

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
University Constituent Engineering Colleges
M. Tech. in ARTIFICIAL INTELLIGENCE & DATA SCIENCE
COURSE STRUCTURE AND SYLLABUS (R25)
EFFECTIVE FROM ACADEMIC YEAR 2025-26 ADMITTED BATCH

I YEAR I SEMESTER

Course Code	Course Title	L	T	P	Credits
Professional Core – I	Artificial Intelligence and Intelligent Systems	3	0	0	3
Professional Core – II	Statistical Foundations for Data Science	3	0	0	3
Professional Elective – I	1. Data Analytics 2. Mining of Massive Datasets 3. Data Engineering 4. Database Programming with PL/SQL	3	0	0	3
Professional Elective – II	1. Federated Machine Learning 2. Generative AI 3. Natural Language Processing 4. Prompt Engineering	3	0	0	3
Lab – I	Artificial Intelligence and Intelligent Systems Lab	0	0	4	2
Lab – II	Professional Elective – I Lab	0	0	4	2
	Research Methodology & IPR	2	0	0	2
Audit – I	Audit Course – I	2	0	0	0
	Total	16	0	8	18

I YEAR II SEMESTER

Course Code	Course Title	L	T	P	Credits
Professional Core – III	Neural Networks & Deep Learning	3	0	0	3
Professional Core – IV	Predictive Analytics	3	0	0	3
Professional Elective – III	1. Big Data Technologies 2. Data Stream Processing 3. Enterprise Cloud Concepts 4. Augmented Reality and Virtual Reality	3	0	0	3
Professional Elective – IV	1. Reinforcement Learning 2. Machine Translation 3. Large Language Models 4. Social Media Mining	3	0	0	3
Lab – III	Neural Networks & Deep Learning Lab	0	0	4	2
Lab – IV	Professional Elective – III Lab	0	0	4	2
	Mini Project with Seminar	0	0	4	2
Audit – II	Audit Course – II	2	0	0	0
	Total	14	0	12	18

II YEAR I SEMESTER

Course Code	Course Title	L	T	P	F	Credits
Professional Elective – V	1. Agentic AI 2. Computer Vision and Robotics 3. Nature Inspired Computing 4. Quantum Computing	3	0	0		3
Open Elective	Open Elective	3	0	0		3
Dissertation	Dissertation Work Review – II*	0	0	0	12	6
	Total	6	0	0	12	12

II YEAR II SEMESTER

Course Code	Course Title	L	T	P	F	Credits
Dissertation	Dissertation Work Review – III*	0	0	0	12	6
Dissertation	Dissertation Viva-Voce	0	0	0	28	14
	Total	0	0	0	40	20

Note: For Dissertation Work Review - I, please refer 7.8 in R25 Academic Regulations.

Audit Course I & II:

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by yoga
8. Personality Development Through Life Enlightenment Skills

Open Electives for other Departments:

1. Foundations of Data Science
2. R Programming
3. Intrusion Detection Systems
4. Digital Forensics
5. Optimization Techniques
6. Cyber Physical Systems
7. Graph Analytics

Artificial Intelligence and Intelligent Systems (PC - I)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Pre-Requisites: UG level course in Mathematics, Data Structures

Course Objectives:

- To impart knowledge about Artificial Intelligence.
- To give understanding of the main abstractions and reasoning for intelligent systems.
- To enable the students to understand the basic principles of Artificial Intelligence in various applications.

Course Outcomes: After completion of course, students would be able to:

1. Solve basic AI based problems.
2. Define the concept of Artificial Intelligence.
3. Apply AI techniques to real-world problems to develop intelligent systems.
4. Select appropriately from a range of techniques when implementing intelligent systems.

UNIT - I

Introduction: Overview of AI problems, AI problems as NP, NP-Complete and NP Hard problems. Strong and weak, neat and scruffy, symbolic and sub-symbolic, knowledge-based and data-driven AI.

UNIT -II

Search Strategies: Problem spaces (states, goals and operators), problem solving by search, Heuristics and informed search, Min-max Search, Alpha-beta pruning. Constraint satisfaction (backtracking and local search methods).

UNIT - III

Knowledge representation and reasoning: propositional and predicate logic, Resolution and theorem proving, Temporal and spatial reasoning. Probabilistic reasoning, Bayes theorem. Totally-ordered and partially-ordered Planning. Goal stack planning, Nonlinear planning, Hierarchical planning.

UNIT - IV

Learning: Learning from example, Learning by advice, Explanation based learning, Learning in problem solving, Classification, Inductive learning, Naive Bayesian Classifier, decision trees.

Natural Language Processing: Language models, n-grams, Vector space models, Bag of words, Text classification. Information retrieval.

UNIT - V

Agents: Definition of agents, Agent architectures (e.g., reactive, layered, cognitive), Multi-agent systems- Collaborating agents, Competitive agents, Swarm systems and biologically inspired models.

Intelligent Systems: Representing and Using Domain Knowledge, Expert System Shells, Explanation, Knowledge Acquisition.

Key Application Areas: Expert system, decision support systems, Speech and vision, Natural language processing, Information Retrieval, Semantic Web.

Textbooks:

1. Artificial Intelligence: A Modern Approach by S. Russell and P. Norvig, Prentice Hall

Reference Books:

1. Artificial Intelligence by Elaine Rich, Kevin Knight and Shivashankar B Nair, Tata McGraw Hill.
2. Introduction to Artificial Intelligence and Expert Systems by Dan W. Patterson, Pearson Education.

Statistical Foundations for Data Science (PC - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Prerequisites: Mathematics courses of first year of study.

Course Objectives:

- The Number Theory basic concepts useful for cryptography etc
- The theory of Probability, and probability distributions of single and multiple random variables
- The sampling theory and testing of hypothesis and making inferences
- Stochastic process and Markov chains.

Course Outcomes: After learning the contents of this course, the student must be able to

1. Apply the number theory concepts to cryptography domain
2. Apply the concepts of probability and distributions to some case studies
3. Correlate the material of one unit to the material in other units
4. Resolve the potential misconceptions and hazards in each topic of study.

UNIT - I

Greatest Common Divisors and Prime Factorization: Greatest common divisors, The Euclidean algorithm, The fundamental theorem of arithmetic, Factorization of integers and the Fermat numbers
Congruences: Introduction to congruences, Linear congruences, The Chinese remainder theorem, Systems of linear congruences

UNIT - II

Simple Linear Regression and Correlation: Introduction to Linear Regression, The Simple Linear Regression Model, Least Squares and the Fitted Model, Properties of the Least Squares Estimators, Inferences Concerning the Regression Coefficients, Prediction, Simple Linear Regression Case Study
Random Variables and Probability Distributions: Concept of a Random Variable, Discrete Probability Distributions, Continuous Probability Distributions, Statistical Independence. Discrete Probability Distributions: Binomial Distribution, Poisson distribution.

UNIT - III

Continuous Probability Distributions: Normal Distribution, Areas under the Normal Curve, Applications of the Normal Distribution, Normal Approximation to the Binomial, Fundamental Sampling Distributions: Random Sampling, Sampling Distributions, Sampling, Distribution of Means and the Central Limit Theorem, Sampling Distribution of S^2 , t-Distribution, F Distribution.

UNIT - IV

Estimation & Tests of Hypotheses: Introduction, Statistical Inference, Classical Methods of Estimation. Estimating the Mean, Standard Error of a Point Estimate, Prediction Intervals, Tolerance Limits, Estimating the Variance, Estimating a Proportion for single mean, Difference between Two Means, between Two Proportions for Two Samples and Maximum Likelihood Estimation.

UNIT - V

Stochastic Processes and Markov Chains: Introduction to Stochastic processes- Markov process. Transition Probability, Transition Probability Matrix, First order and Higher order Markov process, n step transition probabilities, Markov chain, Steady state condition, Markov analysis.

Text Books:

1. Kenneth H. Rosen, Elementary number theory & its applications, sixth edition, AddisonWesley, ISBN 978 0-321-50031-1
2. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye, Probability & Statistics for Engineers & Scientists, 9th Ed. Pearson Publishers.
3. S. D. Sharma, Operations Research, Kedarnath and Ramnath Publishers, Meerut, Delhi

Reference Books:

1. S C Gupta and V K Kapoor, Fundamentals of Mathematical statistics, Khanna publications
2. T.T. Soong, Fundamentals of Probability And Statistics For Engineers, John Wiley & Sons Ltd, 2004.
3. Sheldon M Ross, Probability and statistics for Engineers and scientists, Academic Press.

Data Analytics (Professional Elective - I)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Prerequisites

1. A course on "Database Management Systems".
2. Knowledge of probability and statistics.

Course Objectives:

1. To explore the fundamental concepts of data analytics.
2. To learn the principles and methods of statistical analysis
3. Discover interesting patterns, analyze supervised and unsupervised models and estimate the accuracy of the algorithms.
4. To understand the various search methods and visualization techniques.

