	**Reinforcement Learning Principles**
Type of course	**:**	**OE**
Number of Credits	**:**	**3-0-0-3**

Course Learning Objectives (CLO)

CLO1	To explore the various approaches to reinforcement learning
CLO2	To understand the policy and evaluation strategies of reinforcement learning approaches
CLO3	To learn about the Temporal difference and approximated learning approaches
CLO4	To introduce Deep Reinforcement learning approaches

Course Content

UNIT-I Introduction

Reinforcement learning – Elements of Reinforcement learning – limitations and scope – Example Tic-tac-toe – Tabular solution methods – multi-armed bandits – k-armed bandit problem – action-value methods – 10-armed testbed – incremental implementation – tracking a non-stationary problem – optimistic initial values – Upper-confidence bound action section – gradient bandit algorithm – associative search - finite markov decision processes – agent environment interface – goals and rewards – returns and episodes – unified notation for episodic and continuing tasks – policies and value functions – optimal policies and optimal value functions – optimality and approximation

Unit II – Dynamic Programming and Monte Carlo methods

Policy evaluation – improvement – iteration – value iteration – Asynchronous dynamic programming – generalized policy iteration – Efficiency of DP – Monte carlo prediction – monte carlo estimation of action values – monte carlo control – without exploring starts – off-policy monte carlo control – discounting aware importance sampling – per-decision importance sampling

Unit III – Temporal difference learning and Bootstrapping

TD prediction – Advantages – Optimality of TD Sarsa: On policy TD control – Q-learning off-policy TD control – Expected Sarsa – Maximization Bias and double learning – Games, Afterstates and Special cases – n-step TD prediction – n-step Sarsa – n-step Off-policy learning – per-decision methods with control variates – off-policy learning without importance sampling – n-step tree backup algorithm – A unifying algorithm – n-step Q(σ) – Planning and learning with tabular methods – models and planning – prioritized sweeping – trajectory sampling – planning at decision time - rollout algorithms – monte carlo tree search

Unit IV Approximate solution methods

On-policy prediction with approximation – value-function approximation – prediction objective – stochastic gradient, semi-gradient methods – linear methods – Feature construction – Nonlinear function approximation Least squares TD – Memory based function approximation – kernel based approximation – on-policy control – Episodic semi-gradient control – Semi-gradient n-step sarsa – differential semi-gradient n-step sarsa – off-policy methods – semi-gradient methods – examples – deadly triad – Bellman error – Gradient, Emphatic TD methods – Eligibility Traces – The λ return – TD (λ) – Online λ return algorithm – Sarsa (λ) – Variable λ and γ – Watkins Q(λ) and tree-backup (λ).

Unit V Policy Gradient and Deep Reinforcement learning

Reinforce – Monte carlo policy gradient – with baseline – actor-critic methods – Deep Q-Networks – Learning the Q-function – Action Selection – DQN algorithm – Double DQN algorithm

Text Books:

3. Richard S Sutton and Andrew G Barto, " Reinforcement learning –2nd Edition", MIT Press, 2nd Edition, 2023

4. Laura Gresser and Loon Keng, "Foundations of Deep Reinforcement Learning: Theory and Practice in Python:, Addison and Wesley, 1st Edition, 2022.

Reference Books:

3. Marco Wiering and Martjin Van Otterlo, " Reinforcement learning State of the Art", Springer Verlag, 2012

4. Phil Winder, " Reinforcement learning: Industrial Applications of Intelligent agents", Shroff/O-Reilly, 1st Edition, 2020

Course Outcomes (CO)

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

CO1	Describe and state the key features of Reinforcement learning
CO2	Suggest appropriate Reinforcement learning strategies for solving real-world problem
CO3	Implement common RL and Deep RL algorithms
CO4	Explain the various criteria used for analyzing the RL algorithm by stating the appropriate RL techniques.

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING:

Course Code	Course Title	CO	At the end of the course students will be able	PO1	PO2	PO3
CS703	**Reinforcement Learning Principles**	**CO1**	Describe and state the key features of Reinforcement learning	3	1	2
		CO2	Suggest appropriate Reinforcement learning strategies for solving real-world problem	3	1	2
		CO3	Implement common RL and Deep RL algorithms	3	2	3
		CO4	Explain the various criteria used for analyzing the RL algorithm by stating the appropriate RL techniques.	3	2	3


கணினி அறிவியல் மற்றும் பொறியியல்
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