5th Semester

Course Code	BCAICOS526				5th Semester	
Course Title	Operating Systems				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	2	1	2	4	100	100

Course Learning Outcomes (CLOs)	
CLO1	Introduces operating system concepts which include process, scheduling, synchronization deadlocks, memory management and I/O management.
CLO2	Provides insight of issues to be considered in the design and development of operating systems.
CLO3	Introduces Unix commands, system call interface for process management,communication and I/O in unix.
CLO4	Understand the fundamentals of Disk management and I/O devices.
CLO5	Simulate operating system concepts like scheduling, deadlock, etc.

Syllabus

Units	Content
1	**Introduction to operating systems:** Operating system functions, evolution of operating systems, batch, interactive, time sharing and real-time system, system protection. Operating system structure: System components, operating system services. Process management: Process concept, principle of concurrency, producer consumer problem, critical section problem, semaphores, inter-process communication.
2	**CPU scheduling:** Scheduling concept, scheduling criteria, scheduling algorithms, multiprocessor scheduling. **Deadlock:** System model, deadlock characterization, prevention, avoidance, detection and recovery.
3	**Memory management:** Base machine, Resident monitor, Multiprogramming with fixed partition, Multiprogramming with variable partition, Multiple base register, Paging, Segmentation, Virtual memory concept, Demand paging, Performance, Paged replaced algorithm, Allocation of frames, Thrashing; Cache memory, Organization, Impact on performance

4	**Virtual memory management:** Virtual memory concept, Demand paging, Performance, Page replacement algorithms, Allocation of frames, Thrashing. **File system:** File Concept, File Organization and Access Mechanism, File Directories and File Sharing.
5	**Disk management:** Disk Structure, Disk I/O, Disk scheduling algorithms, RAID Structure. **I/O management:** I/O devices and organization of I/O function, I/O Buffering, DISK I/O, Operating System Design Issues.
S. No.	**Suggested Practicals / Mini Projects**
1	**Execution of basic UNIX commands:** • File/Directory Handling commands. • Explore system variables such as PATH, HOME. • Modifying File Access Permissions and identifying different types of users in UNIX.
2	**Filters and I/O Redirection:** • Demonstrate all features of awk, sed and grep commands. Compare the results of these commands. • Execute commands related to inode, I/O redirection, piping.
3	**Shell Programming:** shell script exercise based on following: • Interactive shell script, Positional parameters, Arithmetic and Logical operators, If structure • While, for, until loop, Meta characters.
4	**Inter-process Communication:** • Write a program to demonstrate a one-way pipe between two Processes. • Write a program to illustrate IPC through pipe and fork system calls –Printing only odd numbers.
5	**Simulation of scheduling algorithms:** Write a shell program to implement the following process scheduling algorithms • First Come First Serve • Shortest Remaining Job First • Round Robin
6	**Implement the following:** The Producer – Consumer problem using semaphores (using UNIX system calls). Banker's algorithm for deadlock avoidance. Paging and Segmentation.
7	**Mini Project/Lab Assignment.**
	Note: This is only a suggested list of lab exercises. Instructors may frame additional exercise relevant to the course contents.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO

CLO1	3	2	0	0	0	0	0	0	0	0	0	1	2
CLO2	3	3	3	2	1	0	0	0	0	0	0	1	2.17
CLO3	3	2	2	1	3	0	0	0	0	0	0	1	2
CLO4	3	2	1	2	2	0	1	0	0	0	0	1	1.71
CLO5	3	3	3	3	3	0	0	0	0	0	0	2	2.43
Avg PLO	3.0	2.4	2.3	2.0	2.3	0.0	1.0	0	0	0	0	1.2	2.1

Suggested Reading	
1	*Silberschatz, A., Peterson, J. L., & Galvin, P. B. (1991). Operating system concepts. Addison-Wesley Longman Publishing Co., Inc...*
2	*Andrew, S. T., & Herbert, B. (2015). Modern operating systems. Pearson Education.*
3	*Stallings, W. (1998). Operating systems internals and design principles. Prentice-Hall, Inc...*
4	Bhatt, P. C. P. (2019). An Introduction to Operating Systems: Concepts and Practice (GNU/Linux and Windows). PHI Learning Pvt. Ltd...
5	*Deitel, H. M., Deitel, P. J., & Choffnes, D. R. (2004). Operating systems. Pearson/Prentice Hall.*

Teaching-Learning Strategies
Lectures and interactive classroom discussions.
Demonstrations and hands-on experiments on Open-Source Operating Systems.
Shell programming to understand the searching and filtering operations.

Course Code	BCAICTC526				Semester: 5th	
Course Title	Theory of Computation				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	0	3	100	0

Course Learning Outcomes (CLOs)	
CLO1	Explain the concepts of formal languages, finite automata, regular expressions, and regular grammars.
CLO2	Analyze context-free grammars, pushdown automata, and their applications in language recognition.
CLO3	Apply Turing machine models to solve computational problems and classify formal languages.
CLO4	Analyze decidability, reducibility, and undecidability problems using formal computational models.
CLO5	Evaluate computational complexity, NP-completeness, and related problems using complexity theory principles.

Syllabus

Units	Content
1	**Introduction to Theory of Computation, Regular Languages and Finite Automata:** Introduction to Theory of Computation: Significance and applications of Theory of Computation in Computer Science; Mathematical Models of Computation; Formal Languages, Alphabets, Strings and Languages; Operations on Languages; Deterministic Finite Automata (DFA); Non-Deterministic Finite Automata (NFA); Equivalence of DFA and NFA; Finite Automata with ε-transitions; Regular Languages; Regular Expressions; Conversion between Finite Automata and Regular Expressions; Closure Properties of Regular Languages; Pumping Lemma for Regular Languages; Applications of Finite Automata.

2	**Context-Free Languages and Pushdown Automata:** Context-Free Grammars (CFGs); Derivations and Parse Trees; Ambiguous and Unambiguous Grammars; Simplification of CFGs; Chomsky Normal Form (CNF); Greibach Normal Form (GNF); Pushdown Automata (PDA); Deterministic and Non-Deterministic Pushdown Automata (DPDA and NPDA); Acceptance by Empty Stack and Final State; Equivalence of CFGs and PDAs; Closure Properties of Context-Free Languages; Pumping Lemma for Context-Free Languages
3	**Turing Machines and Computability:** Turing Machines; Instantaneous Descriptions; Design of Turing Machines; Variants of Turing Machines; Deterministic and Non-Deterministic Turing Machines (DTM and NDTM); Universal Turing Machine; Church-Turing Thesis; Recursive and Recursively Enumerable Languages; Introduction to Computability.
4	**Undecidability:** Decidable and Undecidable Problems; The Halting Problem; Post Correspondence Problem (PCP); Mapping Reducibility; Undecidability Proof Techniques; Examples of Undecidable Problems involving Turing Machines and Context-Free Languages.
5	**Computational Complexity:** Time Complexity and Space Complexity; Complexity Classes P and NP; Polynomial-Time Verification; Polynomial-Time Reductions; NP-Hard and NP-Complete Problems; Cook's Theorem; Satisfiability (SAT), Clique, Vertex Cover and Traveling Salesman Problems. Introduction to Quantum Computing and Quantum Automata.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	0	0	0	0	0	0	0	0	0	1	2.0
CLO2	3	3	2	2	0	0	0	0	0	0	0	1	2.2
CLO3	3	3	3	2	1	0	0	0	0	0	0	1	2.17
CLO4	3	3	2	3	1	0	0	0	0	0	0	1	2.17
CLO5	3	3	2	2	2	0	0	0	0	0	0	2	2.33
Avg PLO	3.0	2.8	2.3	2.25	1.33	0	0	0	0	0	0	1.2	2.17

Suggested Reading

1	*John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education.*
2	*Michael Sipser, Introduction to the Theory of Computation, Cengage Learning.*
3	*Peter Linz, An Introduction to Formal Languages and Automata, Jones & Bartlett Learning.*
4	*John C. Martin, Introduction to Languages and the Theory of Computation, McGraw-Hill Education.*
5	*K. L. P. Mishra and N. Chandrasekaran, Theory of Computer Science, PHI Learning.*

Teaching-Learning Strategies
Interactive lectures supported by examples, visualizations, and derivations of formal computational models.
Problem-solving sessions involving the design and analysis of finite automata, grammars, pushdown automata, and Turing machines.
Tutorial assignments and classroom discussions on language properties, computability, undecidability, and computational complexity.
Case studies and seminars highlighting applications of Theory of Computation in compiler design, formal verification, artificial intelligence, and emerging computational paradigms.

