NANDHA ENGINEERING COLLEGE

(An Autonomous Institution affiliated to Anna University Chennai and approved by AICTE, New Delhi)
Erode - 638 052, Tamilnadu, India, Phone: 04294 - 225585

Curriculum and Syllabi

for

M.E – COMPUTER SCIENCE AND ENGINEERING [R26]

[CHOICE BASED CREDIT SYSTEM]

[This Curriculum and Syllabi are applicable to students admitted from the academic year 2026-2027 onwards]

JULY 2026

INSTITUTE VISION AND MISSION	
VISION	• To be an Institute of excellence providing quality Engineering, Technology and Management education to meet the ever changing needs of the society
MISSION	• To provide quality education to produce ethical and competent professionals with social Responsibility • To excel in the thrust areas of Engineering, Technology and Entrepreneurship by solving real- world problems • To create a learner centric environment and improve continually to meet the changing global needs

M.E – COMPUTER SCIENCE AND ENGINEERING	
VISION	• To emerge as an eminent department in providing quality professionals, researchers, entrepreneurs with software skills and ethical values to cater to the changing needs of the industry and society.
MISSION	• To provide quality education to produce ethically strong Computer Science professionals with social responsibility • To impart the necessary domain skills to excel in solving real world problems. • To create a learner centric platform with ongoing development to fulfill the global computing demands.
PROGRAMME EDUCATIONAL OBJECTIVES (PEO)	The post graduates of Computer Science and Engineering will be **PEO 1:** Demonstrate an exceptional involvement in adopting advanced techniques and tools to build solutions for the problems identified. **PEO 2:** Exhibit leadership skills as an individual or in a team through demonstration of good analytical research, design and implementation skills and contribute towards societal growth. **PEO 3**: Pursue life-long learning to fulfill career goals and upgrade knowledge on the recent technologies for attaining professional and entrepreneurship excellence.
PROGRAMME SPECIFIC OUTCOMES (PSO)	The students of post graduates Computer Science and Engineering will be able to **PSO 1:** Ability to be a technically competent employee, researcher, entrepreneur and excel in providing socially acceptable solutions to real world problems by applying emerging technology in the area of computer science and engineering. **PSO 2:** Ability to work as part of teams on multidisciplinary projects and diverse environments and pursue lifelong professional development in computer domain.

PROGRAM OUTCOMES:

PG Engineering Graduates will be able to:

a-c	GRADUATE ATTRIBUTES	PO No.	PROGRAMME OUTCOMES
a	Research Aptitude	**PO1**	An ability to independently carry out research /investigation and development work to solve practical problems
b	Technical Documentation	**PO2**	An ability to write and present a substantial technical report/document
c	Technical competence	**PO3**	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES WITH PROGRAMME OUTCOMES

A broad relation between the programme objective and the outcomes is given in the following table

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES		
	A	**B**	**C**
1	3	3	3
2	3	3	3
3	3	3	3

MAPPING OF PROGRAM SPECIFIC OUTCOMES WITH PROGRAMME OUTCOMES

A broad relation between the Programme Specific Objectives and the outcomes is given in the following table

PROGRAM SPECIFIC OUTCOMES	PROGRAMME OUTCOMES		
	A	**B**	**C**
1	3	3	3
2	3	3	3

Contribution 1: Reasonable 2: Significant 3: Strong

NANDHA ENGINEERING COLLEGE (AUTONOMOUS), ERODE - 638 052

REGULATIONS - 2026 (R26) **CHOICE BASED CREDIT SYSTEM (CBCS)**

M.E. COMPUTER SCIENCE AND ENGINEERING **CURRICULUM : I – IV SEMESTERS**

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	COURSE TYPE	TEACHING AND LEARNING SCHEME			CREDITS	TCP
					L	T	P		
SEMESTER: I									
1	CP26A01	Applied Mathematics for Computer Engineers	BS	T	3	0	0	3	3
2	CP26C01	Advanced Data Structures and Algorithms	PC	T	3	0	0	3	3
3	CP26C02	Multicore Architectures	PC	T	3	0	0	3	3
4	CP26C03	Advanced Operating Systems	PC	T	3	0	0	3	3
5	CP26C04	Advanced Computer Networks	PC	T	3	0	0	3	3
6	CP26P01	Advanced Data Structures and Algorithms Laboratory	PC	L	0	0	4	2	4
7	E1	Programme Elective I	PE	T	3	0	0	3	3
				TOTAL	**18**	**0**	**4**	**20**	**22**

SEMESTER: II									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	CP26C05	Reinforcement Learning	PC	T	3	0	0	3	3
2	CP26C06	Cloud and Big Data Analytics	PC	T	3	0	0	3	3
3	CP26C07	Quantum AI	PC	T	3	0	0	3	3
4	CP26C08	Advanced Database Technologies	PC	T	3	0	0	3	3
5	E2	Programme Elective II	PE	T	3	0	0	3	3
6	CP26P02	Advanced Database Technologies Laboratory	PC	L	0	0	4	2	4
7	CP26S01	Technical Term Paper	SD	-	0	0	4	2	4
				TOTAL	**15**	**0**	**8**	**23**	**19**

SEMESTER: III									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	E3	Programme Elective III	PE	T	3	0	0	3	3
2	E4	Programme Elective IV	PE	T	3	0	0	3	3
3	E5	Programme Elective V	PE	T	3	0	0	3	3
4	E6	Open Elective / Programme Elective VI (OE/PE)	OE/ PE	T	3	0	0	3	3
5	CP26S02	Project Work I	SD	-	0	0	12	6	12
				TOTAL	**12**	**0**	**0**	**25**	**18**

SEMESTER: IV									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	CP26S03	Project Work II	SD	-	0	0	24	12	24
				TOTAL	0	0	24	24	12

BASIC SCIENCE COURSES (BS)									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	CP26A01	Applied Mathematics for Computer Engineers	BS	T	3	0	0	3	3

PROGRAMME CORE COURSES (PC)									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	CP26C01	Advanced Data Structures and Algorithms	PC	T	3	0	0	3	3
2	CP26C02	Multicore Architectures	PC	T	3	0	0	3	3
3	CP26C03	Advanced Operating Systems	PC	T	3	0	0	3	3
4	CP26C04	Advanced Computer Networks	PC	T	3	0	0	3	3
5	CP26P01	Advanced Data Structures and Algorithms Laboratory	PC	L	0	0	4	2	4
6	CP26C05	Reinforcement Learning	PC	T	3	0	0	3	3
7	CP26C06	Cloud and Big Data Analytics	PC	T	3	0	0	3	3

8	CP26C07	Quantum AI	PC	T	3	0	0	3	3
9	CP26C08	Advanced Database Technologies	PC	T	3	0	0	3	3
10	CP26P02	Advanced Database Technologies Laboratory	PC	L	0	0	4	2	4

PROGRAMME ELECTIVE COURSES (PE)									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	CP26X01	Agentic AI	PE	T	3	0	0	3	3
2	CP26X02	AI in IOT	PE	T	3	0	0	3	3
3	CP26X03	Edge and Fog Computing	PE	T	3	0	0	3	3
4	CP26X04	Bio-Inspired Computing	PE	T	3	0	0	3	3
5	CP26X05	Advanced Deep Learning and Neural Networks	PE	T	3	0	0	3	3

SKILL DEVELOPMENT COURSES (SD)									
S. No.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**COURSE TYPE**	**TEACHING AND LEARNING SCHEME**			**CREDITS**	**TCP**
					L	**T**	**P**		
1	CP26S01	Technical Term Paper	SD	-	0	0	4	2	4
2	CP26S02	Project Work I	SD	-	0	0	12	6	12
3	CP26S03	Project Work II	SD	-	0	0	24	12	24

SEMESTER WISE CREDIT DISTRIBUTION							
SEMESTER	**BS**	**PC**	**PE**	**ES**	**PE/OE**	**SD**	**Total**
I	3	14	3				20
II		15	3			2	20
III			9		3	6	18
IV						12	12
Total	3	29	15		3	20	70

Credits Total: 70

APPLIED MATHEMATICS FOR COMPUTER ENGINEERS			
Course Code:	CP26A01	CIE	40
Course Type: (Theory/Practical/Integrated)	Theory	ESE	60
L:T:P:C	3:0:0:3	Total Marks	100
Total Hours of Pedagogy	45	Exam Hours	3
Pre-requisites	Nil	Credits	3

