SRI KRISHNA COLLEGE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution | Approved by AICTE | Affiliated to Anna University | Accredited by NAAC with A++ Grade
Kuniamuthur, Coimbatore – 641008
Phone : (0422)-2678001 (7 Lines) | Email : info@skcet.ac.in | Website : www.skcet.ac.in

Curriculum & Syllabi

Regulation 2025

M.E COMPUTER SCIENCE AND ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(Batch 2025-2027)

VISION OF THE INSTITUTION

- To Produce Globally Competitive Engineers with High Ethical Values and Social Responsibilities.

MISSION OF THE INSTITUTION

- To impart the highest quality state-of-the-art technical education by providing impetus to innovation, research, and development and empowering students with entrepreneurship skills.
- To instill ethical values, imbibe a sense of social responsibility, and strive for societal well-being.
- To identify the needs of society and offer sustainable solutions through outreach programs.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

VISION OF THE DEPARTMENT

- To prepare professionals with high technical, research and entrepreneurial skills as well as ethical values who will contribute to the computational world.

MISSION OF THE DEPARTMENT

- To develop human resources with the ability and attitude to adapt to emerging technological changes through academic and research-oriented events.
- To identify current socio, economic problems of national and international significance and provide solutions through competency centers.
- To impart ethics, social responsibilities and necessary professional, entrepreneurial and leadership skills through student lead activities

I.	PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)
To enable graduates to	
PEO 1	Pursue higher education and research or have a successful career in industries associated with computer science and engineering, or succeed as entrepreneurs
PEO 2	Be adaptive to the growing needs of global computational environment by engaging in life-long learning

II.	PROGRAMME OUTCOMES (POs)
PO 1	**Engineering Knowledge**: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO 2	**Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.
PO 3	**Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required.
PO 4	**Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.
PO 5	**Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.
PO 6	**The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.
PO 7	**Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws.
PO 8	**Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO 9	**Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO 10	**Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO 11	**Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

Knowledge and Attitude Profile (WK)

WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

III.	**PROGRAMME SPECIFIC OUTCOMES (PSOs)**
The Graduates of B.E – CSE programme will be able to:	
PSO 1	Apply the fundamental knowledge for problem solving and analysis as well as conduct investigations in computer science and engineering for sustainable development
PSO 2	Design and develop the solutions for real time problems and implement them by using modern software tools in lieu of deploying them in the society for its growth
PSO 3	Inculcate effective communication skills and ethics for lifelong learning

IV. MAPPING OF PEOs WITH POs and PSOs														
PEO	**Pos**											**PSO**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	1	2	3
1	3	3	3	2	2	2	2	1	1	1	2	3	3	2
2	1	1	2	2	3	3	2	1	2	2	2	1	2	3
	1- low, 2 - medium, 3 - high, '-' - no correlation													

V. MAPPING OF PEOs WITH PSOs			
	PSO 1	**PSO 2**	**PSO 3**
PEO 1	3	3	2
PEO 2	1	2	3

AUTONOMOUS CURRICULA AND SYLLABI

Regulations 2025 (ME CSE)

SEMESTER I						
S. No.	**Course Code**	**Courses**	**L/T/P**	**Total Hours**	**Credits**	**SDG Mapping**
Theory (Internal 40 Marks & External 60 Marks)						
1	25PF101	Logic, Graph and Applied Probability	3 / 0 / 0	3	3	9,11,12
2	25PF102	Advanced Data Structures and Algorithms	3 / 0 / 0	3	3	4, 9
3	25PF103	Advanced Operating Systems	3 / 0 / 0	3	3	8, 9, 12
4	25PF104	Cloud Computing and Management	3 / 0 / 0	3	3	8, 9, 12,13
5	25PF105	Machine Learning Approaches	3 / 0 / 0	3	3	4,8,9,12
6	25PF106	Research Methodology and IPR	3 / 0 / 0	3	3	9,17
Practical (Internal 60 Marks & External 40 Marks)						
7	25PF107	Data Structures and Operating Systems Laboratory	0 / 0 / 4	4	2	4, 8,9
			Total	**22**	**20**	

SEMESTER II						
S. No.	**Course Code**	**Courses**	**L/T/P**	**Total Hours**	**Credits**	**SDG Mapping**
Theory (Internal 40 Marks & External 60 Marks)						
1	25PF201	Advanced Computer Architecture	3 / 0 / 0	3	3	4,9,17
2	25PFXXX	Professional Elective – I	3 / 0 / 0	3	3	
3	25PFXXX	Professional Elective - II	3 / 0 / 0	3	3	
4	25PFXXX	Professional Elective – III	3 / 0 / 0	3	3	
Theory with Practical (Internal 50 Marks & External 50 Marks)						
5	25PF202	Database Practices	3 / 0 / 2	5	4	4,8,9
Mini Project (Internal 100 Marks)						
6	25PF203	Mini Project	0 / 0 / 6	4	2	3,4,8,9
			Total	**21**	**18**	

SEMESTER III						
S. No.	Course Code	Courses	L/T/P	Total Hours	Credits	SDG Mapping
Theory (Internal 40 Marks & External 60 Marks)						
1	25PFXXX	Professional Elective – IV	3 / 0 / 0	3	3	
2	25PFXXX	Professional Elective - V	3 / 0 / 0	3	3	
3	25PFXXX	Professional Elective – VI	3 / 0 / 0	3	3	
Project (Internal 60 Marks & External 40 Marks)						
4	25PF301	Project - I	0 / 0 / 20	20	10	4,9,17
Mini Project (Internal 100 Marks)						
5	25PF302	Employability Enhancement Skills (Internship)	28 Days		2	8,12,17
			Total	**29**	**21**	

SEMESTER IV						
S. No.	Course Code	Courses	L/T/P	Total Hours	Credits	SDG Mapping
Project (Internal 60 Marks & External 40 Marks)						
1	25PF401	Project - II	0 / 0 / 30	30	15	4,9,17
Total Credits					**74**	

PROFESSIONAL ELECTIVE COURSES (18 Credits)						
SL. No.	Course Code	Course Title	L/T/P	Contact hrs./Wk.	C	SDG Mapping
1	25PF501	Deep Learning Architectures and Applications	3 / 0 / 0	3	3	7,9,11
2	25PF502	Computer Vision Analysis	3 / 0 / 0	3	3	3, 9, 11
3	25PF503	Service Oriented Architecture	3 / 0 / 0	3	3	4,8,9
4	25PF504	Human Computer Interaction	3 / 0 / 0	3	3	3,4,8,12
5	25PF505	Software Project Planning & Management	3 / 0 / 0	3	3	8,9,17
6	25PF506	Social Network Analysis	3 / 0 / 0	3	3	3,8,9
7	25PF507	Social and Information Networks	3 / 0 / 0	3	3	4,9,10,17
8	25PF508	Big Data Frameworks and Technologies	3 / 0 / 0	3	3	3,9,11,13
9	25PF509	Data Engineering & Visualization	3 / 0 / 0	3	3	9,11,17

10	25PF510	Advances In Storage Area Network	3 / 0 / 0	3	3	7,9,11
11	25PF511	Image Processing and Analysis	3 / 0 / 0	3	3	3,9,11
12	25PF512	Wireless Networks & Mobile Computing	3 / 0 / 0	3	3	3,4,9
13	25PF513	Wireless Ad-Hoc and Sensor Networks	3 / 0 / 0	3	3	7,9,11
14	25PF514	Wearable Computing	3 / 0 / 0	3	3	3,10,11
15	25PF515	Advanced Cryptography	3 / 0 / 0	3	3	4,9,16

PROJECT WORK (29 Credits)						
SL. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**SDG Mapping**
1.	25PF203	Mini Project	0 / 0 / 6	4	2	3,4,8,9
2.	25PF301	Project - I	0 / 0 /20	20	10	4,9,17
3.	25PF302	Employability Enhancement Skills (Internship)	28 Days		2	8,12,17
4.	25PF401	Project - II	0 / 0 /30	30	15	4,9,17

INTERN (02 Credits)						
SL. No.	**Course Code**	**Course Title**	**L/T/P**	**Contact hrs./Wk.**	**C**	**SDG Mapping**
1.	25PF302	Employability Enhancement Skills (Internship)	28 Days		2	8,12,17

L: Lecture **T:** Tutorial **P:** Practical **C:** Credit **O:** Outside Class hours **Cat.:** Category

HSMC : Humanities and Social Sciences including Management
BSC : Basic Science Courses
ESC : Engineering Science Courses
PCC : Professional Core Courses
PEC : Professional Elective Courses
OEC : Open and Emerging Elective Courses
PRJ : Project Work
INT : Internship
MC : Mandatory Course

Definition of Credit:

L – Lecture	1 Hr. Lecture (L) per week	1 credit
T – Tutorial	1 Hr. Tutorial (T) per week	1 credit
P - Practical/Practice (Project and Industry based Courses)	1 Hr. Practical (P) per week	0.5 credit

SEMESTER – I

25PF101 SDG NO. 9,11,12	LOGIC, GRAPH AND APPLIED PROBABILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To develop logical thinking and knowledge on how discrete structures actually helped computer engineers to solve problems occurred in the development of programming languages.
2. To Construct and interpret truth tables to determine the validity of logical expressions, including tautologies, contradictions.
3. To develop theoretical knowledge and understanding of graph theory.
4. To enable students to understand the concepts of Probability and Random Variables.
5. To apply the small sample tests through Tests of hypothesis.

Propositional Calculus

Propositions – Logical connectives – Compound propositions – Conditional and biconditional – Truth tables – Tautologies and contradictions – Contrapositive – Logical equivalences and implications – Normal forms – Principal conjunctive and disjunctive normal forms – Rules of inference –Predicates and Quantifiers – Logical equivalences and implications for quantified statements – Theory of inference.

Graph Theory

Basic Concepts – Some special simple graphs – Matrix representation of graphs – paths, cycles, connectivity – Eulerian and Hamiltonian Graphs – Connectedness in Digraphs Trees – Spanning Trees – Binary trees – Shortest path algorithms.

Random Variables

One dimensional random variable – Probability mass function – Probability density function – Discrete and continuous random variables - Standard distributions – Discrete distributions : Binomial – Poisson – Continuous distributions : Uniform – Exponential – Normal distributions.

Two Dimensional Random variables

Joint distributions – Marginal and conditional distributions – Functions of two-dimensional random variables – Regression line – Correlation.

Testing of Hypothesis

Sampling distributions – Type I and Type II errors – Small samples – Tests based on t, Chi square and F distributions for testing of mean, variance and proportions – Tests for independence of attributes and goodness of fit.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Remember the logical thinking and its applications to computer science	[R]
CO2	Understand the theoretical knowledge of Graph theory.	[U]
CO3	Apply the concept of probability in solving engineering problems.	[AP]
CO4	Apply skills to handle situations involving single- and two-dimensional random variables and predict the correlation and regression between the random variables.	[AP]
CO5	Apply the statistical tests in testing hypotheses on data.	[AP]

TEXT BOOKS

1. Kenneth H. Rosen, “Discrete Mathematics and its Applications”, 7th Edition, Tata McGraw – Hill Pub. Co. Ltd., New Delhi, 2018.
2. Peebles Jr. P.Z., “Probability Random Variables and Random Signal Principles”, Tata McGraw-Hill Publishers, Fourth Edition, New Delhi, 2016.
3. Veerarajan. T —Probability, Statistics and Random Processes, Tata McGraw-Hill, Second Edition, New Delhi, 2010.

REFERENCE BOOKS

1. Veerarajan, T, “Discrete mathematics with Graph theory and Combinatorics”, Tata McGraw – Hill Pub. Co. Ltd., New Delhi, 2017.
2. Ross. S., “A First Course in Probability”, Ninth edition, Pearson Education, Delhi, 2014.
3. Johnson R. A. and Gupta C.B., “Miller and Freund’s Probability and Statistics for Engineers”, Pearson India Education, Asia, 9th Edition, New Delhi, 2017.

WEB RESOURCES

1. https://www.coursera.org/courses?query=graph%20theory
2. https://ocw.mit.edu/courses/.../18-440-probability-and-random-variables-spring-2014/
3. https://freevideolectures.com/Course/2311/Digital-Communication/4
4. https://nptel.ac.in/courses/111104079
5. https://www.coursera.org/learn/stanford-statistics

25PF102 SDG NO. 4, 9	ADVANCED DATA STRUCTURES AND ALGORITHMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce advanced data structures and their role in algorithm design.
2. To provide a solid understanding of algorithmic design techniques, including divide-and-conquer and dynamic programming.
3. To teach the implementation and optimization of trees, graphs, and advanced data structures like Fibonacci heaps and B-trees.
4. To equip students with the skills to analyze and compare the efficiency of different algorithms.
5. To explore the application of advanced mathematical tools like the Chinese Remainder Theorem and Discrete Fourier Transform in algorithm design.