Course Code	BCAICCN526				Semester: 5th	
Course Title	Computer Networks				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	2	4	100	100

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamental concepts of computer networks, including network architectures, transmission techniques, network topologies.
CLO2	Analyze data link layer functions including flow control, error control and medium access control techniques.
CLO3	Apply network layer concepts to configure and manage logical addressing, subnetting, packet handling, and routing algorithms for efficient data delivery.
CLO4	Explain the functions and protocols of the transport layer, including TCP, UDP, SCTP, connection management, flow control, and reliable end-to-end communication services.
CLO5	Evaluate network performance and application-layer services by studying congestion control mechanisms, Quality of Service (QoS) techniques, and key Internet applications such as DNS, HTTP, email, file transfer, and remote access services.

Syllabus

Units	Content
1	**Basic Concepts of Networks:** Introduction, history and development of computer networks, Data transmission techniques: simplex, half duplex, full duplex; Types of networks (LAN, MAN and WAN); Different network topologies like bus, star, ring, hybrid. **Network Protocol Architecture:** OSI Reference model, Layers of OSI model: Physical, Data-link, Network, Transport, Session, Presentation and Application layer; Concept of TCP/IP Protocol Suite. **Physical Layer:** Different types of transmission media; role of repeaters; Line Encoding Schemes (NRZ, NRZI, Manchester, 4B/5B, etc.)

2	**Flow and Error Control:** Stop and wait flow control, sliding window flow control, error control protocols, ARQ techniques, Stop-and-wait ARQ, Goback-N ARQ, Selective repeat ARQ. HDLC Protocol, Point to Point Protocol, Ethernet, Token Ring network, WLANs **Medium Access Control Protocols:** Random Access: ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA; Controlled Access: Polling, token passing, reservation. **Network Switching Techniques:** Circuit, message and packet switched networks.
3	**Network layer:** Logical Addressing-IPv4 and IPv6 addresses, Concept of Sub-netting and Classless Addressing, Network Address Translation. **IP Packets:** IPv4 and IPv6 packet format, Packet Fragmentation **Routing Algorithms:** Routing tables, features of a routing algorithm, classification; concept of optimality principle, sink tree, flooding, fixed routing, random routing, adaptive routing; shortest path algorithm, Dijkstra algorithm, distance vector and link state algorithm.
4	**Transport Layer:** Services provided to the upper layers, addressing, Socket Addresses, connection establishment, Connection release, Error Control & Flow Control **Protocols:** User Datagram Protocol (UDP), Introduction to TCP, The TCP Service Model, The TCP Segment Header, The Connection Establishment, The TCP Connection Release, The TCP Sliding Window **Introduction to SCTP:** SCTP Service, SCTP Features, Packet Format, SCTP Association
5	**Congestion Control:** Congestion in networks, congestion control strategies, Congestion control in TCP and Frame Relay; **Quality of Service (QoS):** Techniques to improve QoS **Application Layer:** Client server model, File Transfer, HTTP, Electronic mail, Remote Logging.
S. No.	**Suggested Practicals / Mini Projects**
1	Introduction of LANs and Network Wire Crimping.
2	Experimental study of assigning IP addresses to nodes and sharing resources over the networks.
3	Experiments with packet sniffers to study the TCP/IP protocols.
4	Introduction of Network Simulators.
5	Introduction to NS2 (network simulator) - small simulation exercises to study behaviour of various protocols.
6	Setting up a small IP network: Configure interfaces, IP addresses and routing protocols.

7	Queuing disciplines.
8	Small exercises in socket programming in high level languages.
9	Note: This is only a suggested list of lab exercises. Instructors may frame additional exercise relevant to the course contents.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	0	0	0	0	0	0	0	0	0	1	2
CLO2	3	3	2	2	1	0	0	0	0	0	0	1	2
CLO3	3	3	3	2	2	0	0	0	0	0	0	1	2.33
CLO4	3	2	2	1	1	0	0	0	0	0	0	1	1.67
CLO5	3	3	2	3	2	1	1	0	0	0	0	2	2.13
Avg PLO	3.0	2.6	2.3	2.0	1.5	1.0	1.0	0	0	0	0	1.2	2.0

Suggested Reading

1	*William Stallings: Data and Computer Communications, PHI*
2	*D.P Bertsekas "Data Networks" Prentice Hall*
3	*Andrew Tanenbaum, "Computer Networks", Pearson*
4	*J. F. Kurose "Computer Networking" Addison-Wesley*
5	*Douglas E. Comer, "Internetworking with TCP/IP, Volume1", PHI*
6	*Peterson and Davie, "Computer Networks", Morgan Kaufman*

Teaching-Learning Strategies

Lectures and interactive classroom discussions.

Demonstrations and hands-on laboratory experiments using Network Simulators.
Project-based learning through the Implementation and evaluation of Networking Protocols.

Course Code	BCAICAM526				Semester: 5th	
Course Title	AI and Machine Learning				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	2	4	100	100

Course Learning Outcomes (CLOs)	
CLO1	Explain the fundamentals, history, applications, and agent-based approach of Artificial Intelligence.
CLO2	Apply uninformed, heuristic, and adversarial search techniques for solving AI-based problems.
CLO3	Analyze knowledge representation, logical reasoning, and probabilistic reasoning techniques.
CLO4	Apply supervised and unsupervised Machine Learning algorithms for classification and clustering problems.
CLO5	Explain neural networks, genetic algorithms, fuzzy logic, and basic NLP techniques used in AI and ML applications.

Syllabus	
Units	Content
1	**Introduction to Artificial Intelligence and Uninformed Search:** Introduction, history and applications of Artificial Intelligence. Intelligent agents, structure of intelligent agents and problem-solving agents. Uninformed search strategies: Breadth First Search, Depth First Search, Depth Limited Search, Uniform Cost Search and Iterative Deepening Search.
2	**Heuristic and Adversarial Search Techniques:** Heuristic search, heuristic functions, hill climbing, beam search, A* algorithm, completeness and optimality of search algorithms. Adversarial search, game playing, minimax algorithm, alpha-beta pruning and evaluation functions.
3	**Knowledge Representation and Reasoning:** Propositional logic, first-order logic, inference in first-order logic, forward chaining, backward chaining, theorem proving, resolution theorem proving, rules and rule-based reasoning, structured knowledge representation. Reasoning under uncertainty, probabilistic reasoning, Bayesian inference networks and Hidden Markov Models.

