Master of Technology in Computer Science and Engineering

SYLLABUS
2024
(NEP)

Department of Computer Science and Engineering

Rajiv Gandhi University
Rono Hills, Doimukh

Syllabus:

Semester –I

Mathematical Foundation of Computer Science 3(3-0-0): (CSE-101-CC-5110)

COURSE OBJECTIVE:

- To understand the mathematical fundamentals that is prerequisites for a variety of courses like data mining, network protocols, analysis of web traffic, computer security, software engineering, computer architecture, operating systems, distributed systems, bioinformatics, machine learning.
- To develop the understanding of the mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design and concurrency.
- To study various sampling and classification problems.

Unit 1 14 Lectures

Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains, Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood,

Unit 2 8 Lectures

Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment.

Unit 3 11 Lectures

Graph Theory: Isomorphism, Planar graphs, graph colouring, Hamilton circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems

Unit 4 10 Lectures

Computer science and engineering applications, Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.

Unit 5 5 Lectures

Recent Trends in various distribution functions in mathematical field of computer science for varying fields like bioinformatic, soft computing, and computer vision.

REFERENCE BOOKS:

1. John vince, foundation mathematics for computer science, springer.
2. K. Trivedi, Probability and statistics with reliability, queuing, and computer science applications. Wiley.
3. M. Mitzenmacher and E. Upfal, Probability and computing: randomized algorithms and probabilistic analysis.
4. Alan tucker, applied combinatorics, wiley

Course Outcomes (COs)

1. CO1: Apply Probability Theory – Understand and analyze probability distributions, probabilistic inequalities, and Markov chains to solve real-world problems.
2. CO2: Perform Statistical Estimation – Use sampling distributions, the Method of Moments, and Maximum Likelihood Estimation for parameter estimation in statistical models.
3. CO3: Conduct Statistical Inference and Machine Learning – Implement statistical inference techniques, regression models, and dimensionality reduction methods while addressing overfitting.
4. CO4: Solve Graph Theory and Combinatorial Problems – Apply concepts of graph theory (isomorphism, planarity, Euler/Hamilton cycles) and combinatorial techniques for enumeration problems.
5. CO5: Apply Probabilistic Models in Computer Science – Utilize probabilistic techniques in computer architecture, data mining, security, network analysis, and machine learning.
6. CO6: Explore Recent Trends in Distributions – Analyze advanced probability distributions and their applications in bioinformatics, soft computing, and computer vision.

Legend for POs:

- **PO1**: Engineering Knowledge
- **PO2**: Problem Analysis
- **PO3**: Design/Development of Solutions
- **PO4**: Investigations of Complex Problems
- **PO5**: Modern Tool Usage
- **PO6**: Engineer and Society
- **PO7**: Environment & Sustainability
- **PO8**: Ethics
- **PO9**: Individual and Team Work
- **PO10**: Communication
- **PO11**: Project Management & Finance
- **PO12**: Life-long Learning

CO-PO mapping:

- **3** = Strongly mapped
- **2** = Moderately mapped
- **1** = Weakly mapped
- **0** = No mapping

CO-PO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	1	0	0	2	2		
CO2	3	3	3	3	3	1	1	1	2	3		
CO3	3	3	3	3	3	1	1	1	2	3		
CO4	3	2	3	2	2	0	0	0	2	3		
CO5	3	3	3	2	3	3	2	2	2	3		

Advanced Programming Practices 4(2-0-2):
(CSE-101-CC-5120)

COURSE OBJECTIVES:

- To develop a deep understanding of advanced programming paradigms and techniques.
- To enhance proficiency in writing efficient, maintainable, and scalable code in various programming languages.
- To apply advanced programming concepts to solve complex computational problems and optimize software performance.
- To master the use of modern development tools and frameworks for building sophisticated software applications.
- To foster best practices in software development, including version control, testing, debugging, and documentation.

Unit 1 7Lectures
Advanced Data Structures and Algorithms:
Review of Basic Data Structures and Algorithms: Arrays, Linked Lists, Stacks, Queues, Sorting and Searching Algorithms; Advanced Data Structures: Trees (AVL Trees, Red-Black Trees, Splay Trees), Graphs (Representation, Traversal, Shortest Path Algorithms), Heaps and Priority Queues; Advanced Algorithms: Dynamic Programming, Greedy Algorithms, Divide and Conquer; Computational Complexity: Big-O Notation, NP-Completeness and P vs NP; Case Studies and Practical Implementations: Real-world applications of advanced data structures and algorithms

Unit 2 7 Lectures
Object-Oriented Design and Patterns
Review of Object-Oriented Programming Principles: Encapsulation, Inheritance, Polymorphism, Abstraction; Design Principles: SOLID Principles, GRASP Patterns; Design Patterns: Creational Patterns (Singleton, Factory, Abstract Factory), Structural Patterns (Adapter, Composite, Proxy), Behavioral Patterns (Observer, Strategy, Command); Advanced Object-Oriented Concepts: Dependency Injection, Aspect-Oriented Programming; Case Studies and Practical Implementations: Implementing design patterns in large-scale software projects

Unit 3 8 Lectures
Concurrent and Parallel Programming
Introduction to Concurrency: Processes vs Threads, Multi-threading and Synchronization; Concurrent Programming Techniques: Locking Mechanisms (Mutex, Semaphores), Deadlock, Livelock, and Starvation; Parallel Programming Paradigms: Parallel Algorithms, Data Parallelism vs Task Parallelism; Tools and Libraries: OpenMP, MPI, CUDA; Case Studies and Practical Implementations: Building concurrent and parallel applications;

Unit 4 11Lectures
Software Testing and Quality Assurance
Fundamentals of Software Testing: Types of Testing (Unit, Integration, System, Acceptance), Test-Driven Development (TDD); Advanced Testing Techniques: Mocking and Stubbing, Property-Based Testing, Mutation Testing; Quality Assurance Processes: Continuous Integration/Continuous Deployment (CI/CD), Code Reviews and Static Analysis, Metrics and

Measurements for Software Quality; Tools and Frameworks: JUnit, NUnit, Selenium, Jenkins; Case Studies and Practical Implementations: Implementing effective testing strategies in real-world projects;

Unit 5 10 Lectures

Modern Development Practices and Emerging Technologies

Agile Development: Agile Manifesto and Principles, Scrum and Kanban; DevOps Practices: Infrastructure as Code (IaC), Continuous Integration and Continuous Delivery (CI/CD), Monitoring and Logging; Emerging Programming Paradigms: Functional Programming (FP),Reactive Programming, Domain-Driven Design (DDD); Tools and Technologies: Containerization with Docker, Orchestration with Kubernetes, Cloud Computing Services (AWS, Azure, GCP); Case Studies and Practical Implementations: Adopting modern development practices in complex software projects.

Reference Books:-

1. Cormen, t. H., leiserson, c. E., rivest, r. L., & stein, c. – *introduction to algorithms* (mit press)
2. Goodrich, m. T., tamassia, r., & goldwasser, m. H. – *data structures and algorithms in java/python* (wiley)
3. Martin, r. C. – *agile software development: principles, patterns, and practices* (pearson)
4. Larman, c. – *applying uml and patterns: an introduction to object-oriented analysis and design and iterative development* (pearson)
5. Tanenbaum, a. S., & bos, h. – *modern operating systems* (pearson)
6. Beizer, b. – *software testing techniques* (van nostrand reinhold)

COURSE OUTCOMES:

CO1: Demonstrate advanced knowledge of programming paradigms and techniques.
CO2: Write efficient, maintainable, and scalable code in multiple programming languages.
CO3: Apply advanced programming concepts to solve complex computational problems.
CO4: Optimize software performance through advanced coding techniques and algorithms.
CO5: Utilize modern development tools and frameworks for software development.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	2	2	2	3	2	2
CO2	3	3	3	3	2	2	2	2	3	2
CO3	3	3	3	3	2	2	2	2	2	2
CO4	3	2	3	3	2	3	3	3	2	2
CO5	3	3	3	3	3	2	3	3	3	3

Advanced Algorithm Design (2-0-1)
(CSE-101-CC-5130)

COURSE OBJECTIVES:

- To understand fundamental algorithmic techniques.
- To gain knowledge of np-completeness and computational complexity.
- To master advanced algorithmic analysis techniques.
- To explore geometric and network flow algorithms.
- To develop skills in approximation and parallel algorithms.

UNIT I: INTRODUCTION TO AAA 9 hours

Defining Key Terms: Algorithm complexity, Greedy method, Dynamic Programming, Backtracking, Branch-and-bound Techniques; Examples for understanding above techniques; Memory model, linked lists and basic programming skills.

UNIT II: NP COMPLETENESS 9 hours

Overview - Class P - Class NP - NP Hardness - NP Completeness - Cook Levine Theorem - Important NP Complete Problems. Heuristic and Randomized algorithms.

UNIT III 7 hours

Use of probabilistic inequalities in analysis, Amortized Analysis - Aggregate Method – Accounting Method - Potential Method, competitive analysis, applications using examples.

UNIT IV: GEOMETRIC ALGORITHMS 10 hours

Point location, Convex hulls and Voronoi diagrams, Arrangements, graph connectivity, Network Flow and Matching: Flow Algorithms - Maximum Flow – Cuts - Maximum Bipartite Matching - Graph partitioning via multi-commodity flow, Karger'r Min Cut Algorithm, String matching and document processing algorithms.

UNIT V: APPROXIMATION ALGORITHMS 10 hours

Approximation algorithms for known NP hard problems - Analysis of Approximation Algorithms Use of Linear programming and primal dual; local search heuristics; Parallel algorithms: Basic techniques for sorting, searching, merging, list ranking in PRAMs and Interconnection.

REFERENCES

1. Allan borodin and ran el-yaniv: online computation and competitive analysis, cambridge university press, 2005.
2. Michael t goodric and roberto tamassia, “algorithm design: foundations, analysis and Internet examples”, john wiley and sons, 2002.
3. Thomas h. Cormen, charles e. Leiserson, ronald l. Rivest and clifford stein, “Introduction to algorithms”, third edition, the mit press, 2009.
4. Sanjoy dasgupta, christos papadimitriou and umesh vazirani, “algorithms”, tata mcgrawhill, 2009.
5. R.K. Ahuja, tl magnanti and J. B. Orlin, “network flows: theory, algorithms, and Applications”, prentice hall englewood cliffs, nj 1993.

COURSE OUTCOMES

CO1: Analyze algorithm complexity and apply problem-solving techniques.
CO2: Classify problems based on computational complexity and apply heuristic/randomized algorithms.
CO3: Apply advanced analysis techniques such as amortized and competitive analysis.
CO4: Implement geometric algorithms and network flow techniques in real-world applications.
CO5: Design and analyze approximation and parallel algorithms.

CO-PO Mapping Matrix:

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	1	1	-	2
CO2	3	3	3	3	2	-	-	-	1	1	-	2
CO3	3	3	3	3	2	-	-	-	1	1	-	3
CO4	3	2	3	3	3	-	-	-	2	2	1	2
CO5	3	2	3	3	3	-	-	-	2	2	2	3

Advanced Computer Architecture 3(3-0-0)
(CSE-101-CC-5140)

COURSE OBJECTIVES

- To understand the advance hardware and software issues of computer architecture
- To understand the multi-processor architecture & connection mechanism
- To understand multi-processor memory management

Unit I 15 Lectures

Parallel Computer Models & Program Parallelism: Parallel Processing and its Applications, Flynn's Classification: SISD, SIMD&MIMD, its Architecture, Condition of Parallelism, Data and Resource Dependences, Conditions of Parallelism, Hardware and Software Parallelism, Program Partitioning & Scheduling ,Program Flow Mechanisms: Control Flow versus Data Control, Data Flow Architecture, Demand-Driven Mechanisms. Vector Instruction Types, Vector Access Memory Schemes, Vector and Symbolic Processors.

Unit II 18 Lectures

Scalability and Performance evaluation: Principles of Scalable Performance, Performance Metrics And Measures, Speedup Performance Laws: Amdahl's Law, Gustafson's Law, Scalability Analysis and Approaches, CPU Performance Evaluation.
Pipeline: Linear and Nonlinear Pipeline Processor, Pipeline Performance, Instruction Pipeline Design, Instruction Pipeline, Mechanisms for Instruction Pipeline, Dynamic Instruction Scheduling, Branch Handling Techniques, Arithmetic Pipeline Design, Computer Arithmetic Principles.

Unit III 15 Lectures

Memory Hierarchy & Organization: Cache Memories, Cache Coherence and its Issues, Cache Addressing Models, Direct Mapping and Associative Caches, CISC Scalar Processors, RISC Scalar Processors, Superscalar Processors, VLIW Architectures, Hierarchical Memory Technology, Memory Capacity Planning, Virtual Memory Technology.

Unit IV 12 Lectures

System Interconnection: Multiprocessor System Interconnection and Multi Computers, Network Properties and Routing, Hierarchical Bus Systems, Static Interconnection Networks, Dynamic Interconnection Networks.

REFERENCE BOOKS:

1. Kai Hwang, "advanced computer architecture", 2nd edition, tata mcgraw hill, 2010
2. Morris manno, "computer system architecture", revised 3rd edition, pearson publications, 2017
3. J. P. Hayes, "Computer Architecture and Organization", 3rd edition, tata mcgraw hills, 2017
4. D. A. Patterson, j. L. Hennessy, "computer architecture: a quantitative approach", morgan kauffmann publishers, 2011.
5. Hwang and briggs, "computer architecture and parallel processing", mc graw hills.
6. R. W. Hockney, c. R. Jesshope, "parallel computer 2", 2nd edition, adam hilger.

COURSE OUTCOMES:

CO1: Explain the fundamentals of parallel processing, Flynn's classification, and the conditions for parallelism.

CO2: Analyze program partitioning, scheduling techniques, and different program flow mechanisms for parallel execution.

CO3: Evaluate scalability and performance metrics of parallel systems, including speedup performance laws like Amdahl's Law and Gustafson's Law.

CO4: Demonstrate pipeline architectures, instruction scheduling, and performance optimization techniques in parallel computing.

