**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY GURAJADA**
**VIZIANAGARAM**
**VIZIANAGARAM-535 003, A.P, INDIA**

# M. TECH - COMPUTER SCIENCE & ENGINEERING (Course Code-58)

## COURSE STRUCTURE AND SYLLABUS (R25)

**(Applicable for batches admitted from Academic Year 2025-2026 onwards)**

## COURSE STRUCTURE

**I Year – I SEMESTER**

| S. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | M255801 | **Program Core–1** Data Structures and Algorithm Analysis | 3 | 1 | 0 | 4 |
| 2 | M255802 | **Program Core–2** Machine Learning | 3 | 1 | 0 | 4 |
| 3 | M255803 | **Program Core–3** Mathematical foundations of computer science | 3 | 1 | 0 | 4 |
| 4 | | **Program Elective –I** | 3 | 0 | 0 | 3 |
| 5 | | **Program Elective –II** | 3 | 0 | 0 | 3 |
| 6 | M255814 | **Laboratory–1** Data Structures and Algorithm Analysis lab | 0 | 1 | 2 | 2 |
| 7 | M255815 | **Laboratory–2** Machine Learning Lab | 0 | 1 | 2 | 2 |
| 8 | M255816 | Seminar-I | 0 | 0 | 2 | 1 |
| | | **TOTAL** | **15** | **5** | **6** | **23** |

**List of Professional Elective Courses in I Semester (Electives–I)**

| S. No. | Course Code | Course Title |
|---|---|---|
| 1 | M255804 | Computer Vision and Image Processing |
| 2 | M255805 | Soft computing |
| 3 | M255806 | Advanced Computer Networks |
| 4 | M255807 | Human Computer interaction |
| 5 | M255808 | Any minimum12 weeks MOOCS/NPTEL courses suggested by BOS |

@Students can opt any one course from the above list

**List of Professional Elective Courses in I Semester (Electives–II)**

| S. No. | Course Code | Course Title |
|---|---|---|
| 1 | M255809 | Recommender Systems |
| 2 | M255810 | High Performance Computing |
| 3 | M255811 | Advance operating system |
| 4 | M255812 | Advanced Compiler Design |
| 5 | M255813 | Any minimum12 weeks MOOCS/NPTEL courses suggested by BOS |

@Students can opt any one course from the above list

**I Year – II SEMESTER**

| Sl. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | N255801 | **ProgramCore–4**<br>Advanced Data Mining | 3 | 1 | 0 | 4 |
| 2 | N255802 | **ProgramCore–5**<br>Agile Software Development | 3 | 1 | 0 | 4 |
| 3 | N255803 | **ProgramCore–6**<br>Introduction to Quantum computing | 3 | 1 | 0 | 4 |
| 4 | | **Program Elective –III** | 3 | 0 | 0 | 3 |
| 5 | | **Program Elective –IV** | 3 | 0 | 0 | 3 |
| 6 | N255814 | **Laboratory–3**<br>Advanced Data Mining lab | 0 | 1 | 2 | 2 |
| 7 | N255815 | **Laboratory–4**<br>Quantum computing lab | 0 | 1 | 2 | 2 |
| 8 | N255816 | Seminar–II | 0 | 0 | 2 | 1 |
| | | **TOTAL** | **15** | **5** | **6** | **23** |

**List of Professional Elective Courses in II Semester (Electives III )**

| S. No. | Course Code | Course Title |
|---|---|---|
| 1 | N255804 | Feature Engineering |
| 2 | N255805 | Generative AI |
| 3 | N255806 | Cyber Security |
| 4 | N255807 | Natural Language processing |
| 5 | N255808 | Any minimum12 weeks MOOCS/NPTEL courses suggested by BOS |

@Students can opt any one course from the above list

**List of Professional Elective Courses in II Semester (Electives IV)**

| S. No. | Course Code | Course Title |
|---|---|---|
| 1 | N255809 | Block Chain Technologies |
| 2 | N255810 | DevOps |
| 3 | N255811 | Internet of Things |
| 4 | N255812 | Design Patterns |
| 5 | N255813 | Any minimum12 weeks MOOCS/NPTEL courses suggested by BOS |

@Students can opt any one course from the above list

**II Year – I SEMESTER**

| Sl. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | O255801 | Research Methodology and IPR / *Swayam 12 week MOOC course – RM&IPR* | 3 | 0 | 0 | 3 |
| 2 | O255802 | Summer Internship/ Industrial Training (8-10 weeks)* | - | - | - | 3 |
| 3 | O255803 | Comprehensive Viva[#] | - | - | - | 2 |
| 4 | O255804 | Dissertation Part – A[$] | - | - | 20 | 10 |
| | | **TOTAL** | **3** | **-** | **20** | **18** |

* Student attended during summer / year break and assessment will be done in 3rd Sem.

# Comprehensive viva can be conducted courses completed up to second sem.

$ Dissertation – Part A, internal assessment

**II Year – II SEMESTER**

| Sl. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1 | P255801 | Dissertation Part – B[%] | - | - | 32 | 16 |
| | | **TOTAL** | **-** | **-** | **32** | **16** |

% External Assessment

| Course Code | Data Structures & Algorithms Analysis | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

*Course Objectives***:** The main objective of the course is to

1. Provide an understanding of algorithm design techniques
2. Enhance problem-solving skills by applying appropriate data structures and algorithms to computational problems

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Design effective algorithms based on Divide and Conquer and Greedy methods. | K5 |
| **CO2** | Discuss various problems suitable to Dynamic programming. | K2 |
| **CO3** | Demonstrate various searching, sorting and hash techniques and be able to apply and solve problems of real life | K4 |
| **CO4** | Design and implement variety of data structures including linked lists, binary trees, heaps, graphs and search trees | K3 |
| **CO5** | Ability to compare various search trees and find solutions for IT related problems | K6 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | H | | |
| **CO2** | | | H | H | | |
| **CO3** | | | H | H | | M |
| **CO4** | | | H | H | | H |
| **CO5** | | | H | H | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Divide and Conquer: General Method, Binary Search, Merge sort, Quick sort, Strassen's Matrix Multiplication. The Greedy Method: The general Method, knapsack problem, minimum-cost spanning Trees, Job sequencing within deadlines, Single Source Shortest Path Algorithm. | 10Hrs |
| **UNIT – 2** | Dynamic Programming: The general method, All pairs-shortest paths, Optimal Binary search tree, 0/1 knapsack, Traveling salesperson problem. | 10Hrs |
| **UNIT – 3** | Dictionaries, ADT, The List ADT, Stack ADT, Queue ADT, Hash Table Representation, Hash Functions, Collision Resolution-Separate Chaining, Open Addressing- Linear Probing, Double Hashing | 12Hrs |
| **UNIT – 4** | Priority queues- Definition, ADT, Realising a Priority Queue Using Heaps, Definition, Insertion, Deletion, Search Trees- Binary Search Trees, Definition, ADT, Implementation, Operations- Searching, Insertion, Deletion | 13Hrs |
| **UNIT – 5** | Search Trees- AVL Trees, Definition, Height of AVL Tree, Operations- Insertion, Deletion and Searching. Introduction to Red-Black and Splay Trees, B-Trees, Height of B-Tree, Insertion, Deletion and Searching, Comparison of Search Trees | 13Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. Data Structures: A Pseudocode Approach with C, 2 nd Edition, Richard F.Gilberg, Behrouz A. Forouzon, Cengage Learning, 2004
2. Data Structures, Algorithms and Applications in java, 2 nd Edition, Sartaj Sahni, University Press/Orient BlackSwan, 2005
3. Ellis Horowitz, Sartaj Sahni and SanguthevarRajasekaran, “Fundamentals of Computer Algorithms”, Second Edition, Universities Press, India, 2021.


**Reference Books**:


1. Data Structures And Algorithm Analysis, 2 nd Edition, Mark Allen Weiss, Pearson, 2002
2. Data Structures And Algorithms in C++, 3 rd Edition, Adam Drozdek, Cengage Learning, 2005
3. C and Data Structures: A Snap Shot Oriented Treatise Using Live Engineering Examples, 1st Edition, N.B.Venkateswarulu, E.V. Prasad, S Chand & Co, 2009
4. Classic Data Structures, 2 nd Edition, Debasis Samantha, PHI Learning, 2009

| Course Code | Machine Learning | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The objectives of the course are to

1. Introduce the fundamental concepts, models, and techniques of machine learning.
2. Cultivate the skills to formulate real-world problems as machine learning tasks and design appropriate solutions.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Enumerate the Fundamentals of Machine Learning | K2 |
| **CO2** | Build Nearest Neighbor based models | K2 |
| **CO3** | Apply Models based on decision trees and Bayes rule | K4 |
| **CO4** | Explain the fundamental concepts of linear discriminants and their role in classification tasks. | K2 |
| **CO5** | Choose appropriate clustering technique | K2 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | | |
| **CO2** | M | | H | H | M | M |
| **CO3** | M | | H | H | M | M |
| **CO4** | H | | H | H | M | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Introduction to Machine Learning:** Evolution of Machine Learning, Paradigms for ML, Learning by Rote, Learning by Induction, Reinforcement Learning, Types of Data, Matching, Stages in Machine Learning, Data Acquisition, Feature Engineering, Data Representation, Model Selection, Model Learning, Model Evaluation, Model Prediction, Search and Learning, Data Sets | 10Hrs |
| **UNIT – 2** | **Nearest Neighbor-Based Models:**Introduction to Proximity Measures, Distance Measures, Non-Metric Similarity Functions, Proximity Between Binary Patterns, Different Classification Algorithms Based on the Distance Measures ,K-Nearest Neighbor Classifier, Radius Distance Nearest Neighbor Algorithm, KNN Regression, Performance of Classifiers, Performance of Regression Algorithms | 12Hrs |
| **UNIT – 3** | **Models Based on Decision Trees**: Decision Trees for Classification, Impurity Measures, Properties, Regression Based on Decision Trees, Bias–Variance Trade-off, Random Forests for Classification and Regression<br><br>**The Bayes Classifier:** Introduction to the Bayes Classifier, Bayes' Rule and | 12Hrs |

| | | |
|---|---|---|
| | Inference, The Bayes Classifier and its Optimality, Multi-Class Classification \| Class Conditional Independence and Naive Bayes Classifier (NBC) | |
| **UNIT – 4** | **Linear Discriminants for Machine Learning**: Introduction to Linear Discriminants, Linear Discriminants for Classification, Perceptron Classifier, Perceptron Learning Algorithm, Support Vector Machines, Linearly Non-Separable Case, Non-linear SVM, Kernel Trick, Logistic Regression, Linear Regression, Multi-Layer Perceptron's (MLPs), Backpropagation for Training an MLP | 12Hrs |
| **UNIT – 5** | **Clustering** : Introduction to Clustering, Partitioning of Data, Matrix Factorization \| Clustering of Patterns, Divisive Clustering, Agglomerative Clustering, Partitional Clustering, K-Means Clustering, Soft Partitioning, Soft Clustering, Fuzzy C-Means Clustering, Rough Clustering, Rough K-Means Clustering Algorithm, Expectation Maximization-Based Clustering, Spectral Clustering | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. "Machine Learning Theory and Practice", M N Murthy, V S Ananthanarayana, Universities Press (India), 2024


**Reference Books:**


1. Machine Learning", Tom M. Mitchell, McGraw-Hill Publication, 2017
2. "Machine Learning in Action",Peter Harrington, DreamTech
3. "Introduction to Data Mining", Pang-Ning Tan, Michel Stenbach, Vipin Kumar, 7th Edition, 2019.

| Course Code | Mathematical Foundations for Computer Science | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