Course Objectives

1. To develop knowledge of vector spaces, matrix decompositions, eigen value problems, multivariate analysis, number theory, and modular arithmetic for computational and data-driven applications.
2. To apply graph theory, graph algorithms, and mathematical structures to enhance analytical and problem-solving skills in computer engineering applications.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Apply vector space concepts, matrix factorizations, and singular value decomposition techniques to solve computational problems.	Ap	20%
CO 2	Analyze eigen value problems, canonical forms, pseudo-inverses, and least-squares approximations in mathematical models.	An	20%
CO 3	Apply multivariate statistical techniques, covariance analysis, and principal component analysis for data interpretation.	Ap	20%
CO 4	Analyze number-theoretic concepts, modular arithmetic, and congruence relations to solve mathematical problems.	Ap	20%
CO 5	Apply graph-theoretic concepts and algorithms to model, analyze, and solve network-related problems.	Ap	20%

COs	**POs**			**PSOs**	
	1	2	3	1	2
CO 1	3				
CO 2	2				
CO 3		2			
CO 4			3		
CO 5	3				
CO (W.A)	3	2	3		

Unit- I : Vector Spaces and Matrix Decompositions	**9**
Vector Spaces - Norms - Inner Products - QR Transformations - QR Factorization- Singular Value Decomposition (SVD) and Applications.	
Unit- II : Eigen Value Problems and Applications	**9**
Eigen values using QR Method -Generalized Eigen vectors - Canonical Forms -Pseudo Inverse - Least Squares Approximations.	
Unit- III : Multivariate Analysis	**9**
Random Vectors and matrices- Mean vectors and covariance matrices-Multivariate normal density and its properties-Principal components-Population principal components-Principal components from standardized variables.	
Unit- IV : Number Theory	**9**
Divisibility-Prime numbers-Greatest common divisor-Euclid's algorithm-Fundamental theorem of arithmetic-Fermat's little theorem-Congruence: Linear congruences- Solution of congruences-System of linear congruences: Chinese remainder theorem.	
Unit- V : Graph Theory	**9**
Graphs and Graph models-Graph terminology and special types of graphs-Graph isomorphism-Connectivity-Euler and Hamiltonian paths -Planar and non-planar graphs.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Gilbert Strang, Linear Algebra and Its Applications, 5th Edition, Cengage Learning, Boston, 2016.
2. T. W. Anderson, An Introduction to Multivariate Statistical Analysis, 3rd Edition, Wiley, New York, 2003.
3. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 8th Edition, McGraw-Hill Education, New York, 2019.

Reference Books:

1. Gene H. Golub and Charles F. Van Loan, Matrix Computations, 4th Edition, Johns Hopkins University Press, Baltimore, 2013.
2. Lloyd N. Trefethen and David Bau III, Numerical Linear Algebra, SIAM, Philadelphia, 1997.
3. Richard A. Johnson and Dean W. Wichern, Applied Multivariate Statistical Analysis, 6th Edition, Pearson Education, New Delhi, 2007.
4. Kenneth H. Rosen, Elementary Number Theory and Its Applications, 6th Edition, Pearson Education, Boston, 2011.
5. Douglas B. West, *Introduction to Graph Theory*, 2nd Edition, Prentice Hall, Upper Saddle River, 2001.

ADVANCED DATA STRUCTURES AND ALGORITHMS						
Course Code:	CP26C01				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					

Course Objectives

- To understand advanced data structures and their computational complexity.
- To design efficient algorithms for large-scale and real-time applications.
- To analyze advanced tree, graph, and indexing structures used in modern computing systems.
- To apply optimization and algorithmic paradigms for solving complex engineering problems.
- To develop research-oriented problem-solving skills using modern algorithmic techniques.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Analyze advanced data structures and algorithmic complexities for efficient problem solving.	An	20%
CO 2	Implement advanced tree and indexing structures for optimized data retrieval.	Ap	20%
CO 3	Apply graph algorithms and optimization techniques to solve complex computational problems.	Ap	20%
CO 4	Utilize advanced algorithm design paradigms for large-scale and real-time systems.	Ap	20%
CO 5	Examine modern data structure applications in AI, big data, cloud computing, and research domains.	An	20%

COs	**POs**			**PSOs**	
	1	2	3	1	2
CO 1	3		3	3	3
CO 2	2		3	3	3
CO 3	2		3	3	2
CO 4	3		3	3	2
CO 5	3	2	3	3	3
CO (W.A)	2.6	2	3	3	2.6

Unit- I : Advanced Algorithmic Analysis	**9**
Review of Data Structures and ADT – Algorithm Analysis – Recurrence Relations – Asymptotic Analysis – Amortized Analysis – Complexity Classes: P, NP, NP-Complete and NP-Hard Problems – Divide and Conquer Techniques – Greedy Algorithms – Dynamic Programming – Backtracking and Branch & Bound Techniques.	
Unit- II : Advanced Trees And Indexing Structures	**9**
Balanced Search Trees – AVL Trees – Red-Black Trees – Splay Trees – B-Trees and B+ Trees – Multiway Search Trees – Segment Trees – Fenwick Trees (Binary Indexed Trees) – Trie Structures – Suffix Trees and Suffix Arrays – Applications in Databases and Information Retrieval Systems.	
Unit- III :Advanced Graph Algorithms	**9**
Graph Representations – Graph Traversals – Minimum Spanning Trees– Single Source and All-Pairs Shortest Path Algorithms – Network Flow Algorithms – Maximum Flow and Minimum Cut – Strongly Connected Components – Topological Sorting – Bipartite Graphs – Applications in Social Networks, Routing, and Recommendation Systems.	
Unit- IV : String Processing And Computational Optimization	**9**
String Matching Algorithms – Knuth-Morris-Pratt (KMP) Algorithm – Rabin-Karp Algorithm – Boyer-Moore Algorithm – Computational Geometry Basics – Heuristic and Approximation Algorithms – Randomized Algorithms – Parallel and Distributed Algorithms – External Memory Algorithms.	
Unit- V : Modern Applications Of Data Structures And Algorithms	**9**
Data Structures for Big Data Analytics – Distributed Data Structures – Cloud-based Storage Structures – Graph Databases – Concurrent and Lock-Free Data Structures – Applications in Artificial Intelligence and Machine Learning – Data Structures in Blockchain Systems – Advanced STL and Generic Programming – Research Trends in Algorithms and Data Engineering.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Mark Allen Weiss., Data Structures and Algorithm Analysis in C++, 4th Edition, Pearson Education, 2014.
2. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman., Data Structures and Algorithms, Pearson Education, 2003.
3. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein., Introduction to Algorithms, 4th Edition, MIT Press, Cambridge, 2022.

Reference Books:

1. Michael T. Goodrich, Roberto Tamassia and Michael H. Goldwasser., Data Structures and Algorithms in Python, Wiley India Pvt. Ltd., New Delhi, 2016.

2. Donald E. Knuth., The Art of Computer Programming, Addison-Wesley, California, 2011.
3. Steven S. Skiena., The Algorithm Design Manual, 3rd Edition, Springer, New York, 2020.
4. Sanjoy Dasgupta, Christos Papadimitriou and Umesh Vazirani., Algorithms, McGraw-Hill Education, New York, 2008.
5. Robert Sedgewick and Kevin Wayne., Algorithms, 4th Edition, Addison-Wesley Professional, Boston, 2011.
6. Sartaj Sahni., Data Structures, Algorithms and Applications in C++, Universities Press, Hyderabad, 2011.