CO5: Examine memory hierarchy, cache coherence issues, virtual memory technology, and processor architectures such as RISC, CISC, Superscalar, and VLIW.

CO6: Analyze system interconnection techniques, including multiprocessor communication, hierarchical bus systems, and interconnection networks.

CO-PO Mapping Matrix:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	0	0	0	0	0	0	2
CO2	3	3	2	2	2	1	0	0	0	0	0	2
CO3	3	3	3	2	2	1	0	0	0	0	0	2
CO4	2	3	3	3	2	1	0	0	0	0	0	2
CO5	2	2	3	3	3	2	1	0	0	0	0	3
CO6	2	2	3	3	3	2	1	0	0	0	0	3

ADVANCED COMPUTER NETWORKS 3(2-0-1)
(CSE-101-CC-5150)

COURSE OBJECTIVES

- This course intends to build up some of important topics on computer networks and the design and implementation details for performance improvement of the existing network and some advanced topics.
- To familiarize by covering topics with case studies giving opportunity to explore practical/simulation of some advanced concepts using network simulator and linux operating system environment.
- The course will be instrumental to build the confidence in the students to develop the knowledge of design and develop selected topics in computer network.

Unit 1: 7 Hours

Layering abstraction, Network architecture, Packet switching Performance of Networks: delay, jitter and throughput; Application layer: HTTP and other application protocols, DNS, HTTP transport recent developments, Socket programming, Overlay networks and peer-to-peer (P2P) systems, wrap-up application layer

Unit 2: 8 Hours

Transport layer: introduction, TCP congestion control; Analysis of TCP: General congestion control and queuing, Random Early detection(RED), BBR: Congestion-Based Congestion Control, QUIC protocol, Active Queue Management TCP implementation details, multipath TCP. QoS and fairness, traffic shaping

Unit 3: 7 Hours

Router scheduling algorithms: Implementation and analysis of fair queuing algorithms. Network layer: Linux IP networking, advanced topics in IP, Router architectures, MPLS, routing protocols, IP and MPLS routers, BGP: Introduction, BGP advanced topics with BGP security

Unit 4: 8 Hours

Link layer: introduction, link layer functions, link layer addresses, ARP, shared broadcast, medium access protocols; Network and link layer practical topics: TCP traversal trough NATs and firewalls; Multimedia Networking: RSVP and Integrated Services (IntServ), Differentiated Services (DiffServ), Real-Time Protocol (RTP), RTP Control Protocol (RTCP), Session Initiation Protocol (SIP), Real-time Streaming Protocol (RTSP), Internet video

Unit 5: 7 Hours

Data centre networking: Data centre network architecture, Load balancing issues; Software defined networking: introduction, OpenFlow, B4: Software defined WAN, Google Network and Virtualization: introduction, NFV, NetVM.

REFERENCE BOOKS:

1. Computer networking, a top-down approach featuring the internet, second edition, j.f. kurose and k.w. ross, adition-wesely, 2002.
2. Computer networks: a systems approach, third edition, l. Peterson and b.s.

davie, morgam kaufmann, 2003.
3. Computer networks, fourth edition, a. Tanenbaum, prentice-hall, 2002.
4. Data networks, bertsekas and gallager

COURSE OUTCOMES

CO1: Analyze and evaluate advanced networking protocols and algorithms for performance, scalability, and reliability.
CO2: Design and implement network architectures using modern technologies such as Software-Defined Networking (SDN) and Network Function Virtualization (NFV).
CO3: Investigate and apply network security measures to protect against threats and vulnerabilities in complex networked systems.
CO4: Demonstrate the ability to conduct research and development in advanced networking topics, including IoT networks, 5G, and next-generation wireless technologies.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	2	2	2	3	3	3
CO2	3	3	3	3	3	2	2	3	3	2
CO3	3	3	3	3	2	2	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3

Research Methodology 4(3-1-0)
(CSE-101-RC-5110)

COURSE OBJECTIVES:

- To introduce the basic concepts in research methodology.
- To address the issues inherent in selecting a research problem and discuss the techniques and tools to be employed in completing a research project.
- To enable the students to prepare report writing and framing research proposals.

Unit I 12 Lectures

Research Design-I: Research: Concept, need, types - basic, applied and action. Reviewing Literature: Need, Sources, Purposes and Scope of Review, Steps in conducting review Identifying and defining research problem: Locating, analyzing stating and evaluating problem etc. Method of Research: Descriptive research design-survey, case study, content analysis, Ex-post Facto Research, Correlational and Experimental Research.

Unit II 12 Lectures

Research Design-II: Hypothesis: Meaning, Criteria for constructing hypothesis, Testing Hypothesis and its types. Sampling Techniques: Concept of population and sample, sampling techniques, determining size of sample etc. Design and development of measuring instruments: Tests, questionnaires, checklists, observation, schedules, selecting a standardized test etc. Procedure of data collection, Procedure for writing a research proposal, Procedure for writing a research report etc.

Unit III 12 Lectures

System Simulation & Modelling: System and system environment, components of system, discrete and continuous systems, static and dynamic systems, model of a system, steps required in deriving a model of a system. Verification and validation of simulation model, stochastic nature of the output data. Introduction to Simulation, why and when simulation is an appropriate tool, advantages and disadvantages of Simulation, Areas of application, general steps followed in simulation experiment etc, Factor Analysis: Introduction, Objective and types.

Unit IV 12 Lectures

Statistical analysis through SPSS: Introduction, basic steps of data analysis, SPSS environment, running an analysis, viewing results etc. Quantitative and qualitative analysis techniques, hypothesis testing, chi- square test, t-test, correlation and regression analysis, analysis of variance (ANOVA), choosing appropriate techniques etc. MATLAB: Introduction and key features, Workspace, Variables, Numbers, Character strings, Matrices and Arrays (creation, operations and indexing), Expressions, Functions, etc. Control Structures: Loop Control, Conditional Control.

REFERENCE BOOKS:

1. C.R. Kothari and Gaurav Garg, "research methodology: methods and techniques", new age international publishers,2013.
2. William m. K. Trochim, “Research Methods", second edition, biztantra dreamtech press, 2006.
3. Patel R. S, “Research Methodology”, third edition, Jay publication, 2019
4. W. Borg, m. Gall, “Educational Research: A n Introduction”, New York, Longman, 2003.

5. Wiersma william, “Research methods in education- an introduction”, london, allyn and bacon, Inc.
6. M. N. Borse, “Research methodology- modern, tools and techniques”, hand book, shree niwas publications, 2005.
7. S. P. Gupta, “Statisitcal methods", fourth edition, sultan chand & sons, 2011.
8. Darren George, Paul mallery, “SPSS for windows step by step: A simple guide and reference”, allyn & bacon, inc.
9. B. R. Hunt, R. L. Lipsman, j. M. Rosenberg, “A guide to matlab for beginners and experienced users”, 2e, cambridge university press, 2006.

COURSE OUTCOMES:

CO1: Ability to understand and comprehend the basics in research methodology and applying them in research/ project work.
CO2: This course will help them to select an appropriate research design.
CO3: With the help of this course, students will be able to take up and implement a research project/ study.
CO4: The course will also enable them to collect the data, edit it properly and analyse it accordingly. Thus, it will facilitate students’ prosperity in higher education.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	3	3	3	2	2	2	3	2	2
CO3	3	3	3	2	2	2	3	3	3	2
CO4	3	3	3	2	3	3	3	3	2	2

SEMESTER – II

ADVANCED OPERATING SYSTEM 3(3-0-0)
(CSE-101-5210)

COURSE OBJECTIVES:

- To understand advanced concepts and methodologies used in modern operating systems.
- To analyze and critically evaluate the performance and efficiency of various operating system architectures and algorithms.
- To develop and implement sophisticated algorithms and components for operating system functionalities.
- To design and manage complex operating system modules to address real-world computing challenges.
- To apply theoretical knowledge and practical skills to solve complex problems in operating systems.

Unit 1: 8 Hours

Concurrent Execution: threads, event systems,async/sync I/O,Parallelism, Ordering, and Races, Dynamic Data Race Detector for Multi-Threaded Programs, Discussions of synchronization with an emphasis on monitors, On Optimistic Methods for Concurrency Control, Concurrency Control and Recovery, Communication using lightweight remote procedure call (RPC).

Unit 2: 8 Hours

Memory Management: virtual memory, NUMA machines, memory allocators – Hoard Scalable Memory Allocator, Memory Resource Management in VMware, Global Memory Management in Cluster machines, Scalability: Multicore processing, locking, lock-free data structures, The Scalable Commutativity Rule: Designing Scalable Software for Multicore Processors etc.

Unit 3: 8 Hours

OS Architecture:The structure and design of an operating system, OS Architecture and Extensibility: SPIN and the Exo-kernel, OS architecture for scalable multicore systems: Multi-kernelMobile OS Architecture: Android, iOS; Virtualization:Machine virtualization, binary instrumentation, VMware design etc.

Unit 4: 8 Hours

File Systems and Disk: file system interfaces, networked file systems, AFS, The Design and Implementation of a Log-Structured File System, File system extensibility, non-disk file systems, A Case for Redundant Arrays of Inexpensive Disks (RAID), Using Model Checking to Find Serious File System Errors.

Unit 5: 14 Hours

Big Data System: Google File system, OceanStore, Facebook Photo Storage, SPOCA, Corfu, RAMCloud, Dynamo: Amazon’s Highly Available Key-value Store,MapReduce and Spark, TensorFlow: Large-Scale Machine Learning on Heterogeneous Distributed Systems
Security: Operating systems security fundamentals, data security and integrity, authentication, authorization, etc. Reliability Computing: Operating systems reliability, failure oblivious computing, recovery- oriented computing

REFERENCE BOOKS:

1. Advanced concepts in operating systems: distributed, database, and multiprocessor operating systems by mukesh singhal, niranjan shivaratri, 2017, mcgraw hill.
2. There is no specific textbook for this course. The course is based on a collection of journal and conference papers
3. Modern operating systems, tanenbaum
4. Operating systems: A modern perspective, gary nutt,
5. Advanced operating systems, by silberschatz, 1999

COURSE OUTCOMES

CO1: Understand advanced concepts and techniques used in operating systems.
CO2: Analyze and evaluate the performance of various operating systems.
CO3: Develop and implement algorithms for advanced operating system functionalities.
CO4: Design and manage complex operating system components.
CO5: Apply advanced operating system concepts to real-world problems and scenarios.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	3	2	2	2	2	1	2
CO2	3	2	3	3	2	2	2	2	2	2
CO3	3	2	3	3	2	2	2	2	2	2
CO4	3	2	3	3	2	2	3	2	2	3
CO5	3	2	3	3	3	2	3	2	2	3

MACHINE LEARNING CONCEPTS WITH PYTHON 4(2-0-2): (CSE-101-CC-5220)

COURSE OBJECTIVE:

- The course aims to provide students with a solid foundation in the mathematical concepts underlying machine learning.
- The course aims to provide students with better understanding of probability theory, linear algebra, optimization, and statistical inference.
- By the end of the course, students will be able to understand and apply these concepts to develop and analyze machine learning models.

UNIT-I: 7 Hours

Introduction – Well defined learning problems, Designing a Learning System, Issues in Machine Learning; the concept learning task - General-to-specific ordering of hypotheses, Find-S, List then eliminate algorithm, Candidate elimination algorithm, Inductive bias

UNIT-II: 9 Hours

Decision tree learning - Decision tree learning algorithm-Inductive bias- Issues in Decision tree learning; artificial neural networks – Perceptrons, Gradient descent and the Delta rule, Adaline, Multilayer networks, Derivation of backpropagation rule Backpropagation Algorithm- Convergence, Generalization;

UNIT-III: 8 Hours

EVALUATING hypotheses – Estimating Hypotheses Accuracy, Basics of sampling Theory, Comparing Learning Algorithms; bayesian learning – Bayes theorem, Concept learning, Bayes Optimal Classifier, Naïve Bayes classifier, Bayesian belief networks, EM algorithm;

UNIT-IV: 8 Hours

Computational learning theory – Sample Complexity for Finite Hypothesis spaces, Sample Complexity for Infinite Hypothesis spaces, The Mistake Bound Model of Learning; instance-based learning – k-Nearest Neighbor Learning, Locally Weighted Regression, Radial basis function networks, Case-based learning

UNIT-V: 8 Hours

Genetic algorithms – an illustrative example, Hypothesis space search, Genetic Programming, Models of Evolution and Learning; Learning first order rules-sequential covering algorithms- General to specific beam search-foil; reinforcement learning - The Learning Task, Q Learning.

REFERENCES:

1. Tom.m.mitchell, machine learning, mcgraw hill international edition.
2. Ethern alpaydin, introduction to machine learning. Eastern economy edition, prentice hall of india, 2005.
3. Bishop C., Pattern recognition and machine learning. Berlin: Springer-verlag.

COURSE OUTCOMES:

CO1: Understand and apply fundamental machine learning concepts, including supervised and unsupervised learning algorithms, using Python libraries such as scikit-learn.
CO2: Develop, train, and evaluate machine learning models, and interpret their results using Python-based tools and techniques.
CO3: Implement data preprocessing, feature engineering, and model optimization techniques to enhance the performance and accuracy of machine learning models.

CO4: Utilize Python for advanced machine learning tasks, including deep learning with frameworks such as TensorFlow and PyTorch, and apply these techniques to real-world datasets and problems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	2	2	2	3	2	2
CO2	3	3	3	3	2	2	2	3	2	2
CO3	3	3	3	3	2	2	2	3	2	2
CO4	3	3	3	3	2	2	2	3	2	2

DATA SCIENCE 4(3-0-1)
(CSE-101-CC-5230)

COURSE OBJECTIVE:

1. Provide you with the knowledge and expertise to become a proficient data scientist.
2. Demonstrate an understanding of statistics and machine learning concepts that are vital for data science;
3. Produce python code to statistically analyse a dataset;
4. Critically evaluate data visualisations based on their design and use for communicating stories from data.

Unit 1: 6 Lectures
Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications.