FUNDAMENTAL DATA STRUCTURES AND HASHING **9**

Elementary Data Structures: Stacks and queues - Linked lists - Implementing pointers and objects - Representing rooted trees - Hash Tables: Direct-address tables - Hash tables - Hash functions - Open addressing.

TREES, GRAPHS, AND ALGORITHMIC ANALYSIS **9**

Binary Search Trees: Querying a binary search tree - Insertion and deletion - Randomly built binary search trees -Red-Black Trees - Augmenting Data Structures -Elementary Graph Algorithms: Representations of graphs - Breadth-first search - Depth-first search - Growth of Functions: Asymptotic notations – Standard notations and common functions. Divide-and-Conquer: The maximum-subarray problem – Strassen's algorithm for matrix multiplication – solving recurrences: - substitution method, recursion-tree method.

SORTING TECHNIQUES AND B-TREES **9**

Randomized algorithms - Heap sort - Quick sort - Sorting in Linear Time. - B-Trees: Definition of B-trees - Basic operations on B-trees - Deleting a key from a B-tree.

ADVANCED DATA STRUCTURES AND ALGEBRAIC TOOLS **9**

Fibonacci Heaps: Structure of Fibonacci heaps - Mergeable-heap operations - Decreasing a key and deleting a node - Bounding the maximum degree - Data Structures for Disjoint Sets: Disjoint-set operations - Linked-list representation of disjoint sets - Disjoint-set forests - Modulo Representation of integers/polynomials: Chinese Remainder Theorem, Conversion between base-representation and modulo-representation - Extension to polynomials - Application: Interpolation problem - Discrete Fourier Transform (DFT): In complex field, DFT in modulo ring -Fast Fourier Transform algorithm – Schonhage -Strassen Integer Multiplication algorithm.

DESIGN TECHNIQUES, GRAPH ALGORITHMS, AND COMPLEXITY **9**

Dynamic Programming: Elements of dynamic programming - Matrix-chain multiplication – Optimal binary search trees - Greedy Algorithms: An activity-selection problem - Elements of the greedy strategy -Amortized Analysis: Aggregate analysis - accounting method, potential method - Dynamic tables -Topological sort - Strongly connected components - Minimum Spanning Trees - Single-Source Shortest Paths - All-Pairs Shortest Paths - Maximum Flow NP-Completeness

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply hashing techniques to implement efficient symbol tables and solve lookup problems.	[AP]
CO2	Develop and optimize tree-based structures like Red-Black Trees, B-Trees, and Fibonacci Heaps for various applications.	[A]
CO3	Select and apply suitable algorithmic design paradigms like Divide-and-Conquer and Dynamic Programming.	[AP]
CO4	Analyze the time and space complexity of algorithms using asymptotic notations and recurrence relations.	[A]
CO5	Differentiate between problems in P and NP classes, and apply complexity theory in algorithm evaluation.	[U]

TEXT BOOKS

1. T.H. Cormen, C.E. Leiserson,R.L. Rivest and C. Stein, " Introduction to Algorithms", Prentice Hall of India ,3rd Edition ,2012
2. Mark Allen Weiss, Data Structures and Algorithms in C++, Pearson, 3rd Edition,2009.
3. E. Horowitz, S. Sahni and S. Rajasekaran, Computer Algorithms / C++, University Press, 2nd Edition,2008.

REFERENCE BOOKS

1 S.Sridhar, Design and Analysis of Algorithmsǁ, First Edition, Oxford University Press,1st Edition, 2014.
2 Adam Drozdex, Data Structures and algorithms in C++. New Delhi: Cengage Learning, 4th Edition, 2012.

WEB REFERENCES

1 http://cs-fundamentals.com/data-structures/data-structures-tutorials.php
2 https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-851-advanced-data-structures-spring-2012/index.htm

ONLINE RESOURCES

1 https://www.coursera.org/learn/advanced-data-structures
2 https://onlinecourses.nptel.ac.in/noc18_cs25/preview
3 https://nptel.ac.in/courses/106102064/

25PF103 SDG NO. 8, 9, 12	ADVANCED OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To provide a comprehensive understanding of fundamental operating system concepts.
2. To introduce distributed operating systems and explore communication models, synchronization, and scheduling algorithms.
3. To study real-time operating systems and the specific needs for task scheduling and resource management in such systems.
4. To explore mobile operating systems and their unique features like microkernel design and client-server resource access.
5. To analyze case studies of widely used operating systems like Linux, iOS, and Android, focusing on their kernel architecture and management techniques.

INTRODUCTION TO OPERATING SYSTEMS **9**

Overview – Synchronization Mechanisms – Processes and Threads - Process Scheduling – Deadlocks: Detection, Prevention and Recovery – Models of Resources – Memory Management Techniques.

DISTRIBUTED OPERATING SYSTEMS

9

Architectures - Design issues – Communication models – Clock synchronization –Mutual exclusion – Election algorithms - Distributed Deadlock detection - Distributed scheduling - Distributed shared memory - Distributed File system – Multimedia file systems - File placement – Caching

REAL-TIME SYSTEMS FUNDAMENTALS **9**

Basic Model of Real Time Systems - Characteristics - Applications of Real Time Systems - Real Time Task Scheduling - Handling Resource Sharing

MOBILE OPERATING SYSTEMS

9

Mobile Operating Systems – Micro Kernel Design - Client Server Resource Access – Processes and Threads - Memory Management – File system.

CASE STUDIES IN OPERATING SYSTEMS **9**

Case Study: Linux System: Design Principles - Kernel Modules - Process Management - Scheduling – Memory Management - Input-Output Management - File System – Interprocess Communication. iOS and Android: Architecture and SDK Framework - Media Layer - Services Layer - Core OS Layer – File System.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1 Explain the fundamental concepts of operating systems including process scheduling, memory management, and deadlocks. [U]

CO2 Analyze synchronization issues and apply algorithms to manage processes and threads efficiently. [A]

CO3 Evaluate the design and architecture of distributed operating systems and their components. [A]

CO4 Compare the characteristics of real-time and mobile operating systems for specific applications. [A]

CO5 Illustrate the structure and management techniques used in Linux, Android, and iOS through real-time case studies. [U]

TEXT BOOKS

1. Singhal, Mukesh & N.G. Shivaratri, Advanced Concepts in Operating Systems, Tata McGraw-Hill, 1st Edition, 2008.
2. Abraham Silberschatz, Peter B.Galvin , Greg Gagne, “Operating System Concepts”, Wiley,10th Edition, 2018.

REFERENCE BOOKS

1. Daniel P Bovet and Marco Cesati, “Understanding the Linux kernel”, O’Reilly, 3rd Edition, 2005.
2. A. S. Tanenbaum, Distributed Operating Systems, Pearson Education, 1st Edition,2016.
3. A. S. Tanenbaum, Modern Operating Systems, Pearson Education,4th Edition, 2015.
4. Rajib Mall, “Real-Time Systems: Theory and Practice”, Pearson Education India, 1st Edition, 2007.
5. Neil Smyth, “iPhone iOS 4 Development Essentials – Xcode”, Payload media,4th Edition, 2011.

WEB REFERENCES

1. https://nptel.ac.in/courses/106108101/
2. https://www.geeksforgeeks.org/operating-systems/

ONLINE RESOURCES

1. https://grid.cs.gsu.edu/~cscyqz/courses/aos/aoslectures.html
2. https://lecturenotes.in/subject/185/advanced-operating-system-aos

25PF104 SDG NO. 8,9,12,13	CLOUD COMPUTING AND MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the core concepts of cloud computing, including architecture, deployment models, and service models.
2. To explore virtualization technologies and their role in cloud infrastructure management.
3. To discuss security concerns in cloud computing, including application, data, and infrastructure security.
4. To demonstrate the practical use of cloud platforms such as Amazon EC2, Google App Engine, and Microsoft Azure.
5. To study cloud migration techniques, fault tolerance mechanisms, and the application of MapReduce for distributed computing.

CLOUD FOUNDATIONS AND VIRTUALIZATION **9**

Introduction: Distributed Computing and Enabling Technologies - Cloud Fundamentals: Cloud Definition, Evolution, Architecture, Applications, Deployment Models, and Service Models. Virtualization: Issues with virtualization, virtualization technologies and architectures, Internals of virtual machine monitors/hypervisors, virtualization of data centers Containerization, Docker, Kubernetes - SLA Management. Interoperability and Service Monitoring. MapReduce and its extensions to Cloud - HDFS, and GFS.

CLOUD PLATFORMS AND TOOLS **9**

Implementation: Study of Cloud computing Systems like Amazon EC2 and S3, Google App Engine, and Microsoft Azure Introduction to Open-Source Tools for IaaS: Eucalyptus-OpenStack Open-Source Tools for PaaS: Paasmaker, Cloudify

Open-Source Tools for SaaS: Google Drive, Dropbox - Open-Source Tools for Research: CloudSim, GreenCloud, Salesforces - Deployment of Web Services from Inside and Outside a Cloud Architecture – REST API

SECURITY AND THREAT MODELS IN CLOUD **9**

Security: Vulnerability Issues and Security Threats, Application-level Security, Data level Security, Virtual Machine level Security -Infrastructure Security and Multi-tenancy Issues - Intrusion Detection System -Identity Access Management

CLOUD MIGRATION AND FAULT TOLERANCE **9**

Migration and Fault Tolerance: Broad Aspects of Migration into Cloud, Migration of virtual Machines and techniques- Fault Tolerance Mechanisms

CLOUD APPLICATIONS AND CASE STUDIES **9**

Application-focused study of cloud deployments, performance tuning, monitoring tools, and recent trends in enterprise and research cloud environments.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Describe the architecture, deployment models, and service models of cloud computing.	[U]
CO2	Develop basic cloud-based applications using open-source tools and APIs.	[AP]
CO3	Identify and evaluate cloud security threats at different service levels.	[A]
CO4	Demonstrate the implementation of MapReduce programming using Hadoop.	[AP]
CO5	Deploy private cloud environments using tools like OpenStack and assess their effectiveness.	[A]

TEXT BOOKS

1. Rajkumar Buyya, James Broberg, Andrzej Goscinski, “Cloud Computing Principles and Paradigms”, Wiley Publishers, 2011.
2. Naresh kumar sehgal, Pramod Chan P Bhatt “Cloud computing : concepts and practices” Springer, 2018
3. K. Chandrasekaran, “Essentials of Cloud Computing”, CRC Press, 2014.
4. Barrie Sosinsky, “Cloud Computing Bible”, Wiley Publishers, 2010.
5. Michael Miller, “Cloud Computing: Web-based Applications that change the way you work and collaborate online”, Pearson Education, 2008.
6. Rajkumar Buyya, Christian Vacchiola, S Thamarai Selvi, “Mastering Cloud computing”, McGraw Hill, 2013.
7. Tom Fifield, Diane Fleming, Anne Gentle, Lorin Hochstein, “Openstack Operational Guide”, O’Reilly, 2014.
8. Tim Mather, Subra Kumaraswamy, Shahed Latif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance”, O’Reilly, 2010.

REFERENCE BOOKS

1. Cloud Infrastructure and Services Participant Guide Volume 1 & 2 (EMC Education Services, Oct 2011)
2. Toby Velte, Antohy T Velte, Robert Elsenpeter, “Cloud Computing: A Practical Approach”, McGraw Hill, 2009.
3. David S. Linthicum, “Cloud Computing and SOA Convergence in Your Enterprise: A Step-by-Step Guide”, 2010.

WEB REFERENCES

1. https://nptel.ac.in/courses/106105167/
2. https://www.coursera.org/specializations/cloud-computing#courses
3. https://www.udemy.com/learn-cloud-computing-from-scratch/

ONLINE RESOURCES

1. https://www.udemy.com/docker-and-kubernetes-the-complete-guide/
2. https://dzone.com/articles/container-technologies-overview
3. https://dzone.com/articles/container-technologies-overview
4. https://www.tutorialspoint.com/restful/restful_first_application.htm

25PF105 SDG NO. 4,8,9,12	MACHINE LEARNING APPROACHES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce the basic concepts of machine learning and their real-world applications.
2. To provide in-depth knowledge of supervised learning techniques, including decision trees, neural networks, and support vector machines.
3. To study graphical models such as Bayesian networks, Markov random fields, and Hidden Markov Models, and their use in probabilistic learning.
4. To understand overfitting, model selection, and regularization techniques in regression problems.
5. To explore unsupervised learning methods, clustering algorithms, and dimensionality reduction techniques like Principal Component Analysis (PCA).