Course Outcomes: After completion of this course students will be able to

1. Understand the impact of data analytics for business decisions and strategy
2. Carry out data analysis/statistical analysis
3. To carry out standard data visualization and formal inference procedures
4. Design Data Architecture
5. Understand various Data Sources

UNIT - I

Data Management: Design Data Architecture and manage the data for analysis, understand various sources of Data like Sensors/Signals/GPS etc. Data Management, Data Quality(noise, outliers, missing values, duplicate data) and Data Processing & Processing.

UNIT - II

Data Analytics: Introduction to Analytics, Introduction to Tools and Environment, Application of Modeling in Business, Databases & Types of Data and Variables, Data Modeling Techniques, Missing Imputations etc. Need for Business Modeling.

UNIT - III

Regression – Concepts, Blue property assumptions, Least Square Estimation, Variable Rationalization, and Model Building etc.

Logistic Regression: Model Theory, Model fit Statistics, Model Construction, Analytics applications to various Business Domains etc.

UNIT - IV

Object Segmentation: Regression Vs Segmentation – Supervised and Unsupervised Learning, TreeBuilding – Regression, Classification, Overfitting, Pruning and Complexity, Multiple Decision Trees etc.

Time Series Methods: Arima, Measures of Forecast Accuracy, STL approach, Extract features from generated model as Height, Average Energy etc and Analyze for prediction

UNIT - V

Data Visualization: Pixel-Oriented Visualization Techniques, Geometric Projection Visualization Techniques, Icon-Based Visualization Techniques, Hierarchical Visualization Techniques, Visualizing Complex Data and Relations.

Text Books:

1. Student's Handbook for Associate Analytics – II, III.
2. Data Mining Concepts and Techniques, Han, Kamber, 3rd Edition, Morgan Kaufmann Publishers.

Reference Books:

1. Introduction to Data Mining, Tan, Steinbach and Kumar, Addison Wesley, 2006.
2. Data Mining Analysis and Concepts, M. Zaki and W. Meira
3. Mining of Massive Datasets, Jure Leskovec Stanford Univ. Anand Rajaraman Millway Labs
Jeffrey D Ullman Stanford Univ.

Mining Massive Datasets (Professional Elective - I)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Prerequisites:

1. Students should be familiar with Data mining, algorithms, basic probability theory and Discrete math.

Course Objectives:

- This course will cover practical algorithms for solving key problems in mining of massive datasets.
- This course focuses on parallel algorithmic techniques that are used for large datasets.
- This course will cover stream processing algorithms for data streams that arrive constantly, page ranking algorithms for web search, and online advertisement systems that are studied in detail.

Course Outcomes:

1. Handle massive data using MapReduce.
2. Develop and implement algorithms for massive data sets and methodologies in the context of data mining.
3. Understand the algorithms for extracting models and information from large datasets
4. Develop recommendation systems.
5. Gain experience in matching various algorithms for particular classes of problems.

UNIT - I

Data Mining-Introduction-Definition of Data Mining-Statistical Limits on Data Mining,

MapReduce and the New Software Stack-Distributed File Systems, MapReduce, Algorithms Using MapReduce.

UNIT - II

Similarity Search: Finding Similar Items-Applications of Near-Neighbor Search, Shingling of Documents, Similarity-Preserving Summaries of Sets, Distance Measures.

Streaming Data: Mining Data Streams-The Stream Data Model , Sampling Data in a Stream, Filtering Streams

UNIT - III

Link Analysis-PageRank, Efficient Computation of PageRank, Link Spam

Frequent Itemsets-Handling Larger Datasets in Main Memory, Limited-Pass Algorithms, Counting Frequent Items in a Stream.

Clustering-The CURE Algorithm, Clustering in Non-Euclidean Spaces, Clustering for Streams and Parallelism

UNIT - IV

Advertising on the Web-Issues in On-Line Advertising, On-Line Algorithms, The Matching Problem, The Adwords Problem, Adwords Implementation.

Recommendation Systems- A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering, Dimensionality Reduction, The Netflix Challenge.

UNIT - V

Mining Social-Network Graphs-Social Networks as Graphs, Clustering of Social-Network Graphs, Partitioning of Graphs, Simrank, Counting Triangles

Text Books:

1. Jure Leskovec, Anand Rajaraman, Jeff Ullman, Mining of Massive Datasets, 3rd Edition.

Reference Books:

1. Jiawei Han & Micheline Kamber , Data Mining – Concepts and Techniques 3rd Edition Elsevier.
2. Margaret H Dunham , Data Mining Introductory and Advanced topics, PEA.
3. Ian H. Witten and Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann.

Data Engineering (Professional Elective - I)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives:

- Learn the Basics and Importance of Data Engineering.
- Understand the Steps in Handling Data.
- Design Scalable, Reliable Data Systems.
- Explore Data Tools and Technologies.

Course Outcomes:

On successful completion of this course, students will be able to:

1. Explain data engineering fundamentals, lifecycle, and organizational role.
2. Analyze technologies and architectures for effective data systems.
3. Apply methods for scalable and reliable data storage and ingestion.
4. Design data models, queries, and transformations for analytics and ML.
5. Evaluate security, privacy, and emerging trends in data engineering.

UNIT – I

Foundations of Data Engineering

Data Engineering Defined, Data Engineering Skills and Activities, Data Engineers in Organizations, Data Engineering Lifecycle, Major Undercurrents across the Lifecycle, Designing Good Data Architecture, Principles of Good Data Architecture, Examples and Types of Data Architecture.

UNIT – II

Technologies across the Data Engineering Lifecycle

Considerations for choosing Data technology across Data Engineering lifecycle, Optimization, Performance challenges, Data Generation in Source Systems, Time in Data Systems, Source System Practical Details, Impact of undercurrents on source systems.

UNIT – III

Storage and Ingestion

Ingredients of Data Storage, Data Storage systems, Data Engineering Storage Abstractions, Data Ingestion, Key Engineering Considerations for the Ingestion Phase, Batch Ingestion Considerations, Message and Stream Ingestion Considerations, Ways to Ingest Data.

UNIT – IV

Queries, Modelling, Transformation and Serving Data

Queries, Data Modeling, Transformations, Upstream and Downstream Stakeholders, Serving Data for Analytics, Machine Learning, Ways to Serve Data for Analytics and ML, Reverse ETL.

UNIT – V

Security, Privacy, and Future of Data Engineering

Security and Privacy: People, Processes, Technology, The Data Engineering Lifecycle is here, Decline of Complexity, The Cloud-Scale Data OS, Enterprisey Data Engineering, Moving Beyond the Modern Data Stack, Toward the Live Data Stack.

Text Books:

1. Fundamentals of Data Engineering by Joe Reis and Matt Housley, First Edition, O'Reilly Media.

Database Programming with PL/SQL (Professional Elective - I)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives:

1. Knowledge on significance of SQL fundamentals.
2. Evaluate functions and triggers of PL/SQL
3. Knowledge on control structures, packages in PL/SQL and its applications

Course Outcomes:

1. Understand importance of PL/SQL basics
2. Implement functions and procedures using PL/SQL
3. Understand the importance of triggers in database

UNIT - I

PL/SQL Basics

Block Structure, Behavior of Variables in Blocks, Basic Scalar and Composite Data Types, Control Structures, Exceptions, Bulk Operations, Functions, Procedures, and Packages, Transaction Scope

UNIT - II

Language Fundamentals & Control Structures

Lexical Units, Variables and Data Types, Conditional Statements, Iterative Statements, Cursor Structures, Bulk Statements, Introduction to Collections, Object Types: Varray and Table Collections, Associative Arrays, Oracle Collection API

UNIT - III

Functions and Procedures

Function and Procedure Architecture, Transaction Scope, Calling Subroutines, Positional Notation, Named Notation, Mixed Notation, Exclusionary Notation, SQL Call Notation, Functions, Function Model Choices, Creation Options, Pass-by-Value Functions, Pass-by-Reference Functions, Procedures, Pass-by-Value Procedures, Pass-by-Reference Procedures, Supporting Scripts.

UNIT - IV

Packages

Package Architecture, Package Specification, Prototype Features, Serially Reusable Precompiler Directive, Variables, Types, Components: Functions and Procedures, Package Body, Prototype Features, Variables, Types, Components: Functions and Procedures, Definer vs. Invoker Rights Mechanics, Managing Packages in the Database Catalog, Finding, Validating, and Describing Packages, Checking Dependencies, Comparing Validation Methods: Timestamp vs. Signature.

UNIT - V

Triggers

Introduction to Triggers, Database Trigger Architecture, Data Definition Language Triggers, Event Attribute Functions, Building DDL Triggers, Data Manipulation Language Triggers, Statement-Level Triggers, Row-Level Triggers, Compound Triggers, INSTEAD OF Triggers, System and Database Event Triggers, Trigger Restrictions, Maximum Trigger Size, SQL Statements, LONG and LONG RAW Data Types.