Unit 2: 7 Lectures
Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources

Unit 3: 10 Lectures
Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance,Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes.

Unit 4: 11 Lectures
Data visualisation:Introduction, Types of data visualisation,Data for visualisation:Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings.

Unit 5: 7 Lectures
Applications of Data Science,Technologies for visualisation, Bokeh (Python)

Unit 6: 7 Lectures
Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.

REFERENCE BOOKS:

1. Cathy o’neil and rachel schutt. Doing data science, straight talk from the frontline.
2. O’reilly, jure leskovek, anand rajaraman and jeffrey ullman. Mining of massive datasets.v2.1, cambridge university press.

COURSE OUTCOMES:

CO1: Explain how data is collected, managed and stored for data science;
CO2: Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists;
CO3: Implement data collection and management scripts using MongoDB.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	3	3	3	3
CO2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	2	2	2	3	2	2

PRINCIPLES OF CRYPTOGRAPHY 3(3-0-0)
(CSE-101-CC-5240)

COURSE OBJECTIVES:

- To provide an in-depth idea to cryptography, its mathematical foundations, and its relation to security.
- To cover classical cryptosystems, private-key cryptosystems (including des and aes), hashing and public-key cryptosystems (including rsa).
- The course also provides an inside to data integrity and authentication.

Unit 1: 8 Lectures
Algebra: Group, cyclic group, cyclic subgroup, field, probability. Number Theory: Fermat's theorem, Cauchy 's theorem, Chinese remainder theorem, primality testing algorithm, Euclid's algorithm for integers, quadratic residues etc..

Unit 2: 7 Lectures
Classical cryptosystems and their cryptanalysis, Model of secure communication, Security services, Overview of attacks, X.800 Security Architecture for Open System Interconnection (OSI), and cryptanalysis, Shannon perfect secrecy, OTP, Pseudo random bit generators, stream ciphers and RC4.

Unit 3: 7 Lectures
Block ciphers: Modes of operation, DES and its variants, AES, linear and differential cryptanalysis.

Unit 4: 8 Lectures
One-way function, trapdoor one-way function, Public key cryptography, RSA cryptosystem, Rabin cryptosystem, Diffie-Hellman key exchange algorithm, Elgamal Cryptosystem.

Unit 5: 9 Lectures
Cryptographic hash functions, secure hash algorithm, Message authentication, Zero knowledge proofs, digital signature, RSA digital signature, Elgamal digital signature, Kerberos, X.509 authentication service, PKI Public Key Cryptography standard (PKCS), PKI, Digital Certificates, and Key management techniques.

REFERENCE BOOKS:

1. B. S. Schneier: applied cryptography: protocols, algorithms, and source code in c.
2. Behrouz a. Forouzan and debdeep mukhopadhyay, cryptography and network security, tata mcgraw hill.
3. Alfred j. Menezes, paul c. Van oorschot, and scott a. Vanstone, "handbook of applied cryptography", crc press.
4. Jonathan katz and yehuda lindell, introduction to modern cryptography, chapman and hall/crc press.
5. Oded goldreich, the foundations of cryptography, volume 1 and volume 2, cambridge university press.

COURSE OUTCOMES

CO1: Students will be able to understand the classical and modern concepts related to cryptography and cryptanalysis.
CO2: Students will be able to know the mathematical support for cryptography and learn methods for modern cryptography techniques under the category of stream and block cipher.
CO3: Students will be able to analyze and implement of some of the prominent techniques for symmetric-key encryption schemes like DES, AES etc..

CO4: Students will be able to describe and implement of some of the prominent techniques for public-key cryptosystems and digital signature schemes (e.g., Rabin, RSA, ElGamal, DSA)
CO5: Students will be able to understand the inner workings of Authentication schemes and how to correctly use them in real-world applications.
CO6: Students will be able to explain the notions of public-key infrastructure and digital signatures, and sketch their formal security definitions.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	1	2	1	3	3	2	2
CO2	3	3	3	2	2	2	3	3	2	2
CO3	3	3	3	3	2	2	3	3	2	2
CO4	3	3	3	3	2	2	3	3	2	2
CO5	3	3	3	3	2	2	3	3	2	2
CO6	3	3	3	3	2	2	3	3	2	2

RESEARCH AND PUBLICATION ETHICS 3(3-0-0)
(CSE-101-RC-5210)

COURSE OBJECTIVES:

- To understand the principles and practices of ethical research and publication.
- To develop skills in identifying and addressing ethical issues in research.
- To learn the standards and guidelines for responsible conduct in research and publishing.

Unit 1: 8 Lectures

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: 6 Lectures

Effective literature studies approaches, analysis; Plagiarism, Research ethics,

Unit 3: 7 Lectures

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: 8 Lectures

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: 7 Lectures

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: 7 Lectures

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCE BOOKS:

1. Stuart melville and wayne goddard, research methodology: an introduction for science & engineering students
2. Wayne goddard and stuart melville, research methodology: an introduction.
3. Ranjit kumar, 2nd edition, “research methodology: a step by step guide for beginners.
4. Halbert, “resisting intellectual property”, taylor & francis ltd,2007.
5. Mayall, “industrial design”, mcgraw hill, 1992.
6. Niebel, “product design”, mcgraw hill, 1974.

COURSE OUTCOMES:

CO1:Understand research problem formulation.
CO2: Analyze research related information
CO3: Follow research ethics
CO4: Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

CO5: Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	3	3	2	2
CO2	3	3	3	2	2	2	3	3	3	2
CO3	2	2	2	2	2	2	3	3	3	3
CO4	3	3	3	2	2	2	2	3	2	3
CO5	2	3	2	2	3	2	3	3	2	3

Electives – I

Advanced DBMS 3(2-0-1):
(CSE-101-DE-52010)

COURSE OBJECTIVES:

1. The main objective of this course is to enable students to the fundamental concepts of databases and distributed database.
2. To recognize the importance of database analysis and design in the implementation of any database application and to understand the process normalization.
3. It also gives the knowledge of the roles of transaction processing and concurrency control both in dbms and distributed environment.

Unit 1 15 Lectures

Database Management System: Introduction, Types of Data Models, Schema, relationships, Keys Concept, RDBMS. Normalization: Functional Dependencies, various normal forms.

Unit 2 15 Lectures

Introduction to Object Database Systems: Introduction, Structured Data types, operations on structured data, Encapsulation and ADTS, Inheritance Objects, IDs, and reference types, implementation of various complex types in SQL. ORDBMS: Design, implementation and challenges, OODBMS, comparison of RDBMS, OODBMS and ORDBMS.

Unit 3 15 Lectures

Transaction Management: Transactions basic concepts, and Schedules, Serializability Concept, Concurrency Control Mechanisms- Locking protocols, Timestamp based, and optimistic approaches. Deadlocks Management in DBMS- prevention, handling and avoidance.

Unit 4 15 Lectures

Distributed databases: Introduction, Distributed DBMS architectures, Need of distributed databases, Types of Fragmentation, Distributed query processing, Distributed concurrency control, Distributed Recovery.

REFERENCE BOOKS:

1. Data base management systems, raghu ramakrishnan, johannes gehrke, tmh, 3rd edition, 2003.data base system concepts, a. Silber schatz, h.f. korth, s. Sudarshan, mcgraw hill, vi edition, 2006.
2. Fundamentals of database systems 5th edition. Ramez elma sri, shamkant b. Navathe, pearson education, 2008.
3. Introduction to database systems, c.j. date, pearson education.
4. Principles of distributed database systems, by m tamer ozsu, patrick valduriez, third edition, springer.

COURSE OUTCOMES

CO1: Apply normalization techniques.

CO2: Understand how transactions are processed in a database.

CO3: Discuss/explain the concepts of Distributed Databases and Data Warehousing.

CO3: Discuss/explain some database security issues.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	3	2	2	2	2	2	2
CO2	3	2	3	3	2	2	2	2	2	2
CO3	3	3	3	3	2	2	2	2	3	3
CO4	3	3	3	3	2	2	3	2	2	2

SEMESTER – III & IV

Group –I (Machine Learning)

MATHEMATICAL CONCEPTS OF MACHINE LEARNING 4(3-0-1)
(CSE-101-CW-61010)

COURSE OBJECTIVES:

- To understand the mathematical foundations of machine learning algorithms.
- To develop proficiency in linear algebra, probability, and statistics as they apply to machine learning.
- To apply mathematical concepts to design and analyze machine learning models.

Unit 1: Linear Algebra and Its Applications in Machine Learning 8 Lectures
Vector Spaces and Linear Transformations: Vector spaces, basis, and dimension, Linear transformations and matrices, Eigenvalues and eigenvectors; Matrix Operations and Properties: Matrix addition, multiplication, and inversion, Determinants and rank, Special matrices (symmetric, orthogonal, etc.); Principal Component Analysis (PCA): Covariance matrix and its properties, Dimensionality reduction using PCA, Singular Value Decomposition (SVD); Applications in Machine Learning: Linear regression, Support Vector Machines (SVM), Regularization techniques; Learning Outcomes: Understand and perform matrix operations and transformations., Apply PCA for dimensionality reduction in datasets. Use linear algebra concepts in developing machine learning models.

Unit 2: Probability Theory and Statistics 8 Lectures
Basic Probability Concepts: Probability spaces, random variables, and distributions, Expectation, variance, and moments, Conditional probability and Bayes' theorem; Common Probability Distributions: Discrete distributions: Bernoulli, Binomial, Poisson, Continuous distributions: Uniform, Normal, Exponential; Statistical Inference: Point estimation and properties of estimators, Confidence intervals and hypothesis testing, Maximum likelihood estimation (MLE); Applications in Machine Learning: Naive Bayes classifiers, Gaussian Mixture Models (GMM), Hidden Markov Models (HMM); Learning Outcomes: Apply probability theory to model and analyze random processes. Perform statistical inference and hypothesis testing. Develop probabilistic models for machine learning applications.

Unit 3: Optimization Techniques 8 Lectures
Optimization Basics: Optimization problem formulation, Gradient descent and its variants, Convergence and learning rates; Convex Optimization: Convex sets and functions, Properties of convex optimization problems, Duality theory; Advanced Optimization Methods: Stochastic Gradient Descent (SGD), Newton's method and Quasi-Newton methods, Optimization in large-scale machine learning; Applications in Machine Learning: Training neural networks, Regularization and hyperparameter tuning, Optimization in reinforcement learning; Learning Outcomes: Formulate and solve optimization problems relevant to machine learning. Implement various optimization algorithms. Understand the role of optimization in training machine learning models.

Unit 4: Information Theory 8 Lectures
Basic Concepts of Information Theory: Entropy, mutual information, and Kullback-Leibler divergence, Shannon's Theorems, Source coding and channel coding; Information-Theoretic Measures: Information gain and decision trees, Cross-entropy and its applications, Maximum entropy principle, Applications in Machine Learning: Feature selection and feature extraction, Information theory in clustering, Neural networks and information bottleneck theory; Learning Outcomes: Understand fundamental concepts of information theory. Apply information-theoretic

measures to machine learning tasks. Utilize information theory in feature selection and model evaluation.

Unit 5: Advanced Topics in Mathematical Foundations 8 Lectures
Reproducing Kernel Hilbert Space (RKHS): Introduction to Hilbert spaces, Kernel functions and the kernel trick, Support Vector Machines (SVM) in RKHS, Graph Theory and Spectral Methods: Graphs, adjacency matrices, and Laplacian matrices, Spectral clustering, Graph-based semi-supervised learning.Manifold Learning: Manifolds and dimensionality reduction, Isomap, Locally Linear Embedding (LLE), and t-SNE, Applications in high-dimensional data analysis Recent Trends and Research Directions: Current challenges and open problems in machine learning, Review of recent research papers, Future directions and emerging applications; Learning Outcomes: Explore advanced mathematical concepts used in modern machine learning research. Apply spectral methods and manifold learning techniques to complex datasets. Critically analyze and discuss recent research papers in machine learning.

REFERENCE BOOKS:

1. "Pattern recognition and machine learning" by christopher m. Bishop
2. "machine learning: a probabilistic perspective" by kevin p. Murphy
3. "convex optimization" by stephen boyd and lieven vandenberghe
4. "elements of information theory" by thomas m. Cover and joy a. Thomas

COURSE OUTCOMES:

CO1: Students will develop a strong understanding of key mathematical concepts, including linear algebra, probability theory, and optimization, enabling them to rigorously analyze and implement machine learning algorithms.

CO2: Students will be able to apply mathematical principles to design and optimize machine learning models, including techniques such as principal component analysis (PCA), maximum likelihood estimation (MLE), and various optimization algorithms.

CO3: Students will acquire the skills to critically evaluate and solve complex machine learning problems using advanced mathematical tools, ensuring robust and efficient model development and evaluation.

CO4: Students will explore and engage with advanced mathematical topics and recent research trends, preparing them to contribute to cutting-edge developments in the field of machine learning and pursue further research or professional opportunities.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	2	2	2	3	2	2
CO2	2	3	2	3	2	2	2	2	2	2
CO3	2	2	3	2	2	3	2	2	2	2
CO4	2	2	2	2	3	2	2	2	3	3

Data pre-processing and feature engineering 4(3-0-1)
(CSE-101-CW-61020)

COURSE OBJECTIVES:

- The course aims to provide students with comprehensive knowledge and practical skills in data preprocessing and feature engineering.
- Students will have understanding of crucial steps of the data science and machine learning pipeline.
- By the end of the course, students will be able to clean, transform, and prepare data for building effective machine learning models.

Unit 1: Introduction to Data Preprocessing 8 Lectures
Data Quality: Types of data, data quality issues, data cleaning; Handling Missing Data: Techniques for handling missing values, imputation methods, handling outliers; Data Integration and Transformation: Data integration methods, data transformation techniques, normalization and standardization; Data Reduction: Dimensionality reduction, feature selection methods, principal component analysis (PCA).

Unit 2: Data Cleaning and Preparation 7 Lectures
Data Cleaning Techniques: Handling noise, dealing with inconsistencies, data smoothing; Data Wrangling: Reshaping data, parsing dates, string manipulation; Data Encoding: One-hot encoding, label encoding, binary encoding; Feature Scaling: Min-max scaling, z-score normalization, logarithmic scaling.