INTRODUCTION TO MACHINE LEARNING **9**

What and why of Machine Learning, Designing a learning system, Issues- Examples of Machine Learning Applications - Overview: Supervised Learning, Learning - Associations, Classification, Regression - Unsupervised Learning, Semi-Supervised Learning, and Reinforcement Learning

SUPERVISED LEARNING TECHNIQUES **9**

Generative vs Discriminative Learning - Gaussian Mixture Models - Decision Tree Learning- Neural Networks: Feedforward and Backpropagation - Support Vector Machines - Instance-Based Learning - Ensemble Learning

GRAPHICAL MODELS AND PROBABILISTIC LEARNING **9**

Bayesian Learning - Markov Random Fields - Hidden Markov Models: Definition, Issues Conditional Random Fields

REGRESSION AND OVERFITTING **9**

Linear Regression -Logistic Regression Overfitting and Model Selection

UNSUPERVISED LEARNING AND CASE STUDIES **9**

Discovering Clusters, Latent Factors, Graph Structures - Dimensionality Reduction – Principal Component Analysis- Case Studies: - Conditional Random Field Learning for OCR - Structure Learning for Skeleton Identification - Human Action Recognition with Kinect

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Recall and explain the foundational concepts and application areas of machine learning.	[U]
CO2	Classify different learning paradigms and choose suitable models for given problems.	[AP]
CO3	Implement machine learning algorithms such as Decision Trees, SVMs, and Neural Networks.	[AP]
CO4	Analyze regression models and apply techniques to avoid overfitting in real-world datasets.	[A]
CO5	Evaluate and compare clustering and dimensionality reduction methods for diverse datasets.	[A]

TEXT BOOKS

1. Ethem Alpaydin, “Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)”, MIT Press, 3rd Edition, , 2014.
2 Kevin P. Murphy, “Machine Learning A probabilistic Perspective”, MIT press, 2012
3 Ramez Elmasri, Shamkant B. Navathe, “Fundamentals of Database Systems”, Pearson 4th Edition , 2007.

REFERENCE BOOKS

1 Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.
2 Jason Bell, “Machine learning – Hands on for Developers and Technical Professionals”, Wiley, 1st Edition, 2014.
3 Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2nd Edition, 2014.
4 Tom M. Mitchell – Machine Learning, MCGraw-Hill, 1997

WEB REFERENCES

1. https://onlinecourses.nptel.ac.in/noc16_cs18/preview
2. https://freevideolectures.com/course/2257/machine-learning
3. https://www.coursera.org/learn/machine-learning

ONLINE RESOURCES

1. https://www.analytixlabs.co.in/machine-learning-course-certification-training
2. https://in.udacity.com/course/intro-to-machine-learning--ud120-india

25PF106 SDG NO. 9,17	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

6. Introduce students to the principles and processes of scientific research in engineering and technology.
7. Develop skills in literature review, problem identification, and research methodology selection.
8. Familiarize students with data analysis techniques and tools for qualitative and quantitative research.
9. Provide an overview of IPR laws, patent filing procedures, and the importance of innovation protection
10. Enhance technical writing and presentation skills for effective dissemination of research findings.

INTRODUCTION TO RESEARCH METHODOLOGY **9**

Meaning, objectives, and types of research (Basic vs Applied, Qualitative vs Quantitative) - Research process and design - Ethical considerations in research (Plagiarism, authorship, data fabrication) - Formulating research problems and hypotheses.

RESEARCH DESIGN AND DATA COLLECTION **9**

Literature review techniques (Sources, referencing tools like Zotero/Mendeley) - Sampling methods (Probability & Non-probability sampling) - Data collection methods (Surveys, interviews, experiments, case studies) - Questionnaire design and pilot testing.

DATA ANALYSIS AND INTERPRETATION **9**

Descriptive vs Inferential statistics - Statistical tools (Mean, SD, correlation, regression, hypothesis testing)- Software for data analysis (Excel, SPSS, R/Python basics)- Interpretation and validation of results.

INTELLECTUAL PROPERTY RIGHTS (IPR) FUNDAMENTALS **9**

Introduction to IPR: Patents, Copyrights, Trademarks, Trade Secrets - Patent filing process (Provisional vs Complete specification) - IPR in academia and industry (Case studies) - Global IP organizations (WIPO, USPTO, Indian Patent Office)

RESEARCH REPORTING AND ACADEMIC INTEGRITY **9**

Structure of a research report/thesis - Abstract, Introduction, Methodology, Results, Discussion - Citation styles (APA, IEEE, MLA) and reference management - Avoiding plagiarism - Effective presentation techniques

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Understand the fundamentals of research, including types of research, research design, and ethical considerations	[U]
CO2	Formulate research problems, develop hypotheses, and design appropriate research methodologies	[AN]
CO3	Apply statistical and analytical tools for data collection, interpretation, and validation.	[AP]
CO4	Comprehend the basics of Intellectual Property Rights (IPR), including patents, copyrights, trademarks, and trade secrets.	[AN]
CO5	Prepare and present research reports while adhering to academic integrity and proper citation practices.	[E]

TEXT BOOKS

1. John W. Creswell, "Designing and Conducting Mixed Methods Research", 2nd Edition, SAGE Publications, 2010.
2. Ranjit Kumar, " Cite Them Right: The Essential Referencing Guide", 4th Edition, SAGE Publications, 2024.
3. Deborah E. Bouchoux, “Introduction to Intellectual Property Rights", 4th Edition, Delmar Cengage Learning, 2012.

REFERENCE BOOKS

1. Shirley Dowdy et al., “Statistics for Research", 3rd Edition, Wiley, 2004
2. Richard Pears & Graham Shields, "Research Methodology: A Step-by-Step Guide for Beginners", Palgrave Macmillan, 2010

WEB RESOURCES

1. https://www.openlearning.com/courses/SPPP3042x
2. https://www.goodreads.com/book/show/761696.Research_Methodology
3. https://www.goodreads.com/book/show/761695.Research_Methodology

25MEC03 SDG NO. 4, 9, 11, 12	DESIGN THINKING AND IDEA LABORATORY (Common to All Branches)	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES

1. To choose appropriate data structure, understand the ADT / Libraries and design algorithms for a specific problem
2. To dramatize with advanced paradigms and data structure to solve algorithmic problems
3. To relate the concept of operating system to distributed operating systems
4. To identify the components and management aspects of Real time operating systems

LIST OF EXPERIMENTS FOR DATA STRUCTURES:

1. Implementation of Linked List using Templates.
2. Implementation of Hash Tables.
3. Implementation of Red Black Trees.
4. Implementation of Randomly built Binary Search tree.
5. Implementation of Divide and Conquer algorithm for Maximum sub-array problem and Strassen's algorithm for matrix multiplication.
6. Implementation of B-Trees.
7. Implementation of Fast Fourier Transform application.
8. Implementation of Dynamic Programming for Matrix-chain multiplication and Optimal Binary Search Tree.
9. Implementation of Greedy algorithm for Topological sort and Minimum Spanning Tree.
10. Implementation of Shortest path for Source Shortest Paths and All-Pairs Shortest Paths.

LIST OF EXPERIMENTS FOR OPERATING SYSTEMS:

1. Simulation and Analysis of Non Pre emptive and Pre emptive CPU Scheduling Algorithms.
2. Simulation of Producer – Consumer Problem using Semaphores.
3. Implementation of Dining Philosopher's Problem to demonstrate Process Synchronization.
4. Simulation of Banker's Algorithm for Deadlock Avoidance.
5. Analysis and Simulation of Memory Allocation and Management Techniques.
6. Designing a RMI lottery application in distributed operating systems.
7. Designing a RPC lottery application in distributed operating systems.
8. Designing a CORBA lottery application in distributed operating systems.

9. Implementing an alarm clock in real time operating systems.
10. Design an efficient Traffic Control System to avoid traffic congestion in Metro Cities.

TOTAL PERIODS: 60

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Demonstrate the concepts of Linked list and hashing technique	[AP]
CO2	Develop algorithms for red-black trees and B-trees.	[AP]
CO3	Apply suitable design strategy for solving problems.	[AP]
CO4	Relate the concepts of operating systems to distributed operating systems.	[AP]
CO5	Design an application for real time operating systems	[AP]

TEXT BOOKS

1. T.H. Cormen, C.E. Leiserson,R.L. Rivest and C. Stein, " Introduction to Algorithms", Prentice Hall of India ,3rd Edition ,2012.
2. Mark Allen Weiss, Data Structures and Algorithms in C++, Pearson Education,3rd Edition, 2009.
3. Singhal, Mukesh & N.G. Shivaratri, Advanced Concepts in Operating Systems, Tata McGraw-Hill, 1st Edition, 2008.
4. Abraham Silberschatz, Peter B.Galvin , Greg Gagne, “Operating System Concepts” 10th Editon, Wiley,2018.

REFERENCE BOOKS

1. S.Sridhar, “Design and Analysis of Algorithms”, Oxford University Press, 1st Edition 2014.
2. Adam Drozdex, Data Structures and algorithms in C++, Cengage Learning, 4th Edition, 2012.
3. Daniel P Bovet and Marco Cesati, “Understanding the Linux kernel”, 3rd Edition, O’Reilly,2005.
4. S. Tanenbaum, “Distributed Operating Systems”, Pearson Education,1st Edition,2016.

WEB REFERENCES

1. http://cs-fundamentals.com/data-structures/data-structures-tutorials.php
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-851-advanced-data-structures-spring-2012/index.htm

SEMESTER – II

25PF201 SDG NO. 4,9,17	ADVANCED COMPUTER ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce advanced concepts in processor organization, instruction set design and quantitative performance metrics of modern computer systems.
2. To enable students to identify and exploit instruction-level parallelism using pipelining, superscalar and out-of-order execution techniques.
3. To provide an in-depth understanding of memory hierarchy design, cache optimization, virtual memory and storage subsystems.
4. To expose students to multicore, manycore, GPU and heterogeneous architectures used for high-performance and parallel computing.
5. To develop the ability to reason about power, energy-efficiency, reliability and emerging domain-specific architectures in contemporary systems.

ADVANCED COMPUTER ARCHITECTURE FUNDAMENTALS AND PERFORMANCE 9

Review of computer architecture vs. organization – Evolution of processor architectures – Technology trends and limitations (frequency, power, memory wall) – **Performance metrics**: execution time, CPI, MIPS, MFLOPS, throughput – Amdahl's law and Gustafson's law – Basic pipelining concepts, hazards and their impact on performance – Quantitative principles of computer design (workload characterization, benchmarking, cost–performance–power trade-offs).

INSTRUCTION SET DESIGN, PIPELINING AND INSTRUCTION-LEVEL PARALLELISM 9

Instruction set architectures (RISC, CISC, VLIW) – RISC-V overview and its relevance to modern architecture – **Advanced pipelining**: pipeline depth, structural, data and control hazards – Dynamic scheduling, Tomasulo's algorithm, register renaming – Out-of-order execution and reorder buffer – Branch prediction techniques (static and dynamic, two-level predictors, BTB) – Speculative execution and recovery – VLIW and EPIC architectures – Compiler support for ILP (loop unrolling, software pipelining).

MEMORY HIERARCHY AND STORAGE SYSTEMS 9

Principles of locality and memory hierarchy – Advanced cache organizations (set associativity, write policies, replacement policies) – multi-level caches (L1/L2/L3) and inclusive/exclusive policies – Cache performance metrics and optimization – **Virtual memory**: paging, segmentation, TLB design and performance – DRAM organization and timing, DDR generations – Non-volatile memories and emerging memory technologies – **I/O and storage subsystems:** disk arrays, SSDs, performance considerations.

MULTICORE, MANYCORE AND PARALLEL ARCHITECTURES 9

Symmetric multiprocessors (SMP) and chip multiprocessors (CMP) – Shared memory vs. distributed memory – Cache coherence protocols (snoopy and directory-based) – Memory consistency models (sequential consistency, relaxed models) – Interconnection networks (topologies, routing, flow control) – Manycore architectures and network-on-chip (NoC) – **GPU architecture**: SIMT model, streaming multiprocessors, memory hierarchy in GPUs – Overview

of GPGPU programming concepts (CUDA/OpenCL models, no detailed coding) – Heterogeneous computing and accelerator-based systems.

POWER, RELIABILITY AND EMERGING ARCHITECTURES **9**

Power and energy in modern processors: dynamic and static power – Techniques for low-power and energy-efficient design (clock gating, power gating, DVFS) – Thermal considerations and packaging – Reliability challenges (soft errors, wear-out, process variation) and fault-tolerant architectures – Hardware support for security (basic overview of side-channel and speculation-related threats) – Data center and warehouse-scale computer architectures – Domain-specific accelerators (e.g., machine learning accelerators, TPUs) – Reconfigurable architectures (FPGAs) – Case studies of recent commercial processors and accelerator architectures.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply computer architecture principles to analyze, optimize, and predict the performance of computing systems.	[AP]
CO2	Analyse pipelining, instruction-level parallelism, superscalar and out-of-order execution techniques used in modern processors.	[AN]
CO3	Demonstrate principles of memory hierarchy and storage subsystem design to improve performance for given workloads.	[AP]
CO4	Examine multicore, manycore, GPU and heterogeneous architectures for different classes of applications.	[AN]
CO5	Practice with appropriate architectural techniques and configuration choices to address constraints on performance, power, scalability and reliability in given application scenarios.	[AP]

TEXT BOOKS

1. John L. Hennessy, David A. Patterson, “Computer Architecture: A Quantitative Approach”, 6th Edition, Morgan Kaufmann (Elsevier), 2019
2. Michel Dubois, Murali Annavaram, Per Stenström, “Parallel Computer Organization and Design”, 2nd Edition, Cambridge University Press, 2023.
3. Sarah L. Harris, David Money Harris, “Digital Design and Computer Architecture, RISC-V Edition”, Morgan Kaufmann, 2021.