*Course Objectives***:** The main objective of the course is to

1. Equip students with the knowledge of mathematical reasoning and proof techniques for correctness of algorithms and program verification
2. Cultivate analytical skills to apply mathematical tools and models in problem solving, algorithm analysis, and computational complexity.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Apply equivalence formulas, tautological implications in finding normal forms, and theory of Inference in Statement Calculus and predicates, and explain Mathematical Induction Principle and apply the same | K3 |
| **CO2** | Apply skill in equivalences and inference theory in Predicate Calculus | K5 |
| **CO3** | Explain the properties of relations, POSETS, LATTICES, functions and apply the same in solving the problems. | K2 |
| **CO4** | Apply the principles of counting and probability to solve elementary and advanced probability problems. | K3 |
| **CO5** | Identify the properties of graphs and related structures and solve the related problems | K2 |

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | H | | M |
| **CO2** | M | | M | H | | M |
| **CO3** | H | M | H | H | | M |
| **CO4** | H | | M | H | | M |
| **CO5** | H | M | H | H | | |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Mathematical logic: Fundamentals (statements and notations, connectives, Truth tables), Tautologies, Equivalence of formulas, Tautological implications, Normal forms, Theory of Inference. | 10Hrs |
| **UNIT – 2** | Predicate Calculus: Predicate logic, statement functions, variables and quantifiers, free and bound variables. Inference Theory of the Predicate Calculus: Logical implication involving quantifiers, Statements with more than one variable. | 10Hrs |
| **UNIT – 3** | Relations : Relations, Properties of Relations, Equivalence relations, partial orders, Lattices, properties of Lattices, Special types of Lattices (Proofs not required). | 12Hrs |

| | | |
|---|---|---|
| **UNIT – 4** | Counting, Probability, Discrete random variable, Continuous random variable, Moment generating function, Markov's inequality, Chebyshev's inequality, The geometric and binomial distributions, The tail of the binomial distribution. | 12Hrs |
| **UNIT – 5** | Graph Theory: Basic Concepts of Graphs, Matrix representation of graphs: Adjacency Matrices, Incidence Matrices, Isomorphic Graphs, Paths and Circuits, Eulerin& Hamiltonian graphs, Planar Graphs, Graph coloring | 12Hrs |
| | **Total** | 56Hrs |

Text Books:

1. Trembly J.P. and Manohar.P, "Discrete Mathematical Structures with applications to computer science," Tata McGraw Hill, New Delhi, 2017

2. Kolman B, Busoy R.C, Ross S.C, Discrete MathematicalStructures, 5thEdition,Prentice Hall, 2004.

3. D.S.Chandrasekharaiah, "Mathematical Foundation of Computer Science" Prism Publications 2009.

4. Probability and Statistics with Reliability,2nd edition, K. Trivedi, Wiley, 2011

Reference Books:

1. J.L. Mott, A. Kandel, T.P Baker, "Discrete Mathematics for Computer Scientists and Mathematicians," Prentice Hall India, 2nd Edition 2015

2. Kenneth H. Rosen, "Discrete Mathematics and its Applications," Tata McGraw Hill, New Delhi, 7th edition, 2017

3. V. Krishnamurthy, "Combinatories:Theory and Applications", East-West Press. Seymour Lipschutz, M.Lipson, "Discrete Mathemataics" Tata Mc Graw Hill, 2005.

| Course Code | Computer Vision and Image Processing (Program Elective-I) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

*Course Objectives***:** The main objective of the course is to

1. Introduce the fundamental concepts of digital image processing and the principles underlying computer vision.
2. Cultivate problem-solving skills to apply computer vision and image processing techniques in real-world applications

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Describe and explain basic principles of digital image processing. | K3 |
| **CO2** | Design and implement algorithms that perform basic image processing | K3 |
| **CO3** | Design and implement algorithms for advanced image analysis | K4 |
| **CO4** | Assess the performance of image processing algorithms and systems | K6 |
| **CO5** | Design and develop computer vision solutions that integrate segmentation, morphology, feature extraction, and watermarking for real-world use cases | K5 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | | |
| **CO2** | H | | H | H | M | M |
| **CO3** | H | | H | H | M | H |
| **CO4** | M | M | H | M | | H |
| **CO5** | H | | H | H | M | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Introduction:** Fundamental steps in Image Processing System, Components of Image Processing System, Elements of Visual Perception, Image Sensing and acquisition, Image sampling & Quantization, Basic Relationship between pixels. Image Enhancement Techniques: Spatial Domain Methods: Basic grey level transformation, Histogram equalization, Image subtraction, image averaging | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 2** | **Spatial filtering:** Smoothing, sharpening filters, Laplacian filters, Frequency domain filters, Smoothing and sharpening filters, Homomorphism is filtering. Image Restoration & Reconstruction: Model of Image Degradation/restoration process, Noise models, Spatial filtering, Inverse filtering, Minimum mean square Error filtering, constrained least square filtering, Geometric mean filter, Image reconstruction from projections. Color Fundamentals, Color Models, Color Transformations. | 10Hrs |
| **UNIT – 3** | **Image Compression:** Redundancies- Coding, Interpixel, Psycho visual; Fidelity, Source and Channel Encoding, Elements of Information Theory; Loss Less and Lossy Compression; Run length coding, Differential encoding, DCT, Vector quantization, Entropy coding, LZW coding; Image Compression Standards-JPEG, JPEG 2000, MPEG; Video compression. | 12Hrs |
| **UNIT – 4** | **Wavelet Based Image Compression:** Expansion of functions, Multi-resolution analysis, Scaling functions, MRA refinement equation, Wavelet series expansion, Discrete Wavelet Transform (DWT), Continuous, Wavelet Transform, Fast Wavelet Transform, 2-D wavelet Transform, JPEG-2000 encoding | 12Hrs |
| **UNIT – 5** | **Image Segmentation:** Discontinuities, Edge Linking and boundary detection, Thresholding, Region Based Segmentation, Watersheds; Introduction to morphological operations; binary morphology- erosion, dilation, opening and closing operations, applications; basic gray-scale morphology operations; Feature extraction; Classification; Object recognition. Digital Image Watermarking: Introduction, need of Digital Image Watermarking, applications of watermarking in copyright protection and Image quality analysis. | 12Hrs |
| | **Total** | 56Hrs |

**Text Books**:

1. Digital Image Processing. 2nd ed. Gonzalez, R.C. and Woods, R.E. India: Person Education,2009

**Reference Books**:

**1.** Digital Image Processing. John Wiley, Pratt, W. K, Fourth Edition-2001

**2.** Digital Image Processing, Jayaraman, S., Veerakumar, T. and Esakkiranjan, S.,Tata McGraw-Hill,Edition-3,2009

| Course Code | Soft Computing (Program Elective-I) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**The main objective of the course is to

1. . Provide an understanding of the mathematical foundations and principles behind soft computing techniques.
2. Equip students with the skills to apply soft computing techniques

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Learn soft computing techniques and their applications. | K2 |
| **CO2** | Analyze various neural network architectures. | K3 |
| **CO3** | Define the fuzzy systems | K2 |
| **CO4** | Understand the genetic algorithm concepts and their applications. | K2 |
| **CO5** | Identify and select a suitable Soft Computing technology to solve the problem; construct a solution and implement a Soft Computing solution | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | M | H | M | |
| **CO2** | M | | H | H | | |
| **CO3** | L | | M | M | | |
| **CO4** | M | | H | H | M | |
| **CO5** | H | M | H | H | H | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Introduction to Soft Computing, Artificial neural networks, biological neurons, Basic models of artificial neural networks, Connections, Learning, Activation Functions, McCulloch and Pitts Neuron, Hebb network. | 10Hrs |
| **UNIT – 2** | Perceptron networks, Learning rule, Training and testing algorithm, Adaptive Linear Neuron, Back propagation Network, Architecture, Training algorithm | 10Hrs |
| **UNIT – 3** | Fuzzy logic, fuzzy sets, properties, operations on fuzzy sets, fuzzy relations, operations on fuzzy relations, Fuzzy membership functions, fuzzification, Methods of membership, value assignments, intuition, inference, rank ordering, Lambda –Cuts for fuzzy sets , Defuzzification methods | 12Hrs |
| **UNIT – 4** | Truth values and Tables in Fuzzy Logic, Fuzzy propositions, Formation of fuzzy rules, Decomposition of rules, Aggregation of rules, Fuzzy Inference Systems, Mamdani and Sugeno types, Neuro-fuzzy hybrid systems, characteristics, classification | 12Hrs |
| **UNIT – 5** | Introduction to genetic algorithm, operators in genetic algorithm, coding, selection, crossover, mutation, stopping condition for genetic algorithm flow, Genetic-neuro hybrid systems, Genetic Fuzzy rule based system | 12Hrs |
| | **Total** | 56Hrs |

**Text Books**:


1. S. N. Sivanandam and S. N. Deepa, Principles of soft computing–John Wiley & Sons,2007.
2. Timothy J. Ross, Fuzzy Logic with engineering applications, John Wiley & Sons, 2016.


**Reference Books**:


1. N.K. Sinhaand M.M. Gupta,Soft Computing & Intelligent Systems:Theory& Applications-Academic Press /Elsevier. 2009.
2. Simon Haykin, Neural Network-A Comprehensive Foundation-Prentice Hall International, Inc.1998
3. R. Eberhart and Y. Shi, Computational Intelligence: Concepts to Implementation, Morgan Kaufman/Elsevier, 2007.
3. Driankov D., HellendoornH.andReinfrankM.,An Introduction to Fuzzy Control Narosa Pub., 2001.
4. BartKosko, Neural Network and Fuzzy Systems-Prentice Hall,Inc.,Englewood Cliffs, 1992
5. Goldberg D.E, Genetic Algorithms in Search , Optimization , and Machine Learning Addison Wesley, 1989

| Course Code | Advanced Computer Networks (Program Elective-I) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**This course is aimed at enabling the students to

1. Explore advanced concepts in network design and analysis,
2. Familiarize students with wireless, mobile, and sensor networks, including their unique challenges and protocols.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Illustrate reference models with layers, protocols, and interfaces. | K4 |
| **CO2** | Describe routing algorithms, subnetting, and addressing in IPv4 and IPv6. | K3 |
| **CO3** | Analyze basic network protocols and their use in network design and implementation. | K3 |
| **CO4** | Describe concepts related to wireless networks such as WLANs, WiMAX, IEEE 802.11, cellular and satellite systems. | K4 |
| **CO5** | Describe emerging network trends such as MANETs and Wireless Sensor Networks (WSNs). | K2 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | | | H | H | | |
| **CO2** | | | H | H | | |
| **CO3** | M | | H | H | | M |
| **CO4** | | | M | M | | |
| **CO5** | | | M | M | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Network layer:** Network Layer design issues: store-and forward packet switching, services provided transport layers, implementation connection less services, implementation connection oriented services, comparison of virtual – circuit and datagram subnets, Routing Algorithms-shortest path routing, flooding, distance vector routing, link state routing, Hierarchical routing, congestion control algorithms : Approaches to congestion control, Traffic aware routing, Admission control, Traffic throttling, choke Packets, Load shedding, Random early detection, Quality of Service, Application requirements, Traffic shaping, Leaky and Token buckets. | 12Hrs |
| **UNIT – 2** | **Internetworking and IP protocols:** How networks differ, How networks can be connected, internetworking, tunneling, The network layer in the internet, IPV4 Protocol, IP addresses, Subnets, CIDR, classful and Special addressing, network address translation (NAT),IPV6 Address structure address space, IPV6 Advantages, packet format, extension Headers, Transition from IPV4 to IPV6 , Internet Control Protocols-IMCP, ARP, DHCP. | 12Hrs |
| **UNIT – 3** | **Transport Layer Protocols**: Introduction, Services, Port numbers, User Datagram Protocol: User datagram, UDP services, UDP Applications, Transmission control Protocol: TCP services, TCP features, Segment, A TCP connection, State transition diagram, Windows in TCP, Flow control and error | 12Hrs |