Unit 3: Feature Engineering Fundamentals 8 Lectures
Introduction to Feature Engineering: Importance of feature engineering, feature extraction; Creating Features: Mathematical transformations, interaction features, polynomial features; Feature Construction: Aggregation, domain-specific features, time-based features; Feature Selection: Filter methods, wrapper methods, embedded methods.

Unit 4: Advanced Feature Engineering Techniques 8 Lectures
Feature Engineering for Text Data: Text preprocessing, TF-IDF, word embeddings; Feature Engineering for Image Data: Image preprocessing, feature extraction techniques, convolutional neural networks (CNN) features; Feature Engineering for Time Series Data: Time series decomposition, lag features, rolling statistics; Automated Feature Engineering: Feature tools, deep feature synthesis, feature engineering frameworks.

Unit 5: Practical Applications and Case Studies 9 Lectures
Real-world Applications: Data preprocessing and feature engineering in different domains, healthcare, finance, e-commerce; Case Studies: End-to-end case studies on data preprocessing and feature engineering, exploring datasets, applying techniques learned; Tools and Libraries: Using Python libraries for data preprocessing and feature engineering, pandas, NumPy, scikit-learn, Featuretools;

REFERENCE BOOKS:

1. "Feature engineering for machine learning: principles and techniques for data scientists" by alice zheng and Amanda Casari
2. "Python data science handbook" by Jake Vanderplas
3. "Data preparation for data mining" by Dorian Pyle

COURSE OUTCOMES:

CO1: Develop a thorough understanding of data quality issues and apply various techniques to clean, integrate, and transform raw data, ensuring it is suitable for analysis and model building.

CO2: Demonstrate the ability to perform feature engineering by creating, selecting, and transforming features to improve the performance and accuracy of machine learning models.
CO3: Utilize advanced feature engineering techniques for specialized data types such as text, images, and time series, applying appropriate methods and tools to extract meaningful features.
CO4: Apply data pre-processing and feature engineering concepts in real-world scenarios through case studies and hands-on projects, showcasing the ability to handle practical data challenges and prepare data for machine learning applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	3	2	2	2	2	2	2
CO2	3	3	3	3	2	2	2	3	2	2
CO3	3	3	3	3	2	2	2	2	2	2
CO4	3	3	3	3	3	3	2	2	3	3

Deep Learning 4(3-0-1):
(CSE-101-CW-61030)

COURSE OBJECTIVES:

1. To introduce the idea of artificial neural networks and their applications.
2. To study and implement different architectures of artificial neural networks.
3. To study and implement various optimization techniques on artificial neural networks.
4. To enable design and deployment of deep learning models for machine learning problems.

Unit 1: 8 Lectures

Introduction: Artificial Intelligence and Deep Learning-a historical perspective, Artificial neural networks, Shallow neural networks, Deep neural networks, gradient descent, forward and backpropagation, computational graphs, linear and non-linear activation functions.

Unit 2: 8 Lectures

Optimization techniques: Regularization, Dropout, Batch Normalization, Vanishing/Exploding gradients, Mini-batch gradient, Gradient descent with momentum, RMSprop, Adam optimization, Learning rate decay, Local optima, Global optima. Hyperparameter tuning,

Unit 3: 10 Lectures

Convolutional Neural Networks: Basic operations: padding, stride, pooling; Classic convolutional models: LeNet-5, AlexNet, VGG, Modern Deep Convolutional models: ResNet, GoogleNet; Inception Network, 1-D convolutions, Object detection and Face Recognition with CNN.

Unit 4: 10 Lectures

Recurrent Neural Networks: Sequence modelling, Types of Recurrent Neural Networks, Backpropagation through time, Language modelling and sequence generation, Word Embeddings, vanishing gradients with RNNs, Long-Short Term Memory (LSTM), Gated Recurrent MODULEs (GRU), Bidirectional LSTMs, Sequence-to-Sequence model, Attention Mechanism, Transformer Network.

Unit 5: 8 Lectures

Advanced topics: Deep Reinforcement Learning, Generative Adversarial Networks, Generative vs. Discriminative models, Deep Convolution GANS, Autoencoders.

REFERENCE BOOKS:

1. Charu c. Aggarwal, neural networks and deep learning- a textbook, 2018, springer.
2. Ian goodfellow, yoshua bengio, aaron courville, ”deep learning (adaptive computation and machine learning series”, mit press.
3. Nikhil buduma, nicholas locascio, “fundamentals of deep learning: designing next generation machine intelligence algorithms”, o'reilly media.

COURSE OUTCOMES:

CO1: Students will be able to understand the mathematics and Engineering sciences behind functioning of artificial neural networks.
CO2: Students will be able to analyze the given dataset and data attributes for designing a neural network-based solution.
CO3: Students will be able to identify different neural network architectures, neural network optimization techniques, and apply them on different problem domains.
CO4: Students will be able to design and deploy deep learning solutions for real-world applications with popular deep learning tools.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO1	3	3	3	2	2	2	2	3	2	2
CO2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	2	2	2	3	3	2
CO4	3	3	3	3	3	2	2	3	3	3

Natural Language Processing 4(3-0-1):
(CSE-101-CW-61040)

COURSE OBJECTIVES:

- The students should be able to study language and the tools that are available to efficiently study and analyze large collections of text.
- They should learn about and discuss the effects of electronic communication on our language.

Unit I 15 Lectures

Introduction A computational framework for natural language, description of English or an Indian language in the framework, lexicon, algorithms and data structures for implementation of the framework, Finite state automata, the different analysis levels used for NLP (morphological, syntactic, semantic, pragmatic, Recursive and augmented transition networks. Applications like machine translations.

Unit II 12 Lectures

Word level and syntactic analysis Word Level Analysis: Regular Expressions, Finite-State Automata, Morphological Parsing, Spelling Error Detection and correction, Words and Word classes, Part-of Speech Tagging. -- Syntactic Analysis: Context Machine free Grammar, Constituency, Parsing readable dictionaries and lexical databases, RTN, ATN.

Unit III 10 Lectures

Semantic analysis Probabilistic Parsing. Semantic Analysis: Meaning Representation, Lexical Semantics, Ambiguity, Word Sense Disambiguation. Discourse Processing: cohesion, Reference Resolution, Discourse Coherence and Structure. Knowledge Representation, reasoning.

Unit IV 15 Lectures

Natural Language Generation (NLG): Architecture of NLG Systems, Generation Tasks and Representations, Application of NLG. Machine Translation: Problems in Machine Translation, Characteristics of Indian Languages, Machine Translation Approaches, Translation involving Indian Languages.

REFERENCE BOOKS:

1. Natural language understanding by james allen, pearson education, 2002.
2. Nlp: a paninian perspective by akshar bharati, vineet chaitanya, and rajeev sangal, prentice hall, 2016.
3. Meaning and grammar by g. Chirchia and s. Mcconnell ginet, mit press, 1990.
4. An introduction to natural language processing, computational linguistics, and speech recognition by Daniel Jurafsky and James H. Martin, Pearson Education, 2006.
5. Natural language processing in prolog by gazdar, & mellish, addison-wesley.

COURSE OUTCOMES:

CO1: Develop speech-based applications that use speech analysis (phonetics, speech recognition, and synthesis).
CO2: Analyse the syntax, semantics, and pragmatics of a statement written in a natural language.
CO3: Develop a conversational agent that uses natural language understanding and generation.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO1	3	3	3	3	2	2	2	3	3	2
CO2	3	3	3	3	2	2	2	3	2	2
CO3	3	3	3	3	3	2	2	3	3	2

Big Data Analytics and Visualization 4(3-0-1):
(CSE-101-CW-61050)

COURSE OBJECTIVE:

- To understand the concepts and technologies of big data and its ecosystem.
- To develop skills in applying big data analytics techniques to extract insights from large datasets.
- To master data visualization principles and tools to effectively communicate analytical results.

Unit 1: 5 Lectures
Introduction To Big Data: Introduction To Big Data Platform, Challenges Of Conventional Systems, Intelligent Data Analysis, Types And Characteristics Of Data, Analytic Processes And Tools, Statistical Concepts: Sampling Distributions, Re-Sampling, Statistical Inference - Prediction Error,

Unit 2: 8 Lectures
The Big Data Technology Landscape: Nosql, Types Of No Sql Databases, Sql V Introduction To Mongodb, Data Types In Mongodb, Crud, Practice Examples, Apache Cassandra, Features Of Cassandra, Crud Operations

Unit 3: 11 Lectures
Hadoop Framework: History Of Hadoop, The Hadoop Distributed File System, Components Of Hadoop, Analysing The Data With Hadoop, Scaling Out, Hadoop Streaming, Design Of Hdfs, Java Interfaces To Dfs Basics, Developing A Map Reduce Application, How Map Reduce Works, Anatomy Of A Map Reduce Job Run, Failures, Job Scheduling, Shuffle And Sort, Task Execution, Map Reduce Types And Formats, Map Reduce Features, Hadoop Ecosystem. Hadoop Environment: Setting Up A Hadoop Cluster, Cluster Specification, Hadoop Configuration, Security In Hadoop, Administering Hadoop, Hdfs, Hadoop In The Cloud.

Unit 4: 6 Lectures
Spark, Sparksql - For Database, Spark Web Ui - For Debugging And Optimization, Spark Mllib - Machine Learning Library For Spark, Spark's Graphx - Use For Analytics, R Or Python For Apache Spark (R Is Recommended)

Unit 5: 10 Lectures
Frameworks: Applications On Big Data Using Pig And Hive, Data Processing
Operators In Pig, Hive Services, Hiveql, Querying Data In Hive, Fundamentals Of Hbase And Zookeeper, Ibm Info Sphere Big Insights And Streams, Visualizations, Visual Data Analysis Techniques, Interaction Techniques, Systems And Applications

Unit 6: 5 Lectures
Data Visualization With Tableau/Powerbi: Data Storytelling And Visualization, Building Data Lakes With Different Formats And Sources, Creating Dynamic Dashboard With Various Graphing Techniques

REFERENCE BOOKS:

1. Michael berthold, david j. Hand, intelligent data analysis, springer
2. Tom white, hadoop: the definitive guide, third edition, o'reilly media
3. Chris eaton, dirk deroos, tom deutsch, george lapis, paul zikopoulos, understanding big data: analytics for enterprise class hadoop and streaming data, mcgraw hill publishing
4. Anand rajaraman and jeffrey david ullman, mining of massive datasets, cambridge university press

5. Jiawei han, micheline kamber, data mining concepts and techniques, second edition, elsevier
6. Paul zikopoulos, dirk deroos, krishnan parasuraman, thomas deutsch, james giles, david corrigan, harness the power of big data: the ibm big data platform, tata mcgraw hill publications

COURSE OUTCOMES:

CO1: Understand and apply the fundamental concepts of big data analytics, including data collection, storage, and processing techniques.

CO2: Utilize various big data technologies and tools, such as Hadoop, Spark, and NoSQL databases, to manage and analyze large datasets.

CO3: Develop and implement advanced analytical models and algorithms to extract meaningful insights from big data.

CO4: Design and create effective data visualizations to communicate complex data-driven insights using visualization tools and techniques.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	3	3	3	2	3	3
CO2	3	3	3	3	2	3	3	2	2	3
CO3	3	3	3	3	3	3	3	2	2	3
CO4	3	3	3	3	3	2	3	2	2	2

Computer Vision 4(3-0-1):
(CSE-101-CW-61060)

COURSE OBJECTIVE:

- To understand the fundamental principles and techniques of computer vision.
- To develop proficiency in designing and implementing computer vision applications.
- To explore advanced topics and recent developments in computer vision research.

UNIT I 8 Lectures

Digital Image Formation and low-level processing: Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing, introduction to computer vision.

UNIT II 10 Lectures

Feature Extraction: Shape, histogram, color, spectral, texture, Feature analysis, feature vectors, distance /similarity measures, data preprocessing, Edges - Canny, LOG, DOG; Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT; Line detectors (Hough Transform), Orientation Histogram, SIFT, SURF, GLOH, Corners - Harris and Hessian Affine.

UNIT III 10 Lectures

Depth estimation and Multi-camera views: Perspective, Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Binocular Stereopsis: Camera and Epipolar Geometry; Auto- calibration.

Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean- Shift, MRFs, Texture Segmentation; Object detection.

UNIT IV 8 Lectures

Motion Analysis: Optical Flow, KLT, Spatio-Temporal Analysis, Background Subtraction and Modeling, Dynamic Stereo; Motion parameter estimation.

UNIT V 8 Lectures

Shape from X: Light at Surfaces; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges Albedo estimation; Photometric Stereo; Phong Model; Reflectance Map.

REFERENCES:

1. Richard szeliski, computer vision: algorithms and applications, springer-verlag london limited 2011.
2. Computer vision: a modern approach, d. A. Forsyth, j. Ponce, pearson education, 2003.
3. Richard hartley and andrew zisserman, multiple view geometry in computer vision, second edition, cambridge university press, march 2004.
4. R.C. gonzalez and r.e. woods, digital image processing, addison- wesley, 1992.

COURSE OUTCOMES:

CO1: Understand and apply the fundamental concepts and techniques in computer vision, including image processing, feature extraction, and pattern recognition.
CO2: Develop algorithms for object detection, recognition, and classification using machine learning and deep learning techniques.

CO3: Implement and optimize computer vision applications for real-world problems, such as image segmentation, motion tracking, and 3D reconstruction.
CO4: Utilize and evaluate various computer vision tools and libraries, such as OpenCV, TensorFlow, and PyTorch, for developing advanced vision-based systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	3	2	2	2	3	2	2
CO2	3	3	3	3	3	2	2	3	3	2
CO3	3	3	3	3	2	2	2	3	3	2
CO4	3	3	3	3	3	2	2	3	3	3

Robotics and Automation 4(3-0-1):
(CSE-101-CW-07)

COURSE OBJECTIVES:

- Understand the fundamental concepts and principles of robotics and automation, including their historical development, key components, and applications across various industries.
- Analyze and design robotic mechanisms, including kinematic analysis, motion planning, and control strategies, to develop efficient and effective robotic systems.
- Explore sensing and perception techniques in robotics, including sensor integration, perception algorithms, and feedback control systems, to enhance robot capabilities in diverse environments.
- Develop proficiency in robot programming, control methodologies, simulation tools, and human-robot interaction techniques, enabling students to design, program, and operate robotic systems effectively.