4	**Machine Learning Fundamentals and Algorithms:** Introduction to Machine Learning, supervised learning, unsupervised learning and reinforcement learning. Data preprocessing, training and testing, model evaluation. Classification techniques: Support Vector Machines, Decision Trees and Naive Bayes. Clustering techniques: K-Means clustering, Gaussian Mixture Model and Expectation-Maximization algorithm.
5	**Neural Networks, Soft Computing and Natural Language Processing:** Introduction to neural networks, perceptron, activation functions and basic neural network architectures. Genetic algorithms: operations, applications and limitations. Fuzzy logic: fuzzification, fuzzy sets, operations on fuzzy sets, hedges, reasoning in fuzzy logic and Mamdani inference. Introduction to Natural Language Processing, phases of NLP, parse tree, tokenization, stemming, lemmatization, chunking, Bag of Words and Word2Vec.
S. No.	**Suggested Practicals / Mini Projects**
1	Implement Breadth First Search (BFS) and Depth First Search (DFS) for graph traversal.
2	Implement Uniform Cost Search and Iterative Deepening Search for problem solving.
3	Implement heuristic search techniques including Hill Climbing and A* algorithm.
4	Implement Minimax algorithm for a simple game problem.
5	Implement Alpha-Beta pruning to optimize game tree search.
6	Develop a rule-based expert system using propositional or first-order logic.
7	Implement Bayesian classification or probabilistic reasoning using a suitable dataset.
8	Implement Decision Tree and Naive Bayes classifiers for classification problems.
9	Implement Support Vector Machine (SVM) for supervised learning.
10	Implement K-Means clustering and evaluate clustering performance.
11	Implement a basic neural network using Python for classification or prediction.
12	Perform basic NLP operations such as tokenization, stemming, lemmatization, Bag of Words and Word2Vec.
13	Mini Project: Develop an AI/ML-based application using search, classification, clustering, neural network or NLP techniques.
	CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	0	0	0	0	0	0	0	0	0	1	2
CLO2	3	3	2	2	1	0	0	0	0	0	0	1	2
CLO3	3	3	3	2	2	0	0	0	0	0	0	1	2.33
CLO4	3	2	2	1	1	0	0	0	0	0	0	1	1.67
CLO5	3	3	2	3	2	1	1	0	0	0	0	2	2.13
Avg PLO	3.0	2.6	2.3	2.0	1.5	1.0	1.0	0	0	0	0	1.2	2.0

Suggested Reading

1	*Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson.*
2	*Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, McGraw Hill.*
3	*Tom M. Mitchell, Machine Learning, McGraw Hill.*
4	*Ethem Alpaydin, Introduction to Machine Learning, MIT Press.*
5	*Prateek Joshi, Artificial Intelligence with Python, Packt Publishing.*
6	*S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, Prentice Hall of India.*

Teaching-Learning Strategies

Interactive lectures to explain AI concepts, search techniques, reasoning methods, and ML fundamentals.

Demonstrations using Python-based tools for classification, clustering, neural networks, and NLP tasks.

Assignments, case studies, and mini-projects to strengthen practical understanding of AI and ML applications.

Course Code	BCAICCA526				Semester: 5th	
Course Title	Computer Organization and Architecture				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	0	3	100	0

Course Learning Outcomes (CLOs)

CLO1	Explain the basic structure of a computer system consisting of CPU, main memory, I/O and their functional interconnection.
CLO2	Understand and apply register transfer logic to describe the microoperations in the execution of an instruction.
CLO3	Analyze instruction format to appreciate its implications on opcode and addressing modes.
CLO4	Describe how integers and floating-point numbers are represented and illustrate how arithmetic is performed.
CLO5	Appreciate the hierarchical memory organization in a computer system and compare various cache mapping techniques.

Syllabus

Units	Content
1	**Basic structure and functional interconnection:** Basic structure and functions of a digital computer, Basic functional blocks of a computer: CPU, memory, input-output subsystems, control unit. Von Neuman architecture, hierarchical structure of functional units and their interconnection; System bus. Structure of CPU. CPU registers and their functions viz. Program Counter, Instruction Register, Memory Address Register, Memory Buffer Register, Program Status Word, etc. Execution of a complete (basic) instruction. Instruction set (ISA), Instruction cycle.
2	**Instruction format and addressing modes:** Various addressing modes, Visualization of addressing modes in high level program constructs viz. array indexing. Instruction format and types, Opcode and operands. Micro-operations and Register Transfer Language, CPU organizations- accumulator, general register and stack, Implications on zero, one, two and three address instructions. CISC and RISC architecture.

3	**Data representation and arithmetic:** Signed number representation, fixed and floating-point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication - shift-and-add, Booth multiplier, carry save multiplier, etc. Division - non-restoring and restoring techniques, floating point arithmetic. Control Unit Organization: Hardwired control, micro-programmed control, micro-instructions, address sequencing, control memory.
4	**Memory hierarchy and cache memory organization:** Semiconductor main memory, RAM and its types-SRAM and DRAM, memory hierarchy, locality of reference, cache memory, organization and characteristics, mapping techniques- direct, associative and set associative, replacement algorithms (brief account only), write policies- write-back and write-through.
5	**I/O organization and performance metrics:** I/O modules and their functions, programmed I/O, commands, memory-mapped and isolated I/O, interrupt-driven I/O, DMA, Introduction to standard interfaces viz. PCI, SCSI, and USB. CPU equation and Amdahl's law. Introduction to pipelining.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	1	0	0	0	0	0	0	0	0	0	1	1.67
CLO2	3	2	1	0	0	0	0	0	0	0	0	0	2.00
CLO3	2	3	0	0	0	0	0	0	0	0	0	0	2.50
CLO4	3	2	0	0	0	0	0	0	0	0	0	0	2.50
CLO5	3	2	2	0	0	0	0	0	0	0	0	1	2.00
Avg PLO	2.80	2.00	1.5	0	0	0	0	0	0	0	0	1.00	2.13

Suggested Reading

1	*Computer Organisation and Architecture, William Stallings, Pearson Education.*
2	*David A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, Elsevier.*

3	*Computer System Architecture, J. P. Hayes, Pearson Education*
4	*Computer System Architecture, M. Moris Mano, Pearson Education.*
5	*The Essentials of Computer Organisation and Architecture, Null and Lobur, Jones and Bartlett Publishers, Inc*

Teaching-Learning Strategies

Lectures and interactive discussions.
Illustrative presentations for visualizing internal computer processes.
Student seminars on contemporary processor architectures.

Course Code	BCAILIP526				Semester: 5th	
Course Title	IoT & Smart System Prototyping				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	0	0	4	2	-	50

Course Learning Outcomes (CLOs)	
CLO1	Understand the fundamentals of the Internet of Things (IoT) and smart systems.
CLO2	Design and develop IoT-based solutions using sensors, actuators, and embedded platforms.
CLO3	Explore communication protocols and cloud integration for IoT applications.
CLO4	Develop smart systems for real-world applications such as smart homes, healthcare, agriculture, and industry.
CLO5	Gain hands-on experience in IoT prototyping and deployment.

Suggested Contents/Practicals / Mini Projects/ Hands-on-experiments	
1	**Introduction to IoT and Smart Systems** Evolution and Vision of IoT, Characteristics and Components of IoT, IoT Architecture and Design Principles; Smart Systems: Concepts and Applications, IoT Reference Models, Sensors, Actuators, and Embedded Devices, IoT Hardware Platforms (Arduino, ESP32, Raspberry Pi) Challenges and Future Trends in IoT
2	**Embedded Systems and IoT Prototyping:** Introduction to Embedded Systems: Microcontrollers and Single Board Computers, Arduino Programming Fundamentals, ESP8266/ESP32 Architecture and Programming, Sensor Interfacing Techniques, Actuator Control Mechanisms, Data Acquisition and Signal Conditioning, Rapid Prototyping Techniques

3	**IoT Communication and Networking:** IoT Communication Models, Wireless Sensor Networks, IPv6 for IoT, MQTT Protocol, CoAP Protocol, HTTP and RESTful APIs, ZigBee, Bluetooth Low Energy (BLE), Edge and Fog Computing Concepts
4	**Cloud Integration and Smart Applications:** IoT Cloud Platforms, Device-to-Cloud Communication, Data Storage and Analytics, IoT Dashboards and Visualization, Cloud Services for IoT, Smart Home Systems, Smart Healthcare Systems, Smart Agriculture and Smart City Applications, Industrial IoT (IIoT)
5	**IoT Security, AI Integration and Case Studies:** Security Requirements in IoT, Authentication and Access Control, Secure Communication Protocols, Privacy Issues in IoT, Artificial Intelligence and Machine Learning for IoT, TinyML Concepts, Digital Twins, Case Studies of Smart Systems, Emerging Trends in IoT and Smart Technologies