Textbooks:

1. Oracle Database 12c PL/SQL Programming Michael McLaughlin, McGrawHill Education

References:

1. Benjamin Rosenzweig, Elena Silvestrova Rakhimov, Oracle PL/SQL by example Fifth Edition
2. Dr. P. S. Deshpande, SQL & PL / SQL for Oracle 11g Black Book

Federated Machine Learning (Professional Elective - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Prerequisites

The prerequisite knowledge for this course includes machine learning, basic computer systems and basic programming skills.

Course Objectives

- Understand the key concepts and issues behind Federated Learning
- Get familiar with key theoretical results of Federated Learning

Course Outcomes

1. Understand the basics on privacy-preserving ML
2. Analyze the key concepts of Distributed ML and FL
3. Understand the key concepts and applications of Horizontal FL and Vertical FL
4. Motivates the intensive mechanism design for FL
5. Analyze the concepts of federated reinforcement learning

UNIT - I

Introduction: Motivation, Federated Learning as a Solution, The Definition of Federated Learning, Categories of Federated Learning, Current Development in Federated Learning, Research Issues in Federated Learning, Open-Source Projects, Standardization Efforts, The Federated AI Ecosystem
Background: Privacy-Preserving Machine Learning, PPML and Secure ML, Threat and Security Models, Privacy Threat Models, Adversary and Security Models, Privacy Preservation Techniques, Secure Multi-Party Computation, Homomorphic Encryption, Differential Privacy

UNIT - II

Distributed Machine Learning: Introduction to DML, The Definition of DML, DML Platforms, Scalability-Motivated DML, Large-Scale Machine Learning, Scalability-Oriented DML Schemes, Privacy-Motivated DML, Privacy-Preserving Decision Trees, Privacy-Preserving Techniques, Privacy-Preserving DML Schemes, Privacy-Preserving Gradient Descent, Vanilla Federated Learning, Privacy-Preserving Methods

UNIT - III

Horizontal Federated Learning: The Definition of HFL, Architecture of HFL, The Client- Server Architecture, The Peer-to-Peer Architecture, Global Model Evaluation, The Federated Averaging Algorithm, Federated Optimization, The FedAvg Algorithm, The Secured FedAvg Algorithm, Improvement of the FedAvg Algorithm, Communication Efficiency, Client Selection Vertical Federated Learning: The Definition of VFL, Architecture of VFL, Algorithms of VFL, Secure Federated Linear Regression, Secure Federated Tree-Boosting

UNIT - IV

Federated Transfer Learning: Heterogeneous Federated Learning, Federated Transfer Learning, The FTL Framework, Additively Homomorphic Encryption, The FTL Training Process, The FTL Prediction Process, Security Analysis, Secret Sharing-Based FTL Incentive Mechanism Design for Federated Learning: Paying for Contributions, Profit- Sharing Games, Reverse Auctions, A Fairness-Aware Profit Sharing Framework, Modeling Contribution, Modeling Cost, Modeling Regret, Modeling Temporal Regret, The Policy Orchestrator, Computing Payoff Weightage

UNIT - V

Federated Learning for Vision, Language, and Recommendation: Federated Learning for Computer Vision, Federated CV, Federated Learning for NLP, Federated NLP, Federated Learning for Recommendation Systems, Recommendation Model, Federated Recommendation System

Federated Reinforcement Learning:

Introduction to Reinforcement Learning, Policy, Reward, Value Function, Model of the Environment, RL Background Example, Reinforcement Learning Algorithms, Distributed Reinforcement Learning, Asynchronous Distributed Reinforcement Learning, Synchronous Distributed Reinforcement Learning,

Federated Reinforcement Learning, Background and Categorization

Textbooks:

1. Federated Learning, Qiang Yang, Yang Liu, Yong Cheng, Yan Kang, Tianjian Chen, and Han Yu
Synthesis Lectures on Artificial Intelligence and Machine Learning 2019

Generative AI (Professional Elective - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives

- To introduce the foundations, evolution, and core concepts of AI, ML, DL, NLP, and Generative AI.
- To develop understanding of advanced neural architectures and generative models such as GANs, VAEs, and Transformers.
- To explore Large Language Models, prompt engineering, and their real-world applications.
- To familiarize learners with frameworks, multimodal applications, and ethical considerations in Generative AI.

Course Outcomes

1. Demonstrate knowledge of AI foundations, generative models, and advanced neural architectures.
2. Apply generative AI techniques to create solutions for text, image, video, and multimodal tasks.
3. Design, fine-tune, and optimize Large Language Models for specific applications.
4. Evaluate ethical, social, and legal implications of Generative AI deployments and propose mitigation strategies.

UNIT - I

Foundations of AI and Generative Models: Introduction and historical evolution to Artificial Intelligence (AI), Machine Learning (ML), Natural Language Processing (NLP) and Deep Learning (DL), Structure of Artificial Neural Networks (ANNs), Mathematical and computational foundations of generative modeling, Overview of generative models and their applications across various domains; Importance of Generative AI in modern applications, Transfer learning and in advancing Generative AI

UNIT - II

Advanced Neural Architectures for Generative AI: Variational Autoencoders (VAEs): principles and applications, Generative Adversarial Networks (GANs): architecture and working principles; Transformer architecture and attention mechanisms (in detail); Long Short-Term Memory Networks (LSTMs) and the limitations of traditional RNNs/LSTMs, Advanced Transformer architectures and techniques, Pre-training and transfer learning strategies for generative models

UNIT - III

Large Language Models and Prompt Engineering: Overview of Large Language Models (LLMs), GPT architecture, variants, and working principles, Pre-training and fine-tuning GPT models for applications (e.g., chatbots, text generation), Case study: GPT-based customer support chatbot, BERT architecture, pre-training objectives, and fine-tuning, Prompt Engineering: Designing effective prompts, controlling model behavior, and improving output quality, Fine-tuning language models for creative writing and chatbot development

UNIT - IV

Multi-Agent Systems and Generative AI Applications: Introduction to Multi-Agent Systems (MAS), Types of agents: reactive, deliberative, hybrid, and learning agents, Multi-agent collaboration and orchestration for generative tasks, Use cases: autonomous research assistants, cooperative creative generation, distributed problem-solving, Frameworks and tools: AutoGen, CrewAI, Hugging GPT for LLM-powered multi-agent systems, Generative AI applications: Art, Creativity, Image/Video generation, Music composition, Healthcare, Finance, Real-world case studies and deployment challenges

UNIT - V

Frameworks, Multimodal Applications, and Ethics: Lang Chain framework: components and LLM application development, Retrieval-Augmented Generation (RAG), Embeddings, Indexing networks, and Vector databases, Generative AI across modalities: Text, Code, Image, and Video generation, Image and Video generation using GANs and VAEs, Multimodal Generative AI: integration and training strategies,

Ethical considerations: bias, fairness, trust, and responsible AI deployment, Social and legal implications of Generative AI, Risk mitigation strategies and real-world ethical case studies

Text Books

1. Altaf Rehmani, *Generative AI for Everyone: Understanding the Essentials and Applications of This Breakthrough Technology*.
2. Charu C. Aggarwal, *Neural Networks and Deep Learning: A Textbook*. Joseph Babcock, Raghav Bali, *Generative AI with Python and TensorFlow 2*, 2024.

Reference Books

1. Josh Kalin, *Generative Adversarial Networks Cookbook*.
2. Jesse Sprinter, *Generative AI in Software Development: Beyond the Limitations of Traditional Coding*, 2024.

Online References

1. Fabian Gloeckle et al., Better & Faster Large Language Models via Multi-token Prediction, arXiv:2404.19737v1, 2024. Vaswani et al., Attention Is All You Need, NeurIPS 2017.

Natural Language Processing (Professional Elective - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Prerequisites:

1. Data structures, finite automata and probability theory.

Course Objectives:

- Introduction to some of the problems and solutions of NLP and their relation to linguistics and statistics.

Course Outcomes:

1. Show sensitivity to linguistic phenomena and an ability to model them with formal grammars.
2. Understand and carry out proper experimental methodology for training and evaluating empirical NLP systems
3. Able to manipulate probabilities, construct statistical models over strings and trees, and estimate parameters using supervised and unsupervised training methods.
4. Able to design, implement, and analyze NLP algorithms Able to design different language modeling Techniques.
5. Able to design different language modeling Techniques.

UNIT - I

Finding the Structure of Words: Words and Their Components, Issues and Challenges, Morphological Models

Finding the Structure of Documents: Introduction, Methods, Complexity of the Approaches, Performances of the Approaches

UNIT - II

Syntax Analysis: Parsing Natural Language, Treebanks: A Data-Driven Approach to Syntax, Representation of Syntactic Structure, Parsing Algorithms, Models for Ambiguity Resolution in Parsing, Multilingual Issues

UNIT - III

Semantic Parsing: Introduction, Semantic Interpretation, System Paradigms, Word Sense Systems, Software.

UNIT - IV

Predicate-Argument Structure, Meaning Representation Systems, Software.