| | | |
|---|---|---|
| | control, TCP Congestion control, TCP Timers, SCTP: SCTP services SCTP features, packet format, An SCTP association, flow control, error control | |
| **UNIT – 4** | **Wireless LANS:** Introduction, Architectural comparison, Access control, The IEEE 802.11 Project: Architecture, MAC sub layer, Addressing Mechanism, Physical Layer, Bluetooth: Architecture, Bluetooth Layers Other Wireless Networks: WIMAX: Services, IEEE project 802.16, Layers in project 802.16, Cellular Telephony: Operations, First Generation (1G), Second Generation (2G), Third Generation (3G), Fourth Generation (4G), Satellite Networks: Operation, GEO Satellites, MEO satellites, LEO satellites | 12Hrs |
| **UNIT – 5** | **Emerging trends in Computer networks:Mobile computing:** Motivation for mobile computing, Protocol stack issues in mobile computing environment, mobility issues in mobile computing, security issues in mobile networks, MOBILE Ad Hoc Networks: Applications of Ad Hoc Networks, Challenges and Issues in MANETS, MAC Layer Issues Routing Protocols in MANET, Transport Layer Issues, Ad hoc Network Security<br>**Wireless Sensor Networks:** WSN functioning, Operating system support in sensor devices, WSN characteristics, sensor network operation, Sensor Architecture: Cluster management, Wireless Mesh Networks: WMN design, Issues in WMNs, Computational Grids, Grid Features, Issues in Grid construction design, Grid design features,P2P Networks: Characteristics of P2P Networks, Classification of P2P systems, Gnutella, BitTorrent, Session Initiation Protocol(SIP) , Characteristics and addressing, Components of SIP, SIP establishment, SIP security. | 12Hrs |
| | **Total** | 60Hrs |

**Text Books**:


1. Data communications and networking 4th edition Behrouz A Fourzan,TMH- 2007
2. Computer networks 4th edition Andrew S Tanenbaum, Pearson,2012
3. Computer networks, Mayank Dave,CENGAGE, First edition.2012


**Reference Books**:


1. Computer networks, A system Approach, 5thed, Larry L Peterson and Bruce S Davie, Elsevier-2012.

| Course Code | Human Computer Interaction<br>(Professional Elective – I) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:This course is aimed at enabling the students to**

1. To facilitate communication between students of psychology, design, and computer science on user interface development projects.
2. To provide the future user interface designer with concepts and strategies for making Designdecisions.

**Course Outcomes:At the end of the course, student will be able to**

| | **CourseOutcomes** | Knowledge Level (K) |
|---|---|---|
| CO1 | Apply rules for effective graphical and web design methodology. | K3 |
| CO2 | Evaluate many characteristics and considerations that must be applied to the interface and screen design process. | K4 |
| CO3 | Indentify the components of graphical and web interface and screens, including windows, | K3 |
| CO4 | Understand the using of menus and controls | K2 |
| CO5 | Organizegraphicalscreenstoencouragethefastestandmostaccuratecomprehensionand execution of screen components. | K3 |

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | | | H | H | | |
| **CO2** | | | H | H | | |
| **CO3** | M | | H | H | | M |
| **CO4** | | | M | M | | |
| **CO5** | | | M | M | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| UNIT-1 | Introduction: Importance of user Interface – definition, importance of good design. Benefits of good design. Characteristics of GUI, Popularity of Graphics, Web user – Interface popularity, characteristics- Principles of user interface. | 12 Hrs |
| UNIT-2 | Design Process: Human interaction with computers, importance of human characteristics in design, Human considerations in design. Understanding business functions-business definition and requirement Analysis, Determining Basic Business functions. | 12 Hrs |

| | | |
|---|---|---|
| UNIT-3 | Develop System Menus and Navigation schemes: Structure, Function, Content, Formatting ofMenus, Phrasing the Menu, Selecting Menu Choices, Navigating Menus, Kinds of graphical Menus. | 10 Hrs |
| UNIT-4 | Select the Proper Kinds of Windows: Window Characteristics, Components of Windows, Window Presentation Styles, Types of Windows, Windows Management, Organizing Window Functions and Operations. | 12 Hrs |
| UNIT-5 | Write Clear Text and Messages. Web Systems, Select the Proper Device-Based Controls. Create Meaningful Graphics, Icons and Images. | 12 Hrs |
| | Total | 58 Hrs |

Text Books:


1. WilbertOGalitz ,"Theessentialguidetouser interfacedesign,"WileyDreamTech.
2. BenShneidermann,"Designingtheuserinterface".3rdEdition,PearsonEducationAsia.


ReferenceBooks:


1. Human–ComputerInteraction.ALANDIX,JANETFINCAY,GREGORYD,ABOWD, RUSSELL BEALG, PEARSON.
2. InteractionDesignPRECE,ROGERS,SHARPS.WileyDreamtech,
3. UserInterfaceDesign,SorenLauesen,PearsonEducation.
4. TheEssentialsof InteractionDesign,3rd edition,Wiley2007.

| Course Code | Recommender Systems (Professional Elective – II) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**CourseObjectives:This course is aimed at enabling the students to**

1. Introduce thefundamental concepts and types of recommender systems**,** including content-based, collaborative, and hybrid approaches.
2. Provide knowledge of evaluation metrics and methodologies to assess the quality and effectiveness of recommender systems.

**Course Outcomes**: At the end of the course, student will be able to

| | **CourseOutcomes** | Knowledge Level (K) |
|---|---|---|
| CO1 | ComparedifferenttypesofRecommenderSystems. | K2 |
| CO2 | Understand various issues related to Recommender System development. | K2 |
| CO3 | Designarecommendersystemforagivenproblem. | K6 |
| CO4 | RelatedatacollectedfromaRecommenderSystemtoun- derstand user preferences and/or behaviour. | K2 |
| CO5 | Develop and manage recommender system knowledge bases to efficiently store and retrieve user and item information for personalized recommendations. | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | | | H | H | | |
| **CO2** | | | H | H | | |
| **CO3** | M | | H | H | | M |
| **CO4** | | | M | M | | |
| **CO5** | M | | H | H | | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| UNIT-1 | IntroductiontoRecommenderSystems<br>What is Recommendation engine?, Need for recommender systems, Framework of recommendationsystems,Domain,Purpose,Context,Personalization,howwillyoutargetyourusers?,Personalized vs.Non-Personalized, Semi/Segment - Personalized, Privacy, users data and trustworthiness. Recommender Systems Function, Techniques, Recommender Systems and Human Computer Inter- action, Conversational Systems, Visualization, Issues working with RSs data sets:The cold-start problem. | 12Hrs. |
| UNIT-2 | Collaborativefiltering-basedRecommenderSystem<br>Understanding ratings and rating data, User-based nearest-neighbor recommendation:Similarity Function, User-Based Algorithms Item-based nearest neighbor recommendation:Similarity Function, Item-Based Algorithms, Furthermodel-based and preprocessing-based approaches, Comparing User-Based and Item-Based recommen-dations,datadriftandconceptdrift. | 12Hrs. |
| UNIT-3 | Content-basedRecommenderSystem<br>ArchitectureofContent-basedSystems,AdvantagesandDrawbacksofContent-basedFiltering,Content representation and content similarity, Item profiles, discovering features of data, obtaining item features from tags, representing item profiles, Learning User Profiles and Filtering, Similarity-based retrieval, Classification algorithms, Knowledge base recommendation: Knowledge representation and reasoning,constraint-basedrecommenders,Casebasedrecommenders. | 12Hrs. |
| UNIT-4 | Neighbourhood-basedRecommendationMethods<br>AdvantagesofNeighbourhoodApproaches,Neighbourhood-basedRecommendation,User-basedRat- ing Prediction, User-based Classification Regression Vs Classification, Item-based Recommendation, User-based Vs Item based Recommendation, Rating Normalization, Similarity Weight Computation, Neighbourhood Selection | 12Hrs. |
| UNIT-5 | Constraint-based<br>RecommendersDevelopmentof RecommenderKnowledgeBases, UserGuidanceinRecommendation Processes, Calculating | 10Hrs. |

| | | |
|---|---|---|
| | Recommendations.<br>Context-Aware Recommender SystemsTrust Context in Recommender Systems, Modeling Contextual Information in Recommender Systems. Paradigms for Incorporating Context in Recommender Systems: Contextual Pre- Filtering, Contextual Post-Filtering, Contextual Modeling, Combining Multiple Approaches, Additional Issues in Context-Aware Recommender Systems. | |
| | Total | 58 Hrs |

Text Books:

1. C.C. Aggarwal, \Recommender Systems: The Textbook", Springer, 1st Edition, 2016.

2. Jannach D., Zanker M. and FelFering A., \Recommender Systems: An Introduction", Cambridge University Press, 1st Edition, 2011.

3. Kim Falk, \Practical Recommender Systems", Manning, 1st Edition, 2019

4. RounakBanik, \Hands-On Recommendation Systems with Python: Start building powerful and personalized, recommendation engines with Python", 2018.

| Course Code | High Performance Computing (Program Elective-II) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**This course is aimed at enabling the students to

1. Develop an understanding of parallel programming models, such as shared-memory, distributed-memory, and hybrid models.
2. Provide knowledge of HPC tools, libraries, and frameworks, such as MPI, OpenMP, CUDA, and GPU computing.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Describe different parallel architectures, inter-connect networks, programming models | K3 |
| **CO2** | Develop an efficient parallel algorithm to solve given problem | K4 |
| **CO3** | Analyze and measure performance of modern parallel computing systems | K5 |
| **CO4** | Build the logic to parallelize the programming task | K2 |
| **CO5** | Evaluate the performance of parallel algorithms and CUDA implementations in terms of speedup, efficiency, and scalability. | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | | |
| **CO2** | H | | H | H | M | H |
| **CO3** | H | | H | H | M | H |
| **CO4** | H | | H | H | M | H |
| **CO5** | H | | H | H | M | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Introduction:** Motivating Parallelism, Scope of Parallel Computing, Parallel Programming Platforms: Implicit Parallelism, Trends in Microprocessor and Architectures, Limitations of Memory, System Performance, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines, Scalable design principles, | 10Hrs |

| | | |
|---|---|---|
| | Architectures: N-wide superscalar architectures, Multi- core architecture. | |
| **UNIT – 2** | **Parallel Programming:** Principles of Parallel Algorithm Design: Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models, The Age of Parallel Processing, the Rise of GPU Computing, A Brief History of GPUs, Early GPU. | 12Hrs |
| **UNIT – 3** | **Basic Communication:** Operations- One-to-All Broadcast and All-to-One Reduction, All-to-All Broadcast and Reduction, All-Reduce and Prefix-Sum Operations, Scatter and Gather, All-to-All Personalized Communication, Circular Shift, Improving the Speed of Some Communication Operations. Programming shared address space platforms: threads- basics, synchronization, OpenMP programming | 12Hrs |
| **UNIT – 4** | **Analytical Models:** Sources of overhead in Parallel Programs, Performance Metrics for Parallel Systems, and The effect of Granularity on Performance, Scalability of Parallel Systems, Minimum execution time and minimum cost, optimal execution time. **Dense Matrix Algorithms:** Matrix Vector Multiplication, Matrix-Matrix Multiplication. | 12Hrs |
| **UNIT – 5** | **Parallel Algorithms- Sorting and Graph :** Issues in Sorting on Parallel Computers, Bubble Sort and its Variants, Parallelizing Quick sort, All-Pairs Shortest Paths, Algorithm for sparse graph, Parallel Depth-First Search, Parallel Best First Search. **CUDA Architecture:** CUDA Architecture, Using the CUDA Architecture, Applications of CUDA Introduction to CUDA C-Write and launch CUDA C kernels, Manage GPU memory, Manage communication and synchronization, Parallel programming in CUDA- C. | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, "Introduction to Parallel Computing", 2nd edition, Addison-Wesley, 2003, ISBN: 0-201-64865-2
2. Jason sanders, Edward Kandrot, “CUDA by Example”, Addison-Wesley, ISBN-13: 978-0-13-138768-3