Note: This is only a suggested list of contents/practicals/lab exercises. Instructors may frame additional exercises relevant to the course and contemporary application domains.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	0	0	1	0	0	0	0	0	0	1	1.75
CLO2	3	3	3	2	3	1	1	0	1	0	1	2	2
CLO3	3	3	2	2	3	1	1	0	0	0	0	2	2.13
CLO4	3	3	3	3	3	3	2	1	1	1	1	2	2.17
CLO5	3	2	3	3	3	1	1	0	2	1	1	3	2.09
Avg PLO	3.00	2.6	2.8	2.5	2.6	1.5	1.3	1.0	1.3	1.0	1.0	2.0	2.0

Suggested Reading

1	*Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, Wiley*
2	*Alice James, Avishkar Seth, Subhas Chandra Mukhopadhyay, "IoT System Design: Project Based Approach",Springer*

3	*Milan Milenkovic, "Internet of Things: Concepts and System Design", Springer*
4	*G. R. Kanagachidambaresan, "Internet of Things Using Single Board Computers: Principles of IoT and Python Programming", Apress*
5	*Haider Raad, "Fundamentals of IoT and Wearable Technology Design", Wiley-IEEE Press*

Teaching-Learning Strategies
Hands-on Laboratory Sessions using modern computing tools and development platforms.
Project-Based Learning through collaborative software development and documentation.
Experiential Learning using industry-standard tools and real-world applications.
Seminar and Presentation on emerging IoT and Smart technologies and industry trends.
Collaborative and Peer Learning through teamwork, code review, and technical discussions.

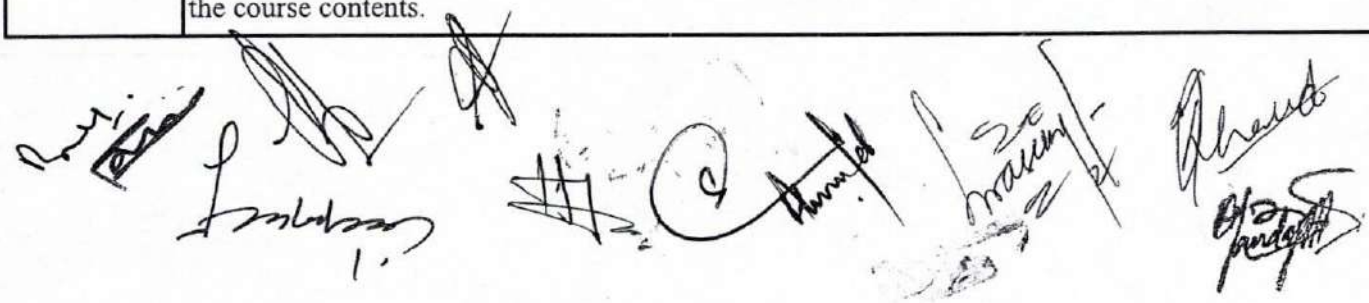
6th Semester

Course Code	*BCAICDA626*				6th Semester	
Course Title	*Big Data Analytics*				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	2	4	100	100

Course Learning Outcomes (CLOs)	
CLO1	Understand the characteristics, architecture, and applications of Big Data and distributed computing systems.
CLO2	Explain the Hadoop ecosystem, including HDFS and YARN, for scalable data storage and resource management.
CLO3	Develop distributed data processing applications using MapReduce and Apache Spark.
CLO4	Apply Hadoop ecosystem tools and NoSQL databases for large-scale data storage, querying, and analytics.
CLO5	Analyze real-world Big Data applications using modern analytics frameworks and cloud-based technologies.

Syllabus	
Units	Content
1	**Big Data Fundamentals and Distributed Systems:** Evolution of Data and Big Data,Characteristics (5Vs), Sources, and Types of Big Data,Challenges and Applications of Big Data,Distributed Computing and Distributed File Systems,Big Data Architecture and Analytics Lifecycle,Overview of the Hadoop Ecosystem
2	**Hadoop Architecture and Distributed Storage:** Introduction to Apache Hadoop, Hadoop Distributed File System (HDFS), HDFS Architecture (NameNode, Secondary NameNode and DataNode), HDFS Read/Write Operations, Replication, Fault Tolerance and Data Integrity, HDFS Commands, Data Formats (Avro and Parquet), YARN Architecture and Resource Management.
3	**Distributed Data Processing:** MapReduce Programming Model, Map and Reduce Phases, Shuffle and Sort, Job Execution, Scheduling and Fault Tolerance, Apache Spark Architecture, Resilient Distributed Datasets (RDDs), DataFrames, Spark SQL.

4	**Hadoop Ecosystem and Data Management:** Data Ingestion using Sqoop and Flume, Apache Hive and HiveQL, Apache Pig and Pig Latin, Introduction to NoSQL Databases and CAP Theorem, MongoDB (Data Model, CRUD Operations, Indexing and Aggregation), HBase Fundamentals and Comparison with Relational Databases.
5	**Big Data Analytics, Cloud Platforms and Applications:** Spark Streaming and Real-Time Data Processing, Introduction to Machine Learning for Big Data, Cloud-Based Big Data Platforms (AWS EMR, Azure HDInsight and Google Cloud Dataproc), Big Data Applications in Healthcare, Finance, IoT, E-Commerce and social media, Case Studies (Fraud Detection, Recommendation Systems, Weather Forecasting and Log Analytics), Emerging Trends (Data Lakes, Lakehouse Architecture and AI-Driven Analytics).
S. No.	**Suggested Practicals / Mini Projects**
1	**Hadoop Installation and HDFS Operations:** Installation and configuration of Hadoop (Pseudo Distributed Mode), HDFS file operations, directory management, replication, permissions, and Hadoop shell commands.
2	**MapReduce Programming:** Develop MapReduce applications for Word Count, Maximum/Minimum Value, Average Calculation, and Log File Analysis.
3	**Apache Spark Programming:** Create and manipulate RDDs, perform Transformations and Actions, implement DataFrames and Spark SQL operations.
4	**Data Ingestion using Sqoop and Flume:** Import data from relational databases into HDFS using Sqoop, export data from HDFS to relational databases, collect streaming log data using Flume.
5	**Apache Hive:** Create databases and tables, load datasets, perform filtering, sorting, aggregation, joins, and execute HiveQL queries.
6	**Apache Pig:** Develop Pig Latin scripts for data loading, filtering, grouping, joins, and User Defined Functions (UDFs).
7	**MongoDB and NoSQL Database:** Create collections, perform CRUD operations, indexing, aggregation pipeline, and execute document-based queries.
8	**HBase Operations:** Create tables, insert, update, retrieve, and delete records, perform scan and filter operations, and compare HBase with relational databases.
9	**Big Data Analytics using Apache Spark MLlib:** Perform data preprocessing, implement classification or clustering algorithms using Spark MLlib, and evaluate model performance using a real-world dataset.
10	**Mini Project – Big Data Analytics:** Develop a Big Data Analytics application using Hadoop, Spark, and NoSQL technologies on a real-world dataset. Suggested application domains include Healthcare, Finance, Retail, social media, IoT, Weather Analytics, Recommendation Systems, and Fraud Detection.
	Note: This is only a suggested list of lab exercises. Instructors may frame additional exercise relevant to the course contents.