REFERENCE BOOKS

1. John Paul Shen, Mikko H. Lipasti, “Modern Processor Design: Fundamentals of Superscalar Processors”, 2nd Edition, Waveland Press, 2013.
2. David A. Patterson & John L. Hennessy, "Computer Organization and Design: The Hardware/Software Interface, RISC-V Edition", 2nd Edition, Morgan Kaufmann (Elsevier), 2020.
3. Linda Null & Julia Lobur, "The Essentials of Computer Organization and Architecture", 6th Edition, Jones & Bartlett, 2024.

WEB RESOURCES

1. https://ocw.mit.edu/courses/6-823-computer-system-architecture-fall-2005/pages/lecture-notes/
2. https://csg.csail.mit.edu/6.5900/Lectures/L01.pdf

25PF202 SDG NO. 4,8,9	DATABASE PRACTICES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES

1. To provide advanced knowledge of relational databases, SQL optimization, indexing, and query processing.
2. To introduce distributed, parallel, NoSQL and emerging data models for large-scale data management.
3. To equip students with skills in database administration, security, backup/restore, performance tuning.
4. To develop hands-on expertise in modern data platforms such as MongoDB, Neo4j, Cassandra and PostgreSQL.
5. To enable students to design and implement real-world database solutions through industry-oriented lab exercises.

ADVANCED RELATIONAL DATABASES **6**

Relational Foundations – Advanced SQL (Window Functions, CUBE/ROLLUP, CTEs, and Recursive Queries) – Query Processing – Query Optimization – Indexing Techniques (B-Tree, Hash, and Bitmap).

PARALLEL & DISTRIBUTED DATABASES **6**

Distributed DBMS Architecture – Fragmentation & Replication – Distributed Query Processing – Concurrency Control – Two-Phase Commit Protocol – Parallel Databases & Shared Architectures.

NOSQL DATABASES & BIG DATA STORAGE **6**

NoSQL Models: Key-Value, Document, Columnar, Graph – CAP Theorem & BASE – MongoDB Data Model, CRUD, Aggregation – Cassandra/HBase Basics – Replication & Partitioning Strategies.

ADVANCED DATA MODELING & EMERGING TRENDS **6**

ER/EER Modeling – Object-Relational Databases – Temporal, Spatial & In-Memory Databases – Graph Databases (Neo4j, Cypher Queries) – Cloud Databases (AWS RDS, Azure SQL).

DATABASE SECURITY & ADMINISTRATION **6**

DB Security Concepts – Authentication, Authorization, Roles, Privileges – SQL Injection Prevention – Backup & Recovery Mechanisms – Performance Tuning – Query Plan Analysis.

TOTAL: 30 PERIODS

LAB EXERCISES:

1. Implementation of Advanced SQL Queries
   Joins, subqueries, window functions, CTEs, grouping sets.
2. Implementation of Stored Procedures, Functions, and Triggers
   PL/SQL or PL/pgSQL procedures, UDFs, BEFORE/AFTER triggers.
3. Implementation of Query Optimization and Indexing
   EXPLAIN/ANALYZE, B-Tree, Hash, Bitmap indexes, performance tuning.
4. Implementation of CRUD Operations in MongoDB
   Document modeling, insert/update/delete/find operations.
5. Implementation of Aggregation Pipeline in MongoDB
   Match, group, project, lookup, unwind operations.
6. Implementation of Data Modeling and Query Execution in Cassandra
   Keyspaces, partition keys, clustering columns, CQL queries.
7. Implementation of Graph Data Modeling and Cypher Queries in Neo4j
   Create nodes/relationships, pattern matching, shortest path queries.
8. Implementation of Database Security and Access Control
   User creation, roles, privileges, SQL injection prevention.
9. Implementation of Backup, Recovery, and Administrative Operations
   Logical/physical backup, restore, WAL concepts, user management.
10. Implementation of a Mini Project Using SQL + NoSQL
    End-to-end data model design, CRUD operations, indexing, security, backups.

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Demonstrate the use of advanced SQL features, indexing strategies, and query optimization techniques for effective data retrieval.	[AP]
CO2	Examine distributed and parallel database architectures to understand their scalability and performance characteristics.	[AN]
CO3	Implement appropriate NoSQL data models based on application requirements and data characteristics.	[AP]
CO4	Differentiate various database security, transaction management, and administrative techniques to ensure data consistency and protection.	[AN]
CO5	Utilize modern database tools and technologies to build practical database-driven applications.	[AP]

TEXT BOOKS

1. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, *"Database System Concepts"*, 7th Edition, McGraw-Hill, 2019.
2. Ramez Elmasri and Shamkant B. Navathe, *"Fundamentals of Database Systems"*, 7th Edition, Pearson Education, 2016.
3. Kristina Chodorow, "MongoDB: The Definitive Guide: Powerful and Scalable Data Storage", 3rd Edition, O'Reilly Media, 2020.

REFERENCE BOOKS

1. Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems", 3rd Edition, McGraw-Hill, 2003.
2. Ian Robinson, Jim Webber and Emil Eifrem, "Graph Databases: New Opportunities for Connected Data", 2nd Edition, O'Reilly Media, 2015.

WEB RESOURCES

1. https://ocw.mit.edu/courses/6-830-database-systems-fall-2010/pages/lecture-notes/
2. https://learn.mongodb.com/
3. https://hrus.in/ocw/CMU15445/

PROFESSIONAL ELECTIVES

25PF501 SDG NO. 7,9,11	DEEP LEARNING ARCHITECTURES AND APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To explain the fundamental concepts and mathematical foundations of neural networks and deep learning.
2. To discuss major deep network architectures such as CNNs, RNNs, LSTMs, GANs, and Transformers.
3. To examine core concepts in deep architecture tuning, including optimization, regularization, and hyperparameter selection.
4. To demonstrate practical applications of deep learning in domains such as computer vision, NLP, and speech processing.
5. To develop the ability to design, implement, and evaluate deep learning models using modern frameworks and tools.

FOUNDATIONS OF NEURAL NETWORKS **9**

Introduction to Neural Networks - Biological vs. Artificial Neurons - Neural Network Architecture & Components - Activation Functions (ReLU, Sigmoid, Tanh, etc.) - Loss Functions (MSE, Cross-Entropy, etc.) - Forward Propagation – Back Propagation Algorithm -Gradient Descent & Optimization Basics – Hyperparameters (learning rate, batch size, epochs) Overfitting & Underfitting Concepts. Neural Network components and architecture - Training Neural Networks - Activation Functions - Loss Functions.

FUNDAMENTALS OF DEEP LEARNING **9**

Key Concepts of Deep Learning - Difference Between Machine Learning & Deep Learning - Deep Neural Networks (DNN) Structure - Building Blocks of Deep Networks Universal Approximation Theorem - Vanishing & Exploding Gradient Problems -Regularization in Deep Learning- Initialization Techniques - Common Architectural Principles of Deep Networks - Optimization Techniques (Adam, RMSProp) - Batch normalization & layer normalization.

DEEP NETWORK ARCHITECTURES **9**

Convolutional Neural Networks (CNNs) - CNN Layers (Convolution, Pooling, Fully Connected) - Recurrent Neural Networks (RNNs) - LSTM Networks - GRU Networks -Recursive Neural Networks - Autoencoders & Sparse Autoencoders - Unsupervised Pre-Trained Networks - Restricted Boltzmann Machines (RBMs) - Deep Belief Networks (DBNs).

TUNING & OPTIMIZING DEEP ARCHITECTURES **9**

Tuning Deep Neural Networks - Hyperparameter Optimization Strategies - Batch Normalization & Layer Normalization - Data Augmentation Techniques - Tuning CNN Architectures - Tuning RNN Architectures - Training Efficiency (GPU acceleration, Parallelism) - Transfer Learning Principles -Fine-tuning Pretrained Models (VGG, ResNet) - Model Evaluation Metrics (Accuracy, F1, RMSE).

APPLICATIONS & CASE STUDIES **9**

Computer Vision Applications - Speech Recognition Applications - Natural Language Processing (NLP) - Recommender Systems - Healthcare Applications of Deep Learning - Deep Learning Tools (TensorFlow, PyTorch, Keras) - Real-World Case Study: Image-based Diagnosis - Real-World Case Study: NLP-based Chatbots - Ethics & Challenges in Deep Learning Deployment.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Design and configure neural network architectures by selecting appropriate components and hyperparameters to optimize model performance.	[AP]
CO2	Analyze, and optimize deep neural network architectures to address gradient problems and enhance model performance across diverse learning scenarios.	[AN]
CO3	Design and implement deep neural network models for classification, sequence modeling, and representation learning.	[AP]
CO4	Optimize and tune deep learning models using regularization, hyperparameter tuning, normalization, and advanced optimization strategies.	[AN]
CO5	Apply deep learning techniques to solve real-world problems in computer vision, NLP, speech recognition, and healthcare.	[AP]

TEXT BOOKS

1. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow", 3rd Edition, O'Reilly Media, 2022.
2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep Learning", 1st Edition, MIT Press, 2016.
3. Charu C. Aggarwal, "Neural Networks and Deep Learning: A Textbook", 1st Edition, Springer, 2018.

REFERENCE BOOKS

1. François Chollet, "Deep Learning with Python", 2nd Edition, Manning Publications, 2021.
2. Michael Nielsen, "Neural Networks and Deep Learning", Online Book, 2019.

WEB REFERENCES

1. http://deeplearning.cs.cmu.edu/
2. http://deeplearning.net/
3. https://arxiv.org/pdf/1706.05098.pdf
4. https://cognitiveclass.ai/courses/deep-learning-tensorflow

		L	T	P	C
25PF502 SDG NO.3, 9, 11	COMPUTER VISION ANALYSIS	3	0	0	3

COURSE OBJECTIVES

1. To provide foundational understanding of image formation, vision geometry, and pixel-level analysis.
2. To develop analytical skills in feature extraction, segmentation, and texture/shapes in visual data.
3. To enable students to apply and evaluate deep-learning-based methods for visual understanding.
4. To introduce object detection, recognition, motion estimation, and tracking frameworks.
5. To familiarize students with modern research trends in computer vision, including transformers and medical imaging applications.

FOUNDATIONS OF COMPUTER VISION ANALYSIS **9**

Image formation – Radiometry – Pinhole camera model – Projection geometry – Camera calibration – Intrinsic and extrinsic parameters. Image sampling and quantization – Image noise models: Gaussian, Poisson, Speckle – Filtering operations: smoothing, sharpening – Fourier domain analysis – Gradients and edges.

FEATURE ANALYSIS AND IMAGE SEGMENTATION **9**

Edge, corner, and blob detection: Harris, FAST, LoG, DoG- Feature descriptors: SIFT, SURF, ORB, BRIEF- Feature matching – RANSAC – Homography Estimation-Texture analysis: LBP, Gabor filters, Haralick features- Segmentation: Thresholding, region growing, watershed, graph-based segmentation, active contours, level sets.

DEEP LEARNING FOR VISION ANALYSIS **9**

CNN architectures: VGG, ResNet, Inception, DenseNet – Convolution operations – Feature hierarchies. Transformer-based vision models (ViT): Patch embeddings, multi-head self-attention. Representation learning: Autoencoders, Variational Autoencoders, contrastive learning (SimCLR) - Generative models: GANs (DCGAN, StyleGAN, CycleGAN) – Diffusion Models (DDPM). Model interpretation: Saliency maps, Grad-CAM, attention visualization.

OBJECT, SHAPE AND MOTION ANALYSIS **9**

Object detection frameworks: R-CNN, Fast/Faster R-CNN, YOLO family, SSD – Anchor-based vs Anchor-free detection. Semantic and instance segmentation: FCN, U-Net, DeepLab, Mask R-CNN. Shape analysis: Shape descriptors, Hu moments, contour-based methods. Motion analysis: Optical flow (Lucas–Kanade, Horn–Schunck), background subtraction. Tracking: Kalman filter, Particle filter, SORT, DeepSORT.