Unit 1: Introduction to Robotics and Automation 6 Lectures
Overview of robotics and automation; History and evolution of robotics; Importance and applications in various industries; Key components of a robotic system; Basic principles of automation; Role of artificial intelligence in robotics and automation.

Unit 2: Robotic Mechanisms and Kinematics 8 Lectures
Types of robotic mechanisms (e.g., manipulators, mobile robots); Kinematic analysis of robots; Forward and inverse kinematics; Degrees of freedom; Jacobian matrix and velocity analysis; End effectors and grippers; Motion planning algorithms.

Unit 3: Sensing and Perception in Robotics 8 Lectures
Sensors used in robotics (e.g., proximity sensors, vision sensors, force/torque sensors); Sensor fusion techniques; Perception algorithms for object detection and recognition; Localization and mapping techniques (e.g., SLAM); Feedback control systems.

Unit 4: Robot Programming and Control 8 Lectures
Programming languages for robotics (e.g., C++, Python, ROS); Robot operating systems (ROS); Motion control techniques (e.g., PID control, trajectory planning); Real-time control systems; Simulation and virtual environments for robotics; Human-robot interaction and collaboration.

Unit 5: Advanced Topics in Robotics and Automation 8 Lectures
Industrial robotics and automation; Collaborative robots (cobots); Autonomous navigation and decision making; Swarm robotics; Soft robotics and bio-inspired design; Ethical considerations in robotics; Future trends and challenges in the field.

REFERENCE BOOKS:

1. "Introduction to robotics: mechanics and control" by john j. Craig
2. "Robotics: control, sensing, vision, and intelligence" by k.s. fu, r.c. gonzalez, c.s.g. lee
3. "Automation, production systems, and computer-integrated manufacturing" by Mikell P. Groover

COURSE OUTCOME:

CO1: Students will be able to demonstrate a comprehensive understanding of robotics and automation, including their historical context, technological components, and real-world applications.
CO2: Students will be proficient in analyzing and designing robotic mechanisms, applying kinematic principles, motion planning algorithms, and control strategies to solve complex robotic challenges.
CO3: Students will develop expertise in sensing and perception techniques, integrating sensors, implementing perception algorithms, and designing feedback control systems for improved robotic performance.
CO4: Students will acquire practical skills in robot programming, control methodologies, simulation environments, and human-robot interaction, enabling them to design, implement, and evaluate robotic systems for various tasks and applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	2	2	3	3	2	2
CO2	3	3	3	2	2	2	2	3	2	2
CO3	3	3	3	2	2	2	3	2	2	2
CO4	3	3	2	2	3	3	2	3	3	3

Group-II (Cyber Security)

Introduction to Cyber security 4(3-0-1):
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COURSE OBJECTIVES:

- To give students an extensive overview of cyber security issues, tools and techniques that are critical in solving problems in cyber security domains.
- To provide students with concepts of computer security, cryptography, digital money, secure protocols, detection and other security techniques.

Unit I 15 Lectures
Cyber Security Concepts: Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning). Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.

Unit II 15 Lectures
Cryptography: Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types Of Firewalls, User Management, VPN Security, Security Protocols: - security at the Application Layer- pGp and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer- IPSec.

Unit III 15 Lectures
System Security: Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.

Unit IV 15 Lectures
Internet Security: Cloud Computing and Security, Social Network sites security, Cyber Security Vulnerabilities-overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment.

Reference Textbooks:

1. "Computer security: principles and practice" by william stallings, lawrie brown
2. "Cybersecurity and Cyberwar: what everyone needs to know" by p.w. singer, allan friedman
3. "Network security essentials: applications and standards" by william stallings

COURSE OUTCOMES:
CO1: Understand fundamental cybersecurity concepts, principles, and terminology.
CO2: Identify and assess various types of cyber threats, attacks, and vulnerabilities.
CO3: Apply cybersecurity tools and techniques to protect information systems and networks.
CO4: Evaluate and implement security policies and procedures to mitigate cybersecurity risks.
CO5: Analyze and respond to cybersecurity incidents and breaches effectively.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO1	3	1	2	2	2	2	2	2	1	2
CO2	3	2	3	2	2	2	2	2	2	2
CO3	3	2	3	2	2	2	2	2	2	2
CO4	3	2	3	2	2	2	3	2	2	3
CO5	3	2	3	3	3	2	3	2	2	3

Ethical hacking 4(3-0-1):
(CSE-101-CW-

COURSE OBJECTIVE:

- Introduces the concepts of ethical hacking
- Give the students the opportunity to learn about different tools and techniques in ethical hacking
- Achieve practical knowledge of security and practically apply some of the tools.

Unit 1: 9 Lectures
Introduction to Ethical Disclosure: Ethics of Ethical Hacking, Ethical Hacking and the legal system, Proper and Ethical Disclosure

Unit 2: 8 Lectures
Penetration Testing and Tools: Using Metasploit, Using BackTrackLiveCD Linux Distribution

Unit 3: 9 Lectures
Vulnerability Analysis: Passive Analysis, Advanced Static Analysis with IDA Pro, Advanced Reverse Engineering

Unit 4: 10 Lectures
Client-side browser exploits, Exploiting Windows Access Control Model for Local Elevation Privilege, Intelligent Fuzzing with Sulley, From Vulnerability to Exploit

Unit 5: 8 Lectures
Malware Analysis: Collecting Malware and Initial Analysis, Hacking Malware

Unit 6: 4 Lectures
Case study of vulnerability of cloud platforms and mobile platforms & devices.

REFERENCE BOOKS:

1. Shon harris, allen harper, chris eagle and jonathan ness, gray hat hacking: the ethical hackers' handbook, tmh edition
2. Jon erickson, hacking: the art of exploitation, spd

COURSE OUTCOMES
CO1: Understand the core concepts related to malware, hardware and software vulnerabilities and their causes
CO2: Understand ethics behind hacking and vulnerability disclosure
CO3: Appreciate the Cyber Laws and impact of hacking
CO4: Exploit the vulnerabilities related to computer system and networks using state of the art

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	3	2	2	2	2	2
CO2	2	3	2	2	2	2	2	2	2	2

CO3	2	2	3	2	2	2	2	2	2	3
CO4	2	2	2	3	3	2	2	2	2	2

Cloud & IoT Security 4(3-0-1):

COURSE OBJECTIVES:

- To understand the fundamentals of internet of things (iot) and cloud computing.
- Explore the cryptographic fundamentals for iot.
- Ability to understand the security requirements in iot.
- To apply the concept of internet of things in the real world scenario**.**

Unit 1: 8 Lectures

Fundamentals of IoT and Cloud Computing: Evolution of Internet of Things, Enabling Technologies, IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models, Simplified IoT Architecture and Core IoT Functional Stack, Fog, Edge and Cloud in IoT, Functional blocks of an IoT ecosystem, Sensors, Actuators, Smart Objects and Connecting Smart Objects.

Unit 2: 8 Lectures

IoT Architectures and Protocols: M2M high-level ETSI architecture, IETF architecture for IoT, OGC architecture. IoT reference model: Domain model, information model, functional model, communication model. IoT reference architecture. Protocol Standardization for IoT: Efforts, M2M and WSN Protocols, SCADA and RFID Protocols. IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, LoRaWAN, Network Layer: IP versions, Constrained Nodes and Constrained Networks. Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, Application Layer Protocols:CoAP and MQTT.

Unit 3: 8 Lectures

Securing the IoT: Security Requirements in IoT Architecture, Security in Enabling Technologies, Security Concerns in IoT Applications. Security Architecture in the Internet of Things, Security Requirements in IoT, Insufficient Authentication/Authorization, Insecure Access Control, Threats to Access Control, Privacy, and Availability, Attacks Specific to IoT. Vulnerabilities. Secrecy and Secret-Key Capacity, Authentication/Authorization for Smart Devices, Transport Encryption, Attack & Fault trees.

Unit 4: 6 Lectures

Cloud Security for IoT: Cloud services and IoT: offerings related to IoT from cloud service providers, Cloud IoT security controls, and an enterprise IoT cloud security architecture. New directions in cloud enabled IoT computing.

Unit 5: 8 Lectures

Applications & Case Study: Real world design constraints, Applications, Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities, participatory sensing. Data Analytics for IoT. Software & Management Tools for IoT Cloud Storage Models & Communication APIs. Cloud for IoT: Amazon Web Services for IoT.

REFERENCE BOOKS:

1. Xu, l. D., & li, s. (2017). Securing the internet of things. Elsevier.
2. Weippl, e. (2018). Internet of things security: fundamentals, techniques and applications. River publishers.
3. Russell, b., & van duren, d. (2016). Practical internet of things security. Packt publishing ltd.
4. Hu, f. (2016). Security and privacy in internet of things (iots): models, algorithms, and implementations. Crc press.
5. Zhou, h. (2012). The internet of things in the cloud: a middleware perspective. Crc press.

6. Hersent, o., boswarthick, d., & elloumi, o. (2011). The internet of things: key applications and protocols. John wiley & sons.
7. Gupta, B., agrawal, d., handbook of research on cloud computing and big data applications in iot, igi global, usa, isbn13: 9781522584070, 2019.

COURSE OUTCOMES:

CO1: Identify and analyze security challenges specific to cloud computing and IoT environments.
CO2: Evaluate and implement security protocols and mechanisms for cloud and IoT systems.
CO3: Design secure cloud and IoT architectures using industry best practices and frameworks.
CO4: Assess the security risks and vulnerabilities in cloud and IoT deployments.
CO5: Apply advanced security measures to protect data and resources in cloud and IoT systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	2
CO3	3	2	3	3	3	2	2	2	2	3
CO4	3	3	3	3	3	2	2	2	2	2
CO5	3	2	3	3	3	2	2	2	3	3

Cyber security Policy and Law 4(3-0-1):

COURSE OBJECTIVES:

1. Develop a comprehensive understanding of cybersecurity policy frameworks, including national and international regulations, standards, and guidelines governing cybersecurity practices.
2. Analyze legal and ethical issues related to cybersecurity, including privacy laws, intellectual property rights, data protection regulations, cybercrime statutes, and ethical considerations in cybersecurity practices.
3. Learn to develop and implement cybersecurity policies, procedures, and guidelines aligned with regulatory requirements and organizational objectives. Understand the process of risk assessment, incident response planning, and compliance management in cybersecurity policy formulation.

UNIT-I: 8 Lectures
Introduction: Review of TCP/IP and TCP, IP Header analysis, Introduction to Cyber World, Cyber attacks and cyber security, Information warfare and cyber terrorism, Tpes of cyber attacks, Cyber Crime and Digital Fraud, Overview of Types of computer forensics i.e. Media Forensics, Network forensics (internet forensics), Machine forensic, Email forensic (e-mail tracing and investigations)

UNIT-II: 7 Lectures
Issues in cyber security: Private ordering solutions, Regulation and Jurisdiction for global Cyber security, Copy Right-source of risks, Pirates, Internet Infringement, Fair Use, postings, criminal liability, First Amendments, Data Loss.

UNIT-III: 7 Lectures
Intellectual property rights: Copy Right-Source of risks, Pirates, Internet Infringement, Fair Use, postings, Criminal Liability, First Amendments, Losing Data, Trademarks, Defamation, Privacy-Common Law Privacy, Constitutional law, Federal Statutes, Anonymity, Technology expanding privacy rights.

UNIT-IV: 7 Lectures
Procedural Issues Duty of Care, Criminal Liability, Procedural issues, Electronic Contracts & Digital Signatures, Misappropriation of information, Civil Rights, Tax, Evidence.

UNIT-V: 7 Lectures
Legal aspects of cyber security: Ethics, Legal Developments, Late 1990 to 2000,Cyber security in Society, Security in cyber laws case. studies, General law and Cyber Law-a Swift Analysis.

REFERENCE BOOKS:

1. Jonathan Rosenoer,“cyber law: the law of the internet”, springer-verlag, 1997.
2. D. Bainbridge, introduction to computer law, 5th edition, pearson education, 2004.
3. P. Duggal, cyber law: the indian perspective, saakshar law publications, 2005.
4. Mark F Grady, Fransesco Parisi, “The law and economics of cyber security”, cambridge university press, 2006.
5. S.P. Tripathy, “Cyber Security”, wiley publications.

COURSE OUTCOMES:

CO1: Students will be able to understand and interpret cybersecurity regulations, standards, and policies at national and international levels.
CO2: Students will be able to analyze the legal implications of cybersecurity breaches, data privacy violations, intellectual property theft, and cybercrime.
CO3: Students will be able to develop and draft cybersecurity policies, procedures, and guidelines to mitigate cyber risks, ensure data protection, and comply with legal requirements.
CO4: Students will be able to evaluate cybersecurity compliance frameworks, assess organizational governance structures, and implement measures to ensure regulatory compliance and accountability.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	3	2	2	3
CO2	3	3	2	2	2	3	3	3	2	3
CO3	2	2	2	2	2	2	3	2	3	3
CO4	3	2	2	2	2	2	2	2	3	3

Wireless network security 4(3-0-1):

Course Objectives:

1. Gain a comprehensive understanding of wireless networking technologies, including protocols, standards, and architectures used in wireless communication systems.
2. Identify common security threats and risks associated with wireless networks, such as eavesdropping, rogue access points, denial-of-service attacks, and unauthorized access.
3. Learn and implement security measures and best practices to secure wireless networks, including encryption techniques, authentication mechanisms, access control policies, intrusion detection systems, and network monitoring tools.