UNIT - V

Discourse Processing: Cohesion, Reference Resolution, Discourse Cohesion and Structure Language Modeling: Introduction, N-Gram Models, Language Model Evaluation, Parameter Estimation, Language Model Adaptation, Types of Language Models, Language-Specific Modeling Problems, Multilingual and Cross Lingual Language Modeling

TEXT BOOKS:

1. Multilingual natural Language Processing Applications: From Theory to Practice – Daniel M. Bikel and Imed Zitouni, Pearson Publication
2. Natural Language Processing and Information Retrieval: Tanvier Siddiqui, U.S. Tiwary

REFERENCES:

1. Speech and Natural Language Processing - Daniel Jurafsky & James H Martin, Pearson Publications

Prompt Engineering (Professional Elective - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives:

- To introduce the principles and techniques of effective prompt engineering for generative AI models.
- To understand the architecture, capabilities, and evolution of large language models such as GPT-3.5, GPT-4, Gemini, and LLaMA.
- To explore standard practices in structured and unstructured text generation using tools like ChatGPT.
- To apply chunking, tokenization, and formatting techniques for improving text generation and manipulation.
- To understand the role of embeddings, vector databases (FAISS, Pinecone), and Retrieval-Augmented Generation (RAG) in modern NLP systems.

Course Outcomes:

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

1. Explain and apply the core principles of prompt engineering for guiding generative AI outputs effectively.
2. Describe the underlying architecture and functionality of state-of-the-art large language models (LLMs).
3. Generate and manipulate structured outputs (JSON, YAML, CSV) using ChatGPT with advanced prompting techniques.
4. Implement text chunking, tokenization, and format control using tools like SpaCy, Tiktoken, and Python.
5. Utilize vector databases such as FAISS and Pinecone in Retrieval-Augmented Generation (RAG) pipelines for efficient information retrieval.

UNIT – I

Fundamentals and Principles of Prompting

Overview of the Five Principles of Prompting: Give Direction, Specify Format, Provide Examples, Evaluate Quality, Divide Labor.

UNIT – II

Introduction to Large Language Models for Text Generation

What Are Text Generation Models, Vector Representations: The Numerical Essence of Language, Transformer Architecture: Orchestrating Contextual Relationships, Probabilistic Text Generation: The Decision Mechanism, Historical Underpinnings: The Rise of Transformer Architectures, OpenAI's Generative Pretrained Transformers, GPT-3.5-turbo and ChatGPT, GPT-4, Google's Gemini, Meta's Llama and Open Source.

UNIT – III

Standard Practices for Text Generation with ChatGPT- Part-A

Generating Lists, Hierarchical List Generation, When to Avoid Using Regular Expressions, Generating JSON, YAMLFiltering YAML Payloads, Handling Invalid Payloads in YAML, Diverse Format Generation with ChatGPT, Mock CSV Data, Universal Translation Through LLMs, Ask for Context, Text Style Unbundling, Identifying the Desired Textual Features, Generating New Content with the Extracted Features, Extracting Specific Textual Features with LLMs.

UNIT – IV

Standard Practices for Text Generation with ChatGPT- Part-B

Chunking Text, Benefits of Chunking Text, Scenarios for Chunking Text, Poor Chunking Example, Chunking Strategies, Sentence Detection Using SpaCy, building a Simple Chunking Algorithm in Python, Sliding Window Chunking, Text Chunking Packages, Text Chunking with Tiktoken, Encodings, Understanding the Tokenization of Strings.

UNIT – V

Vector Databases with FAISS and Pinecone

Retrieval Augmented Generation (RAG), Introducing Embeddings, Document Loading
Memory Retrieval with FAISS, RAG with LangChain, Hosted Vector Databases with Pinecone, Self-Querying, Alternative Retrieval Mechanisms.

Textbook:

1. Phoenix J, Taylor M. Prompt engineering for generative AI. " O'Reilly Media, Inc."; 2024 May 16.

REFERENCES:

1. Tunstall L, Von Werra L, Wolf T. Natural language processing with transformers. " O'Reilly Media, Inc."; 2022 Jan 26.
2. Foster D. Generative deep learning. " O'Reilly Media, Inc."; 2022 Jun 28.

Artificial Intelligence and Intelligent Systems Lab (Lab - I)

M.Tech AI & DS I Year I Sem.

L	T	P	C
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Course Objectives:

- To provide skills for designing and analyzing AI based algorithms.
- To enable students to work on various AI tools.
- To provide skills to work towards solution of real-life problems

Course Outcomes:

1. Elicit, analyze and specify software requirements.
2. Simulate a given problem scenario and analyze its performance.
3. Develop programming solutions for given problem scenario.

List of Programs

1. Installation and working on various AI tools viz. Python, R tool, GATE, NLTK, MATLAB, etc.
2. Data preprocessing and annotation and creation of datasets.
3. Learn existing datasets and Treebanks
4. Implementation of searching techniques in AI.
5. Implementation of Knowledge representation schemes.
6. Natural language processing tool development.
7. Application of Machine learning algorithms.
8. Application of Classification and clustering problem.
9. Working on parallel algorithms.
10. Scientific distributions used in python for Data Science - Numpy, scifi, pandas, scikit learn, statsmodels, nltk.

Data Analytics Lab (Lab - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
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Course Objectives:

1. To explore the fundamental concepts of data analytics.
2. To learn the principles and methods of statistical analysis
3. Discover interesting patterns, analyze supervised and unsupervised models and estimate the accuracy of the algorithms.
4. To understand the various search methods and visualization techniques.

Course Outcomes:

1. Understand linear regression and logistic regression
2. Understand the functionality of different classifiers
3. Implement visualization techniques using different graphs
4. Apply descriptive and predictive analytics for different types of data

List of Experiments:

1. Data Preprocessing
 - a. Handling missing values
 - b. Noise detection removal
 - c. Identifying data redundancy and elimination
2. Implement any one imputation model
3. Implement Linear Regression
4. Implement Logistic Regression
5. Implement Decision Tree Induction for classification
6. Implement Random Forest Classifier
7. Implement ARIMA on Time Series data
8. Object segmentation using hierarchical based methods
9. Perform Visualization techniques (types of maps - Bar, Column, Line, Scatter, 3D Cubes etc)
10. Perform Descriptive analytics on Healthcare data
11. Perform Predictive analytics on Product Sales data
12. Apply Predictive analytics for Weather forecasting.

TEXT BOOKS:

1. Student's Handbook for Associate Analytics – II, III.
2. Data Mining Concepts and Techniques, Han, Kamber, 3rd Edition, Morgan Kaufmann Publishers.

REFERENCES:

1. Introduction to Data Mining, Tan, Steinbach and Kumar, Addison Wesley, 2006.
2. Data Mining Analysis and Concepts, M. Zaki and W. Meira
3. Mining of Massive Datasets, Jure Leskovec Stanford Univ. Anand Rajaraman Millway Labs
Jeffrey D Ullman Stanford Univ.

Mining Massive Datasets Lab (Lab-II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
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Prerequisites:

1. Students should be familiar with Data mining, algorithms, basic probability theory and Discrete math.

Course Objectives:

- This course will cover practical algorithms for solving key problems in mining of massive datasets.
- This course focuses on parallel algorithmic techniques that are used for large datasets.
- This course will cover stream processing algorithms for data streams that arrive constantly, page ranking algorithms for web search, and online advertisement systems that are studied in detail.

Course Outcomes:

1. Handle massive data using MapReduce.
2. Develop and implement algorithms for massive data sets and methodologies in the context of data mining.
3. Understand the algorithms for extracting models and information from large datasets
4. Develop recommendation systems.
5. Gain experience in matching various algorithms for particular classes of problems.

List of Experiments:

Implement the following exercises using Python/Java/Any other programming language of student choice

1. Count word frequencies in a text file.
2. Matrix–vector multiplication to simulate mapper and reducer output.
3. Compute the **Jaccard similarity** between two sets of words taken from two text files.
4. The **Reservoir sampling algorithm** to keep a fixed-size random sample of items from an incoming stream of integers. Feed it a stream of 10,000 numbers and maintain a sample of size 100.
5. Compare two sampling methods (e.g., random sampling vs. systematic sampling) on the same stream. Plot how representative the sample is.
6. Measure and plot false positive rates on a graph at different filter sizes and hash counts.
7. Construct the transition matrix of a given graph and compute PageRank as the stationary distribution of the Markov chain.
8. Simplified CURE clustering algorithm.
9. To find all frequent itemsets(given minimum support) using Apriori algorithm.
10. The Greedy Adwords algorithm.
11. Balance Algorithm and compare it with Greedy on the same dataset.
12. The Girvan–Newman community detection algorithm.
13. Compute the graph Laplacian and its eigenvectors for a given graph; use the second eigenvector (Fiedler vector) to partition the graph into two communities.

Text Books:

1. Jure Leskovec, Anand Rajaraman, Jeff Ullman, Mining of Massive Datasets, 3rd Edition.

Reference Books:

1. Jiawei Han & Micheline Kamber , Data Mining – Concepts and Techniques 3rd Edition Elsevier.
2. Margaret H Dunham , Data Mining Introductory and Advanced topics, PEA.