APPLICATIONS & RESEARCH TRENDS IN COMPUTER VISION ANALYSIS 9

Medical imaging: MRI, CT processing – Preprocessing – Lesion/WMH segmentation – Alzheimer's detection using deep learning. Surveillance and video analytics: Event detection, anomaly detection, embedded vision-3D vision: Depth estimation, stereo vision, structure-from-motion-Modern CV trends: Vision transformers, SAM, multimodal models (CLIP), self-supervised learning (BYOL)-Evaluation metrics for vision analysis: IoU, Dice, mAP, FID, MOT metrics.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply camera models, calibration techniques, and basic image processing operations to analyze and enhance digital images for feature extraction.	[AP]
CO2	Analyze features, descriptors, segmentation techniques, and texture/shape information	[AN]
CO3	Develop deep-learning-based architectures for advanced visual understanding	[AP]
CO4	Examine object detection, segmentation, and motion-tracking algorithms	[AN]
CO5	Practice computer vision techniques to diverse applications and modern research trends	[AP]

TEXT BOOKS

1. Richard Szeliski, "Computer Vision: Algorithms and Applications", 2nd Edition, Springer, 2022.
2. David A. Forsyth & Jean Ponce, "Computer Vision: A Modern Approach", 2nd Edition, Pearson, 2012.

REFERENCE BOOKS

1. Ian Goodfellow, Yoshua Bengio & Aaron Courville, "Deep Learning", 1st Edition, MIT Press, 2016.
2. Rafael C. Gonzalez & Richard E. Woods, "Digital Image Processing", 4th Edition, Pearson, 2018.

WEB RESOURCES

1. https://nptel.ac.in/courses/106105216
2. https://learn.mit.edu/search?q=deep+learning&resource=3916
3. https://www.coursera.org/?cartId=589453438

25PF503 SDG NO. 9, 4	SERVICE ORIENTED ARCHITECTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To understand the fundamental concepts, principles, and motivation behind Service-Oriented Architecture (SOA).
2. To learn the techniques for identifying, designing, and modeling services using standard SOA methodologies.
3. To gain knowledge of SOA implementation technologies including SOAP, REST, WSDL, UDDI, and ESB.
4. To explore integration strategies, service orchestration, choreography, and governance mechanisms.
5. To apply SOA concepts to modern platforms such as microservices, cloud computing, and enterprise systems.

INTRODUCTION TO SOA **9**

Evolution of distributed computing – From object-oriented systems to service-oriented systems – Principles of service orientation: loose coupling, abstraction, autonomy, statelessness, reusability – Service standards: XML, SOAP, WSDL, UDDI – Service description and messaging – SOA reference architecture – Case studies from industry.

SERVICE DESIGN AND MODELING **9**

Service identification and classification – Service-oriented analysis and business process modeling – Service modeling: entity-centric, task-centric, and process-centric services – Service contracts and policies – Orchestration and choreography – WS-* standards: WS-Security, WS-Policy, WS-Coordination, WS-Transaction – SOA design patterns.

ENTERPRISE SERVICE BUS (ESB) & INTEGRATION **9**

ESB architecture – Message transformation, routing, mediation – Enterprise application integration (EAI) concepts – Event-driven architecture – Service versioning and deployment – SOA governance: SLA, policy management, monitoring – ESB tools: WSO2, Apache Synapse, Mule ESB.

SERVICE DEVELOPMENT & PLATFORM TECHNOLOGIES **9**

Developing SOAP-based web services – JAX-WS, WSDL generation – Developing RESTful web services – JAX-RS, JSON/XML serialization – SOA vs Microservices architecture – API gateway concepts – Service registry and discovery – Containerization and orchestration (Docker, Kubernetes) – SOA security: authentication, authorization, token-based access.

ADVANCED SOA & EMERGING TRENDS **9**

Service composition – BPEL – Business Process Management (BPM) integration – QoS in web services (performance, reliability, availability) – Transaction handling in SOA – SOA in cloud, IoT, big data platforms – Service computing research trends – Industrial case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply the principles, standards, and evolutionary motivations of Service-Oriented Architecture to differentiate it from traditional architectures in modern system design contexts.	[AP]
CO2	Model and design services using accepted service engineering techniques.	[AP]
CO3	Implement service-based systems using SOAP, REST, WSDL, UDDI, and supporting middleware.	[AP]
CO4	Apply ESB, orchestration, and governance techniques for enterprise-level integration.	[AP]
CO5	Evaluate and use advanced SOA concepts in cloud, IoT, and microservices environments.	[AN]

TEXT BOOKS

1. Thomas Erl, et al., "SOA with REST: Principles, Patterns & Constraints for Building Enterprise Solutions with REST", 1st Edition, Prentice Hall, 2012.
2. Thomas Erl, et al., "Microservice Architecture: Aligning Principles, Practices, and Culture", 1st Edition, O'Reilly Media, 2016.
3. Sam Newman, "Building Microservices: Designing Fine-Grained Systems", 2nd Edition, O'Reilly Media, 2021.

REFERENCE BOOKS

1. Irakli Nadareishvili, Ronnie Mitra, Matt McLarty, Mike Amundsen, "Microservice Architecture: Aligning Principles, Practices, and Culture", 1st Edition, O'Reilly Media, 2016.
2. Chris Richardson, "Microservices Patterns: With examples in Java", 1st Edition, Manning Publications, 2018.
3. Brendan Burns, "Designing Distributed Systems: Patterns and Paradigms for Scalable, Reliable Services", 1st Edition, O'Reilly, 2018.

WEB RESOURCES

1. https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=soa-rm
2. https://www.w3.org/TR/ws-arch/
3. https://developer.ibm.com/articles/soa-intro/

25PF504 SDG NO. 3,4,8,12	HUMAN COMPUTER INTERACTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To understand the fundamental principles of Interaction Design and evaluate how these principles influence effective product and system design.
2. To apply structured interactive design processes, usability engineering methods, and universal design principles in designing advanced HCI systems.
3. To critically analyze usability issues and design challenges in emerging environments such as groupware, ubiquitous computing, virtual reality, and web-based systems.
4. To examine and employ cognitive models for developing intuitive and efficient human–computer interfaces.
5. To design, prototype, and evaluate interactive systems using modern UI/UX tools, to address complex real-world user needs.

INTRODUCTION AND DESIGN OF AN INTERACTIVE SYSTEM **9**

HCI Paradigms- Usability of Interactive Systems- Principles and Theories- Design Process-Interaction design basics-HCI in the software process-Design rules, Implementation support-Evaluation techniques- Universal design- User support - Design Issues - Quality of Service-Balancing Function and Fashion- User Documentation and Online Help-Information Search-Information Visualization.

MODELS AND THEORIES **9**

Cognitive models- Socio-organizational issues and stakeholder requirements-Communication and collaboration models-Task analysis- Dialogue notations and design-Models of the system-Modelling rich interaction.

INTERACTION STYLES **9**

Interaction Styles – Direct Manipulation and Virtual Environments- Menu Selection- Form Filling and Dialog Boxes-Command and Natural Languages- Interaction Devices- Collaboration and Social Media Participation.

NEW INTERACTION TECHNIQUES **9**

New modes of human–computer communication – Voice, Gesture - Eye movement- Tangible user interfaces- Brain–computer interfaces - Virtual Reality, Speech Recognition and Translation, Multimodal Systems.

UI/UX TOOLS AND PROTOTYPING **9**

Introduction to modern UI/UX design environments- Digital prototyping concepts-Wire framing and mock-up development-Rapid UI design techniques- Overview and practical use of industry UI/UX tools – Rapid UI for interface layout creation-Sketch for vector-based design workflows-Figma - Balsamiq - conceptual design visualization.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO 1	Apply the concepts of human information processing in interactive system design.	[AP]
CO 2	Apply HCI design principles, standards, and guidelines to develop user-centered interface solutions.	[AP]
CO 3	Analyze user tasks, workflows, and dialog interactions using appropriate task analysis and dialog design techniques.	[AN]
CO 4	Apply suitable HCI methods and techniques to design systems that enhance usability and accessibility for diverse users.	[AP]
CO 5	Analyze usability issues in interactive systems across different environments.	[AN]

TEXT BOOKS

1. Alan Dix, Janet Finlay, G D Abowd, R Beale, “Human Computer Interaction”, Pearson Education, 4th Edition, Pearson, 2022.
2. Ben Shneiderman “Designing the User Interface - Strategies for Effective Human Computer Interaction”, 7th Edition (Global Edition), Pearson, 2023.
3. Jenny Preece, Helen Sharp, Yvonne Rogers, “Interaction Design: Beyond Human–Computer Interaction”, 6th Edition, Wiley, 2023.

REFERENCE BOOKS

1. Rosson, M. and Carroll, J “Usability Engineering: Scenario-Based Development of Human-Computer Interaction” , Morgan Kaufmann, 2002.
2. Alan Cooper, Robert Reimann, David Cronin, Christopher Noessel, "About Face: The Essentials of Interaction Design", 5th Edition, Wiley, 2023.
3. Jeff Gothelf & Josh Seiden, "Lean UX: Designing Great Products with Agile Teams", 4th Edition, O'Reilly, 2023.

WEB RESOURCES

1. https://www.oswego.edu/human-computer-interaction/human-computer-interaction-useful-links
2. https://www.interaction-design.org/courses/ui-design-patterns-for-successful-software
3. http://www.nixdell.com/classes/HCI-and-Design-Spring-2017/The-Design-of-Everyday-Things-Revised-and-Expanded-Edition.pdf

25PF505 SDG NO. 8,9,17	SOFTWARE PROJECT PLANNING & MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To explain the concepts and significance of software project management and lifecycle.
2. To develop effective strategies for planning, organizing, and managing software projects.
3. To identify product objectives and apply appropriate investigation strategies that support effective software project management."
4. To gain comprehensive knowledge of the roles, duties, and responsibilities of a software project manager.
5. To become familiar with various project management methods, tools, and techniques used in software development.

INTRODUCTION **9**

Defining of Software Development Process - Process - Tailoring the Process - Improving the process discipline - Need for implementing discipline. Software Production Process - Identify the Software Model - Software Process Models: Waterfall Model, Prototyping Model, RAD Model, Incremental Model, Spiral Model, Component Assembly Model - Software Life Cycle.

PROJECT PLANNING **9**

Software project planning: Introduction-Principles- Issues in Software project planning – Activities in Software project planning- Methods of Planning: Top-Down and Bottom-Up Planning - Types of Activity - Project Duration: Schedule Monitoring Tools - Gantt Chart, PERT Chart, Critical Path.

PROJECT REVIEW **9**

Tracking Meetings - Recovery plans - Schedule Work & Escalation Meetings. Project Engineering: Product Requirements - Understanding the Customer Problem to solve - Initial Investigation, Strategies for determining information requirements, Information gathering Tools - Product Objectives.

SYSTEM TESTING **9**

System Integration Techniques-Incremental, Top-Down Bottom-Up Sandwich and Big Bang, Software and Hardware Integration, Hardware Design Verification Tests, Hardware and Software Compatibility Matrix Test Plan for System Integration. Software reliability – Fault and Failure, Factors Influencing Software, Reliability Models, UI/UX based testing models.

SOFTWARE QUALITY **9**

Software quality – People 's Quality Expectations, Frameworks and ISO-9126, McCall 's Quality Factors and Criteria – Relationship. Quality Metrics. Quality Characteristics ISO 9000:2000 Software Quality Standard. Maturity models- Test Process Improvement, Testing Maturity Model. Case Study: FSM-Based Testing of Web-Based Applications, Role of AI in SQA.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply software development processes by selecting suitable software life-cycle models and Component Assembly for software project execution	[AP]
CO2	Analyze software project planning principles to evaluate and optimize project duration and scheduling effectiveness.	[AN]
CO3	Analyze project tracking and engineering processes to identify customer requirements and establish clear product objectives	[AN]
CO4	Apply system integration methods and reliability evaluation techniques to achieve efficient and dependable system performance	[AP]
CO5	Analyze software quality frameworks and standards, and assess their practical application in real-world contexts	[AN]

TEXT BOOKS

1. Daniel Galin, "Software Quality Assurance: From Theory to Implementation", 2nd Edition, Pearson Education, 2018
2. Kshirasagar Naik and Priyadarshi Tripathy, Software Testing and Quality Assurance: Theory and Practice, John Wiley & Sons Inc, 2008.

REFERENCE BOOKS

1. Jeff Tian, Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement, John Wiley & Sons, Hoboken, New Jersey, 2005.
2. Milind Limaye, Software Quality Assurance, Tata McGraw-Hill (TMH), New Delhi, 2011.

WEB RESOURCES

1. https://www.mountaingoatsoftware.com/articles
2. https://www.sei.cmu.edu/
3. https://www.projectmanagement.com/

25PF506 SDG NO.3,8,9	SOCIAL NETWORK ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. Introduce fundamental concepts, theories, and models used in Social Network Analysis.
2. Develop the ability to mathematically represent and analyse social structures using graphs.
3. Apply centrality, connectivity, and cohesion measures to real-world networks.
4. Train students to use computational tools for modelling, visualising, and interpreting social networks.
5. Enable students to analyse dynamic networks, community detection, and information diffusion.