MULTICORE ARCHITECTURES						
Course Code:	CP26C02				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					

Course Objectives

1. To understand multicore architecture, parallel processing and parallel programming concepts using threading APIs and MPI.
2. To understand memory hierarchy design, memory technologies and interfacing techniques for building efficient computer subsystems.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Analyze the working principle of ILP.	An	20%
CO 2	Implement the concepts of threading and parallel programming constructs.	Ap	20%
CO 3	Understand the concept of Memory Hierarchy Design and virtual machines.	An	20%
CO 4	Identify the issues related to processors, memories, I/O devices.	Ap	20%
CO 5	Use memory technologies, interfacing techniques and subsystem devices efficiently.	Ap	20%

COs	**POs**			**PSOs**	
	1	2	3	1	2
CO 1	3	3	2	3	2
CO 2	3	3	3	2	3
CO 3	3	3	2	3	2
CO 4	3	3	3	2	2
CO 5	3	3	2	3	3
CO (W.A)	3	3	2.4	2.6	2.4

Unit- I : Introduction	**9**
Classes of Computers-Trends in Technology-Trends in Power and Energy in Integrated Circuits-Instruction Level Parallelism-Basic Compiler Techniques for Exposing ILP-Software and hardware multithreading – SMT and CMP architectures –Design issues – Case studies – Intel Multi-core architecture	
Unit- II : Parallel Programming	**9**
Fundamental concepts – Designing for threads – Scheduling - Threading and parallel Programming constructs – Synchronization – Critical sections – Deadlock - Threading APIs	
Unit- III : Memory Hierarchy Design	**9**
Introduction – Optimizations of Cache Performance – Memory Technology and Optimizations – Protection: Virtual Memory and Virtual Machines – Design of Memory Hierarchies	
Unit- IV : MPI Programming	**9**
MPI Model – Collective communication – Data decomposition – Communicators and topologies – Interconnection networks – Buses, crossbar-Multi-stage switches – Point-to-point communication – MPI Library	
Unit- V : Multi Thread and Storage Application	**9**
Algorithms, program development and performance tuning - disk storage-Video control–I/O Performance–SMART technology and fault detection–Processor to network interfaces.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Peter S. Pacheco, "An Introduction to Parallel Programming," Morgan Kaufmann/Elsevier, 2011. Covers: Unit I (ILP, multithreading, multicore architecture basics), Unit II (parallel programming fundamentals, threading, synchronization), Unit IV (MPI programming, collective communication, point-to-point communication)
2. Darryl Gove, "Multicore Application Programming: For Windows, Linux, and Oracle Solaris," Pearson, 2011.Covers: Unit II (threading APIs, scheduling, deadlock), Unit III (memory hierarchy, cache optimization), Unit V (multithread performance tuning, storage applications)

Reference Books:

1. John L. Hennessey and David A. Patterson, “Computer architecture – A quantitative approach”, Morgan
2. Kaufmann/Elsevier Publishers, 7th Edition, 2025.
3. ShameemAkhter and Jason Roberts, “Multi-core Programming”, Intel Press, 2010.
4. Michael J Quinn, “Parallel programming in C with MPI and OpenMP”, Tata McGraw Hill, 2004.
5. David E. Culler, Jaswinder Pal Singh, “Parallel Computing Architecture: A hardware/ Software Approach”Morgan Kaufmann/Elsevier Publishers, 1999.

ADVANCED OPERATING SYSTEMS						
Course Code:	CP26C03				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					

Course Objectives
To understand and apply fundamental concepts and techniques in concurrent, distributed, and database systems to design scalable, reliable, and efficient computing systems

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO1	Apply primitives and memory barriers to resolve race conditions and optimize NUMA locking speeds.	Ap	20%
CO2	Apply logical clocks, mutual exclusion, and deadlock detection to minimize distributed node latency.	Ap	20%
CO3	Analyze memory coherence, task migration, and scheduling to evaluate cluster scalability limits.	An	20%
CO4	Analyze error recovery, checkpoints, and voting protocols to restore crashed systems.	An	20%
CO5	Apply lock-based, timestamp, and optimistic algorithms to guarantee database transaction serializability.	Ap	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	-	-	3	2	-
CO 2	-	-	3	-	-
CO 3	2	-	2	3	-
CO 4	-	-	-	2	-
CO 5	3	-	3	3	1
CO (W.A)	2.5	-	2.75	2.5	1

Unit- I : Modern Process Synchronization and Core Mechanisms	**9**
Functions and Taxonomy of Advanced OS — NUMA & Multicore Core Realities — The Critical Section Problem — Classic OS Synchronization Problems: Bounded-Buffer, Readers-Writers, and Dining Philosophers problems — Kernel Primitives: Mutexes, Semaphores, and Monitors — Modern High-Performance Locking: Spinlocks & Adaptive Mutexes — Lock-Free Programming: Atomic Compare-And-Swap (CAS) — Memory Barriers and CPU Fences.	
Unit- II : Distributed Operating Systems	**9**
Issues – Communication Networks and Primitives – Theoretical Foundations - Inherent Limitations – Lamport's Logical Clock- Vector Clock- Causal Ordering of Messages- Global State- Distributed Mutual Exclusion – Classification- Preliminaries - Non-Token Based Algorithms – Lamport's Algorithm - Token-Based Algorithms – Suzuki-Kasami's Broadcast Algorithm– Distributed Deadlock Detection– Preliminaries – Handling of Deadlocks - Issues –Centralized Deadlock-Detection Algorithms - Distributed Deadlock Detection Algorithms – Hierarchical Deadlock Detection Algorithms.	
Unit- III : Distributed Resource Management	**9**
Distributed File System: Architecture, Design Issues — Distributed Shared Memory (DSM): Algorithms for implementing DSM, Memory Coherence and Coherence Protocols, Design Issues — Distributed Scheduling: Issues in Load Distributing, Components of a Load Distributing Algorithm, Stability, Load Distributing Algorithm, Performance Comparison, selecting a Suitable Load Sharing Algorithm, Requirements for Load Distributing — Task Migration and Issues.	
Unit- IV : Failure Recovery and Fault Tolerance	**9**
Recovery : Introduction – Basic Concepts – Classification of Failures – Backward and Forward Error Recovery Approaches - Recovery in Concurrent Systems – Synchronous and Asynchronous Check Pointing and Recovery – Check Pointing for Distributed Database Systems - Recovery in Replicated Distributed Databases Systems – Fault Tolerance – Issues- Commit Protocol- Non Blocking Commit Protocol-Voting Protocol - Dynamic Voting Protocol – Dynamic Vote Reassignment Protocol – Failure Resilient Processes – Reliable Communication.	
Unit- V : Database Operating Systems	**9**
Introduction- Requirements of a Database Operating System- Concurrency Control: Theoretical Aspects – Database Systems – The Problem of Concurrency Control – Serializability. Theory- Distributed Database Systems- Concurrency Control Algorithms- Basic Synchronization Primitives – Lock Based Algorithms - Timestamp Based Algorithms - Optimistic Algorithms – Data Replication.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Mukherjee, A. and Mukherjee, S., "Advanced Operating Systems: Concepts, Algorithms, and Design", 2nd Edition, CRC Press, 2024.
2. Abraham Silberschatz, Peter Baer Galvin, and Greg Gagne, "Operating System Concepts", 10th Global Edition, Wiley, 2023.

Reference Books:

1. Andrew S. Tanenbaum and Maarten Van Steen, "Distributed Systems: Principles and Paradigms", 4th Edition, Pearson Education, 2023.
2. Tanenbaum, A. S. and Bos, H., "Modern Operating Systems", 5th Global Edition, Pearson Education, 2023.
3. M. Singhal and N. G. Shivaratri, "Advanced Concepts in Operating Systems: Distributed, Databases, and Multiprocessor Operating Systems", Reissue Edition, McGraw Hill, 2021.
4. George Coulouris, Jean Dollimore, Tim Kindberg, and Gordon Blair, "Distributed Systems: Concepts and Design", 6th Edition, Pearson Education, 2021.
5. Kai Hwang, Geoffrey C. Fox, and Jack J. Dongarra, "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things", 2nd Edition, Morgan Kaufmann / Elsevier, 2018.