3. Ian H. Witten and Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques, Morgan Kaufmann.

Data Engineering Lab (Lab-II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
0	0	4	2

Course Objectives:

1. Learn how data is collected, cleaned, transformed, and stored.
2. Understand how to process, analyze, and secure data.
3. Apply techniques to visualize and present results.

Course Outcomes:

1. Use preprocessing and transformation techniques on datasets.
2. Work with databases to store and query data.
3. Apply tools like Apache Kafka, Flink, Airflow, and Spark for processing.
4. Perform basic Data analysis and modeling.
5. Create simple visualizations and dashboards.
6. Secure Data using authentication, encryption, and masking.

Experiments:

1. **MongoDB – Database**
 - a) Implement Data Storage using MongoDB
 - b) Perform Querying Operations in MongoDB
 - c) Demonstrate Sharding in MongoDB
2. **Data Collection:** Collect and store data from multiple sources and formats.
3. **Data Preprocessing:** Clean tabular data, handle missing values, remove noise, and perform feature selection.
4. **Data Transformation:** Normalize, scale, and encode data (converting string/categorical values into numerical form) to prepare it for analysis and modeling.
5. **Data Storage and Processing**
 - a) Implement real-time data ingestion by producing and consuming messages using Apache Kafka.
 - b) Perform stream processing on real-time data (filtering or aggregating records) using Apache Flink.
 - c) Create and execute a workflow (DAG) in Apache Airflow to schedule and manage data pipeline tasks.
 - d) Use Apache Spark for large-scale data processing and storage by loading, transforming, and querying datasets.
6. **Data Analytics:** Perform Data analysis and apply statistical/machine learning techniques to extract insights from data.
7. **Data Visualization:** Create visualizations and build dashboards to display transformed data.
8. **Data Security:** Implement Data Encryption and Masking.

Text Books

1. Rhodes, Ethan M. Mastering Modern Data Engineering: Building Scalable and Reliable Data Pipelines with Spark, Airflow, Kafka, and Cloud. Packt Publishing, 2023.
2. J. Brownlee, Data Preparation for Machine Learning: Data Cleaning, Feature Selection, and Data Transforms in Python. Machine Learning Mastery, 2020.
3. Bradshaw, Shannon, Eoin Brazil, and Kristina Chodorow. *MongoDB: The Definitive Guide*. 3rd ed., O'Reilly Media, 2020.

Database Programming with PL/SQL Lab (Lab - II)

M.Tech AI & DS I Year I Sem.

L	T	P	C
0	0	4	2

Course Objectives:

1. Knowledge on significance of SQL fundamentals.
2. Evaluate functions and triggers of PL/SQL
3. Knowledge on control structures, packages in PL/SQL and its applications

Course Outcomes:

1. Understand importance of PL/SQL basics
2. Implement functions and procedures using PL/SQL
3. Understand the importance of triggers in database

List of Experiments:

1. Write a PL/SQL program using FOR loop to insert ten rows into a database table.
2. Given the table EMPLOYEE (EmpNo, Name, Salary, Designation, DeptID), write a cursor to select the five highest paid employees from the table.
3. Illustrate how you can embed PL/SQL in a high-level host language such as C/Java And demonstrates how a banking debit transaction might be done.
4. Given an integer i, write a PL/SQL procedure to insert the tuple (i, 'xxx') into a given relation.
5. Write a PL/SQL program to demonstrate Exceptions.
6. Write a PL/SQL program to demonstrate Cursors.
7. Write a PL/SQL program to demonstrate Functions.
8. Write a PL/SQL program to demonstrate Packages.
9. Write PL/SQL queries to create Procedures.
10. Write PL/SQL queries to create Triggers.

Research Methodology & IPR

M.Tech AI & DS I Year I Sem.

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2	0	0	2

Prerequisite: None

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

Course Outcomes: At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT - I

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

UNIT - II

Effective literature studies approaches, analysis, Plagiarism, Research ethics

UNIT - III

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

UNIT - IV

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

UNIT - V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
2. C.R. Kothari, Research Methodology, methods & techniques, 2nd edition, New age International publishers

REFERENCES:

1. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Asimov, "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Neural Networks & Deep Learning (PC - III)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives:

- To introduce the foundations of Artificial Neural Networks
- To acquire the knowledge on Deep Learning Concepts
- To learn various types of ANN architectures
- To gain knowledge to apply optimization strategies

Course Outcomes:

1. Understand the concepts of Neural Networks
2. Apply optimization strategies for large scale applications
3. Use an efficient algorithm for Deep Models
4. Select the right ANN architecture for the real world problems

UNIT - I

Artificial Neural Networks Introduction, Basic models of ANN, important terminologies, Supervised Learning Networks, Perceptron Networks, Adaptive Linear Neuron, Back-propagation Network. Associative Memory Networks. Training Algorithms for pattern association, BAM and Hopfield Networks.

UNIT - II

Regularization for Deep Learning

Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Regularization and Under-Constrained Problems, Dataset Augmentation, Noise Robustness, Semi-Supervised Learning, Multi-Task Learning, Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging and Other Ensemble Methods, Dropout, Adversarial Training, Tangent Distance, Tangent Prop, and Manifold Tangent Classifier, Optimization for Training Deep Models, Learning vs Pure Optimization, Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates

UNIT - III

Convolutional Networks

The Convolution Operation, Motivation, Pooling, Convolution and Pooling as an Infinitely Strong Prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features

UNIT - IV

Recurrent and Recursive Nets

Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory

UNIT - V

Practical Methodology: Performance Metrics, Default Baseline Models, Determining Whether to Gather More Data, Selecting Hyperparameters, Debugging Strategies, Example: Multi-Digit Number Recognition

Applications: Large-Scale Deep Learning, Computer Vision, Speech Recognition, Natural Language Processing, Other Applications.

TEXT BOOKS:

1. B. Yegnanarayana, Artificial Neural Networks, PHI
2. Deep Learning: An MIT Press Book By Ian Goodfellow and Yoshua Bengio and Aaron Courville

Predictive Analytics (PC - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives

The course serves to advance and refine expertise on theories, approaches and techniques related to prediction and forecasting

Course Outcomes

1. Understand prediction-related principles, theories and approaches.
2. Learn model assessment and validation.
3. Understand the basics of predictive techniques and statistical approaches.
4. Analyze supervised and unsupervised algorithms

UNIT - I

Linear Methods for Regression and Classification: Overview of supervised learning, Linear regression models and least squares, Multiple regression, Multiple outputs, Subset selection, Ridge regression, Lasso regression, Linear Discriminant Analysis, Logistic regression, Perceptron learning algorithm.

UNIT - II

Model Assessment and Selection : Bias, Variance, and model complexity, Bias-variance trade off, Optimism of the training error rate, Estimate of In-sample prediction error, Effective number of parameters, Bayesian approach and BIC, Cross-validation, Bootstrap methods, conditional or expected test error.

UNIT - III

Additive Models, Trees, and Boosting: Generalized additive models, Regression and classification trees, Boosting methods-exponential loss and AdaBoost, Numerical Optimization via gradient boosting, Examples (Spam data, California housing, New Zealand fish, Demographic data)

UNIT - IV

Neural Networks(NN), Support Vector Machines(SVM), and K-nearest Neighbor: Fitting neural networks, Back propagation, Issues in training NN, SVM for classification, Reproducing Kernels, SVM for regression, K-nearest –Neighbour classifiers(Image Scene Classification)

UNIT - V

Unsupervised Learning and Random forests: Association rules, Cluster analysis, Principal Components, Random forests and analysis.

Textbook:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning-Data Mining, Inference, and Prediction, Second Edition, Springer Verlag, 2009

References:

1. C.M.Bishop –Pattern Recognition and Machine Learning, Springer, 2006
2. L.Wasserman-All of statistics
3. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani. An Introduction to Statistical Learning with Applications in R

Big Data Technologies (Professional Elective - III)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives

- The purpose of this course is to provide the students with knowledge of Big data Analytics principles and techniques.
- This course is also designed to give an exposure of the frontiers of Big data Analytics

Courses Outcomes

1. Ability to explain the foundations, definitions, and challenges of Big Data and various Analytical tools.
2. Ability to program using HADOOP and Map reduce, NOSQL
3. Ability to understand the importance of Big Data in Social Media and Mining.

UNIT - I

Getting an Overview of Big Data

Big Data, History of Data Management – Evolution of Big Data, Structuring Big Data, Elements of Big Data, Big Data Analytics, Careers in Big Data, Future of Big Data

Technologies for Handling Big Data

Distributed and Parallel Computing for Big Data, Introducing Hadoop, Cloud Computing and Big Data, In-Memory Computing Technology for Big Data.