INTRODUCTION TO SOCIAL NETWORK ANALYSIS *9*

Introduction to Semantic Web – Limitations of the current Web – Evolution and development of the Semantic Web – Emergence of the Social Web. **Foundations of Social Network Analysis** (SNA): Historical development, need for network-based perspectives, structural properties of social systems. Key concepts and measures in SNA: actors, ties, dyads, triads, network structure, density, reciprocity, transitivity. **Electronic sources for social network analysis:** electronic discussion forums, email networks, blogs, microblogging platforms, online communities. **Web-based social networks:** hyperlink networks, social media interaction networks, user-generated content networks- Applications-Organizational communication, knowledge systems, and digital behaviour modelling.

GRAPH-BASED REPRESENTATION *9*

Fundamentals of graph theory for network analysis – Node and edge properties – Directed and undirected networks – Weighted, multi-relational and bipartite networks. Centrality measures (degree, betweenness, closeness, eigenvector) – Clustering concepts – Cohesion and connectivity.

NETWORK VISUALIZATION *9*

Network representation techniques: Node–Edge diagrams, adjacency matrices, incidence matrices, Laplacian matrices. Visualizing online social networks: node-link diagrams, force-directed layouts, radial layouts. matrix-based visualization, hybrid visual representations, scalability issues in visualization. Applications of visualization: cover networks, collaboration networks, co-citation networks, community-level welfare mapping.

APPLICATIONS AND TOOLS FOR SOCIAL NETWORK ANALYSIS 9

SNA in social media analytics: Facebook, Twitter, LinkedIn networks – follower graphs, interaction graphs, content-sharing networks. Influence maximization models – information diffusion mechanisms – Independent Cascade Model – Linear Threshold Model – Rumour propagation and misinformation spread. Network visualization techniques for large-scale graphs. Tools and software platforms: Gephi, Pajek, NodeXL, UCINET, NetworkX (Python), SNAP, iGraph.

MODELLING IN SOCIAL NETWORKS **9**

Ontology and its role in the Semantic Web – Knowledge engineering principles. Ontology-based knowledge representation in social systems. Ontology languages: Resource Description Framework (RDF), RDF Schema (RDFS), Web Ontology Language (OWL). Semantic annotation of social network data – Modelling heterogeneous social actors – Representing dynamic relationships.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply fundamental concepts, theories, and models of Social Network Analysis using appropriate terminology to analyze and interpret real-world social networks.	[AP]
CO2	Construct and represent social structures mathematically using graph-theoretic models and analyze their properties.	[AP]
CO3	Demonstrate computational tools for modelling, visualising, and interpreting social network data.	[AP]
CO4	Use computational tools to model, visualize, and interpret social network datasets.	[AP]
CO5	Examine and evaluate dynamic networks, community detection algorithms, and information diffusion processes.	[AN]

TEXT BOOKS

1. Hansen, D., Shneiderman, B., & Smith, M. A., " Analyzing Social Media Networks with NodeXL: Insights from a Connected World", 2nd Edition, Morgan Kaufmann, 2020.
2. Easley, D., & Kleinberg, J., "Networks, Crowds, and Markets: Reasoning About a Highly Connected World", 1st Edition, Cambridge University Press, 2010.
3. Russell, M. A., & Klassen, M., "Mining the Social Web", 3rd Edition, O'Reilly Media, 2018.

REFERENCE BOOKS

1. Liyang Yu, "Introduction to the Semantic Web and Semantic Web Services", 1st Edition, Chapman & Hall/CRC, 2007.
2. Mohammed Zuhair Al-Taie & Seifedine Kadry, "Python for Graph and Network Analysis", 2nd Edition, Springer, 2022.

WEB RESOURCES

1. https://onlinecourses.nptel.ac.in/noc22_cs117/preview
2. https://www.coursera.org/learn/social-network-analysis
3. https://www.coursera.org/learn/social-economic-networks

25PF507 SDG NO. 4,9,10,17	SOCIAL AND INFORMATION NETWORKS	L	T	P	C
		3	0	0	3

Pre-requisites: Social Network Analysis

COURSE OBJECTIVES

1. To understand the key components and structural properties of social networks.
2. To model and visualize social networks using appropriate analytical tools.
3. To explain the role and significance of the Semantic Web in enhancing social network applications.
4. To familiarize students with security, trust, and privacy concepts in social networks.
5. To identify and explore various real-world applications of social networks.

INTRODUCTION TO SOCIAL NETWORK ANALYSIS **9**

Introduction to social network analysis Fundamental concepts in network analysis social network data notations for social network data Graphs and Matrices. Strategic network formation - network centrality measures: degree, betweenness, closeness, eigenvector - network centralization density reciprocity transitivity ego network measures for ego network - dyadic network triadic network - cliques - groups- clustering search.

COMMUNITY NETWORKS AND MODELS **9**

Community structure - modularity, overlapping communities - detecting communities in social networks – Discovering communities: methodology, applications - community measurement - evaluating communities – applications. Small world network - WattsStrogatz networks - Statistical Models for Social Networks Net- work evolution models: dynamical models, growing models - Nodal attribute model: exponential random graph models Preferential attachment - Power Law - random network model: Erdos-Renyi and Barabasi-AlbertEpidemics - Hybrid models of Network Formation.

SEMANTIC WEB **9**

Modelling and aggregating social network data developing social semantic application evaluation of web-based social network extraction Data Mining Text Mining in social network Tools case study.

VISUALIZATION **9**

Visualization of social networks novel visualizations and interactions for social networks applications of social network analysis tools - sna: R Tools for Social Network Analysis - Social Networks Visualiser (SocNetV) - Pajek.

SECURITY & APPLICATIONS **9**

Managing Trust in online social network Security and Privacy in online social network security requirement for social network in Web 2.0 - Say It with Colors: Language-Independent Gender

Classification on Twitter - Friends and Circles - TUCAN: Twitter User Centric ANalyzer.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply social network analysis concepts, notations, and measures to model, analyze, and interpret real-world relational data using graph and matrix representations.	[AP]
CO2	Analyze and evaluate community structures and network models such as small-world networks, scale-free networks, and random graphs.	[AN]
CO3	Apply semantic web technologies, data mining, and text mining techniques for modelling and extracting meaningful insights from social network data.	[AP]
CO4	Use and interpret various visualization tools (R SNA, SocNetV, Pajek) to represent, explore, and analyze complex social networks.	[AP]
CO5	Assess and address trust, security, and privacy issues in online social networks and apply analytical tools like TUCAN for real-world social network applications	[AN]

TEXT BOOKS

1. John Scott, "Social Network Analysis", 4th Edition, SAGE Publications, 2017.
2. John McLevey, John Scott, Peter J. Carrington (Editors), "The SAGE Handbook of Social Network Analysis", 2nd Edition, SAGE, 2023.
3. David Easley & Jon Kleinberg, "Networks, Crowds, and Markets: Reasoning About a Highly Connected World", Cambridge University Press, 2010.

REFERENCE BOOKS

1. Borko Furht, Handbook of Social Network Technologies and applications, Springer, 2010.
2. Jalal Kawash, *Online Social Media Analysis and Visualization*, (Lecture Notes in Social Networks), 2015.
3. Stanley Wasserman & Katherine Faust, *Social Network Analysis: Methods and Applications*, Revised Edition, Cambridge University Press, 1994.

WEB RESOURCES

1. https://onlinecourses.nptel.ac.in/noc22_cs117/preview
2. https://www.coursera.org/learn/social-network-analysis
3. https://www.coursera.org/learn/social-economic-networks

25PF508 SDG NO. 3,9,11,13	BIG DATA FRAMEWORKS AND TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To articulate the core concepts, challenges, and architectural paradigms of Big Data
2. To implement distributed data processing pipelines using the core components of the Apache Hadoop ecosystem
3. To Develop and optimize efficient data processing tasks using high-level frameworks, particularly Apache Spark.
4. To Manage and query large-scale, structured and semi-structured data using SQL-on-Hadoop technologies and NoSQL databases.
5. To Architect an end-to-end Big Data solution for a real-world scenario, integrating ingestion, processing, storage, and analysis components.

INTRODUCTION TO BIG DATA **9**

Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics – Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks – Big Data Analytics Applications

HADOOP FRAMEWORK **9**

Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop – Comparison with other system – Hadoop Components – Hadoop 1 vs Hadoop 2 – Hadoop Daemon's – HDFS Commands – Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining MapReduce jobs

HADOOP ECOSYSTEM AND SPARK FRAMEWORK **9**

Introduction to Hadoop ecosystem technologies – Serialization: AVRO – Co-ordination: Zookeeper – Databases: HBase, Hive – Scripting language: Pig – Streaming: Flink, Storm – Overview of Spark – Hadoop vs Spark – Cluster Design – Cluster Management – performance, Application Programming interface (API): Spark Context, Resilient Distributed Datasets, Creating RDD, RDD Operations, Saving RDD - Lazy Operation – Spark Jobs

DATA ANALYSIS WITH SPARK SHELL, SQL AND GRAPHX **9**

Writing Spark Application - Spark Programming in Scala, Python, R, Java - Application Execution – SQL Context – Importing and Saving data – Data frames – using SQL – GraphX overview – Creating Graph – Graph Algorithms

LARGE SCALE MACHINE LEARNING WITH PYSPARK **9**

Basic Statistics – Data Sources – Pipelines – Extracting – Transforming and selecting features – Classification and Regression – Clustering – Collaborative Filtering – Frequent Pattern Mining – Model selection and tuning

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Analyze the fundamental concepts, challenges, and architectural requirements of Big Data and justify the need for distributed frameworks	[AN]
CO2	Design and implement distributed data storage and batch processing solutions using the core components of the Hadoop framework	[AP]
CO3	Evaluate and utilize various components of the Hadoop ecosystem and the Spark framework for specific data management tasks.	[E]
CO4	Develop scalable data analysis applications using Spark's APIs for structured data processing and graph analytics across multiple programming languages.	[AP]
CO5	Build end-to-end, large-scale Machine Learning pipelines for classification, regression, clustering, and pattern mining using PySpark's MLlib library.	[AP]

TEXT BOOKS

1. Tom White, "Hadoop: The Definitive Guide", 4th Edition, O"Reilly Media, 2015.
2. Perrin, J, “Spark in action”, 2nd Edition, Manning Publications, 2020.
3. Sridhar Alla & Suman Karumuri, "Essential PySpark for Scalable Data Analytics: A beginner's guide to harnessing the power and ease of PySpark 3", Packt Publishing, 2021.

REFERENCE BOOKS

1. Mohammed Guller, “Big Data Analytics with Spark”, 1st Edition, Apress, 2015.
2. Nick Pentreath, “Machine Learning with Spark”, 2nd Edition, Packt Publishing, 2017.

WEB RESOURCES

1. https://nptel.ac.in/courses/106104189
2. https://www.geeksforgeeks.org/blogs/big-data-frameworks/
3. https://www.xenonstack.com/blog/big-data-tools

25PF509 SDG NO. 9,11,17	DATA ENGINEERING & VISUALIZATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To explain the foundational concepts of Data Engineering, including data pipelines, SQL operations, and database fundamentals, and illustrate their role in modern data ecosystems.
2. To apply data ingestion, modeling, and quality validation techniques to design structured data stores.
3. To develop end-to-end data transformation workflows using ETL/ELT principles and construct visual analytics dashboards and streaming pipelines for real-world data engineering solutions.
4. To understand the foundational principles of data visualization
5. To explore advanced visual analytics and multivariate visualization methods, using modern visualization tools.

FOUNDATIONS OF DATA ENGINEERING **9**

Definition and scope of Data Engineering – Importance of data (“Data is the New Oil”) – Overview of end-to-end data engineering pipelines – Introduction to semester project – Basics of PostgreSQL and psql – SQL review (DDL, DML, Joins, Outer Joins) – Advanced SQL (Subqueries, CTEs, Window functions) – Introduction to Data Pipelines and sample project walkthrough.

DATA INGESTION, QUALITY & MODELING **9**

Source systems and data extraction – Data Lake, Data Warehouse, Data Lakehouse concepts – Batch vs Streaming ingestion – Bulk load using COPY command – Data quality issues in source systems – Rule-based and statistical validation – Data modeling fundamentals – Normalization – Dimensional modeling (Star & Snowflake) – Creating schemas and schema migration for warehouse design.

DATA TRANSFORMATION, VISUALIZATION & MODERN TRENDS **9**

Building the Data Warehouse – ETL/ELT and transforming source data into dimensional models – Creating data marts and data products – Business Intelligence tools and introduction to Superset – Visualization design and dashboard building – Data governance (data catalogs, metadata, lineage) – DataOps and observability – Modern trends: Data Mesh, CDC/Streaming/Event processing, Reverse ETL.