ADVANCED COMPUTER NETWORKS						
Course Code:	CP26C04				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites						

Course Objectives

1. Apply wireless networking standards, IPv6 addressing, and Mobile IPv6 mechanisms to support modern communication networks.
2. Analyze multicast communication, distributed routing protocols, VPNs, MPLS, and peer-to-peer network architectures.
3. Explore mobile ad hoc network routing protocols, advanced transport protocols, and QUIC-based communication.
4. Examine Multipath TCP, TCP congestion control mechanisms, QoS provisioning, and transport protocols in wireless networks.
5. Investigate advanced networking architectures and apply network security principles to modern communication systems.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Apply wireless networking standards, IPv6 addressing, and Mobile IPv6 mechanisms to support communication in modern networks.	Ap	20%
CO 2	Analyze multicast routing, distributed routing protocols, VPNs, MPLS, and peer-to-peer architectures for efficient network operation.	An	20%
CO 3	Apply advanced MANET routing protocols and analyze the performance of QUIC and transport layer enhancements in communication networks.	Ap	20%
CO 4	Analyze Multipath TCP, TCP congestion control mechanisms, and QoS techniques to optimize transport layer performance.	An	20%
CO 5	Apply network security principles, cryptographic techniques, key distribution protocols, and Cisco Packet Tracer to implement and evaluate secure communication networks.	Ap	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	3	2	1	3	1
CO 2	3	3	1	3	2
CO 3	3	3	2	3	2
CO 4	3	3	2	3	2
CO 5	3	3	3	2	3
CO (W.A)	3	2.8	1.8	2.8	2

Unit- I : Wireless Standards	**9**
IEEE 802.11a/b/n/g/p, 802.15, and 802.16 standards for Wireless PAN, LAN, and MAN. IPv6: Header, Addressing, Neighbour Discovery, Auto-Configuration, Header Extensions and options, support for QoS, security, etc., DHCPv6. Mobile IPv6: rationale and operation - intra and inter site.	
Unit- II : IP Multicasting, Distributed Routing	**9**
Multicast routing protocols, Virtual private network service, multiprotocol label switching. Peer-to-Peer network architectures, Overlay networks, flat routing protocols (DHTs), and peer-to-peer architectures. Distributed Routing: RIP, OSPF and BGP Routing.	
Unit- III : Mobile Adhoc Networks, Transport Layer Advances, Quic	**9**
Advanced Routing Protocols and Improvements in AODV, DSR, DSDV etc., Hot Potato(deflection) Routing Schemes and cut-through routing . TCP Improvements and Extensions, Performance issues, Client-server communication. QUIC: UDP-Based Multiplexed and Secure Transport, Using TLS to Secure QUIC, Handshake of QUIC compared to TCP with TLS 1.2, QUIC Loss Detection and Congestion Control, Relationship between HTTP, TLS and QUIC.	
Unit- IV : Multipath TCP (MPTCP), TCP Congestion Control	**9**
TCP Extensions for Multipath Operation with Multiple Addresses, TCP Congestion Control: fairness, scheduling and Delay modeling, QoS issues, differentiated services, ECN, Transport layer in Wireless Networks.	
Unit- V : Advanced Networking Architectures, Network Security	**9**
Software Defined Networking, Opportunistic Networks, Cognitive Radio Networks, Wireless Sensor Networks. Network Security: Network Security principles, Security related issues in wireless networks, Public and Private Key Cryptography, Key distribution protocols. Cash study using Cisco Packet Tracer.	
	Total (L : 45)

Suggested Learning Resources
Text Books : 1. G. R. Wright and W. R. Stevens, TCP/IP Illustrated, Volume 2: The Implementation, 2nd Edition, Addison-Wesley, 2011. 2. Theodore Rappaport, Wireless Communications: Principles and Practice, 2nd Edition, Pearson, 2002.
Reference Books: 1. William Stallings, Data and Computer Communications, 11th Edition, Pearson, 2023. 2. William Stallings, Cryptography and Network Security: Principles and Practice, 8th Edition, Pearson, 2023. 3. Behrouz A. Forouzan, TCP/IP Protocol Suite, 5th Edition, McGraw-Hill Education, 2022. 4. Jie Wu and Yunsheng Wang, Opportunistic Mobile Social Networks, 1st Edition, CRC Press, 2015. 5. HeshamSoliman, Mobile IPv6: Mobility in a Wireless Internet, 1st Edition, Pearson Education, 2004.

ADVANCED DATA STRUCTURES AND ALGORITHMS LABORATORY						
Course Code:	CP26P01				CIA	60
Course Type: (Theory/Practical/Integrated)	Practical				ESE	40
L:T:P:C	0	0	4	2	Total Marks	100
Total Hours of Pedagogy	60				Exam Hours	3
Pre-requisites						
Course Objectives						
To design and implement efficient algorithms using appropriate algorithmic paradigms.						

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Develop programs using greedy and backtracking strategies.	AP	20%
CO 2	Implement operations on non-linear data structures	AP	20%
CO 3	Apply graph algorithms to solve engineering problems.	AP	20%
CO 4	Develop algorithms for text processing applications.	AP	20%
CO 5	Implement scalable solutions using modern applications of data structures	AP	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	3		3		
CO 2	2		3		
CO 3	2		3	2	
CO 4	3		3	2	2
CO 5	3	2	3	2	2
CO (W.A)	3	2	3	2	2

List of Experiments:
1. Implementation of Huffman coding. 2. Solve NP Problems- sum of Subset problem using backtracking. 3. Implementation of the following Search Structures i) Splay Trees (Insertion, Deletion and Search) ii) B-Trees (Insertion, Deletion and Search) iii) Red-Black Trees iv) Design a suffix tree-based algorithm for DNA sequence matching 4. Implementation of Topological sort. 5. Implement Network Flow algorithm. 6. String Matching using Knuth-Morris-Pratt (KMP) and Rabin-Karp algorithms. 7. Develop simple applications using Graph Databases. 8. Program for Data structures in Blockchain systems. 9. Implement KD-Trees for nearest neighbor search.
Total (P : 60)

Hardware/ Software
Hardware: LAN System with 6 nodes (OR) Standalone PCs – 6 Nos. Software: Compiler – Python, Turbo C, Java, Dev C

REINFORCEMENT LEARNING						
Course Code:	CP26C05				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					

Course Objectives

1. Understand the Fundamentals of Reinforcement Learning
2. Apply Core RL Algorithms and Develop Deep Reinforcement Learning Models
3. Experiment with RL Frameworks and tools

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Apply the fundamental Reinforcement Learning concepts like Markov Decision Processes, rewards, policies and value functions.	Ap	20%
CO 2	Apply core algorithms like Dynamic Programming, Monte Carlo and Temporal Difference methods to solve complex decision-making problems.	Ap	20%
CO 3	Analyze advanced Deep RL techniques including DQNs, Policy Gradients and Actor-Critic models to optimize complex tasks.	Ap	20%
CO 4	Evaluate RL models in simulated environments using frameworks like OpenAI Gym, PyTorch or Tensor Flow to assess their performance.	An	20%
CO 5	Design and implement a Reinforcement Learning agent for a real-world application in areas such as robotics, finance, healthcare or autonomous systems.	An	20%

COs	**POs**			**PSOs**	
	1	2	3	1	2
CO 1	3		3	3	
CO 2	2	1	3	3	
CO 3	3	1	3	3	
CO 4	3	3	3	3	
CO 5	2	1	3	3	
CO (W.A)	2.6	1.5	3	3	

Unit- I : Introduction to Reinforcement Learning	**9**
Basics of Reinforcement Learning (RL), RL vs. Supervised & Unsupervised Learning, Key Concepts: Agent,Environment, State, Action, Reward, Policy, Markov Decision Process (MDP), Bellman Equations & Value Iteration, Dynamic Programming for RL, Exploration vs. Exploitation Trade-off.	
Unit- II : Model-Free Learning Methods	**9**
Monte Carlo (MC) Methods, Temporal Difference (TD) Learning, Q-Learning: Theory & Implementation, SARSA Algorithm, Eligibility Traces: n-Step TD, TD (λ) Function Approximation in RL.	
Unit- III : Policy-Based & Actor-Critic Methods	**9**
Policy Gradient Methods REINFORCE Algorithm, Advantage Actor-Critic (A2C), Deep Deterministic Policy Gradient (DDPG), Proximal Policy Optimization (PPO), Soft Actor-Critic (SAC).	
Unit- IV : Deep Reinforcement Learning	**9**
Introduction to Deep RL, Deep Q-Networks (DQN): Theory & Implementation, Experience Replay& Target Networks, Double DQN & Duelling DQN, Multi-Agent Reinforcement Learning (MARL), Applications: Robotics, Game AI, Autonomous Vehicles.	
Unit- V : Applications ,Challenges and Future Trends	**9**
RL in Robotics, Finance, Healthcare, and Autonomous Systems, Safety & Ethics in RL, Transfer Learning in RL, Meta-Reinforcement Learning, Recent Advances: Alpha Go, MuZero, GPT for RL, Challenges & Open Research Problems in RL.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Richard S. Sutton and Andrew G. Barto., Reinforcement Learning: An Introduction, MIT Press, 2nd Edition, 2018.
2. Csaba Szepesvári., Algorithms for Reinforcement Learning, Morgan & Claypool Publishers, 2010.
3. Ian Goodfellow, YoshuaBengio and Aaron Courville., Deep Learning, MIT Press, 2016.