CLO-PLO Mapping Matrix													
CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	0	0	1	0	0	0	0	0	0	1	1.75
CLO2	3	3	2	2	2	0	0	0	0	0	0	1	2.17
CLO3	3	3	3	2	3	0	0	0	1	0	0	1	2.29
CLO4	3	3	2	2	3	0	0	0	0	1	0	1	2.14
CLO5	3	3	2	3	3	0	0	0	1	2	0	2	2.38
Avg PLO	3.0	2.8	2.25	2.25	2.4	0	0	0	1.0	1.5	0	1.2	2.15

Suggested Reading

1	*Tom White, Hadoop: The Definitive Guide, 4th Edition, O'Reilly Media.*
2	*Seema Acharya and Subhashini Chellappan, Big Data and Analytics, Wiley India.*
3	*EMC Education Services, Data Science and Big Data Analytics, Wiley Publishers.*
4	*Mohammed Guller, Big Data Analytics with Spark, Apress.*
5	*Anand Rajaraman and Jeffrey D. Ullman, Mining of Massive Datasets, Cambridge University Press.*

Teaching-Learning Strategies

Interactive lectures supported by multimedia presentations and real-world case studies.

Hands-on laboratory sessions using Hadoop, Apache Spark, NoSQL databases, and Python-based data analytics tools.

Problem-Based Learning (PBL) through case studies on big data applications in healthcare, finance, and IoT.

Collaborative mini-projects involving end-to-end big data analytics solutions.

Group discussions on emerging trends like Data Lakes, Lakehouse architecture, and AI-driven analytics.

Flipped classroom approach for complex topics using pre-recorded tutorials and in-class problem-solving.

Course Code	*BCAICDL626*				6th Semester	
Course Title	*Deep Learning*				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	2	4	100	100

Course Learning Outcomes (CLOs)

CLO1	Understand the mathematical foundations and architectures of deep neural networks.
CLO2	Design and implement Convolutional Neural Networks (CNNs) for computer vision applications.
CLO3	Develop sequence models using RNNs, LSTMs, GRUs, and Transformer architectures
CLO4	Explore generative deep learning models such as Autoencoders and GANs.
CLO5	Apply deep learning techniques using modern frameworks to solve real-world AI problems.

Syllabus

Units	Content
1	**Foundations of Deep Learning** Introduction to Artificial Intelligence, Machine Learning and Deep Learning, Biological and Artificial Neurons, Perceptron and Multi-Layer Perceptron (MLP), Feedforward Neural Networks, Activation Functions (Sigmoid, Tanh, ReLU, Leaky ReLU and Softmax), Loss Functions, Backpropagation Algorithm, Gradient Descent Optimization.
2	**Training Deep Neural Networks** Weight Initialization, Learning Rate Scheduling, Vanishing and Exploding Gradient Problems, Optimization Algorithms (SGD, Momentum, RMSProp and Adam), Regularization Techniques (L1/L2 Regularization, Dropout, Early Stopping and Data Augmentation), Batch Normalization, Hyperparameter Tuning, Introduction to TensorFlow, Keras and PyTorch.

3	**Convolutional Neural Networks** Convolution Operation, Feature Maps, Padding, Stride, Pooling Layers, CNN Architecture, Transfer Learning and Fine-Tuning, CNN Architectures (LeNet, AlexNet, VGG, ResNet and MobileNet), Image Classification, Object Detection (YOLO Concept), Image Segmentation (U-Net Overview).
4	**Sequence Models and Attention** Recurrent Neural Networks (RNNs), Backpropagation Through Time (BPTT), Long Short-Term Memory (LSTM), Gated Recurrent Units (GRUs), Bidirectional RNNs, Sequence-to-Sequence Models, Attention Mechanism, Transformer Architecture, Introduction to BERT, GPT and Vision Transformers (ViT).
5	**Generative Deep Learning and Applications** Autoencoders and Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Deep Learning Model Deployment, TensorBoard for Model Visualization, GPU and TPU Acceleration, Ethics and Responsible AI, Deep Learning Applications in Healthcare, Natural Language Processing, Autonomous Systems, Finance and Computer Vision.
S. No.	**Suggested Practicals / Mini Projects**
1	**Introduction to Deep Learning Frameworks** Installation and setup of Python, TensorFlow/Keras and PyTorch, creation of tensors, basic tensor operations, loading datasets, and introduction to GPU acceleration.
2	**Artificial Neural Networks (ANN)** Design and implement a Multi-Layer Perceptron (MLP) for a classification problem, train the model using backpropagation, evaluate performance using accuracy and loss curves.
3	**Model Optimization and Regularization** Implement optimization algorithms (SGD and Adam), apply Dropout and Batch Normalization, perform hyperparameter tuning, and compare model performance.
4	**Convolutional Neural Networks (CNN)** Design and implement a CNN for handwritten digit classification (MNIST/Fashion-MNIST), evaluate model performance, and visualize feature maps.
5	**Transfer Learning** Implement transfer learning using a pre-trained CNN model (VGG16, ResNet50, or MobileNet) for image classification on a custom dataset.

6	**Sequence Modeling using RNNs and LSTMs** Develop RNN and LSTM models for sequence prediction or sentiment analysis using text or time-series datasets.
7	**Attention Mechanism and Transformer Models** Implement a simple Transformer-based model using a pre-trained architecture (BERT or GPT) for text classification or question answering using transfer learning.
8	**Autoencoders and Generative Models** Develop an Autoencoder for image reconstruction or dimensionality reduction and compare its performance with Principal Component Analysis (PCA).
9	**Generative Adversarial Networks (GANs)** Implement a simple GAN (DCGAN) for image generation using the MNIST or Fashion-MNIST dataset and visualize generated samples.
10	**Mini Project – Deep Learning Application** Develop an end-to-end deep learning solution for a real-world application using TensorFlow/Keras or PyTorch. Suggested application domains include Image Classification, Medical Image Analysis, Sentiment Analysis, Object Detection, Face Recognition, Crop Disease Detection, Speech Recognition, or Recommendation Systems.
	Note: This is only a suggested list of lab exercises. Instructors may frame additional exercise relevant to the course contents.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	2	0	1	0	0	0	0	0	0	1	1.80
CLO2	3	3	3	2	3	0	0	0	1	0	0	1	2.29
CLO3	3	3	3	2	3	0	0	0	1	0	0	2	2.43
CLO4	3	2	2	3	3	0	0	0	0	1	0	2	2.29
CLO5	3	3	3	3	3	0	0	0	1	2	0	2	2.50
Avg PLO	3.0	2.6	2.6	2.5	2.6	0	0	0	1.0	1.5	0	1.5	2.26

Suggested Reading	
1	*Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016.*
2	*Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022.*
3	*Aston Zhang, Zack C. Lipton, Mu Li, and Alexander J. Smola, Dive into Deep Learning, Cambridge University Press, 2023.*
4	*François Chollet, Deep Learning with Python, 2nd Edition, Manning Publications, 2021.*
5	*Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.*

Teaching-Learning Strategies
Lectures, Hands-on Lab Sessions, Group Discussions, Assignments, Case Studies, Peer Learning, Demonstrations, Mini Projects.

Course Code	*BCAICMO626*				Semester: 6th	
Course Title	MLOps and Model Deployment				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	2	4	100	100

Course Learning Outcomes (CLOs)

CLO1	Understand the principles, lifecycle, and significance of MLOps in deploying machine learning solutions.
CLO2	Design and automate machine learning pipelines using modern data and experiment management tools.
CLO3	Apply CI/CD practices, version control, and model management techniques for machine learning workflows.
CLO4	Deploy machine learning models using containerization, cloud platforms, and model serving frameworks.
CLO5	Monitor, maintain, and manage machine learning systems in production environments following MLOps best practices.