**Reference Books**


1. Kai Hwang, ”Scalable Parallel Computing”, McGraw Hill 1998, ISBN:0070317984
2. Shane Cook, “CUDA Programming: A Developer's Guide to Parallel Computing with GPUs”, Morgan Kaufmann Publishers Inc. San Francisco, CA, USA 2013 ISBN: 9780124159884
3. David Culler Jaswinder Pal Singh, ”Parallel Computer Architecture: A Hardware/ Software Approach”, Morgan Kaufmann,1999, ISBN 978-1-55860-343-1
4. Rod Stephens, “Essential Algorithms”, Wiley, ISBN: ISBN: 978-1-118-61210-1

| Course Code | Advanced Operating System (Professional Elective – II) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

*Course Objectives***:** The main objective of the course is to

1. Familiarize students with modern operating system architectures and advanced concepts relevant to distributed and multi-core systems**.**
2. To provide an in-depth understanding of process management including process states, scheduling, and inter-process communication**.**

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Analyze and demonstrate process management concepts | K5 |
| **CO2** | Understand and implement interprocess communication (IPC) mechanisms | K2 |
| **CO3** | Apply file system optimization methods | K4 |
| **CO4** | Analyze the concepts and implementation of device drivers | K3 |
| **CO5** | Analyze resource management issues and classify different types of resources, | K6 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | H | | |
| **CO2** | | | H | H | | |
| **CO3** | | | H | H | | M |
| **CO4** | | | H | H | | H |
| **CO5** | | | H | H | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | PROCESSES AND SCHEDULING<br><br>Process States and System Call Interface; Life Cycle of a Process: Process Dynamics; Scheduler:working and implementation; Linux Process States and System Calls; Process Groups, Sessions, Foreground and Background Processes. | 10Hrs |
| **UNIT – 2** | INTERPROCESS COMMUNICATION AND SYNCHRONISATION<br>Signals, Pipes and Named Pipes (FIFOs); Threads and pthread library; Mutexes and Condition Variables; Semaphores; Producer-Consumer Problem and Solutions using mutexes, condition variables and semaphores | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 3** | FILES AND FILE SYSTEMS<br>File and File Meta-data; File Naming Systems; File System Operations; File System Implementation; File System Structures; Booting an OS; File System Optimisation. | 12Hrs |
| **UNIT – 4** | DEVICES AND DEVICE DRIVERS<br>Devices and Types of Devices; Terminal, Disk, SCSI, Tape and CD devices; Unification of Files and Devices; Device Drivers: Concepts and Implementation Details. | 13Hrs |
| **UNIT – 5** | RESOURCE MANAGEMENT AND SECURITY<br>Resource Management Issues; Types of Resources; Integrated Resource Scheduling; Queuing Models of Scheduling; Protection of Resources – hardware, software, and attacks; Security Policies | 13Hrs |
| | **Total** | 58Hrs |

**Text Books**:

Charles Crowley. Operating Systems: A Design-Oriented Approach, Tata McGraw-Hill (2001 or later)

Richard Stevens, Stephen Rago. Advanced Programming in the Unix Environment, Addison-Wesley (2013). Available for free download in PDF.

**Reference Books**:

Maekawa, M. and Arthur E. Oldehoeft and Oldehoeft, R.R. Operating Systems: Advanced Concepts, Benjamin Cummings (1987). Available through Google Books.

David A. Rusling. The Linux Kernel, http://www.tldp.org/LDP/tlk/tlk.html

| Course Code | Advanced Compiler Design (Program Elective-II) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:** This course is aimed at enabling the students to

1. Introduce the principles and architecture of modern compilers, including lexical analysis, syntax analysis, semantic analysis, and code generation.
2. Explore intermediate representations, symbol tables, and abstract syntax trees for program analysis and transformation.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Demonstrate various phases involved in the design of compiler | K4 |
| **CO2** | Organize and apply Syntax Analysis Techniques such as Top Down Parsing and LL(1) grammars | K3 |
| **CO3** | Design Bottom Up Parsing and Construct LR parsers | K4 |
| **CO4** | Analyse synthesized, inherited attributes and syntax directed translation schemes | K5 |
| **CO5** | Determine appropriate algorithms for a target code generation | K6 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | | M |
| **CO2** | | | H | H | | |
| **CO3** | M | | H | H | | M |
| **CO4** | H | | H | H | | M |
| **CO5** | H | | H | H | M | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Lexical Analysis:** Language Processors, Structure of a Compiler, Lexical Analysis, The Role of the Lexical Analyzer, Bootstrapping, Input Buffering, Specification of Tokens, Recognition of Tokens, Lexical Analyzer Generator-LEX, Finite Automata, Regular Expressions and Finite Automata, Design of a Lexical Analyzer Generator. | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 2** | **Syntax Analysis:** The Role of the Parser, Context-Free Grammars, Derivations, Parse Trees, Ambiguity, Left Recursion, Left Factoring, Top Down Parsing: Pre Processing Steps of Top Down Parsing, Backtracking, Recursive Descent Parsing, LL (1) Grammars, Non-recursive Predictive Parsing, Error Recovery in Predictive Parsing | 12Hrs |
| **UNIT – 3** | **Bottom Up Parsing:** Introduction, Difference between LR and LL Parsers, Types of LR Parsers, Shift Reduce Parsing, SLR Parsers, Construction of SLR Parsing Tables, More Powerful LR Parses, Construction of CLR (1) and LALR Parsing Tables, Dangling Else Ambiguity, Error Recovery in LR Parsing, Handling Ambiguity Grammar with LR Parsers | 12Hrs |
| **UNIT – 4** | **Syntax Directed Translation:** Syntax-Directed Definitions, Evaluation Orders for SDD's, Applications of Syntax Directed Translation, Syntax-Directed Translation Schemes, Implementing L-Attributed SDD's. Intermediate Code Generation: Variants of Syntax Trees, Three Address Code, Types and Declarations, Translation of Expressions, Type Checking, Control Flow, Backpatching, Intermediate Code for Procedures. | 12Hrs |
| **UNIT – 5** | **Run Time Environments:** Storage Organization, Run Time Storage Allocation, Activation Records, Procedure Calls, Displays, Code Optimization: The Principle Sources of Optimization, Basic Blocks, Optimization of Basic Blocks, Structure Preserving Transformations, Flow Graphs, Loop Optimization, Data-Flow Analysis, Peephole Optimization, Code Generation: Issues in the Design of a Code Generator, Object Code Forms, Code Generation Algorithm, Register Allocation and Assignment. | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


**1.** Compilers: Principles, Techniques and Tools, Second Edition, Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffry D. Ullman, Pearson Publishers,2007


**Reference Books:**


1. Compiler Construction, Principles and Practice, Kenneth C Louden,Cengage Learning, 2006
2. Modern compiler implementation in C, Andrew W Appel, Revised edition, Cambridge University Press.
3. Optimizing Compilers for Modern Architectures, Randy Allen, Ken Kennedy, Morgan Kauffmann, 2001.
4. Levine, J.R., T. Mason and D. Brown, Lex and Yacc, edition, O'Reilly & Associates, 1990

| Course Code | Data Structures and Algorithm Analysis Lab | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**Course Objectives:** This course is aimed at enabling the students to

1. Enhance understanding of algorithm analysis, including time and space complexity using asymptotic notations.
2. Equip students with the skills to apply appropriate data structures and algorithms to solve real-world computational problems.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Ability to write and analyze algorithms for algorithm correctness and efficiency | K2 |
| **CO2** | Master a variety of advanced abstract data type (ADT) and data structures and their Implementation. | K4 |
| **CO3** | Demonstrate various searching, sorting and hash techniques and be able to apply and solve problems of real life | K4 |
| **CO4** | Design and implement variety of data structures including linked lists, binary trees, heaps, graphs and search trees | K3 |
| **CO5** | Ability to compare various search trees and find solutions for IT related problems | K6 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | H | | |
| **CO2** | | | H | H | | |
| **CO3** | | | H | H | | M |
| **CO4** | | | H | H | | H |
| **CO5** | | | H | H | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **Experiment– 1** | Write a java program to perform various operations on single linked list | 3Hrs |
| **Experiment– 2** | Write a java program for the following<br>a) Reverse a linked list<br>b) Sort the data in a linked list | 3Hrs |

| | | |
|---|---|---|
| | c) Remove duplicates<br>d) Merge two linked lists | |
| **Experiment– 3** | Write a java program to perform various operations on doubly linked list | 3Hrs |
| **Experiment– 4** | Write a java program to perform various operations on circular linked list | 3Hrs |
| **Experiment– 5** | Write a java program for performing various operations on stack using linked list | 3Hrs |
| **Experiment– 6** | Write a java program for performing various operations on queue using linked list | 3Hrs |
| **Experiment– 7** | Write a java program for the following using stack<br>a) Infix to postfix conversion.<br>b) Expression evaluation.<br>c) Obtain the binary number for a given decimal number. | 3Hrs |
| **Experiment– 8** | Write a java program to implement various operations on Binary Search Tree Using Recursive and Non-Recursive methods. | 3Hrs |
| **Experiment– 9** | Write a java program to implement the following for a graph.<br>a) BFS b) DFS | 3Hrs |
| **Experiment– 10** | Write a java program to implement Merge & Heap Sort of given elements | 3Hrs |
| **Experiment– 11** | Write a java program to implement Quick Sort of given elements | 3Hrs |
| **Experiment– 12** | Write a java program to implement various operations on AVL trees | 3Hrs |
| **Experiment– 13** | Write a java program to perform the following operations:<br>a) Insertion into a B-tree b) Searching in a B-tree | 3Hrs |
| **Experiment– 14** | Write a java program to implementation of recursive and non-recursive functions to Binary tree Traversals | 3Hrs |
| **Experiment– 15** | Write a java program to implement all the functions of Dictionary (ADT) using Hashing | 3Hrs |
| | **Total** | 45Hrs |

| Course Code | Machine Learning Lab | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**COURSE OBJECTIVES:** The main objective of the course is to

1. Provide hands-on experience in implementing fundamental machine learning algorithms
2. Enable students to apply machine learning algorithms to practical problems in domains