Unit 1: 9 Lectures

Wireless Networking Trends, Key Wireless Physical Layer Concepts: Frequency, Wavelength, Phase, Coding and modulation, Shannon Theorem, Hamming Distance, Multiple Access Methods, Doppler Shift; Signal Propagation: Reflection, Diffraction, Scattering, Fading, Shadowing, Multipath, Multi Antenna Systems, Beam forming, MIMO, OFDM; Wireless Local Area Networks: IEEE802.11, Amendments; Wireless Personal Area Networks.

Unit 2: 8 Lectures

GSM: Overview, Architecture, GSM Security Principles; General Packet Radio Services (GPRS): Overview, Architecture; Universal Mobile Telecommunication System (UMTS): Overview, Architecture and Subsystems; LTE: Overview, Architecture and Subsystems;

Unit 3: 8 Lectures

Radio Frequency Identification (RFID); WiMAX (Physical layer, Media access control, Mobility and Networking); Multi hop wireless networks: Position & topology base ad-hoc routing protocols, Proactive and Reactive routing protocols. Route disruption, diversion, routing state based attacks, SRP, Ariadne, SAODV, ARAN, SMT secure routing protocols, Wireless Sensor Networks,

Unit 4: 8 Lectures

Security of wireless networks: GSM, UMTS, WEP, IEEE 802.11i, Public Wifi hotspots, Bluetooth; Vehicular Ad-hoc Networks: vulnerabilities, challenges, Security architecture

Unit 5: 8 Lectures

Naming & addressing principles, attacks and protection techniques, Misbehavior at MAClayer of CSMA/CA, its impact and preventive measures, Mobile IPv4, Mobile IPv6, TCP over Wireless Networks.

REFERENCE BOOKS:

1. Jochen schiller, "Mobile communications", phi.
2. K Makki, P Reiher,et. al. "mobile and wireless network security and privacy",springer.
3. Levente buttyan, j p hubaux. "security and cooperation in wireless networks", cambridgeuniversity press.
4. Frank adelstein, sandeep ks gupta, golden richard, fundamentals of mobile and pervasive computing, mcgraw-hill
5. Butty L. &hubaux j.p.: security and cooperation in wireless networks: thwartingmalicious and selfish behavior in the age of ubiquitous computing, cambridge university press.
6. Wireless ad hoc and sensor networks – protocols, performance and control, jagannathan sarangapani, crc press, taylor & francis group.

COURSE OUTCOME:

CO1: To understand the architecture of wireless network and associated technologies.
CO2: Familiarize with the issues and technologies involved in designing a wireless and mobile system that is robust against various attacks.
CO3: Gain knowledge and understanding of the various ways in which wireless networks can be attacked and trade-offs in protecting networks.
CO4: Identify security threats in wireless networks and design strategies to manage network security

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	3	2	2	3	2	3
CO2	2	2	3	3	2	3	2	3	2	2
CO3	2	2	3	3	2	3	2	3	2	2
CO4	2	3	2	3	2	3	2	3	2	3

AI and Cyber security 4(3-0-1):

COURSE OBJECTIVES:

1. To understand the intersection of artificial intelligence (ai) and cyber security.
2. To learn how ai techniques can be applied to enhance cyber security measures.
3. To explore the vulnerabilities introduced by ai technologies and methods to mitigate them.
4. To develop skills for designing and implementing ai-based security solutions.

Unit 1: 6 Lectures

Introduction to AI and Cyber Security: Overview of AI in Cyber Security, Importance of AI in modern cyber security, AI techniques and their applications in security, Cyber Security Fundamentals, Basics of cyber threats and vulnerabilities, Overview of traditional security measures

Unit 2: 8 Lectures

Machine Learning for Cyber Security: Supervised Learning, Classification and regression techniques for threat detection, Case studies on phishing detection, malware classification, Unsupervised Learning, Clustering and anomaly detection for identifying unusual activities, Applications in network security and fraud detection

Unit 3: 8 Lectures

Deep Learning for Cyber Security: Neural Networks and Deep Learning, Introduction to neural networks and deep learning, Applications in intrusion detection systems (IDS) and user behavior analytics (UBA), Advanced Deep Learning Techniques, Convolutional Neural Networks (CNNs) for image-based threat detection, Recurrent Neural Networks (RNNs) for sequence-based threat analysis.

Unit 4: 8 Lectures

AI for Threat Intelligence and Incident Response: Threat Intelligence, Gathering and analyzing threat intelligence using AI, Predictive analytics for proactive threat mitigation, Incident Response, Automated incident response using machine learning, AI-based solutions for rapid detection and response.

Unit 5: 8 Lectures

Adversarial Machine Learning: Adversarial Attacks, Understanding adversarial examples and attacks on machine learning models, Techniques for generating adversarial examples, Defense Mechanisms, Methods to protect AI models from adversarial attacks, Case studies on securing AI systems.

Unit 6: 6 Lectures

Security Implications of AI: AI Vulnerabilities, Identifying and analyzing vulnerabilities in AI systems, Privacy and ethical considerations in AI

REFERENCE BOOKS:

1. "Artificial intelligence in cybersecurity" by leslie f. Sikos
2. "Machine learning for cybersecurity cookbook" by emmanuel tsukerman

COURSE OUTCOMES:

CO1: Understand the role of AI in cyber security and its applications.
CO2: Identify and analyze security threats that AI can help mitigate.
CO3: Design AI-based solutions for enhancing cyber security.
CO4: Evaluate the security implications of deploying AI technologies.
CO5: Implement machine learning algorithms for threat detection and response.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2	3	2	1	2	2	1	2
CO2	3	2	3	3	3	2	2	2	1	2
CO3	3	2	3	3	3	2	2	2	2	2
CO4	2	3	2	1	2	3	3	2	2	3
CO5	3	2	3	3	3	2	2	2	3	2

Coding Theory 4(3-0-1):

COURSE OBJECTIVES:

- To understand the fundamental concepts and principles of coding theory.
- To learn various coding techniques for error detection and correction.
- To apply coding theory concepts to solve real-world communication problems.
- To develop skills for designing and analyzing efficient codes.

Unit 1: 6 Lectures

Introduction to Coding Theory: Basic concepts and definitions, importance of coding theory in communication systems, historical background and evolution of coding theory, types of codes: linear, block, cyclic, convolutional, coding and decoding processes, overview of applications in modern communication systems.

Unit 2: 8 Lectures

Linear Block Codes: Introduction to linear block codes, generator matrices and parity-check matrices, encoding and decoding of linear block codes, Hamming codes: construction, properties, and error correction capabilities, syndrome decoding, distance properties of linear codes, applications of linear block codes in digital communication.

Unit 3: 8 Lectures

Cyclic Codes: Definition and properties of cyclic codes, generator polynomial and check polynomial, encoding and decoding of cyclic codes, algebraic structure of cyclic codes, BCH codes: construction, decoding algorithms, and error correction capabilities, Reed-Solomon codes: properties and applications in data storage and transmission, practical examples and use cases of cyclic codes.

Unit 4: 8 Lectures

Convolutional Codes: Introduction to convolutional codes, encoding using shift registers, state diagram, tree diagram, and trellis diagram representations, Viterbi algorithm for maximum likelihood decoding, distance properties and performance analysis of convolutional codes, Turbo codes and LDPC codes: concepts and applications in modern communication systems, comparative study of convolutional and block codes.

Unit 5: 8 Lectures

Error Detection and Correction: Types of errors in communication systems, error detection techniques: parity checks, checksums, cyclic redundancy check (CRC), error correction techniques: single-bit and burst error correction, forward error correction (FEC) schemes, automatic repeat request (ARQ) protocols, hybrid ARQ schemes, performance analysis of error detection and correction methods.

Unit 6: 6 Lectures

Advanced Topics in Coding Theory: Introduction to algebraic-geometric codes, Goppa codes: construction and decoding, network coding: concepts and applications in data networks, fountain codes: principles and applications in multimedia transmission, polar codes: construction, properties, and performance analysis, current research trends and future directions in coding theory.

REFERENCE BOOKS:

1. "Error control coding" by shu lin and daniel j. Costello
2. "The theory of error-correcting codes" by f. J. Macwilliams and n. J. A. Sloane

COURSE OUTCOMES:

CO1: Understand the basic concepts of coding theory and its importance in communication systems.
CO2: Analyze and construct different types of codes for error detection and correction.
CO3: Apply coding techniques to improve the reliability of data transmission.
CO4: Evaluate the performance and efficiency of various coding schemes.
CO5: Design and implement coding solutions for practical applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2	3	2	1	2	2	1	2
CO2	3	2	3	3	3	2	2	2	1	2
CO3	3	2	3	3	3	2	2	2	2	2
CO4	2	3	2	1	2	3	3	2	2	3
CO5	3	2	3	3	3	2	2	2	3	2

Group-III (Data Science)

Data Warehousing & Data Mining 4(3-0-1):

COURSE OBJECTIVES:

- To understand the fundamental concepts of data warehousing and the architecture of data warehouse systems.
- To develop proficiency in data mining techniques and their applications in extracting meaningful patterns from large datasets.
- To apply data warehousing and data mining concepts to solve complex data analysis and decision-making problems.

Unit 1: 6 Lectures
Introduction to Data Warehousing; Data Mining: Mining frequent patterns, association and correlations; Sequential Pattern Mining concepts, primitives, scalable methods;

Unit 2: 8 Lectures
Classification and prediction; Cluster Analysis – Types of Data in Cluster Analysis, Partitioning methods, Hierarchical Methods; Transactional Patterns and other temporal based frequent patterns,

Unit 3: 6 Lectures
Mining Time series Data, Periodicity Analysis for time related sequence data, Trend analysis, Similarity search in Time-series analysis;

Unit 4: 8 Lectures
Mining Data Streams, Methodologies for stream data processing and stream data systems, Frequent pattern mining in stream data, Sequential Pattern Mining in Data Streams, Classification of dynamic data streams, Class Imbalance Problem; Graph Mining; Social Network Analysis;

Unit 5: 8 Lectures
Web Mining, Mining the web page layout structure, mining web link structure, mining multimedia data on the web, Automatic classification of web documents and web usage mining; Distributed Data Mining.

REFERENCE BOOKS:

1. Jiawei Han and m kamber, data mining concepts and techniques,, second edition, elsevier publication, 2011.
2. Vipin kumar, introduction to data mining - pang-ning tan, michael steinbach, addison wesley, 2006.
3. G Dong and j pei, sequence data mining, springer, 2007.

COURSE OUTCOMES:

CO1: Understand the principles and architectures of data warehousing, including data modelling.
CO2: Apply data mining techniques such as classification, clustering, association rule mining, and anomaly detection to extract meaningful patterns from large datasets.
CO3: Design and implement data warehousing solutions to support business intelligence and decision-making processes.

CO4: Evaluate and utilize data mining tools and software for real-world data analysis and predictive modeling.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	2
CO2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	2	2	3	3	2
CO4	3	3	3	3	3	2	2	3	3	3

Group-III(Data Science)
Data Engineering 4(3-0-1):

COURSE OBJECTIVES:

- To understand the principles and practices of data engineering.
- To learn techniques for designing and managing data pipelines and workflows.
- To develop skills for handling and processing large-scale data.
- To apply data engineering concepts to build scalable and efficient data systems.

Unit 1: 6 Lectures
Introduction to Data Engineering: Definition and scope of data engineering, importance in the data lifecycle, data engineering vs. data science, roles and responsibilities of a data engineer, key concepts: data ingestion, data processing, data storage, data pipelines, introduction to data engineering tools and technologies.

Unit 2: 8 Lectures
Data Ingestion and Extraction : Sources of data: structured, semi-structured, and unstructured data, data ingestion techniques: batch processing, real-time processing, data extraction methods: web scraping, APIs, databases, tools for data ingestion: Apache Kafka, Apache NiFi, Flume, case studies on data ingestion strategies.

8 Lectures
Unit 3: Data Transformation and Cleaning: Importance of data transformation and cleaning, ETL (Extract, Transform, Load) process, data cleaning techniques: handling missing values, outlier detection, data normalization and standardization, data transformation: aggregation, filtering, joining, tools for ETL: Apache Spark, Talend, Apache Beam, practical examples and case studies.

Unit 4: 8 Lectures
Data Storage Solutions: Overview of data storage systems: relational databases, NoSQL databases, data lakes, data warehouses, comparative analysis of storage solutions, introduction to cloud storage: AWS S3, Google Cloud Storage, Azure Blob Storage, best practices for data storage: partitioning, indexing, backup and recovery, case studies on selecting appropriate storage solutions.

Unit 5: 8 Lectures
Data Processing Frameworks: Introduction to big data processing frameworks, Apache Hadoop: architecture and components, Apache Spark: architecture, RDDs, and DataFrames, real-time data processing with Apache Flink, comparative analysis of data processing frameworks, practical applications and case studies using these frameworks.

Unit 6: 6 Lectures
Workflow Orchestration and Automation: Importance of workflow orchestration in data engineering, introduction to Apache Airflow: architecture, DAGs, scheduling, monitoring workflows, other orchestration tools: Prefect, Luigi, automation techniques for data pipelines, case studies on workflow orchestration and automation.

Unit 7: 6 Lectures
Performance Tuning and Optimization: Key performance metrics for data systems, techniques for performance tuning: optimizing queries, resource allocation, data partitioning, strategies for improving data processing speed and efficiency, monitoring and profiling data pipelines, tools for performance tuning: Ganglia, Grafana, case studies on optimizing data engineering workflows.

REFERENCE BOOKS:

1. "Data engineering with python" by Paul crickard
2. "The data warehouse toolkit" by Ralph kimball and Margy Ross

COURSE OUTCOMES:

CO1: Understand the core concepts and techniques in data engineering.
CO2: Design and implement scalable data pipelines for data ingestion, processing, and storage.
CO3: Apply data transformation and cleaning techniques to prepare data for analysis.
CO4: Use modern data engineering tools and frameworks effectively.
CO5: Evaluate and optimize the performance of data systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	2	1	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	3
CO3	3	3	3	3	3	2	2	2	2	2
CO4	2	2	2	3	2	2	2	2	2	2
CO5	3	3	3	3	3	2	2	2	3	3

Social Network Analysis 4(3-0-1):

COURSE OBJECTIVES:

1. To understand the fundamental concepts and techniques in social network analysis.
2. To learn methods for modeling and analyzing social networks.
3. To explore advanced topics and recent developments in social network analysis.
4. To apply social network analysis techniques to real-world problems.