Reference Books:

1. Vincent François-Lavet et al., An Introduction to Deep Reinforcement Learning, Foundations and Trends in Machine Learning, 2018.
2. Marc G. Bellemare, Will Dabney and RémiMunos., Deep Reinforcement Learning Handbook, Springer, 2020.
3. Shangtong Zhang et al., Deep Reinforcement Learning: Fundamentals, Research and Applications, Springer, 2022.
4. Phil Winder., Reinforcement Learning: Industrial Applications of Intelligent Agents, O'Reilly Media, 2020.
5. Maxim Lapan., Deep Reinforcement Learning Hands-On, Packt Publishing, 3rd Edition, 2024.

CLOUD AND BIG DATA ANALYTICS						
Course Code:	CP26C06				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	NIL					

Course Objectives

- Apply cloud computing paradigms and service models.
- Apply big data technologies and storage techniques.
- Apply Hadoop ecosystem tools for data processing.
- Analyze large-scale data using appropriate techniques.
- Analyze cloud-based big data applications.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Apply cloud computing paradigms and service models to select suitable cloud solutions.	AP	20%
CO 2	Apply big data technologies and storage techniques to manage large-scale datasets.	AP	20%
CO 3	Apply Hadoop ecosystem tools to process large-scale data.	AP	20%
CO 4	Analyze large-scale data to derive meaningful insights.	An	20%
CO 5	Analyze cloud-based big data applications to evaluate scalability and performance	An	20%

COs	**POs**			**PSOs**	
	1	2	3	1	2
CO 1	3	2		3	2
CO 2	2	3		3	2
CO 3		2	3	3	3
CO 4		2	3	2	3
CO 5		2		3	3
CO (W.A)	2.5	2	3	2.8	2.6

Unit- I : Cloud Computing	**9**
Introduction to Cloud Computing - Service Models: IaaS, PaaS, SaaS - Deployment Models: Public, Private, Hybrid, Community - Virtualization: Hypervisors, VM provisioning - Cloud providers: AWS, Azure, Google Cloud overview. **Activities:** Create a free-tier AWS account and explore EC2, S3.	
Unit- II : Big Data Ecosystem and Hadoop	**9**
Big Data characteristics (Volume, Velocity, Variety, Veracity, Value) - Challenges in Big Data - Hadoop Architecture and HDFS - MapReduce Programming Model –YARN. **Activities:** Submit a summary report on Hadoop.	
Unit- III : Data Storage & Processing Techniques:	**9**
NoSQL Databases: MongoDB, Cassandra, HBase - Data Ingestion: Sqoop, Flume - Hive, Pig – Architecture and Querying - Data Cleaning and Preparation. **Activities:** HiveQL assignments on datasets from Kaggle.	
Unit- IV :Advanced Big Data Analytics:	**9**
Introduction to Apache Spark - Spark vs. MapReduce - Spark SQL, Data Frames, RDDs- Machine Learning using Spark MLlib - Real-time processing: Kafka and Spark Streaming. **Activities:** Mini-project using PySpark on any dataset.	
Unit- V : Cloud Integration and Security:	**9**
Data on Cloud – Storage and Compute Services - Data Security and Privacy in Cloud - Cloud-based Data Analytics Use Cases - Cloud-Native vs Traditional Applications - Case Study: Smart Cities / Healthcare Analytics. **Activities:** Create a cloud deployment report using Azure/AWS.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Rajkumar Buyya, James Broberg, Andrzej Goscinski, Cloud Computing: Principles and Paradigms, Wiley, First Edition, 2011.
2. Vignesh Prajapati, Big Data Analytics with R and Hadoop, Packt Publishing, First Edition, 2013.

Reference Books:

1. Tom White, Hadoop: The Definitive Guide, O'Reilly Media. Fourh Edition 2015.
2. Kleppmann, Martin, Designing Data-Intensive Applications, O'Reilly. Second t Edition 2026.
3. Alan Gates, Programming Pig,O'Reilly, Second Edition 2016.
4. Jure Leskovec et al., Mining of Massive Datasets, Cambridge University Press,Third Edition2020.

QUANTUM AI						
Course Code:	CP26C07				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	NIL					

Course Objectives

1. To understand the principles of quantum computing and quantum information processing.
2. To learn quantum algorithms and their computational advantages over classical algorithms.
3. To apply quantum machine learning techniques for AI applications.
4. To design hybrid quantum-classical optimization algorithms using modern quantum frameworks.
5. To explore quantum error correction, quantum cryptography, and emerging Quantum AI applications.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Able to explain qubits, superposition, entanglement, and quantum gates.	Ap	20%
CO 2	Analyze and implement fundamental quantum algorithms using Qiskit.	An	20%
CO 3	Design and evaluate quantum machine learning models for AI applications using PennyLane and related frameworks.	Ap	20%
CO 4	Develop hybrid quantum-classical optimization solutions using variational quantum algorithms.	Ap	20%
CO 5	Assess quantum error correction techniques, quantum cryptography, and emerging Quantum AI applications for real-world engineering problems.	An	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	3	2		3	2
CO 2	3	3	2	3	3
CO 3	2	3	3	3	3
CO 4	2	3	3	3	3
CO 5	2	3	2	2	3
CO (W.A)	2.4	2.8	2	2.8	2.8

Unit- I : Quantum Computing Foundations	**9**
Postulates of quantum mechanics - Qubits, superposition & entanglement - Quantum gates & circuit model Bloch sphere & Dirac notation - Quantum measurement & decoherence - Qiskit circuits on IBM Quantum.	
Unit- II : Quantum Algorithms	**9**
Deutsch-Jozsa& Bernstein-Vazirani, Grover's search algorithm - Shor's factoring algorithm - Quantum Fourier Transform (QFT) - HHL algorithm for linear systems - Grover's & QFT in Qiskit.	
Unit- III : Quantum Machine Learning	**9**
Quantum kernel methods & SVM - Quantum principal component analysis - Variational quantum classifiers (VQC) - Quantum neural networks (QNN) - Barren plateau problem & mitigation - QML with PennyLane + PyTorch - Quantum generative models (QGAN) - Data encoding: amplitude & angle.	
Unit- IV : Variational Algorithms & Optimisation	**9**
Variational Quantum Eigensolver (VQE) - QAOA for combinatorial optimisation - Quantum annealing & D-Wave - Hybrid classical-quantum pipelines - Gradient estimation (parameter shift) - QAOA on graph problems.	
Unit- V : Quantum Error Correction & Applications	**9**
Noise models & NISQ limitations - Stabiliser codes & surface codes - Quantum cryptography & QKD Quantum AI for drug discovery - Quantum NLP (lambeq / DisCoCat) - Noise mitigation in Qiskit.	
	Total (L : 45)
Suggested Learning Resources	
Text Books : 1. Maria Schuld and Francesco Petruccione, Machine Learning with Quantum Computers, Springer, 2021. 2. Jack D. Hidary, Quantum Computing: An Applied Approach, 2nd Edition, Springer, 2021.	
Reference Books: 1. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010. 2. Ronald de Wolf, Quantum Computing: Lecture Notes, 2023. 3. Chris Bernhardt, Quantum Computing for Everyone, MIT Press, 2019.	