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Implement and experiment with fundamental supervised and unsupervised machine learning algorithms. | K2 |
| **CO2** | Apply machine learning algorithms such as linear regression, logistic regression, decision trees, k-nearest neighbors, clustering, and support vector machines to solve real-world problems. | K4 |
| **CO3** | Evaluate and compare model performance using metrics like accuracy, precision, recall, F1-score, and cross-validation. | K4 |
| **CO4** | Use modern ML tools and frameworks | K3 |
| **CO5** | Design and implement end-to-end machine learning solutions for practical applications, including image processing, NLP, and recommendation systems. | K6 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | H | | |
| **CO2** | | | H | H | | |
| **CO3** | | | H | H | | M |
| **CO4** | | | H | H | | H |
| **CO5** | | | H | H | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **Experiment– 1** | Compute Central Tendency Measures: Mean, Median, Mode Measure of Dispersion: Variance, Standard Deviation. | 3Hrs |
| **Experiment– 2** | Apply the following Pre-processing techniques for a given dataset.<br>a. Attribute selection<br>b. Handling Missing Values<br>c. Discretization<br>d. Elimination of Outliers | 3Hrs |

| | | |
|---|---|---|
| **Experiment– 3** | Apply KNN algorithm for classification and regression | 3Hrs |
| **Experiment– 4** | Demonstrate decision tree algorithm for a classification problem and perform parameter tuning for better results | 3Hrs |
| **Experiment– 5** | Demonstrate decision tree algorithm for a regression problem | 3Hrs |
| **Experiment– 6** | Apply Random Forest algorithm for classification and regression | 3Hrs |
| **Experiment– 7** | Demonstrate Naïve Bayes Classification algorithm | 3Hrs |
| **Experiment– 8** | Apply Support Vector algorithm for classification | 3Hrs |
| **Experiment– 9** | Demonstrate simple linear regression algorithm for a regression problem | 3Hrs |
| **Experiment– 10** | Apply Logistic regression algorithm for a classification problem | 3Hrs |
| **Experiment– 11** | Demonstrate Multi-layer Perceptron algorithm for a classification problem | 3Hrs |
| **Experiment– 12** | Implement the K-means algorithm and apply it to the data you selected. Evaluate performance by measuring the sum of the Euclidean distance of each example from its class center. Test the performance of the algorithm as a function of the parameters K. | 3Hrs |
| **Experiment– 13** | Demonstrate the use of Fuzzy C-Means Clustering | 3Hrs |
| **Experiment– 14** | Demonstrate the use of Expectation Maximization based clustering algorithm | 3Hrs |
| | **Total** | 42Hrs |

| Course Code | Advanced Data Mining | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

*Course Objectives***:** The main objective of the course is to

1. Provide an in-depth understanding of advanced concepts, models, and algorithms in data mining and knowledge discovery.
2. Enable students to apply data mining frameworks and tools to solve real-world problems

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Describe the architecture, modeling techniques, and implementation strategies of data warehouses and OLAP systems, including modern cloud-based approaches | K2 |
| **CO2** | Apply statistical and visualization techniques to describe datasets and perform data preprocessing tasks such as cleaning, integration, reduction, and transformation. | K3 |
| **CO3** | Develop and evaluate classification models using decision trees, Bayesian classifiers, and rule-based methods for solving predictive analytics problems. | K4 |
| **CO4** | Discovermeaningful associations and sequential patterns in data using algorithms like Apriori, FP-Growth, and sequential pattern mining techniques. | K3 |
| **CO5** | Implement clustering techniques such as K-means, hierarchical clustering, and DBSCAN, and analyze advanced data mining for text, spatial, and graph data. | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | | | H | M | H | |
| **CO2** | | | H | H | M | |
| **CO3** | M | | H | H | M | |
| **CO4** | M | | H | H | M | |
| **CO5** | M | | H | H | H | |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Data Warehousing and Online Analytical Processing: Basic concepts, Data Warehouse Modeling: Data Cube and OLAP, Data Warehouse Design and Usage, Data Warehouse Implementation, Cloud Data Warehouse; Data Mining Methodologies: CRISP-DM and SEMMA, Comparison of Data Mining Methodologies. Statistical Limits on Data Mining, Introduction to Predictive Analytics, Technologies, Applications, Major issues (Text Book- 1) | 10Hrs |
| **UNIT – 2** | Data Objects & Attribute Types, Basic Statistical Descriptions of Data, Data Visualization, Measuring Data Similarity and Dissimilarity. Data Preprocessing: An Overview, Data Cleaning, Data Integration, Data Reduction, Data Transformation and Data Discretization. (Text Book- 1) | 10Hrs |
| **UNIT – 3** | **Classification:** Basic Concepts, General Approach to solving a classification problem, Decision Tree Induction: Attribute Selection Measures, Tree Pruning, Scalability and Decision Tree Induction, Visual Mining for Decision Tree Induction, Bayesian Classification Methods: Bayes Theorem, Naïve Bayes Classification, Rule-Based Classification, Model Evaluation and Selection. (Text Book- 2) | 12Hrs |
| **UNIT – 4** | **Association Analysis:** Problem Definition, Frequent Itemset Generation, Rule Generation: Confident Based Pruning, Rule Generation in Apriori Algorithm, Compact Representation of frequent item sets, FP-Growth Algorithm, *Sequential Patterns*: Preliminaries, Sequential Pattern Discovery (Text Book- 2) | 12Hrs |
| **UNIT – 5** | **Cluster Analysis:** Clustering techniques, Different Types of Clusters; K-means: The Basic K-means Algorithm, K-means Additional Issues, Bi-secting K Means, *Agglomerative Hierarchical Clustering*: Basic Agglomerative Hierarchical Clustering Algorithm DBSCAN: Traditional Density Center-Based Approach, DBSCAN Algorithm, Strengths and Weaknesses. *Mining rich data types*: Mining text data, Spatial-temporal data, Graph and networks. (Text Book- 2) | 12Hrs |
| | **Total** | 56Hrs |

**Text Books**:

1. Data Mining concepts and Techniques, 3rd edition, Jiawei Han, Michel Kamber, Elsevier, 2011.
2. Introduction to Data Mining: Pang-Ning Tan & Michael Steinbach, Vipin Kumar, Pearson, 2012.

**Reference Books**:

3. Data Mining: VikramPudi and P. Radha Krishna, Oxford Publisher.
4. Data Mining Techniques, Arun K Pujari, 3rd edition, Universities Press,2013.

**Online Resources:**(NPTEL course by Prof.PabitraMitra)

1. http://onlinecourses.nptel.ac.in/noc17_mg24/preview
2. http://www.saedsayad.com/data_mining_map.htm

| Course Code | Agile Software Development | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

*Course Objectives***:** The main objective of the course is to

1. To provide students with an understanding of the Agile Manifesto, principles, and their importance in modern software engineering.

2. To cultivate the ability to design, plan, and deliver software through iterative development cycles and incremental releases.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Interpret the concept of agile software engineering and its advantages in software development | K5 |
| **CO2** | Analyze the core practices behind several specific agile methodologies | K2 |
| **CO3** | Identify the roles and responsibilities in agile projects and their difference from projects following traditional methodologies. | K4 |
| **CO4** | Access implications of functional testing, unit testing, and continuous integration. | K3 |
| **CO5** | Determine the role of design principles in agile software design. | K6 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | H | | |
| **CO2** | | | H | H | | |
| **CO3** | | | H | H | | M |
| **CO4** | | | H | H | | H |
| **CO5** | | | H | H | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Introduction: Need of Agile software development, agile context– Manifesto, Principles, Methods, Values,Roles, Artifacts, Stakeholders, and challenges. Business benefits ofsoftware agility. | 10Hrs |
| **UNIT – 2** | Project Planning: Recognizing the structure of an agile team– Programmers, Managers, Customers. Userstories– Definition, Characteristics and content. Estimation– Planning poker, Prioritizing, and selectinguserstories with the customer, projecting team velocity for releases and iterations. | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 3** | Project Design: Fundamentals, Design principles–Single responsibility, Open-closed, Liskov substitution,Dependency-inversion, Interface-segregation. | 12Hrs |
| **UNIT – 4** | Design Methodologies: Need of scrum, Scrum practices –Working of scrum, Project velocity, Burn downchart, Sprint backlog, Sprint planning and retrospective, Daily scrum, Scrum roles– Product Owner, ScrumMaster, Scrum Team. Extreme Programming- Core principles, values and practices. Kanban, Feature-drivendevelopment, Lean software development. | 13Hrs |
| **UNIT – 5** | Testing: The Agile lifecycle and its impact on testing, Test driven development– Acceptance tests andverifying stories, writing a user acceptance test, Developing effective test suites, Continuous integration, Coderefactoring. Risk based testing, Regression tests, Test automation | 13Hrs |
| | **Total** | 58Hrs |

Text Books

1. Ken Schawber, Mike Beedle, "Agile Software Development with Scrum", International Edition, Pearson.
2. Robert C. Martin, "Agile Software Development, Principles, Patterns and Practices", First International Edition, Prentice Hall. 3. Pedro M. Santos, Marco Consolaro, and Alessandro Di Gioia, "Agile Technical Practices Distilled: A learning journey in technical practices and principles of software design", First edition, Packt Publisher.

Reference Books

1. Lisa Crispin, Janet Gregory, "Agile Testing: A Practical Guide for Testers and Agile Teams", International edition, Addison Wesley.
2. Alistair Cockburn, "Agile Software Development: The Cooperative Game", 2nd Edition, Addison-Wesley

| Course Code | Introduction to Quantum Computing | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:** The main objectives of the course are to

1. .Introduce fundamental concepts of quantum mechanics and its mathematical formalism.
2. Explore quantum computing and communication principles and technologies.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Describe the Historical development of quantum theory and its relevance to modern computing | K2 |
| **CO2** | Define Qubits and Compare the Classical vs. quantum information | K4 |
| **CO3** | Explain the Classical computing review and limitations | K3 |
| **CO4** | Demonstrate the principles and techniques of Quantum error correction | K4 |
| **CO5** | Discuss the working, applications and potential of Quantum sensors in real-world scenarios | K3 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | M | | | |
| **CO2** | M | | H | H | | |
| **CO3** | M | | H | M | | |
| **CO4** | H | | H | H | M | L |
| **CO5** | M | | M | M | H | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **History of Quantum Computing:** Importance of Mathematics, Physics and Biology. Introduction to Quantum Computing: Bits Vs Qubits, Classical Vs Quantum logical operations | 10Hrs |
| **UNIT – 2** | **Background Mathematics**: Basics of Linear Algebra, Hilbert space, Probabilities and measurements.<br>**Background Physics:** Paul's exclusion Principle, Superposition, Entanglement and super-symmetry, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis. Background Biology: Basic concepts of Genomics and Proteomics (Central Dogma) | 12Hrs |

| | | |
|---|---|---|
| **UNIT – 3** | **Qubit:** Physical implementations of Qubit. Qubit as a quantum unit of information. The Bloch sphere Quantum Circuits: single qubit gates, multiple qubit gates, designing the quantum circuits. Bell states. | 12Hrs |
| **UNIT – 4** | **Quantum Algorithms:** Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor's factorization algorithm, Grover's search algorithm | 12Hrs |
| **UNIT – 5** | **Noise and error correction:** Graph states and codes, Quantum error correction, fault-tolerant computation. Quantum Information and Cryptography: Comparison between classical and quantum information theory. Quantum Cryptography, Quantum teleportation | 12Hrs |
| | **Total** | 58Hrs |

**Text Books:**

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge

**Reference Books:**

1. Quantum Computing for Computer Scientists by Noson S. Yanofsky and Mirco A. Mannucci
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol.I: Basic Concepts, Vol II
3. Basic Tools and Special Topics, World Scientific. Pittenger A. O., An Introduction to Quantum Computing Algorithms

| Course Code | Feature Engineering (Program Elective-III) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:** The main objectives of the course are to

1. Expose students to tools and frameworks for feature engineering
2. Develop an understanding of data preprocessing technique