Unit 1: 6 Lectures

Introduction to Social Network Analysis: Definition and scope of social network analysis, history and evolution of social network analysis, key concepts: nodes, edges, adjacency matrix, types of networks: directed, undirected, weighted, unweighted, basic measures: degree, density, path length, introduction to social network analysis tools and software.

Unit 2: 7 Lectures

Graph Theory and Network Models: Basic graph theory concepts: graph representation, subgraphs, cliques, components, network models: random graph models, small-world networks, scale-free networks, properties and characteristics of different network models, practical applications and examples of network models.

Unit 3: 6 Lectures

Centrality Measures: Importance of centrality measures in social networks, degree centrality, closeness centrality, betweenness centrality, eigenvector centrality, PageRank algorithm, comparative analysis of centrality measures, practical examples and case studies using centrality measures.

Unit 4: 7 Lectures

Community Detection: Concepts of communities and clusters in networks, community detection methods: hierarchical clustering, modularity optimization, Girvan-Newman algorithm, Louvain method, evaluation of community detection algorithms, case studies on identifying communities in real-world networks.

Unit 5: 6 Lectures

Network Dynamics and Evolution: Temporal analysis of networks, network growth models: preferential attachment, evolving networks, diffusion and contagion processes in networks, models of influence and information spread, epidemics on networks, case studies on network dynamics and evolution.

Unit 6:

Visualization of Social Networks: 6 Lectures

Importance of network visualization, principles of effective network visualization, visualization tools and software: Gephi, Cytoscape, NetworkX, techniques for visualizing large-scale networks, dynamic and interactive network visualization, practical examples and case studies on network visualization.

Unit 7: 7 Lectures

Applications of Social Network Analysis: Social network analysis in various domains: sociology, biology, computer science, economics, political science, applications in online social networks: Facebook, Twitter, LinkedIn, analysis of social interactions and influence, recommendation systems, fraud detection, case studies on real-world applications of social network analysis.

REFERENCE BOOKS:

1. "Networks, crowds, and markets: reasoning about a highly connected world" by David

easley and Jon kleinberg

2. "Social network analysis: methods and applications" by Stanley Wasserman and Katherine Faust.

COURSE OUTCOMES:

CO1: Understand the core concepts and techniques in social network analysis.
CO2: Model and analyze social networks using appropriate tools and methods.
CO3: Interpret and visualize the structure and dynamics of social networks.
CO4: Apply social network analysis techniques to various types of data.
CO5: Explore advanced topics and recent developments in the field.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	3
CO3	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	2	2
CO5	3	3	3	3	3	2	2	2	3	3

Block chain technology 4(3-0-1):

COURSE OBJECTIVES:

1. To understand the fundamental concepts and techniques in blockchain technology.
2. To learn methods for designing and implementing blockchain-based systems.
3. To explore advanced topics and recent developments in blockchain technology.
4. To apply blockchain technology to real-world problems and use cases.

Unit 1: 6 Lectures
Introduction to Blockchain Technology: Definition and scope of blockchain technology, history and evolution of blockchain, key concepts: blocks, chains, nodes, consensus mechanisms, types of blockchains: public, private, consortium, benefits and challenges of blockchain technology, introduction to major blockchain platforms: Bitcoin, Ethereum, Hyperledger.

Unit 2: 6 Lectures
Cryptographic Foundations: Basic concepts of cryptography: hash functions, digital signatures, public key cryptography, Merkle trees, cryptographic techniques in blockchain: SHA-256, elliptic curve cryptography, zero-knowledge proofs, practical applications of cryptographic techniques in blockchain, case studies on cryptographic foundations in blockchain.

Unit 3: 6 Lectures
Blockchain Consensus Algorithms: Importance of consensus in blockchain, types of consensus algorithms: Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Practical Byzantine Fault Tolerance (PBFT), consensus in permissioned blockchains, comparative analysis of consensus algorithms, practical examples and case studies on consensus algorithms.

Unit 4: 6 Lectures
Smart Contracts and Decentralized Applications: Concepts of smart contracts, programming languages for smart contracts: Solidity, Vyper, design and implementation of smart contracts on Ethereum, security issues and best practices for smart contracts, introduction to decentralized applications (DApps), development and deployment of DApps, case studies on smart contracts and DApps.

Unit 5: 6 Lectures
Blockchain Security and Privacy: Security threats in blockchain systems: double spending, 51% attacks, Sybil attacks, techniques for ensuring blockchain security: consensus mechanisms, cryptographic proofs, network security, privacy in blockchain: confidential transactions, ring signatures, stealth addresses, case studies on blockchain security and privacy.

Unit 6: 6 Lectures
Performance and Scalability of Blockchain: Challenges in blockchain performance and scalability, techniques for improving blockchain performance: sharding, sidechains, off-chain transactions, layer 2 solutions: Lightning Network, Raiden Network, evaluation of performance and scalability techniques, case studies on improving blockchain performance.

Unit 7:

6 Lectures

Applications and Use Cases of Blockchain: Blockchain in finance: cryptocurrencies, decentralized finance (DeFi), blockchain in supply chain management, blockchain in healthcare, blockchain in government and public services, analysis of real-world blockchain use cases, future trends and research directions in blockchain technology, case studies on applications of blockchain technology.

REFERENCE BOOKS:

1. "Mastering bitcoin: unlocking digital cryptocurrencies" by andreas m. Antonopoulos
2. "Blockchain basics: a non-technical introduction in 25 steps" by daniel drescher
3. "Mastering Ethereum: building smart contracts and dapps" by Andreas M. Antonopoulos and Gavin Wood

COURSE OUTCOMES:

CO1: Understand the core concepts and techniques in blockchain technology.
CO2: Design and implement blockchain-based applications.
CO3: Analyze the security and performance aspects of blockchain systems.
CO4: Apply blockchain technology to various domains such as finance, healthcare, and supply chain.
CO5: Explore advanced topics and recent developments in the field of blockchain technology.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	3
CO3	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	2	2
CO5	3	3	3	3	3	2	2	2	3	3

Agent based Intelligent System 4(3-0-1):

COURSE OBJECTIVES:

- To introduce the fundamental concepts and theories in agent-based intelligent systems.
- To provide an understanding of the architecture and development of intelligent agents.
- To explore the applications of agent-based systems in various domains.
- To develop skills for designing and implementing agent-based solutions.

Unit 1:
Introduction to Agent-Based Systems: Overview of Intelligent Agents, Definitions and characteristics, Types of agents (simple reflex, model-based, goal-based, utility-based), Agent Environments, Types of environments (deterministic, stochastic, static, dynamic, discrete, continuous)

Unit 2:
Agent Architectures: Reactive Agents, Behavior-based architectures, Subsumption architecture, Deliberative Agents, BDI (Belief-Desire-Intention) architecture, STRIPS (Stanford Research Institute Problem Solver), Hybrid Architectures, Combining reactive and deliberative approaches

Unit 3:
Agent Communication and Coordination: Agent Communication Languages (ACL), KQML (Knowledge Query and Manipulation Language), FIPA (Foundation for Intelligent Physical Agents) ACL, Coordination Strategies, Cooperation, competition, negotiation, Distributed problem-solving, Task and resource allocation

Unit 4:
Multi-Agent Systems : Multi-Agent System Design, Architectures and frameworks
Interaction protocols, Applications of Multi-Agent Systems, E-commerce, distributed sensing, network management

Unit 5:
Learning in Agents: Machine Learning Techniques for Agents, Reinforcement learning
Evolutionary algorithms, Adaptive Agents, Learning in dynamic environments, Agent-based modelling and simulation

Unit 6:
Advanced Topics and Applications: Robotics and Autonomous Systems, Mobile robots,
Swarm robotics, Game Theory and Strategic Interaction, Game-theoretic approaches in agent systems, Auctions and mechanism design, Security and Privacy in Agent Systems, Ensuring trust and security, Privacy concerns and solutions

REFERENCE BOOKS:

1. "Multi-agent systems: An introduction to distributed artificial intelligence" by Jacques ferber
2. "Artificial intelligence: A modern approach" by Stuart Russell and Peter Norvig

COURSE OUTCOME:

CO1: Understand the principles and concepts of agent-based intelligent systems.
CO2: Analyze different types of agent architectures and their applications.
CO3: Design and implement intelligent agents for solving complex problems.
CO4: Evaluate the performance of agent-based systems in real-world scenarios.
CO5: Apply agent-based techniques in various domains such as robotics, distributed systems, and game theory.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	2	1	1	3	1	2
CO2	3	2	3	3	3	1	2	2	2	2
CO3	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	3	3
CO5	3	3	3	3	3	3	3	3	3	2

Network Security 4(3-0-1):

COURSE OBJECTIVE

- To understand the fundamental concepts and techniques in network security.
- To analyze and design secure network protocols.
- To apply security measures to protect network infrastructure from various threats and attacks.

Unit 1:
Introduction to Network Security: Overview of network security, principles of security: confidentiality, integrity, availability, authentication, non-repudiation, types of attacks: passive attacks, active attacks, security services and mechanisms, security policies, standards, and protocols.

Unit 2:
Cryptographic Techniques for Network Security: Symmetric key cryptography: DES, AES, asymmetric key cryptography: RSA, ECC, hash functions: MD5, SHA, digital signatures, key management and distribution, Public Key Infrastructure (PKI), practical applications of cryptography in network security.

Unit 3:
Network Security Protocols: Secure communication protocols: SSL/TLS, IPsec, SSH, secure email: PGP, S/MIME, wireless security protocols: WEP, WPA, WPA2, security in routing protocols: BGP security, secure multicast and broadcast.

Unit 4:
Network Security Tools and Technologies: Firewalls: types and architectures, intrusion detection and prevention systems (IDS/IPS), Virtual Private Networks (VPNs), honeypots and honeynets, security information and event management (SIEM), network security monitoring tools: Wireshark, Snort, Metasploit.

Unit 5:
Security in Emerging Network Technologies: Security challenges in cloud computing, security issues in Internet of Things (IoT), securing mobile networks, software-defined networking (SDN) security, network function virtualization (NFV) security, case studies on security in emerging network technologies.

Unit 6:
Network Threats and Mitigation: Types of network threats: malware, phishing, denial-of-service (DoS) attacks, distributed denial-of-service (DDoS) attacks, man-in-the-middle (MitM) attacks, advanced persistent threats (APTs), threat detection and response strategies, incident response and recovery.

Unit 7:
Network Security Management and Policies: Security risk assessment and management, security policies and procedures, compliance and regulatory requirements, network security auditing and monitoring, security best practices, case studies on network security management.

REFERENCE BOOKS:

1. "Network security essentials: applications and standards" by william stallings
2. "cryptography and network security: principles and practice" by william stallings
3. "network security: private communication in a public world" by charlie kaufman, radia perlman, and mike speciner

COURSE OUTCOMES

CO1: Understand the principles and practices of network security.
CO2: Analyze security vulnerabilities in network protocols and architectures.
CO3: Implement security measures to protect network infrastructure.
CO4: Design and evaluate secure network systems and protocols.
CO5: Apply advanced network security techniques to real-world scenarios.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	3
CO3	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	2	2
CO5	3	3	3	3	3	2	2	2	3	3

Data ethics and privacy 4(3-0-1):

COURSE OBJECTIVES:

- To understand the ethical implications of data collection, analysis, and use.
- To learn about privacy-preserving techniques and regulations.
- To critically evaluate the impact of data practices on individuals and society.
- To develop strategies for ethical decision-making in data science.

Unit 1:
Introduction to Data Ethics: Definition and importance of data ethics, historical context and evolution of data ethics, key ethical principles in data science, the role of ethics in the lifecycle of data, case studies highlighting ethical dilemmas in data use, introduction to ethical frameworks and theories.

Unit 2:
Data Collection and Consent: Ethical considerations in data collection, informed consent: principles and challenges, transparency and user awareness in data collection, ethical issues in data mining and profiling, balancing data utility with privacy, methods for obtaining and documenting consent.

Unit 3:
Privacy and Anonymization Techniques: Fundamentals of data privacy, types of data anonymization techniques: k-anonymity, l-diversity, t-closeness, differential privacy: concepts and applications, privacy risks in data sharing and publishing, trade-offs between data utility and privacy, practical examples of implementing anonymization techniques.

Unit 4:
Legal and Regulatory Frameworks: Overview of global data protection regulations: GDPR, CCPA, HIPAA, comparative analysis of data protection laws, understanding data subject rights, legal implications of data breaches and non-compliance, the role of regulatory bodies and enforcement mechanisms, future trends in data privacy legislation.

Unit 5:
Ethical Use of AI and Machine Learning: Ethical challenges in AI and machine learning, bias and fairness in AI systems, accountability and transparency in algorithmic decision-making, ethical implications of predictive analytics, frameworks for responsible AI development, case studies on ethical AI practices.

Unit 6:
Data Security and Protection: Introduction to data security principles, techniques for data protection: encryption, access control, and authentication, managing data breaches and incident response, best practices for securing personal and sensitive data, ethical implications of data security measures, evaluating the effectiveness of data protection strategies.

REFERENCE BOOKS:

1. "Data ethics: The new competitive advantage" by Gry Hasselbalch and Pernille Tranberg
2. "The ethical algorithm: the science of socially aware algorithm design" by Michael Kearns and Aaron Roth

COURSE OUTCOMES:

CO1: Understand fundamental concepts of data ethics and privacy.
CO2: Analyze ethical issues related to data collection and usage.
CO3: Apply privacy-preserving techniques to protect sensitive data.
CO4: Evaluate the legal and regulatory frameworks governing data privacy.
CO5: Develop ethical guidelines and policies for data-driven projects.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	2	3	2	2	1	3
CO2	2	3	3	1	2	2	3	2	2	3
CO3	3	2	3	3	2	2	2	2	2	2
CO4	2	3	2	1	2	2	3	2	2	3
CO5	3	2	3	2	2	3	3	2	3	3

Information Retrieval 4(3-0-1):

COURSE OBJECTIVES:

- To understand the fundamental concepts and techniques in information retrieval.
- To learn the principles of designing and evaluating information retrieval systems.
- To explore advanced topics and recent developments in information retrieval.
- To apply information retrieval techniques to real-world problems.