UNIT - II

Understanding Hadoop Ecosystem

Hadoop Ecosystem, Hadoop Distributed File System, MapReduce, Hadoop YARN, Hbase, Hive, Pig and Pig Latin, Sqoop, ZooKeeper, Flume, Oozie

Understanding MapReduce Fundamentals and HBase

The MapReduce Framework, Techniques to Optimize MapReduce Jobs, Uses of MapReduce, Role of HBase in Big Data Processing

UNIT - III

Exploring Hive

Introducing Hive, Getting Started with Hive, Data Types in Hive, Built-In Functions in Hive, Hive DDL, Data Manipulation in Hive, Data Retrieval Queries, Using JOINS in Hive

Analyzing Data with Pig

Introducing Pig, Running Pig, Getting Started with Pig Latin, Working with Operators in Pig, Working with Functions in Pig

UNIT - IV

Using Oozie

Introducing Oozie, Installing and Configuring Oozie, Understanding the Oozie Workflow, Oozie Coordinator, Oozie Bundle, Oozie Parameterization with EL, Oozie Job Execution Model, Accessing Oozie, Oozie SLA

NoSQL Data Management

Introduction to NoSQL, Aggregate Data Models, Key Value Data Model, Document Databases, Relationships, Graph Databases, Schema-Less Databases, Materialized Views, Distribution Models, Sharding, MapReduce Partitioning and Combining, Composing MapReduce Calculations

UNIT - V

Zookeeper: Installing and Running ZooKeeper, An Example, Group Membership in ZooKeeper, Creating the Group, Joining a Group, Listing Members in a Group, The ZooKeeper Service, Data Model, Operations, Implementation, Consistency, Sessions, Building Applications with ZooKeeper, A Configuration, Service, The Resilient ZooKeeper Application, A Lock Service, More Distributed Data Structures and Protocols, ZooKeeper in Production

Sqoop: Getting Sqoop, Sqoop Connectors, A Sample Import, Generated Code, Imports: A Deeper Look, Working with Imported Data, Importing Large Objects, Performing an Export, Exports: A Deeper Look

Textbooks:

1. Big data, blackbook, DreamTech Press, 2015
2. Hadoop: The Definitive Guide, Tom White, 3rd Edition, O'Reilly Media, 2012.

References:

1. Big Data Analytics, Seema Acharya, Subhashini Chellappan, Wiley 2015.
2. Simon Walkowiak, Big Data Analytics with R, Packt Publishing, ISBN: 9781786466457
3. Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Business, Michael Minelli, Michehe Chambers, 1st Edition, Ambiga Dhiraj, Wiley CIO Series, 2013.
4. Big Data Analytics: Disruptive Technologies for Changing the Game, Arvind Sathi, 1st Edition, IBM Corporation, 2012.

Data Stream Processing (Professional Elective-III)

M.Tech AI & DS I Year II Sem.

L	T	P	C
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Course Objectives

- Introduce the student to use cases of stream processing, the data stream model
- Present algorithmic techniques for stream processing, including map-and-reduce.
- Present current techniques on monitoring parallel and distributed streams.
- Implement streams in the continuous distributed monitoring model, and the parallel streaming model.
- Provide practical perspective on building software for stream processing

Course Outcomes

1. Explain the need for stream processing
2. Comprehend the architectures of stream processing.
3. Explain and run Distributed Processing and Resilience Model
4. Design effective streaming solutions using Structured Streaming
5. Design effective streaming solutions using Spark Streaming

UNIT - I

Introduction To Stream Processing Model

Fundamentals of Stream Processing: What Is Stream Processing? Examples of Stream Processing- Scaling Up Data Processing- Distributed Stream Processing- Introducing Apache Spark. Stream-Processing Model: Sources and Sinks- Immutable Streams Defined from One Another Transformations and Aggregations- Window Aggregations - Stateless and Stateful Processing- The Effect of Time.

UNIT - II

Streaming Architectures

Components of a Data Platform- Architectural Models- The Use of a Batch-Processing Component in a Streaming Application- Referential Streaming Architectures- Streaming Versus Batch Algorithms. Apache Spark as a Stream-Processing Engine: Spark's Memory Usage- Understanding Latency- Throughput Oriented Processing- Fast Implementation of Data Analysis

UNIT - III

Distributed Processing And Resilience Model

Spark's Distributed Processing Model: Running Apache Spark with a Cluster Manager- Spark's Own Cluster Manager - Resilience and Fault Tolerance in a Distributed System- Data Delivery Semantics- Micro Batching and One-Element-at-a-Time - Bringing Micro batch and One-Record-at a- Time Closer Together- Dynamic Batch Interval- Structured Streaming Processing Model. Spark's Resilience Model: Resilient Distributed Datasets in Spark - Spark Components - Spark's Fault-Tolerance Guarantees.

UNIT - IV

Structured Streaming

Introducing Structured Streaming- The Structured Streaming Programming Model – Structured Streaming in Action – Structured Streaming Sources – Structured Streaming Sinks - Event Time– Based Stream Processing.

UNIT - V

Spark Streaming

Introducing Spark Streaming - The Spark Streaming Programming Model - The Spark Streaming Execution Model - Spark Streaming Sources - Spark Streaming Sinks - Time-Based Stream Processing- Working with Spark SQL – Checkpointing - Monitoring Spark Streaming- Performance Tuning.

Text Books:

1. Gerard Maas and François Garillot , “Stream Processing with Apache Spark: Mastering Structured Streaming and Spark Streaming”, O'Reilly, 2019.

Reference Books:

1. Henrique C. M. Andrade, Buğra Gedik and Deepak S. Turaga, “Fundamentals of Stream Processing: Application Design, Systems, and Analytics”, Cambridge University Press, 2014.
2. Bryon Ellis, “Real-Time Analytics: Techniques to Analyze and Visualize Streaming Data”, Wiley, 1st edition, 2014.
3. Anindita Basak, Krishna Venkataraman, Ryan Murphy, Manpreet Singh, “Stream Analytics with Microsoft Azure”, Packt Publishing, December 2017.

Web references:

1. <https://github.com/stream-processing-with-spark>

E -Text Books:

1. <https://www.edx.org/course/processing-real-time-data-streams-in-azure>
2. <https://www.coursera.org/learn/big-data-integration-processing>

Enterprise Cloud Concepts (Professional Elective - III)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives:

Knowledge on significance of cloud computing and its fundamental concepts and models.

Course Outcomes:

1. Understand importance of cloud architecture
2. Illustrating the fundamental concepts of cloud security
3. Analyze various cloud computing mechanisms
4. Understanding the architecture and working of cloud computing.

UNIT - I

Understanding Cloud Computing:

Origins and influences, Basic Concepts and Terminology, Goals and Benefits, Risks and Challenges.

Fundamental Concepts and Models:

Roles and Boundaries, Cloud Characteristics, Cloud Delivery Models, Cloud Deployment Models.

UNIT - II

Cloud-Enabling Technology:

Broadband Networks and Internet Architecture, Data Center Technology, Virtualization Technology

Cloud Infrastructure Mechanisms: Logical Network Perimeter, Virtual Server, Cloud Storage Device, Cloud Usage Monitor, Resource Replication

UNIT - III

Cloud Management Mechanisms: Remote Administration System, Resource Management System, SLA Management System, Billing Management System, Case Study Example

Fundamental Cloud Architectures :Workload Distribution Architecture, Resource Pooling Architecture, Dynamic Scalability Architecture, Elastic Resource Capacity Architecture, Service Load Balancing Architecture, Cloud Bursting Architecture, Elastic Disk Provisioning Architecture, Redundant Storage Architecture, Case Study Example

UNIT - IV

Cloud-Enabled Smart Enterprises

Introduction, Revisiting the Enterprise Journey, Service-Oriented Enterprises, Cloud Enterprises, Smart Enterprises, The Enabling Mechanisms of Smart Enterprises

Cloud-Inspired Enterprise Transformations

Introduction, The Cloud Scheme for Enterprise Success, Elucidating the Evolving Cloud Idea, Implications of the Cloud on Enterprise Strategy, Establishing a Cloud-Incorporated Business Strategy

UNIT - V

Transitioning to Cloud-Centric Enterprises

The Tuning Methodology, Contract Management in the Cloud

Cloud-Instigated IT Transformations

Introduction, Explaining Cloud Infrastructures, A Briefing on Next-Generation Services, Service Infrastructures, Cloud Infrastructures, Cloud Infrastructure Solutions, Clouds for Business Continuity, The Relevance of Private Clouds, The Emergence of Enterprise Clouds

Text Books:

1. Erl Thomas, Puttini Ricardo, Mahmood Zaigham, Cloud Computing: Concepts, Technology & Architecture 1st Edition,
2. Pethuru Raj, Cloud Enterprise Architecture, CRC Press

References:

1. James Bond, The Enterprise Cloud, O'Reilly Media, Inc.

Augmented Reality and Virtual Reality (Professional Elective - III)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course objectives

- The objective of this course is to provide a foundation to the fast growing field of AR and make the students aware of the various AR devices.
- To give historical and modern overviews and perspectives on virtual reality. It describes the fundamentals of sensation, perception, technical and engineering aspects of virtual reality systems.