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Describe the Basic concepts of Data, Tasks, Models, Features and Model building | K2 |
| **CO2** | Explain the concept ofconverting Text into Flat Vectors using Bag- of-Words, and Bag-of-n-Grams | K3 |
| **CO3** | Demonstrate techniques for Dimensionality Reduction | K4 |
| **CO4** | Discuss non linear Featurization | K4 |
| **CO5** | Explain the concept of Item-Based Collaborative Filtering | K3 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | M | | |
| **CO2** | M | | H | H | | |
| **CO3** | H | | H | H | M | |
| **CO4** | H | | H | H | M | L |
| **CO5** | M | | M | H | H | L |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **The Machine Learning Pipeline:** Data, Tasks, Models, Features, Model Evaluation Fancy Tricks with Simple Numbers: Scalars, Vectors, and Spaces, Dealing with Counts, Binarization, Quantization or Binning, Log Transformation, Log Transform in Action, Power Transforms: Generalization of the Log Transform, Feature Scaling or Normalization, Min-Max Scaling, Standardization (Variance Scaling), ℓ2 Normalization, Interaction Features, Feature Selection | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 2** | **Text Data: Flattening, Filtering, and Chunking: Bag-of-X:** Turning NaturalText into Flat Vectors,Bag- of-Words, Bag-of-n-Grams, Filtering for Cleaner Features: Stopwords, Frequency-Based Filtering, Stemming; Atoms of Meaning: From Words to n-Grams to Phrases: Parsing and Tokenization, Collocation Extraction for Phrase Detection The Effects of Feature Scaling: From Bag-of-Words to Tf-Idf :Tf-Idf : A Simple Twist on Bag-of- Words, Putting It to the Test : Creating a Classification Dataset, Scaling Bag-of-Words with Tf-Idf Transformation, Classification with Logistic Regression, Tuning Logistic Regression withRegularization | 12Hrs |
| **UNIT – 3** | **Categorical Variables:** Counting Eggs in the Age of Robotic Chickens: Encoding Categorical Variables: One-Hot Encoding, Dummy Coding, Effect Coding, Pros and Cons of Categorical Variable Encodings; Dealing with Large Categorical Variables: Feature Hashing, Bin Counting. **Dimensionality Reduction:** Squashing the Data Pancake with PCA: Intuition, Derivation: Linear Projection, Variance and Empirical Variance, Principal Components: First Formulation, Principal Components: Matrix-Vector Formulation, General Solution of the Principal Components; Transforming Features, Implementing PCA: PCA in Action, Whitening and ZCA, Considerations and Limitations of PCA | 12Hrs |
| **UNIT – 4** | **Nonlinear Featurization via K-Means Model Stacking:** k-Means Clustering, Clustering as SurfaceTiling, k-Means Featurization for Classification: Alternative Dense Featurization, Pros, Cons, and Gotchas | 12Hrs |
| **UNIT – 5** | **Item-Based Collaborative Filtering, First Pass:** Data Import, Cleaning, and Feature Parsing, Academic PaperRecommender: Naïve Approach,SecondPass:MoreEngineeringandaSmarterModel,Academic Paper Recommender: Take 2, Third Pass: More Features is More Information, Academic Paper Recommender: Take 3 | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. "Feature EngineeringforMachineLearningPrinciples and Techniquesfor Data Scientists",Alice Zheng& Amanda Casari, O'REILLY, 2018
2. "Feature Engineering and Selection: APractical Approach for Predictive Models", Max Kuhn, Kjell Johnson, CRC Press, 2019

| Course Code | Generative AI (Program Elective-III) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

1. To learn Python and TensorFlow skills for Generative AI.
2. To study techniques for cleaning and preparing data for Generative AI tasks.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Implement Python and TensorFlow basics, including data handling and preprocessing techniques | K5 |
| **CO2** | Implement Generative AI models such as GANs, VAEs, LSTM networks, and Transformer models for image text, and music generation tasks | K4 |
| **CO3** | Evaluate model performance and experiment with hyper parameters and optimization techniques to enhance Generative AI outcomes. | K6 |
| **CO4** | Develop innovative applications in image, text, and music generation, showcasing practical skills | K5 |
| **CO5** | Leverage modern programming tools and frameworks | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | M | H | M | |
| **CO2** | H | | H | H | H | L |
| **CO3** | H | | H | H | H | M |
| **CO4** | H | M | H | H | H | H |
| **CO5** | H | M | H | H | H | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Introduction To Gen Ai:** Historical Overview of Generative modelling, Difference between Gen AI and Discriminative Modeling, Importance of generative models in AI and Machine Learning, Types of Generative models, GANs, VAEs, autoregressive models and Vector quantized Diffusion models, Understanding if probabilistic modeling and generative process, Challenges of Generative Modeling, Future of Gen AI, Ethical Aspects of AI, Responsible AI, Use Cases | 10Hrs |
| **UNIT – 2** | **Generative Models For Text:** Language Models Basics, Building blocks of Language models, Transformer Architecture, Encoder and Decoder, Attention mechanisms, Generation of Text, Models like BERT and GPT models, Generation of Text, Autoencoding, Regression Models, Exploring ChatGPT, | 12Hrs |

| | | |
|---|---|---|
| | Prompt Engineering: Designing Prompts, Revising Prompts using Reinforcement Learning from Human Feedback (RLHF), Retrieval Augmented Generation, Multimodal LLM, Issues of LLM like hallucination | |
| **UNIT – 3** | **Generation of Images:** Introduction to Generative Adversarial Networks, Adversarial Training Process, Nash Equilibrium, Variational Autoencoders, Encoder-Decoder Architectures, Stable Diffusion Models, Introduction to Transformer-based Image Generation, CLIP, Visual Transformers ViT- Dall-E2 and Dall-E3, GPT-4V, Issues of Image Generation models like Mode Collapse and Stability. | 12Hrs |
| **UNIT – 4** | **Generation of Painting, Music, and Play:** Variants of GAN, Types of GAN, Cyclic GAN, Using Cyclic GAN to Generate Paintings, Neural Style Transfer, Style Transfer, Music Generating RNN, MuseGAN, Autonomous agents, Deep Q Algorithm, Actor-critic Network. | 12Hrs |
| **UNIT – 5** | **Open Source Models And Programming Frameworks**: Training and Fine tuning of Generative models, GPT 4 All, Transfer learning and Pretrained models, Training vision models, Google Copilot, Programming LLM, LangChain, Open Source Models, Llama, Programming for TimeSformer, Deployment, Hugging Face. | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. Denis Rothman, "Transformers for Natural Language Processing and Computer Vision", Third Edition , Packt Books, 2024


**Reference Books:**


1. David Foster, "Generative Deep Learning", O'Reily Books, 2024.
2. Altaf Rehmani, "Generative AI for Everyone", BlueRose One, 2024.

| Course Code | CyberSecurity<br>(ProfessionalElective–IV) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives: This course is aimed at enabling the students to**

.1. Familiarize students with **cyber attack types**

**2.** Develop an understanding of **network security principles**

**Course Outcomes: At the end of the course, student will be able to**

| | **CourseOutcomes** | Knowledge Level (K)# |
|---|---|---|
| CO1 | Understandkeytermsand concepts in cyber securityfundamentals. | K2 |
| CO2 | Gainknowledgeaboutattackertechniquesandmotivations. | K3 |
| CO3 | Differentiatevariousgoverningbodiesofcyber laws. | K2 |
| CO4 | Understandprinciplesof maliciouscode. | K2 |
| CO5 | ObtaincomprehensiveknowledgeonDefense andAnalysisTechniques. | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | | | H | H | | |
| **CO2** | | | H | H | | |
| **CO3** | M | | H | H | | M |
| **CO4** | | | M | M | | |
| **CO5** | | | M | M | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| UNIT-1 | **Cyber Security Fundamentals:** Information Assurance Fundamentals, Basic Cryptography, Symmetric Encryption, Public Key Encryption, The Domain Name System (DNS), Microsoft Windows Security Principles: Windows Tokens, Window Messaging, Windows Program Execution | 12 Hrs |
| UNIT-2 | **Introduction to cyber-attacks**, application security (design, development and testing), operations security, monitoring, identifying threats and remediating them, Principles of data security - Confidentiality, Integrity and Availability, Data | 12 Hrs |

| | | |
|---|---|---|
| | Privacy, Data breaches, preventing attacks and breaches with security controls, Compliance standards, Computer Ethics. | |
| UNIT-3 | **Cyber Security Management** Security Planning - Business Continuity Planning - Handling Incidents - Risk Analysis - Dealing With Disaster –Legal Issues – Protecting programs and Data.<br>**Introduction to Cyber Law:** Cyber Law, Need for Cyber Law Jurisprudence of Indian Cyber, Law, Evolution of Cyber Crime | 12 Hrs |
| UNIT-4 | **Malicious Code:** Self-Replicating Malicious Code, Evading Detection and Elevating Privileges, Stealing Information and Exploitation, Research ideas in Cyber Security. | 12 Hrs |
| UNIT-5 | **Defense and Analysis Techniques:** Memory Forensics, Honeypots, Malicious Code Naming, Automated Malicious Code Analysis Systems, Cyber Security current trends and standards. | 10 Hrs |
| | **Total** | 58 Hrs |

Text Books:


1. James Graham, Richard Howard, Ryan Olson "CYBER SECURITY ESSENTIALS", CRC Press, Taylor & Francis Group, LLC, 2011.
2. Sammons,John,andMichaelCross.Thebasicsofcybersafety:computerandmobiledevice safety made easy. Elsevier, 2016.

| Course Code | Natural Language Processing (Professional Elective – III) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:** The main objective of the course is to

1. Explore statistical and machine learning approaches for NLP tasks, including language modeling, classification, and sequence labeling.
2. Provide knowledge of advanced NLP techniques, such as word embeddings, transformer models, attention mechanisms, and contextual representations.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Demonstrate a given text with basic Language features | K5 |
| **CO2** | Design an innovative application using NLP components | K3 |
| **CO3** | Explain a rule based system to tackle morphology/syntax of a language | K3 |
| **CO4** | Design a tag set to be used for statistical processing for real-time applications | K3 |
| **CO5** | Compare and contrast the use of different statistical approaches for different types of NLP applications | K5 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | M | H | | |
| **CO2** | H | M | H | H | H | H |
| **CO3** | M | | H | H | | |
| **CO4** | M | | H | H | M | |
| **CO5** | M | M | H | H | H | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **INTRODUCTION:** Origins and challenges of NLP – Language Modeling: Grammar-based LM, Statistical LM – Regular Expressions, Finite-State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling Errors, Minimum Edit Distance | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 2** | **WORD LEVEL ANALYSIS:** Unsmoothed N-grams, Evaluating N-grams, Smoothing, Interpolation and Backoff – Word Classes, Part- of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in PoS tagging – Hidden Markov and Maximum Entropy models | 12Hrs |
| **UNIT – 3** | **SYNTACTIC ANALYSIS**: Context-Free Grammars, Grammar rules for English, Treebanks, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Shallow parsing Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs – Feature structures, Unification of feature structures | 12Hrs |
| **UNIT – 4** | **SEMANTICS AND PRAGMATICS:** Requirements for representation, First-Order Logic, Description Logics – Syntax-Driven Semantic analysis, Semantic attachments – Word Senses, Relations between Senses, Thematic Roles, selectional restrictions – Word Sense Disambiguation, WSD using Supervised, Dictionary & Thesaurus, Bootstrapping methods – Word Similarity using Thesaurus and Distributional methods. | 12Hrs |
| **UNIT – 5** | **DISCOURSE ANALYSIS AND LEXICAL RESOURCES:** Discourse segmentation, Coherence – Reference Phenomena, Anaphora Resolution using Hobbs and Centering Algorithm – Coreference Resolution – Resources: Porter Stemmer, Lemmatizer, Penn Treebank, Brill's Tagger, WordNet, PropBank, FrameNet, Brown Corpus, British National Corpus (BNC | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, 2nd Edition, Daniel Jurafsky, James H. Martin - Pearson Publication,2014.
2. Natural Language Processing with Python, First Edition, Steven Bird, Ewan Klein and Edward Loper, OReilly Media,2009.