Syllabus

Units	Content
1	**Introduction to MLOps** Introduction to MLOps, Evolution from Machine Learning to MLOps, DevOps vs MLOps, MLOps Lifecycle, Challenges in Production Machine Learning, Components of MLOps, Machine Learning Workflow, Overview of MLOps Tools and Technologies.
2	**Data and Machine Learning Pipelines** Machine learning pipelines, data collection and data versioning, data validation and data quality, feature engineering, feature stores, data pipeline automation, and Introduction to Data Version Control (DVC) and experiment tracking

3	**Model Development and Experiment Management** Machine Learning Model Development Lifecycle, Hyperparameter Tuning, Model Evaluation and Validation, Experiment Tracking using MLflow, Model Registry, Reproducibility in Machine Learning, and Version Control using Git and GitHub.
4	**CI/CD and Model Deployment** Continuous Integration and Continuous Deployment (CI/CD) for Machine Learning, Automated Testing and Validation, Containerization using Docker, Introduction to Kubernetes, Model Serving, REST APIs for Model Deployment, Deployment on Cloud Platforms (AWS, Azure and Google Cloud).
5	**Monitoring, Governance and Production MLOps** Model Monitoring and Performance Tracking, Concept Drift and Data Drift, Logging and Alerting, Model Retraining Strategies, Security and Governance in MLOps, Responsible AI, Explainability, Case Studies of Production Machine Learning Systems.
S. No.	**Suggested Practicals / Mini Projects**
1	**Setting up the MLOps Environment:** Installation and configuration of Python, Git, GitHub, Jupyter Notebook, VS Code, Docker, MLflow, and DVC. Create a Git repository and perform basic version control operations.
2	**Dataset Versioning using DVC:** Create a machine learning project, track datasets using Data Version Control (DVC), compare dataset versions, and manage remote storage.
3	**Machine Learning Pipeline Development:** Develop a simple machine learning pipeline including data preprocessing, feature engineering, model training, and evaluation using Scikit-learn.
4	**Experiment Tracking using MLflow:** Track model parameters, metrics, artifacts, and compare multiple experiments using MLflow
5	**Model Versioning and Registry:** Register trained models in MLflow Model Registry, manage model versions, and transition models between development, staging, and production.
6	**CI/CD for Machine Learning:** Implement version control using Git and GitHub, automate testing using GitHub Actions (or Jenkins), and build a basic CI/CD workflow for an ML project.
7	**Model Deployment using Docker:** Containerize a machine learning model using Docker and deploy it as a REST API using Flask or FastAPI.
8	**Model Serving and Cloud Deployment:** Deploy the containerized model on a cloud platform (AWS, Azure, Google Cloud, or Hugging Face Spaces) or a local Kubernetes environment, and test prediction services.

9	**Model Monitoring and Performance Evaluation:** Monitor deployed model performance, detect data drift and concept drift, log predictions, and evaluate model accuracy using monitoring dashboards.
10	**Mini Project – End-to-End MLOps Pipeline:** Develop an end-to-end machine learning application incorporating data versioning, experiment tracking, model registry, containerization, deployment, and monitoring on a real-world dataset.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO12	Avg CLO
CLO1	3	2	1	0	2	0	0	0	0	0	0	1	1.80
CLO2	3	3	3	2	3	0	0	0	1	1	1	2	2.11
CLO3	3	3	3	2	3	0	0	0	2	2	2	2	2.44
CLO4	3	3	3	2	3	0	0	0	1	2	2	2	2.33
CLO5	3	3	2	3	3	0	0	0	2	2	2	2	2.50
Avg PLO	3.0	2.8	2.4	2.25	2.8	0	0	0	1.5	1.67	1.67	1.8	2.24

Suggested Reading

1	*Mark Treveil, Nicolas Omont, Clément Stenac, and others, Introducing MLOps, O'Reilly Media, 2020.*
2	*Noah Gift and Alfredo Deza, Practical MLOps, O'Reilly Media, 2021.*
3	*Chip Huyen, Designing Machine Learning Systems, O'Reilly Media, 2022.*
4	*Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022.*
5	*François Chollet, Deep Learning with Python, 2nd Edition, Manning Publications, 2021.*

Teaching-Learning Strategies

Lectures, Hands-on Labs, Case Studies, Project-based Learning, Collaborative Group Work, Peer Review

Course Code	*BCAICIT626*				Semester: 6th	
Course Title	*Introduction to IoT*				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	0	3	100	0

Course Learning Outcomes (CLOs)	
CLO1	Understand the fundamentals, architecture, and enabling technologies of the Internet of Things (IoT).
CLO2	Explain IoT devices, communication technologies, and networking protocols used in IoT systems.
CLO3	Design and develop basic IoT systems using embedded platforms and programming tools.
CLO4	Understand cloud integration, data management, and communication models in IoT.
CLO5	Analyze security challenges, emerging trends, and real-world implementation of IoT systems.

Syllabus	
Units	Content
1	**Fundamentals of Internet of Things:** Introduction to Internet of Things, Evolution of IoT, Characteristics and Enabling Technologies, IoT Architecture, Functional Blocks of IoT, IoT Ecosystem, M2M Communication and IoT, Smart Objects, Challenges and Opportunities in IoT.
2	**IoT Devices and Communication Technologies** Sensors and Actuators, Sensor Characteristics, Embedded Systems for IoT, Microcontrollers and Single Board Computers (Arduino, ESP32, Raspberry Pi), IoT Communication Technologies (Wi-Fi, Bluetooth Low Energy, ZigBee, LoRaWAN), IPv6 and 6LoWPAN.
3	**IoT Networking and Protocols** IoT Communication Models, Device-to-Device, Device-to-Cloud and Cloud-to-Cloud Communication, IoT Gateway, MQTT, CoAP, HTTP/REST Protocols, Data Formats (JSON and XML), Security Considerations in IoT Communication.

4	**IoT System Development** IoT Design Methodology, IoT System Building Blocks, Python Programming Basics for IoT, Sensor Interfacing, Data Acquisition, Cloud Integration, IoT Platforms (ThingSpeak and Blynk), Data Visualization.
5	**IoT Security and Emerging Trends** IoT Security Challenges, Authentication and Privacy, Secure Communication in IoT, Edge Computing and Fog Computing, Introduction to TinyML, Industry 4.0 Concepts, Future Trends in IoT

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	–	2	1	0	0	0	0	0	1	1.67
CLO2	3	3	2	1	3	1	0	0	0	0	0	1	2.00
CLO3	3	3	3	2	3	1	1	0	1	0	0	1	2.00
CLO4	3	3	2	2	3	1	0	0	0	1	0	2	1.89
CLO5	3	3	2	3	2	2	2	2	0	2	0	2	2.30
Avg PLO	3.0	2.8	2.0	2.0	2.6	1.2	1.5	2.0	1.0	1.5	0	1.4	2.01

Suggested Reading

1	*Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-On Approach, Universities Press, 2015.*
2	*Rajkumar Buyya and Amir Vahid Dastjerdi, Eds., Internet of Things: Principles and Paradigms, Morgan Kaufmann, Elsevier.*
3	*David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press.*
4	*Samuel Greengard, The Internet of Things, MIT Press.*
5	*Olivier Hersent, David Boswarthick and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley.*

Teaching-Learning Strategies

Lecture, Discussion, Demonstration, Hands-on Lab Practice, Problem-Based Learning, Case Study, Project-Based Learning, Collaborative Group Work, Peer Teaching, Virtual Simulation

Course Code	*BCAIDSL626*				6th Semester	
Course Title	*Introduction to Statistical Learning*				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	0	3	100	0

Course Learning Outcomes (CLOs)

CLO1	Understand the fundamental concepts of statistical learning and its role in data-driven decision making.
CLO2	Apply regression and classification techniques for predictive modelling.
CLO3	Evaluate and compare statistical learning models using appropriate performance measures.
CLO4	Understand modern statistical learning techniques for dimensionality reduction, clustering, and ensemble learning.
CLO5	Develop statistical learning solutions using Python for real-world applications.