Course Outcomes

1. Describe how AR systems work and list the applications of AR.
2. Understand and analyze the hardware requirement of AR.
3. Describe how VR systems work and list the applications of VR.
4. Understand the design and implementation of the hardware that enables VR systems to be built.

UNIT - I: Introduction to Augmented Reality

What Is Augmented Reality - Defining augmented reality, history of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality Augmented Reality Concepts- How Does Augmented Reality Work? Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

UNIT - II: AR Devices & Components

AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene
AR Devices – Optical See- Through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, Video see-through systems

UNIT - III: Introduction to Virtual Reality

Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality

UNIT - IV: Representing the Virtual World

Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR
CaseStudy: GHOST (General Haptics Open Software Toolkit) software development toolkit.

UNIT - V: Visual Perception & Rendering

Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information
Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates.

Text Books:

1. Allan Fowler-AR Game Development II, 1st Edition, A press Publications, 2018, ISBN 978-1484236178
2. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016

References:

1. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016), ISBN-10: 9332578494
2. Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers,

San Francisco, CA, 2002

3. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009
4. Designing for Mixed Reality, Kharis O'Connell Published by O'Reilly Media, Inc., 2016, ISBN: 9781491962381
5. Sanni Siltanen- Theory and applications of marker-based augmented reality. Julkaisija –Utgivare Publisher. 2012. ISBN 978-951-38-7449-0
6. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.

Reinforcement Learning (Professional Elective - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives

- Knowledge on fundamentals of reinforcement learning and the methods used to create agents that can solve a variety of complex tasks.

Course Outcomes

1. Understand basics of RL
2. Understand RL Framework and Markov Decision Process
3. Analyzing RL through the use of Dynamic Programming and Monte Carlo
4. Understand TD(0) algorithm, TD(λ) algorithm

UNIT - I

Basics of probability and linear algebra, Definition of a stochastic multi-armed bandit, Definition of regret, Achieving sublinear regret, UCB algorithm, KL-UCB, Thompson Sampling.

UNIT - II

Markov Decision Problem, policy, and value function, Reward models (infinite discounted, total, finite horizon, and average), Episodic & continuing tasks, Bellman's optimality operator, and Value iteration & policy iteration

UNIT - III

The Reinforcement Learning problem, prediction and control problems, Model-based algorithm, Monte Carlo methods for prediction, and Online implementation of Monte Carlo policy evaluation

UNIT - IV

Bootstrapping; TD(0) algorithm; Convergence of Monte Carlo and batch TD(0) algorithms; Model-free control: Q-learning, Sarsa, Expected Sarsa.

UNIT - V

n-step returns; TD(λ) algorithm; Need for generalization in practice; Linear function approximation and geometric view; Linear TD(λ). Tile coding; Control with function approximation; Policy search; Policy gradient methods; Experience replay; Fitted Q Iteration; Case studies.

Textbooks:

1. "Reinforcement learning: An introduction," First Edition, Sutton, Richard S., and Andrew G. Barto, MIT press 2020
2. "Statistical reinforcement learning: modern machine learning approaches," First Edition, Sugiyama, Masashi. CRC Press 2015

References:

1. "Bandit algorithms," First Edition, Lattimore, T. and C. Szepesvári. Cambridge University Press. 2020
2. "Reinforcement Learning Algorithms: Analysis and Applications," Boris Belousov, Hany Abdulsamad, Pascal Klink, Simone Parisi, and Jan Peters First Edition, Springer 2021
3. Alexander Zai and Brandon Brown "Deep Reinforcement Learning in Action," First Edition, Manning Publications 2020

Machine Translation (Professional Elective - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives:

1. To teach students machine translation approaches.
2. To evaluate the performance of machine translation Systems.
3. To develop translation models for Indian Languages.

Course Outcomes: Upon the Successful Completion of the Course, the Students would be able to:

1. Understand machine translation approaches.
2. Apply and assess manual and automatic evaluation methods for machine translation.
3. Build machine translation model using existing tools for machine translation.

UNIT - I

Introduction to Machine Translation, MT Approaches: vauquois Triangle, Three major paradigms of Machine Translation, MT Evaluation

UNIT - II

Learning Bilingual word Mappings

A Combinatorial Argument, Deeper look at one- one alignment, Heuristic based Computation of the V_E * V_F Table, Iterative Computation of the V_E * V_F Table, EM: Study of progress in Parameter values

UNIT - III

Phrase based Machine Translation

Need for phrase alignment, An example to illustrate phrase alignment technique, Phrase table, Mathematics of Phrase based SMT, Decoding, Moses.

UNIT - IV

Rule based Machine Translation (RBMT)

Two kinds of RBMT: Interlingua and Transfer, Universal networking Language(UNL), UNL expressions as binary predicates, Interlingua and Word Knowledge, Translation using Interlingua, Details of english to UNL Conversion: with illustration, Transfer based MT.

UNIT - V

Example based Machine Translation

Essential steps of EBMT, EBMTs working, EBMT and case based reasoning, Text similarity computation, EBMT and Translation Memory, EBMT and SMT.

Textbooks:

1. Pushpak Bhattacharyya, Machine Translation, CRC Press

References:

1. Statistical Machine Translation by Philipp Koehn, Cambridge University Press.
2. Deep Learning by Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press.
3. Linguistic Fundamentals for Natural Language Processing by Emily Bender, Morgan & Claypool.

Large Language Models (Professional Elective - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives

- To introduce the foundations of transformer architectures and their evolution into LLMs.
- To equip students with skills to train, fine-tune, and deploy LLMs for various tasks.
- To explore ethical, legal, and societal implications of LLMs in real-world applications.
- To expose students to state-of-the-art LLM frameworks, evaluation techniques, and research trends.

Course Outcomes (COs)

1. Understand the architecture and inner workings of transformer-based LLMs.
2. Apply prompt engineering and fine-tuning techniques for domain-specific tasks.
3. Evaluate LLM performance using standard metrics and benchmarks.
4. Identify challenges in LLM training, deployment, and scaling.
5. Analyze ethical, legal, and societal implications of LLM usage.

UNIT - I

Foundations of Large Language Models

Introduction to LLMs: Definition, scope, and historical evolution from statistical NLP to transformers. The Transformer architecture: Attention mechanisms, self-attention, multi-head attention. Pretraining objectives: Masked language modeling (MLM), Causal language modeling (CLM). Evolution of LLMs: BERT, GPT series, T5, LLaMA, Mistral.

UNIT - II

Training and Fine-Tuning LLMs

Pretraining datasets and tokenization: BPE, SentencePiece, WordPiece. Fine-tuning approaches: Full fine-tuning, LoRA, adapters, instruction tuning. Domain adaptation and few-shot/zero-shot learning. Data augmentation for LLMs and prompt-based tuning.

UNIT - III

Prompt Engineering and Applications

Principles of prompt design: Zero-shot, few-shot, and chain-of-thought prompting. System prompts, role prompting, and context length optimization.

Use cases: Text generation, summarization, code generation, question answering, chatbots. Tools & frameworks: Lang Chain, Llama Index, Hugging Face Transformers.

UNIT - IV

Evaluation and Deployment of LLMs

Evaluation metrics: Perplexity, BLEU, ROUGE, METEOR, human evaluation.

Benchmark datasets: GLUE, SuperGLUE, HELM, BIG-bench.

Deployment strategies: API-based deployment, on-prem deployment, inference optimization.

Scaling and latency considerations; quantization and pruning for LLMs.

UNIT - V

Ethics, Safety, and Future Directions

Bias, fairness, and toxicity in LLMs. Hallucination problem and mitigation techniques. Legal and regulatory issues: Copyright, data privacy, AI Act. Trends in LLM research: Multimodal LLMs, retrieval-augmented generation (RAG), open-source LLM ecosystems.

Textbooks:

1. Vaswani, A. et al. (2017) *Attention Is All You Need* – NIPS Conference Paper.
2. Lewis, P. et al. (2021) *Language Models are Few-Shot Learners* – OpenAI Research Paper.
3. Tunstall, L., von Werra, L., & Wolf, T. (2022) *Natural Language Processing with Transformers* – O'Reilly Media.

Reference Books

1. Bommasani, R. et al. (2021) *On the Opportunities and Risks of Foundation Models* – Stanford CRFM.
2. Jurafsky, D., & Martin, J. H. (2023) *Speech and Language Processing* (3rd Edition draft) – Pearson.
3. Mollick, E., & Mollick, L. (2024) *Co-Intelligence: Living and Working with AI* – Little, Brown Spark.
4. Hugging Face Documentation – <https://huggingface.co/docs/>

Social Media Mining (Professional Elective - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
3	0	0	3

Course Objectives:

- The objective of this course is to study techniques for modeling, analyzing, and understanding large-scale social media and dynamic processes over social and information networks, as well as to explore the connection between qualitative and quantitative methods of social media mining.