ADVANCED DATABASE TECHNOLOGIES						
Course Code:	CP26C08				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					

Course Objectives

To provide a comprehensive understanding of high-performance database architectures, including parallel, distributed and object-based systems, while exploring advanced data modeling and the design of intelligent NoSQL solutions for big data applications

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Selection and implementation of high-performance architectures to optimize I/O, query and operation parallelism.	Ap	20%
CO 2	Management of distributed data storage and execution of transactions using specific commit protocols and concurrency control.	An	20%
CO 3	Modelling and representation of complex real-world data structures using object identity, encapsulation and inheritance.	Ap	20%
CO 4	Design of semantic-based database systems by embedding rule sets, temporal logic and spatial access methods.	Ap	20%
CO 5	Apply Big Data storage concepts and NoSQL database models to select an appropriate database solution for different application requirements.	Ap	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	3	3		3	
CO 2	3	3		3	
CO 3	3			3	
CO 4	3	3	3	3	
CO 5	3	3		3	
CO (W.A)	3	3	3	3	

Unit- I : Parallel Databases	**9**
Database System Architectures: Centralized and Client-Server Architectures - Server System Architectures - Parallel Systems- Parallel Databases: 1/0 Parallelism - Inter and Intra Query Parallelism - Inter and Intra operation Parallelism- Design of Parallel Systems.	
Unit- II : Distributed Databases	**9**
Distributed Database Concepts - Distributed Data Storage - Distributed Transactions - Commit Protocols - Concurrency Control - Distributed Query Processing.	
Unit- III : Object Based Databases	**9**
Concepts for Object Databases: Object Identity - Object structure - Type Constructors - Encapsulation of Operations - Methods - Persistence - Type and Class Hierarchies - Inheritance - Complex Objects - Object Database Standards, Languages and Design: ODMG Model - ODL - OQL .	
Unit- IV : Intelligent Databases	**9**
Active Databases: Syntax and Semantics -Taxonomy- Applications- Design Principles for Active Rules- Temporal Databases: Overview of Temporal Databases- Deductive Databases: Logic of Query Languages - Data log Recursive Rules-Syntax and Semantics of Data log Languages- Implementation of Rules and Recursion Recursive Queries in SQL- Spatial Databases- Spatial Data Types- Spatial Relationships- Spatial Data Structures Spatial Access Methods- Mobile Databases.	
Unit- V : NoSQL Databases	**9**
Introduction to Big Data-Storage- NoSQL Introduction - Differences from relational databases- Column family store- Document stores - key-value databases - Graph databases - Choosing a NoSQL database.	
	Total (L : 45)

Suggested Learning Resources

Text Books :

1. Abraham Silberschatz, Henry F. Korth and S. Sudarshan, Database System Concepts, 7th Edition, McGraw Hill, 2021
2. Thomas Connolly and Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation, and Management, 7th Edition, Pearson, 2026

Reference Books:

1. M. Tamer Özsu and Patrick Valduriez, Principles of Distributed Database Systems, 4th Edition, Springer, 2020
2. Seema Acharya, 'Demystifying NoSQL'. Wiley, 2020
3. Andreas Meier and Michael Edward Kaufmann, 'SQL & NoSQL Databases: Models, Languages, Consistency Options and Architectures for Big Data Management'. Springer, 2019
4. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2020). Database system concepts, McGraw Hill Education.

ADVANCED DATABASE TECHNOLOGIES LABORATORY						
Course Code:	CP26P02				CIA	60
Course Type: (Theory/Practical/Integrated)	Practical				ESE	40
L:T:P:C	0	0	4	2	Total Marks	100
Total Hours of Pedagogy	60				Exam Hours	3
Pre-requisites						

Course Objectives

1. Provide practical exposure to advanced database concepts and technologies.
2. Enable students to design, implement and optimize complex database applications.
3. Develop skills in distributed, parallel and NoSQL database systems.
4. Introduce database security, transaction management and recovery mechanisms.
5. Enhance problem solving skills using modern database tools and frameworks.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Design and implement advanced relational database applications using SQL and PL/SQL.	AP	20%
CO 2	Develop database applications using indexing, query optimization and transaction management techniques.	AP	20%
CO 3	Implement distributed and parallel database concepts using suitable tools.	AP	20%
CO 4	Build NoSQL database applications for handling unstructured and semi-structured data.	AP	20%
CO 5	Apply database security, backup and recovery mechanisms in real-time scenarios.	AP	20%

COs	POs			POs	
	1	2	3	1	2
CO 1	3	2	2		
CO 2	3	3	2		
CO 3	3	3	3		
CO 4	3	2	3		
CO 5	3	2	2		
CO (W.A)	3				

List of Experiments:
1. Advanced SQL queries using joins, views and subqueries. 2. PL/SQL procedures, functions, cursors and triggers. 3. Query optimization using indexing and execution plans. 4. Transaction management and concurrency control. 5. Distributed database implementation. 6. NoSQL applications using MongoDB/Cassandra. 7. Wide-column NoSQL data modeling and querying. 8. Graph database modeling and relationship queries using Cypher. 9. Case study on Big Data storage and retrieval. 10. Backup and recovery mechanisms. 11. Database security and access control.
Total (P : 60)

TECHNICAL TERM PAPER						
Course Code:	CP26S01				CIA	
Course Type: (Theory/Practical/Integrated)	Practical				ESE	
L:T:P:C	0	0	4	2	Total Marks	
Total Hours of Pedagogy					Exam Hours	
Pre-requisites: Nil						
Course Objective						
• To provide exposure to the students to refer, read and review the research articles in referred journals and conference proceedings.						

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	At the end of the course the student will be able to read and review the research articles and publish a technical paper.	AP	100%

COs	POs			POs	
	1	2	3	1	2
CO 1	3	3	3	3	3
CO (W.A)	3	3	3	3	3

METHODOLOGY	• Each student is allotted to a faculty of the department by the Dean/ HOD. • By mutual discussions, the faculty guide will assign a topic in the general / subject area to the student. • The students have to refer the Journals and Conference proceedings and collect the published literature. • The student is expected to collect at least 20 such Research Papers published in the last 5 years. • Using OHP/PowerPoint, the student has to make presentation for 15-20 minutes followed by 10 minutes discussion. • The student has to make two presentations, one at the middle and the other near the end of the semester. • The student has to write a Technical Report for about 30-50 pages (Title page, one page Abstract, Review of Research paper under various sub headings, Concluding Remarks and List of References).The technical report has to be submitted to the Dean/ HOD one week before the final presentation, after the approval of the faculty guide.

EXECUTION	**Week**	**Activity**
	I	Allotment of Faculty Guide by the Dean/ HoD
	II	Finalizing the topic with the approval of Faculty Guide
	III-IV	Collection of Technical papers
	V-VI	Mid semester presentation
	VII-VIII	Report writing
	IX	Report submission
	X-XI	Final presentation

EVALUATION	**100%by Continuous Assessment - 3 Hrs/week and 1 credit**	
	Component	Weight age
	Mid semester presentation	25%
	Final presentation(Internal)	25%
	End Semester Examination Report	30%
	Presentation	20%
	Total	100%

AGENTIC AI						
Course Code:	CP26X01				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					

Course Objective
To develop the ability to design and analyze intelligent agent systems using modern AI techniques for autonomous decision-making and real-world applications.

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Analyze the concepts, architectures, and environment models of intelligent agents.	An	20%
CO 2	Apply planning and decision-making techniques for autonomous agent systems.	Ap	20%
CO 3	Apply reinforcement learning methods for adaptive agent behavior.	Ap	20%
CO 4	Implement multi-agent and LLM-based approaches for real-world intelligent applications.	Ap	20%
CO 5	Analyze ethical issues and emerging applications of agentic AI systems.	An	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	2		3	3	
CO 3	2		3	3	
CO 2	3		3	3	
CO 4	2		3	3	2
CO 5	2			2	
CO (W.A)	2.2		3	2.8	2

Unit I – Foundations of Agentic AI	**9**
Introduction to Agentic AI: History, Motivation, and Applications – Agents and Environments: Sensors, Actuators, and Environment Types – Types of Intelligent Agents: Simple Reflex, Goal-Based, Utility-Based, and Learning Agents – Agent Architectures: Reactive, Deliberative, Hybrid, and Subsumption Architectures – Characteristics of Autonomous and Rational Agents.	
Unit II – Agent Decision-Making and Planning	**9**
Rationality and Utility Theory – Task Environment Analysis – AI Planning Techniques: STRIPS and Classical Planning – Decision-Making under Uncertainty – Markov Decision Processes (MDPs) – Bayesian Models and Game Theory – Goal-Oriented and Utility-Based Decision Systems	
Unit III – Learning in Agentic Systems	**9**
Introduction to Reinforcement Learning – Q-Learning and SARSA – Value Iteration and Policy Iteration – Deep Reinforcement Learning: Deep Q Networks (DQNs), Policy Gradient Methods, and Actor-Critic Models – Tools and Frameworks: OpenAI Gym, PettingZoo, TensorFlow RL.	
Unit IV – Multi-Agent Systems and LLM Agents	**9**
Multi-Agent Coordination: Cooperation and Competition – Agent Communication and Negotiation – Human-AI Collaboration and Mixed-Initiative Systems – Language-Based Agents: Tool Use, Planning, and Reasoning – Memory-Augmented and Situated Agents – Platforms and Frameworks: NetLogo, RoboCup Simulation, Hugging Face Tools.	
Unit V – Ethics, Embodied AI and Applications of Agentic AI	**9**
Agents in Robotics and Smart Environments – Unity ML-Agents for Embodied AI – AI Alignment, Fairness, and Explainability – Social and Environmental Implications of Agentic AI – Case Studies: Autonomous Vehicles and Conversational Agents – Emerging Trends and Real-World Applications of Agentic AI.	
	Total (L : 45)

Suggested Learning Resources

Reference Books:

1. Velankar, Mahalle & Shinde – Cognitive Computing for Machine Thinking, CRC Press, 2024.
2. Judith S. Hurwitz, Marcia Kaufman, Adrian Bowles – Cognitive Computing and Big Data Analytics, Wiley, 2015.
3. Peter Fingar , Cognitive Computing: A Brief Guide for Game Changers, Meghan Kiffer, 2015.
4. Building Cognitive Applications with IBM Watson Services, Redbooks, 2017
5. Steven Bird, Ewan Klein, Edward Loper, Natural Language Processing with Python, O'Reilly, 2009.
6. Fuchun Sun, Qinghu Meng, Zhumu Fu, Bin Fang (Editors), Communications in Computer and Information Science (CCIS, volume 1918) – Springer Series, 2024.