**Reference Books:**


1. Language Processing with Java and Ling Pipe Cookbook, 1st Edition, Breck Baldwin, Atlantic Publisher, 2015.
2. Natural Language Processing with Java, 2nd Edition, Richard M Reese, OReilly Media,2015.
3. Handbook of Natural Language Processing, Second, Nitin Indurkhya and Fred J. Damerau, Chapman and Hall/CRC Press, 2010.Edition

   Natural Language Processing and Information Retrieval, 3rd Edition, Tanveer Siddiqui, U.S. Tiwary, Oxford University Press,2008.

| Course Code | Block Chain Technologies (Program Elective-IV) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

1. Architect sensor networks for various application setups.
2. Devise appropriate data dissemination protocols and model links cost.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Discuss the Cryptographic primitives used in Blockchain | K2 |
| **CO2** | Discuss about various technologies borrowed in blockchain | K2 |
| **CO3** | Illustrate various models for blockchain | K2 |
| **CO4** | Discuss about Ethereum | K2 |
| **CO5** | Discuss about Hyperledger Fabric | K2 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | L | | M | H | M | M |
| **CO2** | L | | M | M | H | M |
| **CO3** | | | M | M | M | |
| **CO4** | | | M | M | H | M |
| **CO5** | | | M | M | H | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **INTRODUCTION TO BLOCKCHAIN:** Introduction, history of Bitcoin and origins of Blockchain, Fundamentals of Blockchain and key components **(Chapter 1-book1),** Permission and Permission-less platforms**(Chapter 1-book2),** Introduction to Cryptography, SHA256 and ECDSA, Hashing and Encryption, Symmetric/ Asymmetric keys, Private and Public Keys(**Chapter 3-book2)**. | 10Hrs |
| **UNIT – 2** | **TECHNOLOGIESBORROWEDINBLOCKCHAIN:**TechnologiesBorrowed inBlockchain–hashpointers—Digitalcashetc.-Bitcoinblockchain-Wallet–Blocks Merkley Tree - hardness of mining - Transaction verifiability - Anonymity - | 12Hrs |

| | | |
|---|---|---|
| | forks - Double spending - Mathematical analysis of properties of Bitcoin - Bitcoin-thechallengesandsolutions. (**Chapter 3-book2)**. | |
| **UNIT – 3** | **CONSENSUS MECHANISMS :ConsensusAlgorithms:** ProofofWork(PoW)asrandomoracle-Formaltreatmentofconsistency-LivenessandFairness-ProofofStake(PoS)based Chains -Hybrid models (PoW + PoS), ByzantineModelsoffaulttolerance. ((**Chapter 1-book2)**) | 12Hrs |
| **UNIT – 4** | **ETHEREUM:**Ethereum-EthereumVirtualMachine(EVM)-WalletsforEthereum-Solidity-SmartContracts **(Chapter 5-book1),**-TheTuringCompletenessofSmartContractLanguagesandverificationchallenges-Usingsmartcontractstoenforcelegalcontracts-Comparing Bitcoin scripting vs. Ethereum Smart Contracts-Some attacks onsmartcontracts (**Chapter 6 and Chapter 7-book2)** | 12Hrs |
| **UNIT – 5** | **HYPERLEDGERFABRIC:** Hyperledgerfabric- the plug and play platform and mechanisms in permissioned blockchain - Beyond Cryptocurrency – applications of blockchain in cyber security- integrity of information- E-Governance and othercontractenforcementmechanisms-Limitationsofblockchainasatechnologyandmythsvsrealityofblockchaintechnology **(Chapter 16-book1),** (**Chapter 9 -book2)** | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:


1. Blockchain Technology Chandramouli Subramanian, Asha A George, Abhilash K A and Meena Karthikeyan, University Press, 2020.
2. Mastering Blockchain - Distributed ledger technology, decentralization, and smart contracts explained, Imran Bashir,2nd ed. Edition,2018, pakct publication


**Reference Books:**


1. .Shukla,M.Dhawan,S.Sharma,S.Venkatesan"BlockchainTechnology:CryptocurrencyandApplications",OxfordUniversityPress2019.
2. Cryptography and network security principles and practice, William Stallings,Pearson, 8th edition,


**WEBREFERENCES:**

1. https://drive.google.com/file/d/1PtYaDmWYaqPVGjKDnMYGWO5eoI5wMPtJ/view
2. https://archive.nptel.ac.in/courses/106/104/106104220/
3. https://www.tutorialspoint.com/blockchain/index.htm

| Course Code | DevOps<br>(Program Elective-IV) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives**: The main objectives of this course are to:

1. Describe the agile relationship between development and IT operations.
2. Understand the skill sets and high-functioning teams involved in DevOps and related methods to reach a continuous delivery capability.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Explain DevOps Life cycle process | K2 |
| **CO2** | Demonstrate the concept of Code coverage | K3 |
| **CO3** | Explain Jenkins , jenkins workflow, jenkins master slave architecture, Jenkins Pipelines | K2 |
| **CO4** | Discuss the concept of Dockers Command and running containers | K2 |
| **CO5** | Analyze and troubleshoot configuration and deploymentissues in automated environments. | K4 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | L | | M | M | H | |
| **CO2** | | | M | H | H | |
| **CO3** | | | M | H | H | |
| **CO4** | | | M | M | H | |
| **CO5** | **CO4** | | | M | M | H |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | **Introduction to DevOps:** Introduction to SDLC, Agile Model. Introduction to DevOps. DevOps Features, DevOps Architecture, DevOps Lifecycle, Understanding Workflow and principles, Introduction to DevOps tools, Build | 10Hrs |

| | | |
|---|---|---|
| | Automation, Delivery Automation, Understanding Code Quality, Automation of CI/ CD. Release management, Scrum, Kanban, delivery pipeline, bottlenecks, examples | |
| **UNIT – 2** | **Source Code Management (GIT**): The need for source code control, The history of source code management, Roles and code, source code management system and migrations. What is Version Control and GIT, GIT Installation, GIT features, GIT workflow, working with remote repository, GIT commands, GIT branching, GIT staging and collaboration. UNIT TESTING-CODECOVERAGE: Junit ,nUnit& Code Coverage with Sonar Qube, SonarQube - Code Quality Analysis. | 12Hrs |
| **UNIT – 3** | **Build Automation - Continuous Integration (CI):** Build Automation, What isCI Why Cl is Required, CI tools, Introduction to Jenkins (With Architecture), jenkins workflow, jenkins master slave architecture, Jenkins Pipelines, PIPELINE BASICS - Jenkins Master, Node, Agent, and Executor Freestyle Projects& Pipelines, Jenkins for Continuous Integration, Create and Manage Builds, User Management in Jenkins Schedule Builds, Launch Builds on Slave Nodes. | 12Hrs |
| **UNIT – 4** | **Continuous Delivery:** Importance of Continuous Delivery, CONTINUOUS DEPLOYMENT CD Flow, Containerization with Docker: Introduction to Docker, Docker installation, Docker commands, Images & Containers, Docker File, running containers, working with containers and publish to Docker Hub.<br>Testing Tools: Introduction to Selenium and its features, Java Script testing | 12Hrs |
| **UNIT – 5** | **Configuration Management - ANSIBLE**: Introduction to Ansible, Ansible tasks Roles, Jinja2 templating, Vaults, Deployments using Ansible. CONTAINERIZATION USING UBERNETES(OPENSHIFT): Introduction to Kubernetes Namespace & Resources, CI/CD - On OCP, BC, DC& Config Maps, Deploying Apps on Open shift Container Pods. Introduction to Puppet master and Chef | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**


1. Joyner, Joseph., DevOps for Beginners: DevOps Software Development Method Guide for Software Developers and It Professionals, 1st Edition MihailsKonoplows, 2015.
2. Alisson Machado de Menezes., Hands-on DevOps with Linux,1st Edition, BPB Publications, India, 2021.


**Reference Books**


1. Len Bass, Ingo Weber, Liming Zhu. DevOps: A Software Architect's Perspective. Addison Wesley; ISBN-10

2. Gene Kim Je Humble, Patrick Debois, John Willis. The DevOps Handbook, 1st Edition, IT Revolution Press, 2016.
3. Verona ,Joakim Practical DevOps,1stEdition,Packt Publishing,2016.
4. Joakim Verona. Practical Devops, Second Edition.In gram short title; 2nd edition (2018). ISBN10: 1788392574
5. Deepak Gaikwad, Viral Thakkar. DevOps Tools from Practitioner's View point. Wiley publications. ISBN:9788126579952

**Web Resources:**

1. https://archive.nptel.ac.in/courses/106/104/106104220/
2. https://www.tutorialspoint.com/blockchain/index.htm

| Course Code | Internet of Things (Professional Elective – IV) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**CourseObjectives:This course is aimed at enabling the students to**

1. TounderstandaboutthefundamentalsofInternetofThingsanditsbuildingblocksalong with their characteristics
2. Tounderstandthe recentapplicationdomains of IoTineverydaylife

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

| | **CourseOutcomes** | Knowledge Level (K) |
|---|---|---|
| CO1 | UnderstandCharacteristicsandDesignof InternetofThings(IoT). | K2 |
| CO2 | ComparevariousM2Mand IoT architectures. | K4 |
| CO3 | Studyvarious Cloud StorageModels forIoT. | K2 |
| CO4 | DesignIoTSystemusing Python. | K5 |
| CO5 | Applyvarious Data Analyticstools forIoT. | K3 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | | | H | H | | |
| **CO2** | | | H | H | | |
| **CO3** | M | | H | H | | M |
| **CO4** | | | M | M | | |
| **CO5** | | | M | M | M | M |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| UNIT-1 | **Introduction**: Internet of Things, Definition & Characteristics of IoT, Physical Design of IoTLogical Design of IoT, IoT Enabling Technologies, IoT Levels & Deployment Templates. Domain Specific IoTs: Home, Cities, Environment, Energy systems, Logistics, Agriculture, Health &Lifestyle. | 12 Hrs |
| UNIT-2 | **IoT & M2M:** Introduction, M2M, Difference between IoT and M2M, SDN and NFV for IoT, Need for IoT Systems Management, Simple Network Management Protocol (SNMP), Limitations of SNMP, | 12 Hrs |

| | | |
|---|---|---|
| | Network Operator Requirements, NETCONF, YANG, IoT Systems, Management with NETCONF-YANG, NETOPEER. | |
| UNIT-3 | IoT Platforms Design Methodology IoT Design Methodology, Case Study on IoT System for Weather Monitoring , Motivation for Using Python , IoT Systems - Logical Design using Python, Installing Python , Python Data Types & Data Structures ,Control Flow , Functions, Modules, Packages , File Handling, Date/Time Operations , Classes ,Python Packages of Interest for IoT. | 12 Hrs |
| UNIT-4 | IoTPhysicalDevices&Endpoints,RaspberryPi,AbouttheBoard,LinuxonRaspberryPi ,RaspberryPiInterfaces, ProgrammingRaspberryPiwithPython,OtherIoTDevices. PhysicalServers&CloudOfferings,IntroductiontoCloudStorageModels&CommunicationAPIs ,WAMP - AutoBahn for IoT , Xively Cloud for IoT , Python Web Application Framework- Django, Amazon Web Services for IOT | 12 Hrs |
| UNIT-5 | Data Analytics for IoT , Introduction , Apache Hadoop, Using Hadoop MapReduce for Batch Data Analysis , Apache Oozie, Apache Spark , Apache Storm, Using Apache Storm for Realtime Data Analysis. | 10 Hrs |
| | Total | 58 Hrs |

Text Books:


1. A.BahgyaandV.Madisetti,"InternetofThings",UnivesityPress,2015.
2. RajKamal"InternetofThings", MGH,2015.


ReferenceBooks:


1. K.A.LambertandB.L.Juneja"Fundamentalsof Python",,CengageLearning,2012.
2. Rajkumar BuyaaandAmirVDastjerdi, Internetofthings:PrinciplesandParadigms,MorganKaufmann.
3. OlivierHersent,DavidBoswarthickandOmarElloumi,TheInternetofThings:Keyapplications and Protocols, Wiley

| Course Code | Design Patterns (Program Elective-IV) | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives :This course is aimed at enabling the students to**

1. Demonstration of patterns related to object oriented design.
2. Describe the design patterns that are common in software applications.