FOUNDATIONS OF DATA VISUALIZATION & TECHNIQUES **9**

Overview of data visualization – Data abstraction and task abstraction – Dimensions and measures – Four levels of analysis and validation – Statistical charts: bar chart, stacked bar chart, line chart, histogram, pie chart, frequency polygon, box plot, scatter plot, regression curves – Visualization tools overview – Scalar, point, vector and multidimensional visualization techniques – Cluster visualization: K-means and hierarchical clustering – Time series visualization – Text data visualization – Spatial data visualization

ADVANCED VISUAL ANALYTICS, MULTIVARIATE VISUALIZATION & DASHBOARDS 9

Visual analytics: networks, trees, heat maps, tree maps – Manipulating views using map color and other visual channels – Visual attributes – Multivariate visualization: geometric projection, icon-based, pixel-oriented and hierarchical techniques – Scatterplot matrix, hyperbox, trellis display, parallel coordinates – Tableau basics: marks, channels, arranging tables, facets, spatial data – Dashboard concepts: taxonomies, user interaction, organizational functions, dashboard design – Worksheets, workbooks, optimization, protection – Domain use cases in finance, marketing, insurance and healthcare

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply core Data Engineering concepts, including designing data pipelines, performing SQL operations, and organizing database structures to solve practical data processing tasks.	[AP]
CO2	Utilize data ingestion, modeling, and quality validation techniques to construct structured data repositories and differentiate schema design strategies for effective data management.	[AP]
CO3	Design comprehensive ETL/ELT-driven data transformation workflows and develop visual analytics dashboards.	[AP]
CO4	Select and design effective visualizations by applying foundational principles of data and task abstraction	[AN]
CO5	Examine advanced visual analytics and multivariate visualization techniques and produce interactive dashboards	[AN]

TEXT BOOKS

1. Andy Kirk, "Data Visualization: A Handbook for Data Driven Design", 2nd Edition, SAGE Publications, 2019.
2. Claus O. Wilke, "Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures", 1st Edition, O'Reilly Media, 2019.
3. Tamara Munzner, "Visualization Analysis and Design", 1st Edition, A K Peters/CRC Press, 2014.

REFERENCE BOOKS

1. Bill Franks, "97 Things Every Data Engineer Should Know: Collective Wisdom from the Experts", 1st Edition, O'Reilly Media, 2021.
2. Ben Fry, "Visualizing Data: Exploring and Explaining Data with the Processing Environment", 1st Edition, O'Reilly Media, 2007.

WEB RESOURCES

1. https://www.datacamp.com/tutorial/introduction-to-data-pipelines-for-data-professionals
2. https://www.tableau.com/visualization/what-is-data-visualization
3. https://www.data.org/resources/introduction-to-data-visualization-for-the-web/

25PF510 SDG NO. 7,9,11	ADVANCED STORAGE AREA NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To identify and describe the basic components of storage systems
2. To explain the architecture and operation of intelligent disk subsystems, and describe their role in improving storage performance and availability.
3. To differentiate between SAN and NAS architectures, describe Fibre Channel and IP storage protocols
4. To define storage virtualization concepts, identify implementation approaches at different levels
5. To list and describe the hardware and software components of a Storage Area Network

INTRODUCTION TO STORAGE TECHNOLOGY **9**

Information storage - Evolution of storage technology and architecture – Data centre infrastructure - Key challenges in Managing information – Information lifecycle - Storage system Environments - Components of storage system environment - Disk Drive component - Disk Drive Performance – Fundamental laws governing disk performance - Logical components of the host –Application requirements and disk performance.

INTELLIGENT DISK SUBSYSTEMS **9**

Architecture of Intelligent Disk Subsystems - Hard disks and Internal I/O Channels – JBOD – Storage virtualization using RAID and different RAID levels - Caching - Acceleration of Hard Disk Access - Intelligent disk subsystems - Availability of disk subsystems - The Physical I/O path from the CPU to the Storage System - SCSI.

NETWORK ATTACHED STORAGE & FILE SYSTEM **9**

Fiber Channel Protocol Stack - Fiber Channel SAN - IP Storage - The NAS Architecture - The NAS hardware Architecture - The NAS Software Architecture - Network connectivity - NAS as a storage system - Local File Systems - Network file Systems and file servers - Shared Disk file systems - Comparison of Fiber Channel and NAS.

STORAGE VIRTUALIZATION **9**

Definition of Storage virtualization - Implementation Considerations – Storage virtualization on Block or file level - Storage virtualization on various levels of the storage Network - Symmetric and Asymmetric storage virtualization in the Network

SAN HARDWARE DEVICES & SOFTWARE COMPONENTS OF SAN **9**

Overview - Creating a Network for storage - SAN Hardware devices - The Fiber channel switch - Host Bus adapters - Putting the storage in SAN – Fabric operation from a Hardware perspective – The switch's Operating system - Device Drivers - The Supporting the switch's components – Configuration options for SANs - Planning for business continuity.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student should be able to

CO1	Apply the principles of information storage, disk drive architecture, and performance laws to design storage system environments that meet specific application and data centre requirements.	[AP]
CO2	Examine and interpret various SAN technologies.	[AP]
CO3	Apply the techniques used for data maintenance and realize storage virtualization concept.	[AP]
CO4	Classify the applications as per their requirements and select relevant SAN solutions.	[AP]
CO5	Analyze different SAN management strategies to fulfil business continuity requirements.	[AN]

TEXT BOOKS

1. Ulf Troppens, Rainer Erkens, Wolfgang Müller, et al., "Storage Networks Explained: Basic and Applications of Fibre Channel SAN, NAS, iSCSI, InfiniBand and FCoE", 2nd Edition, Wiley, 2009.
2. Robert Spalding, “Storage Networks: The Complete Reference”, Reprint, Tata McGraw Hill, 2017
3. Richard Barker and Paul Massiglia, “Storage Area Network Essentials: A Complete Guide to understanding and Implementing SANs”, John Wiley India, 2002.

REFERENCE BOOKS

1. Marc Farley, “Storage Networking Fundamentals”, Cisco Press, 2005.
2. Vaishali Khairnar, Nilima Dongre, “Storage Network Management and Retrieval,” Wiley, India, 2015.
3. Jon Tate, Pall Beck, Hector Hugo Ibarra, Shanmuganathan Kumaravel and Libor Miklas, “Introduction to Storage Area Networks”, Ninth Edition, IBM, 2017.

WEB REFERENCES:

1. https://nptel.ac.in/courses/106108058/
2. https://www.snia.org/education/storage_networking_primer/san/what_san
3. https://www.youtube.com/watch?v=99KCv25x2YU
4. https://digimat.in/nptel/courses/video/121106007/121106007.html

25PF511 SDG NO. 3,9,11	IMAGE PROCESSING AND ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To understand the fundamentals of digital image formation, sampling, quantization, and imaging models.
2. To analyze image enhancement, restoration, transformation, segmentation, and morphological operations.
3. To Apply feature extraction, texture/shape analysis, and image classification techniques to practical datasets.
4. To Examine machine-learning and deep-learning methods used in image analysis, segmentation, and recognition.
5. To Develop appropriate image-processing workflows for applications such as biomedical imaging, remote sensing, and industrial inspection.

IMAGE FORMATION, REPRESENTATION AND TRANSFORM TECHNIQUES 9

Image formation – light, sensors, and imaging systems – digital image representation – sampling & quantization – colour models (RGB, HSV, YCbCr) – image histograms – image noise models (Gaussian, Poisson, Speckle) – image quality metrics (PSNR, SSIM). 2D Fourier transform – DCT – DWT – Hadamard/KLT transforms – convolution, correlation – spatial & frequency domain filtering – smoothing and sharpening filters.

IMAGE ENHANCEMENT, RESTORATION AND FILTERING 9

Spatial-domain enhancement: point processing, contrast stretching, histogram equalisation, adaptive histogram equalisation–Frequency-domain enhancement: high/low-pass filtering, homomorphic filtering-Image degradation models – motion blur, atmospheric blur – inverse filtering, Wiener filtering – regularisation-based restoration – geometric transformations – image registration.

IMAGE SEGMENTATION AND MORPHOLOGICAL PROCESSING 9

Thresholding (global, Otsu, adaptive), region growing, split-and-merge, clustering (K-means)–Edge-based segmentation (Sobel, Canny, Laplacian, LoG)-Watershed segmentation – graph-based segmentation – active contours (snakes) – level sets-Morphological operations: erosion, dilation, opening, closing – morphological gradients – skeletonization – shape descriptors.

FEATURE EXTRACTION, IMAGE ANALYSIS AND CLASSIFICATION 9

Image descriptors: statistical moments, Haralick texture features, LBP, Gabor Filters-Shape features: contours, Fourier descriptors, HOG-Dimensionality reduction:PCA, LDA-Classification: k-NN, SVM, decision trees, Bayesian classifiers – introduction to deep learning for image classification (CNN basics)-Object recognition pipeline – template matching – bag-of-features.

IMAGE COMPRESSION, APPLICATIONS AND EMERGING TRENDS **9**

Lossless compression: RLE, Huffman, arithmetic coding-Lossy compression: transform coding, quantisation, bit allocation –JPEG, JPEG-2000-Video coding basics: MPEG framework-Applications: biomedical image analysis, remote sensing, industrial inspection, surveillance–Recent trends: deep learning-based segmentation (U-Net), attention-based models, transformer architectures, multimodal models (CLIP), diffusion models for image generation–Evaluation metrics: MSE, PSNR, SSIM, Dice, IoU, mAP.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply principles of image formation, sampling techniques, and digital transforms to implement and analyze fundamental image processing operations.	[AP]
CO2	Analyze enhancement, restoration, segmentation, and morphological methods	[AN]
CO3	Apply feature extraction, texture/shape analysis, and classification techniques	[AP]
CO4	Evaluate image compression methods and modern analytical frameworks	[E]
CO5	Apply image processing and analysis methods in real-world and advanced research applications	[AP]

TEXT BOOKS

1. Rafael C. Gonzalez & Richard E. *Woods, Digital Image Processing*, 4th Edition, Pearson, 2018.
2. Scott E. Umbaugh, *Digital Image Processing and Analysis: Applications with MATLAB and CVIP Tools*, 4th Edition, CRC Press, 2023.

REFERENCE BOOKS

1. Bernd Jähne, *Digital Image Processing and Image Acquisition*, 7th Edition, Springer, 2022.
2. S. Sasi Kumar & A. Ravichandran, *Digital Image Processing and Machine Vision*, Wiley, 2023.

WEB RESOURCES

1. https://nptel.ac.in/courses/106105216
2. https://ocw.mit.edu
3. https://scikit-image.org
4. https://opencv.org

25PF512 SDG NO. 3,4,9	WIRELESS NETWORKS & MOBILE COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To understand the fundamental principles of cellular network architecture, including frequency reuse, access protocols, location management, and handoff management.
2. To articulate IEEE 802.11 standards (Wi-Fi 4/5/6) and related access mechanisms.
3. To analyze real-world applications that use context and location information securely and efficiently.
4. To infer the fundamentals of Low Earth Orbit (LEO) satellite networks including architecture, orbits, and communication principles
5. To explore Mobile IP, RFID, and Wireless Sensor Networks (WSNs) and their use in mobile computing ecosystems.

CELLULAR NETWORKS AND 5G **9**

Frequency Reuse - Access Protocols - Location Management - Handoff Management - Cellular Network Standards (2G/3G/4G/5G) - Key Features and Advancements in 5G (e.g., enhanced mobile broadband - ultra-reliable low-latency communication - massive IoT connectivity)

WIRELESS LAN, PAN AND BLUETOOTH **9**

Overview of IEEE 802.11 Standards (Wi-Fi 4/5/6) - Access Protocols - Mobility Management - Advances in High-Efficiency WLANs - Overview of Bluetooth Standards - Piconet and Scatternet – Frequency Hopping - Baseband Protocol - Link Manager Protocol - Logical Link Control and Adaptation Protocol - Bluetooth Low Energy (BLE)

SECURITY AND LOCATION-AWARE COMPUTING **9**

Security in Cellular Networks (including 5G), Wi-Fi Security, Bluetooth Security - Security Challenges in Satellite Communication - Location-aware Computing – GPS - Indoor Positioning Techniques - Location-aware Applications - Emerging Positioning Solutions in 5G and Satellite Networks

LEO SATELLITE COMMUNICATION **9**

Fundamentals of Low Earth Orbit (LEO) Satellite Networks - Architecture and Communication Protocols - Integration with Terrestrial Networks - Applications in Global Connectivity and IoT

MOBILE COMPUTING APPLICATIONS **9**

Mobile Apps - Edge Computing for Mobile Devices - Case Studies of Real-world Applications - Mobile IP – RFID - Wireless Sensor Networks - Recent Trends and Emerging Technologies in Mobile and Wireless Communication

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply cellular network concepts to design, analyze, and optimize cellular coverage, capacity, and connectivity in mobile network scenarios.	[AP]
CO2	Demonstrate understanding of IEEE 802.11 (Wi-Fi 4/5/6) standards and their access mechanisms.	[AP]
CO3	Determine security mechanisms and vulnerabilities in cellular networks, Wi-Fi, Bluetooth, and satellite communication.	[AP]
CO4	Examine how LEO satellites integrate with terrestrial networks to support global connectivity and IoT.	[AN]
CO5	Compare recent trends and emerging technologies in mobile and wireless communication using real-world case studies.	[AN]

TEXT BOOKS

1. W. Stallings, Wireless Communications & Networks, 2nd ed., NJ: Pearson Education, 2011.
2. Raj Kamal, Mobile Computing, 3rd ed., Oxford, UK: Oxford University Press, 2018.
3. X. Lin and N. Zein, 5G and Beyond: Fundamentals and Standards. Cham: Springer, 2021.