Unit 1:
Introduction to Information Retrieval: Definition and scope of information retrieval, history and evolution of information retrieval, types of information retrieval systems, information retrieval vs. database management systems, basic concepts: documents, queries, relevance, retrieval models, overview of information retrieval process, introduction to major information retrieval tools and software.

Unit 2:
Retrieval Models: Boolean retrieval model: concepts and limitations, vector space model: term weighting, TF-IDF, cosine similarity, probabilistic retrieval models: Binary Independence Model, BM25, language models for information retrieval, neural network-based retrieval models: word embeddings, transformers, BERT, comparative analysis of retrieval models, practical examples and applications.

Unit 3:
Indexing and Searching: Inverted index construction: tokenization, stopword removal, stemming, and lemmatization, index compression techniques: delta encoding, variable byte coding, search algorithms: linear search, binary search, pattern matching algorithms: KMP, Boyer-Moore, wildcard queries, phrase queries, proximity searches, introduction to distributed indexing and search engines, case studies on indexing and searching techniques.

Unit 4:
Evaluation of Information Retrieval Systems: Evaluation metrics: precision, recall, F-measure, mean average precision (MAP), normalized discounted cumulative gain (NDCG), evaluation methods: test collections, relevance judgments, A/B testing, experimental design for evaluating retrieval systems, analyzing and interpreting evaluation results, challenges in evaluating modern retrieval systems, case studies on evaluating retrieval systems.

Unit 5:
Query Expansion and Relevance Feedback: Concepts of query expansion: synonyms, related terms, automatic and manual query expansion techniques, pseudo-relevance feedback, Rocchio algorithm, relevance feedback: explicit and implicit feedback, methods for incorporating user feedback into retrieval systems, case studies on query expansion and relevance feedback.

Unit 6:
Advanced Topics in Information Retrieval: Information retrieval in different domains: web, enterprise, social media, multimedia retrieval, cross-language information retrieval, personalized search, introduction to question answering systems, information extraction and retrieval, recent trends and advancements in information retrieval: deep learning for IR, neural ranking models, case studies on advanced topics in information retrieval.

Unit 7:
Applications of Information Retrieval: Web search engines: architecture, crawling, indexing, ranking, recommendation systems: collaborative filtering, content-based filtering, hybrid

approaches, information retrieval in digital libraries, biomedical information retrieval, legal and patent retrieval systems, case studies on real-world applications of information retrieval.

REFERENCE BOOKS:

1. "Introduction to information retrieval" by christopher d. Manning, prabhakar raghavan, and hinrich schütze
2. "Search Engines: information retrieval in practice" by w. Bruce croft, donald metzler, and trevor strohman

COURSE OUTCOMES:

CO1: Understand the core concepts and techniques in information retrieval.
CO2: Design and implement efficient retrieval algorithms.
CO3: Evaluate the performance of information retrieval systems.
CO4: Apply information retrieval techniques to various types of data.
CO5: Explore advanced topics and recent developments in the field.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	3
CO3	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	2	2
CO5	3	3	3	3	3	2	2	2	3	3

Semantic Data Analysis 4(3-0-1):

COURSE OBJECTIVES:

- To understand the fundamental concepts and techniques in semantic data analysis.
- To learn methods for extracting and analyzing semantic information from structured and unstructured data.
- To explore advanced topics and recent developments in semantic data analysis.
- To apply semantic data analysis techniques to real-world problems.

Unit 1:
Introduction to Semantic Data Analysis: Definition and scope of semantic data analysis, history and evolution of semantic technologies, key concepts: ontology, RDF, SPARQL, types of semantic data: structured, semi-structured, unstructured, introduction to major semantic data analysis tools and software.

Unit 2:
Ontologies and Knowledge Representation: Basic concepts of ontologies: classes, properties, instances, ontology languages: OWL, RDF Schema, designing and building ontologies, ontology engineering methodologies, role of ontologies in semantic data analysis, practical examples and case studies on ontology development.

Unit 3:
Semantic Web Technologies: Introduction to the Semantic Web, standards and protocols: RDF, RDFS, OWL, SPARQL, Linked Data principles, publishing and consuming Linked Data, semantic annotation and metadata, practical applications of Semantic Web technologies, case studies on Semantic Web implementations.

Unit 4:
Text Mining and Natural Language Processing: Introduction to text mining and NLP, techniques for extracting semantic information from text: named entity recognition, topic modeling, sentiment analysis, relation extraction, semantic similarity, semantic role labeling, tools and frameworks for text mining and NLP, case studies on text mining and NLP.

Unit 5:
Semantic Data Integration and Interoperability: Challenges in semantic data integration, techniques for integrating heterogeneous data sources, data fusion and conflict resolution, semantic mapping and alignment, role of ontologies in data integration, practical examples of semantic data integration, case studies on semantic data interoperability.

Unit 6:
Semantic Search and Querying: Concepts of semantic search, semantic search engines, query languages: SPARQL, advanced SPARQL queries and optimization, federated querying, semantic search algorithms, practical applications of semantic search, case studies on semantic search and querying.

Unit 7:
Advanced Topics in Semantic Data Analysis: Recent developments in semantic data analysis, machine learning and semantics, knowledge graphs: construction and applications, semantic data in big data and cloud environments, privacy and security issues in semantic data analysis, future trends and research directions, case studies on advanced topics in semantic data analysis.

REFERENCE BOOKS:

1. "Semantic web for the working ontologist: effective modeling in rdfs and owl" by dean allemang and james hendler
2. "Foundations of semantic web technologies" by Pascal Hitzler, Markus Krötzsch, and Sebastian Rudolph.

COURSE OUTCOMES:

CO1: Understand the core concepts and techniques in semantic data analysis.
CO2: Model and analyze data using semantic technologies and frameworks.
CO3: Extract and interpret semantic information from various data sources.
CO4: Apply semantic data analysis techniques to various types of data.
CO5: Explore advanced topics and recent developments in the field.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	2	2	2	1	2
CO2	3	3	3	3	2	2	2	2	2	3
CO3	3	2	3	3	3	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	2	2
CO5	3	3	3	3	3	2	2	2	3	3

Mobile Security 4(3-0-1):

COURSE OBJECTIVES:

- To understand the fundamental principles and concepts of mobile security.
- To learn about the various threats and vulnerabilities associated with mobile devices.
- To explore different security mechanisms and solutions for protecting mobile environments.
- To study the legal, ethical, and policy issues related to mobile security.

Unit 1:
Introduction to Mobile Security: Mobile Ecosystem and Security Challenges ,Overview of mobile platforms (iOS, Android, Windows), Mobile device security landscape, Security Models and Architectures, Mobile operating system security models, Trusted Execution Environment (TEE) and Secure Elements

Unit 2:
Mobile Threats and Vulnerabilities: Types of Mobile Threats, Malware, spyware, and ransomware, Phishing and social engineering attacks, Vulnerabilities in Mobile Devices and Applications, Platform-specific vulnerabilities (iOS, Android), Common vulnerabilities and exposures (CVEs) in mobile apps

Unit 3:
Mobile Application Security: Secure Mobile Application Development, Secure coding practices, Application sandboxing and isolation, Mobile Application Testing and Assessment, Static and dynamic analysis, Penetration testing for mobile apps

Unit 4:
Network Security for Mobile Devices: Mobile Network Architecture and Security, Cellular networks (3G, 4G, 5G) and security implications, Wireless Network Security, Wi-Fi security and encryption protocols, Bluetooth and NFC security

Unit 5:
Data Protection and Privacy: Data Encryption and Secure Storage, Encryption algorithms and key management, Secure storage solutions for mobile devices, Privacy Issues in Mobile Computing, Data leakage and privacy concerns, Privacy-preserving techniques and frameworks

Unit 6:
Mobile Device Management: Mobile Device Management (MDM) Solutions, Features and functionalities of MDM, Implementing MDM in organizations, BYOD (Bring Your Own Device) Security, BYOD policies and best practices Securing enterprise data on personal devices; Legal, Ethical, and Policy Issues: Legal and Regulatory Frameworks, Laws and regulations related to mobile security, Compliance and enforcement, Ethical Considerations in Mobile Security, Ethical hacking and responsible disclosure, Impact of mobile security on society.

REFERENCE BOOKS:

1. "Mobile security and privacy: advances, challenges and future research directions" by Man Ho Au and Raymond Choo
2. "Android security internals: an in-depth guide to android's security architecture" by Nikolay Elenkov

COURSE OUTCOMES:

CO1: Understand the architecture and security models of mobile platforms.
CO2: Identify and analyze security threats and vulnerabilities in mobile devices and applications.
CO3: Apply security measures and best practices to secure mobile environments.
CO4: Evaluate mobile security policies and legal frameworks.
CO5: Develop and implement secure mobile applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2	3	2	1	1	2	1	2
CO2	3	2	3	2	2	1	1	2	1	2
CO3	3	1	3	3	2	2	2	2	2	2
CO4	2	3	2	1	1	3	3	3	2	3
CO5	3	2	3	3	2	2	2	2	3	2

FOUNDATIONS OF MODERN COMPUTING 4(3-0-1)

COURSE OBJECTIVES:

- **To provide an understanding of the key historical milestones in the development of computer science.**
- **To highlight the stories behind significant discoveries and inventions that shaped modern computing.**
- **To generate interest and enthusiasm among students about the evolution and impact of computer science.**

Unit 1:
Introduction to the History of Computer Science, Overview of the origins of computing, Early computing devices: Abacus, Pascaline, and Jacquard Loom, Charles Babbage and Ada Lovelace: The Analytical Engine

Unit 2:
The Birth of Modern Computing, Alan Turing and the Turing Machine, The development of electronic computers: ENIAC, UNIVAC, and IBM's early machines, The invention of the transistor and its impact

Unit 3:
Programming Languages and Software Development, The creation of assembly language and the first high-level programming languages (FORTRAN, COBOL, LISP), Development of operating systems: UNIX and its significance, The rise of software engineering as a discipline

Unit 4:
Networking and the Internet, The development of ARPANET and the foundations of the Internet, The invention of the World Wide Web by Tim Berners-Lee, Milestones in networking: Ethernet, TCP/IP, and Wi-Fi

Unit 5:
Milestones in Hardware Development, Evolution of microprocessors: Intel 4004 to modern multi-core processors, Development of personal computers: Apple I/II, IBM PC, and the rise of home computing, Advances in storage technology: From magnetic tapes to solid-state drives

Unit 6:
Pioneering Software and Applications, The first operating systems and application software Early word processors, spreadsheets, and database systems, The development of graphical user interfaces (GUIs)

Unit 7:
Artificial Intelligence and Machine Learning, Early AI research and the Turing Test, Development of expert systems and neural networks, Significant AI milestones: Deep Blue, AlphaGo, and contemporary AI applications

Unit 8:
Cybersecurity Milestones, The first computer virus and the history of malware, Key developments in encryption and cryptography, Significant cybersecurity incidents and their impact

Unit 9:
The Digital Revolution and Social Impact, The rise of social media and its societal implications, The impact of mobile computing and smartphones, Ethical considerations and the future of computer science

Unit 10:
Firsts in Computer Science and Their Stories, The first chatbot: ELIZA and its legacy, The story of the first computer virus: Creeper and the development of antivirus software, The first online transaction and the birth of e-commerce, The first video game: Spacewar! and the evolution of the gaming industry

RECOMMENDED READING:

1. **"Computer: a history of the information machine" by martin campbell-kelly and william aspray**
2. **"the innovators: how a group of hackers, geniuses, and geeks created the digital revolution" by walter isaacson**
3. **"turing's cathedral: the origins of the digital universe" by george dyson**
4. **"eniac: the triumphs and tragedies of the world's first computer" by scott mccartney**
5. **"a history of modern computing" by paul e. Ceruzzi**

COURSE OUTCOMES:
CO1: Understand the major milestones and figures in the history of computer science.
CO2: Gain insights into the technological advancements that led to the modern computer.
CO3: Develop an appreciation for the historical context of key discoveries in computer science.
CO4: Be inspired by the stories of early pioneers and innovators in the field.
CO5: Connect historical developments to current trends and future directions in computer science.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	3	3	2	2	1	3
CO2	3	2	3	2	3	2	2	2	1	3
CO3	2	2	3	1	2	3	2	2	1	3
CO4	2	1	3	1	2	3	2	2	1	3
CO5	3	2	3	2	3	2	2	3	2	3

Soft Computing 4(3-0-1):

COURSE OBJECTIVE:

- To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario.
- To implement soft computing based solutions for real-world problems.
- To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms.
- To provide students an hand-on experience on matlab to implement various strategies.

Unit 1 7 Lectures

Introduction to Soft Computing and Neural Networks: Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics

Unit 2 8 Lectures

Fuzzy Logic: Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision making.

Unit 3 10 Lectures

Neural Networks: Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks

Unit 4 5 Lectures

Genetic Algorithms: Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition.

Unit 5 13 Lectures

Matlab/Python Lib: Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic

Unit 6 5 Lectures

Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm. Implementation of recently proposed soft computing techniques.

REFERENCES:

1. Jyhshing roger jang, chuen:tsai sun, eijimizutani, neuro:fuzzy and soft computing, prentice:hall of india, 2003.
2. George j. Klir and bo yuan, fuzzy sets and fuzzy logic:theory and applications, prentice hall, 1995.
3. Matlab toolkit manual

COURSE OUTCOMES

CO1: Identify and describe soft computing techniques and their roles in building intelligent machines

CO2: Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems.

CO3: Apply genetic algorithms to combinatorial optimization problems.
CO4: Evaluate and compare solutions by various soft computing approaches for a given problem.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	2	2	2	3	2	2
CO4	3	3	3	3	2	2	2	3	3	2