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Construct a design consisting of a collection of modules | K6 |
| **CO2** | Exploit well-known design patterns (such as Iterator, Observer, Factory and Visitor). Analyze | K4 |
| **CO3** | Distinguish between different categories of design patterns. Analyze | K4 |
| **CO4** | Ability to understand and apply common design patterns to incremental/iterative development. | K3 |
| **CO5** | identify appropriate patterns for design of given problem | K3 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | M | |
| **CO2** | M | | H | H | M | |
| **CO3** | | | H | H | | |
| **CO4** | | | M | H | M | |
| **CO5** | | | H | H | M | |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | What is a Design Pattern, Design Patterns in Smalltalk MVC, Describing Design Patterns, The Catalogue of Design Patterns, Organizing The Cato log, How Design Patterns solve Design Problems, How to Select a Design pattern, How to Use a Design Pattern. | 10Hrs |

| | | |
|---|---|---|
| **UNIT – 2** | **A Case Study**: Designing a Document Editor, Design Problems , Document Structure, Formatting , Embellishing the User Interface, Supporting Multiple Look-and-Feel Standards, Supporting Multiple Window Systems, User Operations Spelling Checking and Hyphenation, Summary, Creational Patterns, Abstract Factory, Builder , Factory Method, Prototype, Singleton, Discussion of Creational Patterns. | 12Hrs |
| **UNIT – 3** | Structural Pattern Part-I, Adapter, Bridge, Composite. Structural Pattern Part-II, Decorator, Facade, Flyweight, Proxy. | 12Hrs |
| **UNIT – 4** | Behavioral Patterns Part: I, Chain of Responsibility, Command, Interpreter, Iterator. Behavioral Patterns Part: II, Mediator, Memento, Observer, Discussion of Behavioral Patterns. | 12Hrs |
| **UNIT – 5** | **Behavioral Patterns Part:** III, State, Strategy, Template Method, Visitor, Discussion of Behavioral Patterns. What to Expect from Design Patterns, A Brief History, The Pattern Community, An Invitation, A Parting Thought. | 12Hrs |
| | **Total** | 58Hrs |

**Text Books**:

1. Design Patterns By Erich Gamma, Pearson Education

**Reference Books:**

1. Patterns in JAVA Vol-I (or) Vol-II By Mark Grand, Wiley Dream Tech.
2. Java Enterprise Design Patterns Vol-III By Mark Grand Wiley Dream Tech

| Course Code | Advanced Data Mining Lab | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**COURSE OBJECTIVES:** The main objective of the course is to

1. Inculcate Conceptual, Logical, and Physical design of Data Warehouses OLAP applications and OLAP deployment
2. Design a data warehouse or data mart to present information needed by management in a form that is usable

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Preprocess and analyze complex datasets for mining meaningful patterns using advanced techniques. | K6 |
| **CO2** | Implement advanced data mining algorithms, including association rule mining, sequential pattern mining, and outlier detection. | K4 |
| **CO3** | Use modern data mining tools and frameworks (e.g., Python, R, Weka, or Spark MLlib) for practical implementations. | K4 |
| **CO4** | Evaluate and compare model performance using relevant metrics, and optimize models for accuracy and efficiency. | K3 |
| **CO5** | Apply data mining techniques to domain-specific applications, such as business intelligence, bioinformatics, and social network analysis. | K3 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | M | |
| **CO2** | M | | H | H | M | |
| **CO3** | | | H | H | | |
| **CO4** | | | M | H | M | |
| **CO5** | | | H | H | M | |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **Experiment– 1** | Creation of a Data Warehouse.<br>➢ Build Data Warehouse/Data Mart (using open source tools like Pentaho Data Integration Tool, Pentaho Business Analytics; or other data warehouse tools like Microsoft-SSIS, Informatica, Business Objects,etc.,)<br>➢ Design multi-dimensional data models namely Star, Snowflake and Fact Constellation schemas for any one enterprise (ex. Banking, Insurance, Finance, Healthcare, manufacturing, Automobiles, sales etc).<br>➢ Write ETL scripts and implement using data warehouse tools.<br>➢ Perform Various OLAP operations such slice, dice, roll up, drill up and pivot | 3Hrs |
| **Experiment– 2** | Explore machine learning tool "WEKA"<br>➢ Explore WEKA Data Mining/Machine Learning Toolkit.<br>➢ Downloading and/or installation of WEKA data mining toolkit.<br>➢ Understand the features of WEKA toolkit such as Explorer, Knowledge Flow interface, Experimenter, command-line interface.<br>➢ Navigate the options available in the WEKA (ex. Select attributes panel, Preprocess panel, Classify panel, Cluster panel, Associate panel and Visualize panel)<br>➢ Study the arff file format Explore the available data sets in WEKA. Load a data set (ex. Weather dataset, Iris dataset, etc.)<br>➢ Load each dataset and observe the following:<br>1. List the attribute names and they types<br>2. Number of records in each dataset<br>3. Identify the class attribute (if any)<br>4. Plot Histogram<br>5. Determine the number of records for each class.<br>6. Visualize the data in various dimensions | 3Hrs |
| **Experiment– 3** | Perform data preprocessing tasks and Demonstrate performing association rule mining on data sets<br>➢ Explore various options available in Weka for preprocessing data and apply<br>Unsupervised filters like Discretization, Resample filter, etc. on each dataset<br>➢ Load weather. nominal, Iris, Glass datasets into Weka and run Apriori<br>Algorithm with different support and confidence values.<br>➢ Study the rules generated. Apply different discretization filters on numerical attributes and run the Apriori association rule algorithm. Study the rules generated.<br>➢ Derive interesting insights and observe the effect of discretization in the rule generation process. | 3Hrs |

| | | |
|---|---|---|
| **Experiment– 4** | Demonstrate performing classification on data sets Weka/R<br>➢ Load each dataset and run 1d3, J48 classification algorithm. Study the classifier output. Compute entropy values, Kappa statistic.<br>➢ Extract if-then rules from the decision tree generated by the classifier, Observe the confusion matrix.<br>➢ Load each dataset into Weka/R and perform Naïve-bayes classification and k-Nearest Neighbour classification. Interpret the results obtained.<br>➢ Plot RoC Curves<br>➢ Compare classification results of ID3, J48, Naïve-Bayes and k-NN classifiers for each dataset, and deduce which classifier is performing best and poor for each dataset and justify. | 3Hrs |
| **Experiment– 5** | Demonstrate performing clustering of data sets<br>➢ Load each dataset into Weka/R and run simple k-means clustering algorithm with different values of k (number of desired clusters).<br>➢ Study the clusters formed. Observe the sum of squared errors and centroids, and derive insights.<br>➢ Explore other clustering techniques available in Weka/R.<br>Explore visualization features of Weka/R to visualize the clusters. Derive interesting insights and explain | 3Hrs |
| **Experiment– 6** | Demonstrate knowledge flow application on data sets into Weka/R<br>➢ Develop a knowledge flow layout for finding strong association rules by using Apriori, FP Growth algorithms<br>➢ Set up the knowledge flow to load an ARFF (batch mode) and perform a cross validation using J48 algorithm<br>Demonstrate plotting multiple ROC curves in the same plot window by using j48 and Random forest tree | 3Hrs |
| **Experiment– 7** | Demonstrate ZeroR technique on Iris dataset (by using necessary preprocessing technique(s)) and share your observations | 3Hrs |
| **Experiment– 8** | Write a java program to prepare a simulated data set with unique instances | 3Hrs |
| **Experiment– 9** | Write a Python program to generate frequent item sets / association rules using Apriori algorithm | 3Hrs |
| **Experiment– 10** | Write a program to calculate chi-square value using Python/R. Report your observation. | 3Hrs |
| **Experiment– 11** | Implement a Java/R program to perform Apriori algorithm | 3Hrs |
| **Experiment– 12** | Write a R program to cluster your choice of data using simple k-means algorithm using JDK | 3Hrs |
| **Experiment– 13** | Write a program of cluster analysis using simple k-means algorithm Python/R programming language | 3Hrs |

| | | |
|---|---|---|
| **Experiment– 14** | Write a program to compute/display dissimilarity matrix (for your own dataset containing at least four instances with two attributes) using Python | 3Hrs |
| **Experiment– 15** | Visualize the datasets using matplotlib in python/R.(Histogram, Box plot, Bar chart, Pie chart etc.,) | 3Hrs |
| | **Total** | 45Hrs |

| Course Code | Quantum Computer lab | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**COURSE OBJECTIVES:** The main objective of the course is to

1. To introduce the historical background and interdisciplinary foundations of Quantum Computing.
2. To provide a strong foundation in linear algebra, probability, and quantum physics required for quantum computing

**Course Outcomes**: At the end of the course, student will be able to

| | | Knowledge Level (K) |
|---|---|---|
| **CO1** | Differentiate between classical and quantum computation paradigms | K2 |
| **CO2** | Apply mathematical and physical principles to analyze quantum systems | K3 |
| **CO3** | Design and simulate quantum circuits using quantum programming frameworks | K5 |
| **CO4** | Implement basic quantum algorithms (Deutsch, Grover, Shor, etc.) and evaluate their performance | K3 |
| **CO5** | Demonstrate understanding of quantum error correction and quantum cryptographic protocols | K3 |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | | H | H | M | |
| **CO2** | M | | H | H | M | |
| **CO3** | | | H | H | | |
| **CO4** | | | M | H | M | |
| **CO5** | | | H | H | M | |

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **Experiment– 1** | Classical vs Quantum Bits Simulation<br>• Implement a basic program to show difference between bit and qubit (superposition of states). | 3Hrs |

| | | |
|---|---|---|
| **Experiment– 2** | Single Qubit Gates<br>Implement and visualize operations of Pauli-X, Y, Z, Hadamard, Phase gates on Bloch Sphere | 3Hrs |
| **Experiment– 3** | Multiple Qubit Gates<br>Design and execute a CNOT gate and show how entanglement arises | 3Hrs |
| **Experiment– 4** | Superposition & Measurement<br>• Apply Hadamard to \|0⟩, measure in both computational and Hadamard basis. | 4Hrs |
| **Experiment– 5** | Bell State Preparation & Verification<br>• Generate Bell states using Hadamard + CNOT and verify entanglement. | 3Hrs |
| **Experiment– 6** | Deutsch Algorithm Implementation<br>Implement and test Deutsch's Algorithm for constant and balanced functions | 4Hrs |
| **Experiment– 7** | Deutsch–Jozsa Algorithm<br>Demonstrate exponential speed-up over classical algorithms | 4Hrs |
| **Experiment– 8** | Grover's Algorithm<br>• Implement Grover's search for finding a marked element in an unsorted dataset. | 3Hrs |
| **Experiment– 9** | Shor's Algorithm (Simulation)<br>• Demonstrate factoring small numbers (e.g., 15) on a quantum simulator. | 4Hrs |
| **Experiment– 10** | Quantum Cryptography & Teleportation<br>• Simulate BB84 protocol and quantum teleportation using entangled qubits. | 4Hrs |
| | **Total** | 45Hrs |