Syllabus

Units	Content
1	**Introduction to Statistical Learning** Introduction to Statistical Learning, Types of Learning (Supervised, Unsupervised and Reinforcement Learning), Statistical Learning vs Machine Learning, Types of Data, Exploratory Data Analysis (EDA), Data Preprocessing, Sampling Techniques, Bias-Variance Tradeoff, Training, Validation and Test Datasets.
2	**Regression Models** Simple Linear Regression, Multiple Linear Regression, Polynomial Regression, Model Assumptions, Model Evaluation Metrics (MAE, MSE, RMSE and R^2 Score), Regularization Techniques (Ridge and Lasso Regression), Regression Applications.
3	**Classification Methods** Introduction to Classification, Logistic Regression, K-Nearest Neighbors (KNN), Decision Trees, Naïve Bayes, Support Vector Machines (SVM), Performance Evaluation using Confusion Matrix, Accuracy, Precision, Recall, F1-Score and ROC-AUC

4	**Model Selection and Unsupervised Learning** Cross-validation techniques, hyperparameter tuning, feature selection, dimensionality reduction using principal component analysis (PCA), clustering techniques (K-Means and hierarchical clustering), and model comparison and selection.
5	**Ensemble Learning and Applications** Ensemble Learning Concepts, Bagging, Random Forest, Boosting (AdaBoost and Gradient Boosting), Introduction to XGBoost, Model Interpretability, Statistical Learning Applications in Healthcare, Finance, Marketing, Manufacturing and Recommendation Systems, Ethical Considerations in Predictive Analytics

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	0	1	0	0	0	0	0	0	1	1.60
CLO2	3	3	3	2	3	0	0	0	0	0	0	1	2.50
CLO3	3	3	2	3	2	0	0	0	0	1	0	1	2.14
CLO4	3	2	2	3	2	0	0	0	0	1	0	2	2.14
CLO5	3	3	3	2	3	0	0	0	1	2	0	2	2.38
Avg PLO	3.0	2.6	2.2	2.5	2.2	0	0	0	1.0	1.33	0	1.4	2.15

Suggested Reading

1	*Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, An Introduction to Statistical Learning with Python, Springer, 2023.*
2	*Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning, 2nd Edition, Springer.*
3	*Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media.*
4	*Charu C. Aggarwal, Data Mining: The Textbook, Springer.*
5	*Richard O. Duda, Peter E. Hart, and David G. Stork, Pattern Classification, Wiley.*

Teaching-Learning Strategies

Lectures, Interactive Discussions, Hands-on Coding Labs, Case Studies, Peer Learning, Problem-Based Learning, Flipped Classroom

Course Code	BCAIDDV626				6th Semester	
Course Title	*Data Science and Visualization*				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	0	3	100	0

Course Learning Outcomes (CLOs)	
CLO1	Understand the data science lifecycle and the role of data-driven decision making.
CLO2	Perform data collection, preprocessing, transformation, and exploratory data analysis.
CLO3	Apply statistical techniques and visualization methods to analyze structured and unstructured data.
CLO4	Design effective visualizations and interactive dashboards for communicating insights.
CLO5	Utilize Python-based data science libraries to solve real-world analytical problems.

Syllabus

Units	Content
1	**Introduction to Data Science:** Introduction to Data Science, Data Science Lifecycle, Types of Data, Data Sources, Data Collection Techniques, Data Science Process (CRISP-DM), Data Science Tools and Python Ecosystem, Applications of Data Science.
2	**Data Preprocessing and Exploratory Data Analysis:** Data Cleaning, Handling Missing Values, Data Transformation, Feature Engineering, Data Integration, Data Reduction, Descriptive Statistics, Exploratory Data Analysis (EDA), Correlation Analysis, Outlier Detection.
3	**Data Visualization Techniques:** Principles of Data Visualization, Visual Encoding, Types of Charts (Bar, Line, Scatter, Histogram, Box Plot, Pie, Heatmap), Multivariate Visualization, Geospatial Visualization, Choosing Appropriate Visualizations, Data Storytelling.
4	**Visualization Libraries and Dashboard Development:** NumPy and Pandas for data analysis, Matplotlib and Seaborn for statistical visualization, interactive visualization using Plotly, dashboard development using Streamlit or Power BI, report generation, and data presentation.

5	**Data Analytics and Applications:** Introduction to Predictive Analytics, Time Series Visualization, Business Intelligence Concepts, Data Ethics and Privacy, Visualization Best Practices, Case Studies in Healthcare, Finance, Marketing, social media, and Smart Cities.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	0	1	0	0	0	0	1	0	1	1.50
CLO2	3	3	2	3	3	0	0	0	0	1	0	1	2.29
CLO3	3	3	2	3	3	0	0	0	0	2	0	1	2.43
CLO4	2	2	3	2	3	0	0	0	1	3	0	1	2.13
CLO5	3	3	3	2	3	0	0	0	1	2	0	2	2.38
Avg PLO	2.8	2.6	2.2	2.5	2.6	0	0	0	1.0	1.8	0	1.2	2.15

Suggested Reading

1	Cathy O'Neil and Rachel Schutt, *Doing Data Science*, O'Reilly Media.
2	Joel Grus, *Data Science from Scratch*, 2nd Edition, O'Reilly Media.
3	Claus O. Wilke, *Fundamentals of Data Visualization*, O'Reilly Media.
4	Jake VanderPlas, *Python Data Science Handbook*, O'Reilly Media.
5	Cole Nussbaumer Knaflic, *Storytelling with Data*, Wiley.

Teaching-Learning Strategies

Lectures, Case Studies, Project-Based Learning, Peer Learning, Demonstrations, Group Discussions, and Self-directed Learning.

Course Code	BCAIDIP626				6th Semester	
Course Title	*Digital Image Processing*				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	3	0	0	3	100	0

Course Learning Outcomes (CLOs)	
CLO1	Understand the fundamentals of digital image processing and image representation.
CLO2	Apply image enhancement and restoration techniques in spatial and frequency domains.
CLO3	Understand image segmentation, morphological operations, and feature extraction methods.
CLO4	Learn image compression techniques and color image processing.
CLO5	Apply digital image processing techniques to solve real-world problems.

Syllabus

Units	Content
1	**Digital Image Fundamentals:** Introduction to Digital Image Processing, Human Visual System, Image Acquisition, Image Sampling and Quantization, Pixel Relationships, Image Representation, Color Models.
2	**Image Enhancement:** Gray Level Transformations, Histogram Processing, Spatial Domain Filtering, Frequency Domain Filtering, Fourier Transform, Image Sharpening and Smoothing.
3	**Image Restoration and Compression:** Image Degradation Model, Noise Models, Image Restoration Techniques, Inverse and Wiener Filtering, Image Compression, Lossless and Lossy Compression, JPEG Standards.
4	**Image Segmentation and Morphological Processing:** Edge Detection, Thresholding, Region-Based Segmentation, Morphological Operations (Dilation, Erosion, Opening and Closing), Basic Feature Extraction.

5	**Color Image Processing and Applications:** Color Image Processing, Image Registration (Introduction), Image Analysis and Classification (Introduction), Applications of Digital Image Processing in Medical Imaging, Biometrics, Remote Sensing, OCR, and Industrial Inspection.