AI IN IOT						
Course Code:	CP26X02				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites						
Course Objective						
To apply Artificial Intelligence techniques and tools in IoT systems for data processing, real-time decision-making, security, and the development of intelligent and sustainable IoT applications.						

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Analyze the concepts, architectures, and environment models of intelligent agents.	An	20%
CO 2	Implement planning and decision-making techniques for autonomous agent systems.	Ap	20%
CO 3	Utilize reinforcement learning methods for adaptive agent behavior.	Ap	20%
CO 4	Integrate multi-agent systems and LLM-based agent frameworks in real-world intelligent applications.	Ap	20%
CO 5	Analyze ethical considerations and emerging applications of agentic AI systems.	An	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	2		3	3	
CO 3	2		3	3	
CO 2	3		3	3	
CO 4	2		3	3	3
CO 5	2		2	2	
CO (W.A)	2		3	3	3

Unit- I : Introduction to AI In IoT and Data Acquisition	**9**
Fundamentals of AI and IoT - IoT Architecture and AI Integration - AI Models for IoT (Machine Learning, Deep Learning) - AI-Driven IoT Applications (Smart Cities, Healthcare, Industrial IoT) -Data Acquisition and Pre-processing in AI-Enabled IoT: Sensor Data Collection and Processing - Challenges in Data Handling and Storage for AI Models.	
Unit- II : Data Processing and AI Models for Iot	**9**
AI-Based Data Normalization, Filtering and Feature Engineering - Supervised &Unsupervised AI Models in IoT - Classification, Clustering & Anomaly Detection -Deep Learning Models for IoT: CNNs, RNNs - Performance Metrics & Model Optimization – Case Study: AI-Driven Traffic Monitoring System	
Unit- III : Edge Ai and Security for IOT Systems	**9**
Edge AI & Security for IoT Systems: Edge AI Deployment Strategies - Edge AIfor Real-Time Decision-Making - Deploying AI Models in Resource-Constrained IoT Devices - AI-Powered Security & Intrusion Detection in IoT Networks – Ethical Implications & Privacy Concerns – Case Study: AI- Based Intrusion Detection in Healthcare IoT Networks.	
Unit- IV : Industry Trends	**9**
Industry Applications of AI in IoT - Smart Cities, Healthcare, & Industrial IoT - AI in Smart Agriculture and Environmental Monitoring - Digital Twins and Predictive Maintenance in Industry - Scaling AI for Large-Scale IoT Deployments -Sustainability & Scalability Challenges in AI-Enabled IoT	
Unit- V : Ethics and Future Trends	**9**
Ethical Considerations in AI Enabled IoT –Ethical Considerations in AI Driven Data Processing.- Monetization Strategies & AI Business Models in IoT - Green AI and IoT Regulations and Standardization - Edge AI advancements for real-time IoT decision-making - Quantum AI &IoT interoperability for future applications - Case Study: AI-Driven Smart Cities for Sustainable Urban Development	
	Total (L : 45)

Suggested Learning Resources

Reference Books:

1. Fadi Al-Turjman, “Artificial Intelligence in IoT”, Springer, 2019
2. Ambika Nagaraj,” The Role of AI in Enhancing IoT-Cloud Applications”, Bentham Books, 2023
3. Rajkumar Buyya and Amir Vahid Dastjerdi, "Internet of Things: Principles and Paradigms", Elsevier, 2016
4. Jason Ioannou, "Data Analytics for IoT and Smart Systems", Springer, 2020
5. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep Learning", MIT Press, 2016

6. Weisong Shi, "Edge Computing: Vision and Challenges", Springer, 2020
7. Mauro Conti, "Security and Privacy in the Age of IoT", Springer, 2020
8. François Chollet, “Deep Learning with Python” (2nd Edition), Manning Publications , 2021
9. Stuart Russell & Peter Norvig, “Artificial Intelligence: A Modern Approach”, 4th Edition, Pearson, 2020
10. Arshdeep Bahga& Vijay Madisetti, “Internet of Things: A Hands-On Approach” ,2nd Edition, Universities Press, 2016

EDGE AND FOG COMPUTING						
Course Code:	CP26X03				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					
Course Objective						
This course aims to provide knowledge on fog and edge computing concepts, architectures, and technologies for developing efficient distributed IoT applications.						

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Analyze distributed computing models to meet the performance requirements of IoT applications.	An	20%
CO 2	Apply task scheduling, workload distribution, and resource allocation techniques to improve system performance.	Ap	20%
CO 3	Implement middleware services, container technologies, and communication protocols for distributed computing environments.	Ap	20%
CO 4	Analyze intelligent data processing, security mechanisms, and privacy-preserving techniques for real-time applications.	An	20%
CO 5	Examine advanced technologies and future trends in edge computing.	Ap	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	2		3	3	
CO 3	2		3	3	2
CO 2	2		3	3	2
CO 4	2		3	3	2
CO 5	2		2	2	
CO (W.A)	2		2.8	2.8	2

Unit I – Introduction To Edge, Fog and Cloud Computing	**9**
Evolution from Cloud to Fog and Edge Computing – IoT Architecture Requirements and Latency Limitations – Fog vs Edge vs Cloud Computing: Characteristics and Differences in Computation and Storage – Multi-access Edge Computing (MEC) Concepts – Multi-tier Architectural Models for Distributed Systems – Cloud-to-Fog-to-Things (C2F2T) Integration – Applications of Edge and Fog Computing in Smart Systems.	
Unit II : Edge Offloading And Resource Management	**9**
Edge Offloading Strategies and Task Placement Issues – Challenges in Latency, Energy Efficiency, QoS, and Privacy – Queuing Theory and System Performance Metrics – Resource Virtualization using SDN and NFV – Container-Based Federation – Network Slicing for 5G/6G: Slice Types and Lifecycle – Modeling and Simulation for Resource Management.	
Unit III – Edge Middleware And Communication Technologies	**9**
Middleware Design Goals: Heterogeneity, Discovery, and Scalability – Service Orchestration at the Edge – Lightweight Containers: Docker and Kubernetes on Constrained Devices – Edge Cluster Formation and Node Coordination – Communication Protocols: MQTT, CoAP, and Microservices – Distributed Storage, Synchronization, and Fault Recovery.	
Unit IV – Edge Intelligence, Analytics And Security	**9**
Data Management at the Fog Layer: Caching, Placement, and Lifecycle Management – Federated Learning and Distributed Machine Learning for Edge Analytics – Stream Processing and Real-Time Analytics Frameworks – Use Cases in Smart Cities, Healthcare, and Smart Homes – ML-Based Threat Detection and Behavioral Analysis – Privacy Techniques: Differential Privacy and Federated Anonymization – Security and Privacy Challenges in Edge Environments.	
Unit V – Advanced and Emerging Trends in Edge Computing	**9**
Blockchain for Fog Resource Security and Transparency – Software-defined Edge Networks and Intent-Based Networking – Green and Sustainable Edge Computing – Edge AI and TinyML: Neural Compression, Quantization, and Model Deployment – 6G Vision: Ultra-Low Latency and Terahertz Communications – Advanced Paradigms: Digital Twins, Serverless Edge, and Cognitive Networks .	
	Total (L : 45)

Suggested Learning Resources
Reference Books:
1. Rajiv Pandey, Sunil Kumar Khatri, Neeraj Kumar Singh, Parul Verma, Artificial Intelligence and Machine Learning for EDGE Computing, 1st Edition,2022, Academic Press 2. S. Goundar, Ed., 'Edge Computing - Technology, Management and Integration'. IntechOpen,2023. 3. Ahmed Banafa, Secure And Smart Internet of Things (IoT) using Blockchain and Artificial Intelligence (AI).2018, River publications 4. Javid Taheri, Schahram Dustdar, Albert Zomaya, Shuiguang Deng, Edge Intelligence From Theory to Practice, 2023, Springer 5. Fog, Edge, and Pervasive Computing in Intelligent IoT Driven Applications Deepak Gupta, Aditya Khamparia ,2021, Wiley-IEEE Press

BIO-INSPIRED COMPUTING						
Course Code:	CP26X04				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					
Course Objective						
This course aims to provide knowledge on bio-inspired optimization algorithms for solving engineering problems and image processing applications.						