REFERENCE BOOKS

1. A. Osseiran, J. F. Monserrat, and P. Marsch, *5G Mobile and Wireless Communications Technology*. Cambridge: Cambridge University Press, 2016.
2. W. Xiang, K. Zheng, and X. (Sherman) Shen, *5G Mobile Communications*. Cham, Switzerland: Springer, 2017.
3. Erik Dahlman, Stefan Parkvall, and Johan Sköld, "5G NR: The Next Generation Wireless Access Technology", 2nd Edition, Academic Press, 2021.

WEB RESOURCES

1. https://www.qualcomm.com/research/5g
2. https://www.ericsson.com/en/5g
3. https://www.rfwireless-world.com/Tutorials/5G-tutorials.html

25PF513 SDG NO. 7,9,11	WIRELESS AD-HOC AND SENSOR NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To introduce students to the fundamentals of wireless Ad-Hoc Networks.
2. To learn the operation and performance of various Ad-hoc wireless network protocols.
3. To understand the architecture and protocols of Wireless sensor networks.
4. To explore Transport Layer Protocols of Wireless sensor networks
5. To study Sensor Network Architecture, data dissemination and data gathering.

INTRODUCTION **9**

Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture – Hardware components, energy consumption of sensor nodes, Network architecture – Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks. Wireless channel and communication fundamentals

MAC PROTOCOLS **9**

Introduction, Issues in Designing a MAC protocol for Ad Hoc Wireless Networks, Design goals of a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols, Contention - Based Protocols, Contention - Based Protocols with reservation Mechanisms, Contention – Based MAC Protocols with Scheduling Mechanisms, MAC Protocols that use Directional Antennas, Other MAC Protocols.

ROUTING PROTOCOLS **9**

Introduction, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classification of Routing Protocols, Table –Driven Routing Protocols, On – Demand Routing Protocols, Hybrid Routing Protocols, Routing Protocols with Efficient Flooding Mechanisms, Hierarchical Routing Protocols, Power – Aware Routing Protocols.

TRANSPORT LAYER PROTOCOLS **9**

Introduction, Issues in Designing a Transport Layer Protocol for Ad Hoc Wireless Networks, Design Goals of a Transport Layer Protocol for Ad Hoc Wireless Networks, Classification of Transport Layer Solutions, TCP Over Ad Hoc Wireless Networks, Other Transport Layer Protocol for Ad Hoc Wireless Networks

WIRELESS SENSOR NETWORKS **9**

Introduction, Sensor Network Architecture, Data Dissemination, Data Gathering, MAC Protocols for Sensor Networks, Location Discovery, Quality of a Sensor Network, Evolving Standards, Other Issues.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Design the wireless sensor network architectures by comparing design principles, for specific sensing scenarios.	[AP]
CO2	Select appropriate MAC protocols by analyzing contention mechanisms, reservation strategies, and scheduling approaches to optimize medium access for varying ad hoc network conditions and QoS requirements.	[AN]
CO3	Compare and adapt routing protocols by evaluating table-driven, on-demand, and hybrid approaches to design resilient routing strategies.	[AN]
CO4	Analyze and propose transport layer solutions by examining TCP adaptations and alternative protocols to optimize end-to-end reliability and congestion control	[AN]
CO5	Integrate and optimize WSN components to develop comprehensive sensor network solutions that meet evolving standards and application requirements.	[AP]

TEXT BOOKS

1. C. Siva Ram Murthy & B.S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols", 1st Edition, Prentice Hall, 2004.
2. Jun Zheng & Abbas Jamalipour, "Wireless Sensor Networks: A Networking Perspective", 1st Edition, Wiley-IEEE Press, 2009.
3. Jagannathan Sarangapani, "Wireless Ad-Hoc and Sensor Networks: Protocols, Performance, and Control", 1st Edition, CRC Press, 2007

REFERENCE BOOKS

1. C.K. Toh, “Ad- Hoc Mobile Wireless Networks: Protocols & Systems”, 1st Ed. Pearson Education, 2002.
2. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", 1st Edition, Wiley, 2005.

WEB RESOURCES

1. https://wsn.eecs.berkeley.edu/
2. https://www.cs.utexas.edu/~weiqand/wireless/
3. https://www.monarch.cs.cmu.edu/dsr.html
4. https://www.icir.org/floyd/tcp_wireless.html
5. https://github.com/tinyos/tinyos-main

25PF514 SDG NO. 3,10,11	WEARABLE COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To understand the history, components, and ecosystems of wearable computing.
2. To apply programming and embedded systems skills using Arduino, Raspberry Pi, and similar platforms.
3. To analyze sensor data for activity and health monitoring.
4. To design wearable devices with a focus on usability and human-centered feedback.
5. To explore advanced wearable applications, including AR/VR and AI-based systems.

INTRODUCTION TO WEARABLE COMPUTING & COMPONENTS 9

History and evolution of wearable computing-Wearable ecosystems: hardware, sensors, embedded computing, software-Open-source platforms: PIC, Arduino, Raspberry Pi, ARM devices-Iterative coding methodology, Python programming, and mobile devices-Basic electronics: circuit theory, measurements, components identification-**Human-Centric Design & HCI overview:** ergonomics, usability, cognitive load-Cybernetic perspective: wearable systems as feedback-enabled extensions of humans.

BUILDING BLOCKS FOR WEARABLE COMPUTING 9

Body-worn sensors: accelerometer, gyroscope, PPG, ECG, EMG-Sensor interfacing and analog/digital conversion (ADC/DAC)-**Embedded computing:** microcontrollers, Arduino language (C/C++), Raspberry Pi-Communication protocols: BLE, NFC, SPI, I2C, Wi-Fi-Low-power computing and energy-efficient design for wearables-Cloud integration: Google Fit, Apple HealthKit, mobile interfaces-Security & privacy principles for wearable data

AI-DRIVEN DATA PROCESSING IN CONTEXT-AWARE WEARABLES 9

Data acquisition and preprocessing from wearable sensors-multi-threading, concurrency, and performance tuning for wearable computing-Signal processing for physiological and motion data-Machine learning / AI for activity recognition, health monitoring, and predictive analytics-**Context-aware computing:** adapting wearable behaviour to environment and user state-Data persistence, storage, and secure communication-Feedback loops and cybernetic principles in wearable systems

FRAMEWORKS AND DESIGN INNOVATION IN WEARABLE COMPUTING 9

Open software frameworks -Prototyping and modelling wearable devices-Three-tier wearable architecture-**Design patterns** -Methods for wearable computing-Innovation process for lifestyle, healthcare, fitness, and AR/VR applications-Project-based hands-on experience: building functional wearable prototypes

ADVANCED APPLICATIONS, AR/VR & CYBERNETIC SYSTEMS 9

Augmented Reality (AR) and Virtual Reality (VR) in wearables-Mixed reality and immersive computing interfaces-IoT and smart cities: wearable computing as part of urban systems-Advanced I/O and live data integration (push/pull network feeds)-Case studies: Oculus Rift,

smart health systems, exosuits-Cybernetic systems: human-wearable feedback loops, adaptive computing-Future trends: AI-integrated wearables, smart textiles, neural interfaces

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply wearable computing principles using open-source platforms, to create cybernetic systems that extend human capabilities through interactive feedback.	[AP]
CO2	Develop working wearable prototypes with embedded platforms and basic electronics.	[AP]
CO3	Process and interpret data from wearable sensors for real-world applications.	[AP]
CO4	Analyze the implementation of human-cantered design and feedback principles in wearable systems	[AN]
CO5	Assess wearable computing applications and propose improvements or innovations.	[E]

TEXT BOOKS

1. Linowes Jonathan, *Augmented Reality for Developers*, 1st edition, Packt Publishing Limited, 2017
2. Fortino, Giancarlo, Raffaele Gravina, and Stefano Galzarano, *Wearable computing: from modeling to implementation of wearable systems based on body sensor networks*, 1st Edition, John Wiley & Sons, 2018.

REFERENCE BOOKS

1. Simon Monk, *Programming the Raspberry Pi: Getting Started with Python,* 3rd Edition, 2021.
2. Barfield, Woodrow, ed. *Fundamentals of wearable computers and augmented reality*, 1st edition, CRC press, 2015.

WEB RESOURCES

1. https://www.happiestminds.com/insights/wearable-technology/
2. https://www.happiestminds.com/insights/wearable-technology/
3. https://undergraduatescr.lagosstate.gov.ng/fulldisplay/i0gG06/4OK073/web__design-and-wearable-technology.pdf

25PF515 SDG NO. 4,9,16	ADVANCED CRYPTOGRAPHY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

1. To understand the foundational principles, terminology, and core components of modern cryptography.
2. To analyze and apply cryptographic protocols and mechanisms for securing real-world applications.
3. To acquire the necessary mathematical background to model and understand the security of cryptographic algorithms.
4. To examine the structure and properties in constructing advanced cryptographic systems
5. To evaluate key establishment, management, certification protocols, and key distribution techniques for both symmetric and asymmetric cryptographic environments.

OVERVIEW OF CRYPTOGRAPHY **9**

Introduction, Information security and cryptography, Basic terminology and concepts, Symmetric key encryption, Digital signatures, Public-key cryptography, Hash functions, Protocols and mechanisms, Key establishment, management, and certification, Pseudorandom numbers and sequences, Classes of attacks and security models.

E-MAIL SECURITY **9**

Pretty Good Privacy (PGP), S/MIME IP Security: IP Security overview, IP Security architecture, Authentication Header, Encapsulating security payload, Combining security associations, Internet Key Exchange

MATHEMATICAL BACKGROUND **9**

Probability theory, Information theory, Complexity theory, Number theory, Abstract algebra, Finite fields, The integer factorization problem, The RSA problem, The Diffie-Hellman problem, Composite moduli.

FIELDS - CHARACTERISTIC OF A FIELD **9**

Fields, Characteristic of a field, prime fields, Arithmetic of polynomials over fields. Field extensions, Galois group of a field extensions, Fixed field and Galois extensions. Minimum polynomial, Construction of fields with the help of an irreducible polynomial. Splitting field of a polynomial, Separable polynomial and Separable extensions.

KEY ESTABLISHMENT PROTOCOLS **9**

Introduction, Key transport based on symmetric encryption, Key agreement based on symmetric techniques, Key transport based on public-key encryption, Key agreement based on asymmetric techniques, Secret sharing, Key Management Techniques, Techniques for distributing public keys, Techniques for controlling key usage, Key management involving multiple domains. **TOTAL: 45 PERIODS**

COURSE OUTCOMES

Upon completion of the course, students shall have ability to

CO1	Apply fundamental security concepts by implementing appropriate mechanisms in different scenarios, such as secure communication channels or system access controls.	[AP]
CO2	Implement and analyze security standards for practical applications by configuring protocols for email security and understanding the architecture of IPsec for network-layer security.	[AN]
CO3	Apply mathematical concepts from probability, number theory, and abstract algebra to analyze the hardness of problems underlying cryptographic schemes.	[AP]
CO4	Construct finite fields and their extensions, and relate the theory of fields to the design and security analysis of block ciphers and error-correcting codes.	[AP]
CO5	Design and critique key establishment and management protocols, and secret-sharing schemes, while assessing their resilience against various classes of attacks.	[AN]

TEXT BOOKS

1. William Stallings, "Cryptography and Network Security: Principles and Practice", 8th Edition, Prentice Hall, 2023.
2. Matt Bishop, “Computer Security: Art and Science”, 2nd Edition, Addison-Wesley, 2018.
3. Mihir Bellare and Phillip Rogaway, “Introduction to Modern Cryptography”, 3rd Edition, 2020, CRC Press.

REFERENCE BOOKS

1. W. Mao, “Modern Cryptography – Theory and Practice”, Pearson Education, 2004.
2. Charles P. Pfleeger, Shari Lawrence Pfleeger, “Security in computing”, 5th Edition, 2015, Prentice Hall of India.

WEB RESOURCES

1. https://www.udemy.com/course/cryptography-for-beginners
2. https://www.exed.hbs.edu/leading-digital-era
3. https://bitspilani-digital.edu.in/bitsdigital-campaign/cybersecurity-secure-software-development-course