CLO-PLO Mapping Matrix

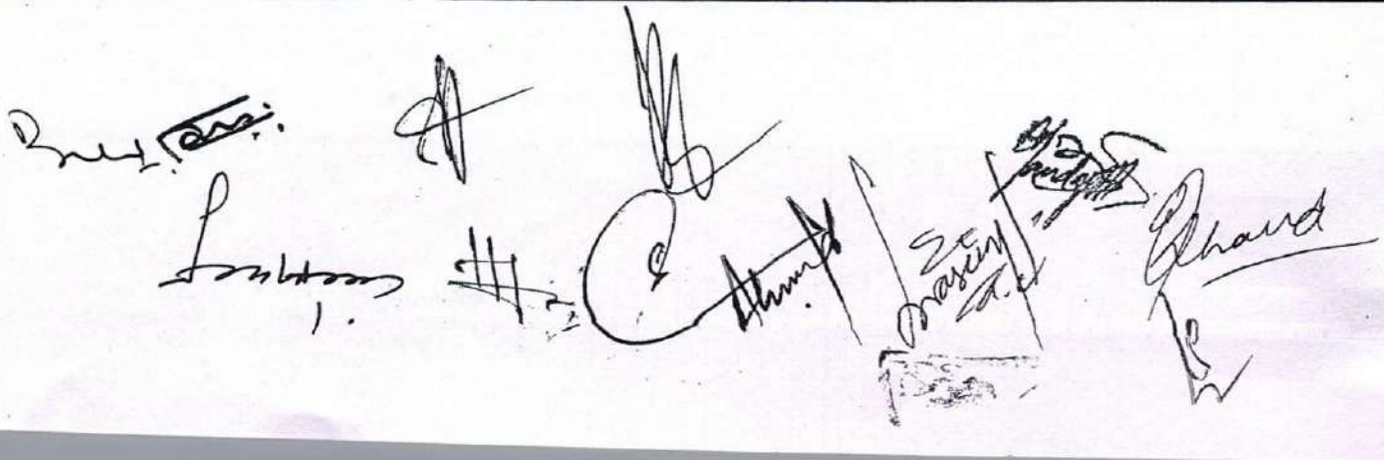
CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	1	0	1	0	0	0	0	0	0	1	1.60
CLO2	3	3	3	2	3	0	0	0	0	1	0	1	2.29
CLO3	3	3	2	3	3	0	0	0	0	1	0	1	2.29
CLO4	3	2	2	2	3	0	0	0	0	1	0	2	2.14
CLO5	3	3	3	3	3	0	0	0	1	2	0	2	2.50
Avg PLO	3.0	2.6	2.2	2.5	2.6	0	0	0	1.0	1.25	0	1.4	2.16

Suggested Reading

1	Rafael C. Gonzalez and Richard E. Woods, **Digital Image Processing**, 4th Edition, Pearson Education, 2018.
2	Anil K. Jain, **Fundamentals of Digital Image Processing**, Pearson Education, 2009.
3	Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, **Digital Image Processing Using MATLAB**, Pearson Education.
4	Wilhelm Burger and Mark J. Burge, **Digital Image Processing: An Algorithmic Introduction Using Java**, Springer.
5	Richard Szeliski, **Computer Vision: Algorithms and Applications**, 2nd Edition, Springer. *(Recommended for advanced reading and applications.)*

Teaching-Learning Strategies

Lectures, Interactive Discussions, Demonstrations, Practical Hands-on Labs, Problem-Based Learning, Case Studies, Peer Learning



Course Code	BCAILWP626				Semester: 6th	
Course Title	Web programming				Maximum Marks	
Scheme & Credits	Hours Per Week			Credits	Theory	Practical
	L	T	P			
	0	0	4	2	0	50

Course Learning Outcomes (CLOs)	
CLO1	Design well-structured, responsive web pages using HTML5 and CSS3 to create user-friendly interfaces.
CLO2	Develop interactive client-side web applications using JavaScript, DOM manipulation, jQuery, and JSON for dynamic user experiences.
CLO3	Apply object-oriented programming concepts in Java and implement database connectivity using JDBC for data-driven applications.
CLO4	Develop server-side web applications using Servlets, JSP, and Web Services, incorporating session management and data exchange mechanisms.
CLO5	Design, integrate, test, and demonstrate a complete full-stack web application by combining front-end, back-end, and database technologies to solve a real-world problem.

Suggested Contents/Practicals / Mini Projects/ Hands-on-experiments	
1	**Explore HTML5 Fundamentals:** Create simple web pages using headings, paragraphs, text formatting, lists, hyperlinks, images, tables, and semantic HTML5 elements.
2	**Design Web Forms and Page Layouts:** Develop web pages using forms, input controls, multimedia, navigation menus, iframes, and HTML5 validation attributes.
3	**Apply CSS3 for Web Styling:** Experiment with selectors, colors, fonts, backgrounds, borders, margins, padding, box model, positioning, and responsive layouts.
4	**Develop Interactive Webpages using JavaScript:** Implement variables, operators, control statements, functions, arrays, events, DOM manipulation, and client-side form validation
5	**Build a Responsive Front-End Web Application:** Integrate HTML5, CSS3, JavaScript, jQuery, and JSON to create a responsive multi-page website with dynamic features.

6	**Implement Core Java Programs:** Develop programs demonstrating classes, objects, inheritance, interfaces, exception handling, file handling, collections, and multithreading.
7	**Develop Database Applications using JDBC:** Connect Java applications to a relational database and perform CRUD operations using JDBC.
8	**Develop Dynamic Web Applications using Servlets and JSP**: Create applications that process user requests, manage sessions, handle cookies, and interact with databases.
9	**Implement XML and JSON Processing:** Create, parse, validate, and exchange data using XML and JSON in web applications.
10	**Develop Basic Web Service Integration:** Consume REST APIs or simple web services to retrieve and display dynamic information within a web application.
11	**Develop an Integrated Database-Driven Web Application:** Combine front-end technologies, Servlets, JSP, JDBC, XML/JSON, and session management to implement a complete CRUD-based application.
12	**Minor Project:** Design, develop, test, and demonstrate a real-world web application (e.g., Student Management System, Library Management System, Online Examination System, Event Registration System, Hospital Management System, or E-Commerce Portal) integrating all relevant technologies studied during the course.

Note: This is only a suggested list of contents/practicals/lab exercises. Instructors may frame additional exercises relevant to the course and contemporary application domains.

CLO-PLO Mapping Matrix

CLO/PLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12	Avg CLO
CLO1	3	2	3	1	3	0	0	0	0	2	0	1	2.14
CLO2	3	3	3	2	3	0	0	0	1	2	0	2	2.38
CLO3	3	3	3	2	3	0	0	0	1	2	0	2	2.38
CLO4	3	3	3	3	3	0	0	0	1	2	0	2	2.50
CLO5	3	3	3	3	3	1	0	1	2	2	1	3	2.27
Avg PLO	3.0	2.8	3.0	2.2	3.0	1.0	0	1.0	1.25	2.0	1.0	2.0	2.33

Suggested Reading	
1	*Deitel, P. J., & Deitel, H. M., Internet & World Wide Web: How to Program, 5th Edition, Pearson Education.*
2	*Jon Duckett, HTML and CSS: Design and Build Websites, John Wiley & Sons.*
3	*Jon Duckett, JavaScript and jQuery: Interactive Front-End Web Development, John Wiley & Sons.*
4	*Bryan Basham, Kathy Sierra, & Bert Bates, Head First Servlets and JSP, 2nd Edition, O'Reilly Media.*
5	*Brett McLaughlin & Justin Edelson, Java XML, O'Reilly Media.*

Teaching-Learning Strategies
Demonstrate each experiment through live coding before students perform the practical independently in the laboratory.
Conduct guided hands-on laboratory sessions to develop web applications using HTML5, CSS3, JavaScript, Java, JDBC, servlets, JSP, XML/JSON, and REST APIs.
Encourage experiment-based learning through coding, debugging, testing, and incremental enhancement of web applications.
Promote collaborative laboratory activities, peer code reviews, and mini-projects to strengthen problem-solving, teamwork, and communication skills.
Reinforce learning through a capstone web application project integrating front-end, back-end, database connectivity, and web services.