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Analyze optimization problems and bio-inspired computing principles for solving complex engineering problems.	An	20%
CO 2	Apply randomization and annealing techniques to solve optimization problems efficiently.	Ap	20%
CO 3	Implement evolutionary optimization techniques to obtain optimal solutions for engineering applications.	Ap	20%
CO 4	Analyze swarm-based optimization methods for solving complex search and optimization problems.	An	20%
CO 5	Apply bio-inspired optimization techniques to image processing and intelligent vision application	Ap	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1	3		3	3	
CO 3	2		3	3	
CO 2	2		3	3	
CO 4	3		3	3	2
CO 5	2		3	3	2
CO (W.A)	2		3	3	2

Unit I – Bio-Inspired Computing Fundamentals	**9**
Introduction to Computing - Algorithm - Newton's method – Optimization algorithm - No-Free-Lunch Theorems - Nature-Inspired Meta-heuristics -Analysis of Algorithms -Nature Inspired Algorithms - - Parameter tuning and parameter control.	
Unit II Random Walk and Anealing	**9**
Random variables - Isotropic random walks - Levy distribution and flights - Markov chains - step sizes and search efficiency - Modality and intermittent search strategy - importance of randomization- Eagle strategy Annealing and Boltzmann Distribution - parameters -SA algorithm - Stochastic Tunneling	
Unit III – Genetic Alogorithms and Differential Evolution	**9**
Introduction to genetic algorithms and - role of genetic operators - choice of parameters - GA varients schema theorem - convergence analysis - introduction to differential evolution - varients - choice of parameters - convergence analysis - implementation	
Unit IV – Swarm Optimization and Firefly Algorithm	**9**
Swarm intelligence - PSO algorithm - accelerated PSO - implementation - convergence analysis – binary PSO - The Firefly algorithm - algorithm analysis - implementation - varients- Ant colony optimization toward feature selection.	
Unit V – Application In Image Processing	**9**
Bio-Inspired Computation and its Applications in Image Processing: An Overview - Fine- Tuning Enhanced Probabilistic Neural Networks Using Meta-heuristic-driven Optimization - Fine-Tuning Deep Belief Networks using Cuckoo Search - Improved Weighted Thresholded Histogram Equalization Algorithm for Digital Image Contrast Enhancement Using Bat Algorithm - Ground Glass Opacity Nodules Detection and Segmentation using Snake Model - Mobile Object Tracking Using Cuckoo Search.	
	Total (L : 45)

Suggested Learning Resources

Reference Books:

1.. Eiben, A.E.,Smith, James E, "Introduction to Evolutionary Computing", Springer 2015.
2. Helio J.C. Barbosa, "Ant Colony Optimization - Techniques and Applications", Intech 2013
3. Xin-She Yang , Jaao Paulo papa, "Bio-Inspired Computing and Applications in Image Processing", Elsevier 2016
4. Xin-She Yang, "Nature Ispired Optimization Algorithm, Elsevier First Edition 2014
5. Yang ,Cui, Xlao, Gandomi, Karamanoglu ,"Swarm Intelligence and Bio-Inspired Computing", Elsevier First Edition 2013

ADVANCED DEEP LEARNING AND NEURAL NETWORKS						
Course Code:	CP26X05				CIA	40
Course Type: (Theory/Practical/Integrated)	Theory				ESE	60
L:T:P:C	3	0	0	3	Total Marks	100
Total Hours of Pedagogy	45				Exam Hours	3
Pre-requisites	Nil					
Course Objective						
To provide knowledge on machine learning and deep learning concepts, models and applications for solving real-world problems.						

Course Outcomes		Cognitive Level	Weightage of COs in ESE
CO 1	Apply appropriate data preprocessing, statistical techniques and machine learning methods to prepare datasets and evaluate predictive models.	An	20%
CO 2	Analyze the performance of neural network training using suitable activation functions, loss functions, optimization algorithms and hyperparameter tuning techniques.	Ap	20%
CO 3	Apply deep learning architectures such as Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) for image and sequential data processing applications.	Ap	20%
CO 4	Analyze unsupervised and generative deep learning models including Autoencoders, Variational Autoencoders (VAE) and Restricted Boltzmann Machines (RBM) for feature learning and data representation.	An	20%
CO 5	Apply deep learning techniques to real-world applications and analyze model performance, convergence behavior and computational efficiency in practical deployment scenarios.	Ap	20%

COs	POs			PSOs	
	1	2	3	1	2
CO 1			3	3	
CO 3	3		3	3	
CO 2			3	3	2
CO 4	3		3	3	2
CO 5			3	3	2
CO (W.A)	3		3	3	2

Unit I – Fundamentals of Machine Learning and Data Preprocessing	**9**
Introduction to Artificial Intelligence, Machine Learning and Deep Learning – Types of Learning – Supervised, Unsupervised and Reinforcement Learning – Data Collection and Dataset Preparation – Statistical Measures – Mean, Variance and Standard Deviation – Handling Missing Data and Outlier Detection – Feature Scaling and Normalization Techniques – Training, Validation and Test Datasets – Performance Metrics for Classification – Precision, Recall and F1-Score – Regression Metrics – MSE and RMSE.	
Unit II - Neural Networks and Training Mechanisms	**9**
Biological Neuron and Artificial Neuron Model – Perceptron and Multilayer Feed Forward Neural Networks – Activation Functions – Sigmoid, Tanh, ReLU and Softmax –Loss Functions for Classification and Regression – Forward Propagation and Backpropagation Algorithm – Gradient Descent and Stochastic Gradient Descent – Optimization Algorithms – SGD, Momentum and Adam – Hyperparameter Tuning – Learning Rate, Batch Size and Epochs – Overfitting, Underfitting and Regularization Techniques.	
Unit III – Deep Learning Architectures	**9**
Introduction to Deep Neural Networks – Deep Feed Forward Networks – Convolutional Neural Networks (CNN) – Pooling Layers and Feature Extraction – Image Classification using CNN – Recurrent Neural Networks (RNN) – Sequence Modeling and Time Dependent Data – Vanishing and Exploding Gradient Problems – Attention Mechanism in Sequence Learning	
Unit IV – Unsupervised and Generative Models	**9**
Introduction to Unsupervised Deep Learning – Autoencoders and Dimensionality Reduction – Sparse and Denoising Autoencoders – Variational Autoencoders (VAE) – Encoder and Decoder Architectures – Restricted Boltzmann Machines (RBM) – Deep Belief Networks – Feature Learning and Representation Learning – Generative Models for Synthetic Data Generation.	

Unit V – Advanced Applications of Deep Learning	**9**
Deep Learning for Image Processing – Speech Recognition using RNN – Natural Language Processing Applications – Recommendation Systems using Deep Learning – Model Evaluation and Validation Strategies – Convergence Analysis and Training Stability – Model Complexity and Computational Efficiency – Deployment Challenges in Deep Learning – Case Studies in Healthcare, Finance and Smart Systems.	
	Total (L : 45)

Suggested Learning Resources
Reference Books:
1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016. 2. Charu C. Aggarwal, Neural Networks and Deep Learning, Springer, 2018. 3. Francois Chollet, Deep Learning with Python, Manning Publications, 2018. 4. Simon Haykin, Neural Networks and Learning Machines, Pearson Education, 2009. 5. Aston Zhang, Zachary Lipton, Mu Li and Alexander Smola, Dive into Deep Learning, Cambridge University Press, 2023.