Course Outcomes:

1. Understand the social media mining and its challenges
2. Analyze how to detect communities and influencers
3. Understand Community analysis
4. Measuring Assortative, Influence, Homophily, Recommendation in Social Media

UNIT - I

Introduction

What is Social Media Mining, New Challenges for social media Mining

Graph Essentials

Graph Basics, Graph Representation, Types of Graphs, Connectivity in Graphs, Special Graphs, Graph Algorithms

UNIT - II

Network Measures

Centrality, Transitivity and Reciprocity, Balance and Status, Similarity.

Network Models

Properties of Real-World Networks, Random Graphs, Small-World Model, Preferential Attachment Model

UNIT - III

Data Mining Essentials

Data, Data Preprocessing, Data Mining Algorithms, Supervised Learning, Unsupervised Learning

Community Analysis

Community Detection, Community Evaluation, Community Evaluation

UNIT - IV

Information Diffusion in Social Media

Herd Behavior, Information Cascades, Diffusion of innovations, Epidemics

Influence and Homophily

Measuring Assortativity, Influence, Homophily, Distinguishing Influence and Homophily

UNIT - V

Recommendation in Social Media

Challenges, Classical Recommendation Algorithms, Recommendation Using Social Context, Evaluating Recommendations

Behavior Analytics

Individual Behavior, Collective Behavior.

Text Books:

1. Social Media Mining (An Introduction), Reza Zafarani, Mohammad Ali Abbasi, Huan Liu, Cambridge University Press, Draft Version: April 20, 2014

References:

1. Mining the Social Web, 2nd Edition Data Mining Face book, Twitter, LinkedIn, Google+, GitHub, and More, Matthew A. Russell Publisher: O'Reilly Media.
2. Social Media Mining with R [Kindle Edition] NATHAN DANNEMAN RICHARD HEIMANN

Neural Networks & Deep Learning (Lab - III)

M.Tech AI & DS I Year II Sem.

L	T	P	C
0	0	4	2

Course Objectives:

- Introduce the foundations and principles of Artificial Neural Networks (ANNs) and their role in machine learning.
- Develop understanding of Deep Learning paradigms and modern neural network architectures.
- To learn various ANN architectures, including feed-forward, convolutional, recurrent, and associative networks.
- Impart knowledge of optimization and regularization strategies for effective training of deep neural networks.
- To apply ANN and deep learning techniques to real-world problems in computer vision, speech, and natural language processing.

Course Outcomes:

1. Understand the fundamental concepts of neural networks and deep learning models.
2. Design and implement various ANN architectures such as Perceptrons, Multi-Layer Networks, CNNs, and RNNs for different tasks.
3. Apply optimization and regularization techniques (e.g., SGD, adaptive learning rates, L1/L2 penalties, dropout, early stopping) to train deep models effectively.
4. Evaluate and analyze neural network models using relevant performance metrics to ensure accuracy and reliability.
5. Select and deploy appropriate architectures for solving complex real-world problems in computer vision, NLP, speech recognition, and large-scale data processing.

LIST OF PROGRAMS

1. Write a program to create and train a single-layer perceptron to separate linearly separable data.
2. Build a multi-layer neural network from scratch to solve the XOR problem using back propagation.
3. Implement a 2-layer MLP (input-hidden-output) for MNIST digit classification.
4. Train a Multi-Layer Perceptron (MLP) on the CIFAR-10 dataset using the following configurations:
 - a. L1/L2 regularization
 - b. Dropout
 - c. Early stopping
5. Build and train a simple CNN (e.g., on fashion-MNIST or CIFAR-10 dataset).
6. Implement an RNN to predict the next character in a string sequence.
7. Compare performances of RNN and LSTM on sequential data such as stock prices or word sequences.
8. Build a bidirectional RNN for sentiment analysis.
9. Train an encoder-decoder RNN for sequence translation
10. Build a deep CNN model to recognize multi-digit numbers from images similar to SVHN dataset.
11. Write a program to implement RNN/LSTM for simple speech-to-text conversion.
12. Build a deep learning model to classify sentiment from movie reviews or tweets.

Reference Books:

1. Géron A. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc."; 2022 Oct 4.
2. Zhang, A., Lipton, Z. C., Li, M., & Smola, A. J. (2023). *Dive into deep learning*. Cambridge University Press.
3. Chollet, Francois. *Deep learning with Python*. simon and schuster, 2021.

Additional Resources

1. <https://nptel.ac.in/courses/106106184>
2. <https://github.com/Gaurav0502/deep-learning-lab>
3. <https://github.com/roatienza/Deep-Learning-Experiments>

Big Data Technologies Lab (Lab - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
0	0	4	2

Course Objectives

- The purpose of this course is to provide the students with the knowledge of Big data Analytics principles and techniques.
- This course is also designed to give an exposure of the frontiers of Big data Analytics

Course Outcomes

1. Use Excel as an Analytical tool and visualization tool.
2. program using HADOOP and Map reduce
3. perform data analytics using ML in R.
4. Use cassandra to perform social media analytics

List of Experiments

1. Implement a simple map-reduce job that builds an inverted index on the set of input documents (Hadoop)
2. Process big data in HBase
3. Store and retrieve data in Pig
4. Perform Social media analysis using cassandra
5. Buyer event analytics using Cassandra on suitable product sales data.
6. Using Power Pivot (Excel) Perform the following on any dataset
 - a. Big Data Analytics
 - a. Big Data Charting

Use R-Project to carry out statistical analysis of big data

Use R-Project for data visualization of social media data

Textbooks:

1. Big Data Analytics, SeemaAcharya, Subhashini Chellappan, Wiley 2015.
2. Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Business, Michael Minelli, Michehe Chambers, 1st Edition, AmbigaDhiraj, Wiely CIO Series, 2013.
3. Hadoop: The Definitive Guide, Tom White, 3rd Edition, O'Reilly Media, 2012.
4. Big Data Analytics: Disruptive Technologies for Changing the Game, Arvind Sathi, 1st Edition, IBM Corporation, 2012.

References:

1. Big Data and Business Analytics, Jay Liebowitz, Auerbach Publications, CRC press (2013)

2. Using R to Unlock the Value of Big Data: Big Data Analytics with Oracle R Enterprise and Oracle R Connector for Hadoop, Tom Plunkett, Mark Hornick, McGraw-Hill/Osborne Media (2013), Oracle press.
3. Professional Hadoop Solutions, Boris Iublinky, Kevin t. Smith, Alexey Yakubovich, Wiley, ISBN: 9788126551071, 2015.
4. Understanding Big data, Chris Eaton, Dirk deroos et al. , McGraw Hill, 2012.
5. Intelligent Data Analysis, Michael Berthold, David J. Hand, Springer, 2007.
6. Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Bill Franks, 1st Edition, Wiley and SAS Business Series, 2012.

Data Stream Processing Lab (Lab - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
0	0	4	2

Course Objectives

- To teach the students basics of SPA programs and its execution
- To teach the students the differences between Structured streaming and spark streaming.
- To make the students learn concepts like data sources and data sinks.
- To make the students understand pipeline Processing of a stream
- To make the students understand the usage of Streaming application.
- To teach the student, to develop real time application using spark.

Course Outcomes

1. Able to Install and Configure Apache Spark, Scala IDE, and JDK
2. Able to write Spark Streaming program to count words and print tweets
3. Able to use RDD and read .txt/.csv files into RDD
4. Develop a Stream Processing Application
5. Implement Stream Processing using Structured Streaming

List Of Experiments:

1.
 - a. Installing and configuring Apache Spark
 - b. Installing and configuring the Scala IDE
 - c. Installing and configuring JDK
2. Write your own Spark Streaming program, to count the number of words in text data received from a data server listening on a TCP socket
3. Write a simple Spark Streaming program that prints a sample of the tweets it receives from Twitter every second.
4. Create Spark RDD using parallelize with sparkContext.parallelize() method and using Spark shell
5. Write a script in Spark to Read all text files from a directory into a single RDD
6. Write a spark program to load a CSV file into Spark RDD using a Scala
7. Write a Spark Streaming program for adding 1 to the stream of integers in a reliable, fault tolerant manner, and then visualize them.
8. Develop a streaming application by- Connecting to a Stream, Preparing the Data in the Stream, Performing Operations on Streaming Dataset, creating a Query, Starting the Stream Processing and Exploring the data.
9. Create a Structured streaming job by Initializing Spark, acquiring streaming data from sources, declaring the operations we want to apply to the streaming data and outputting the resulting data using Sinks.
10. a. Create a small but complete Internet of Things (IoT)-inspired streaming program.

- b. Define the schema in Structured Streaming to handle the data at different levels.
- 11. Create custom sinks to write data to systems not supported by the default implementations.
- 12. Develop any Spark Streaming application and do the following:
 - a. Create a Spark Streaming Context,
 - b. Define one or several DStreams from data sources or other DStreams
 - c. Define one or more output operations to materialize the results of these DStream operations
 - d. Start the Spark Streaming Context to get the stream processing going

Text Books:

- 1. Stream Processing with Apache Spark: Mastering Structured Streaming and Spark Streaming- Gerard Maas , Francois Garillot .

Enterprise Cloud Concepts Lab (Lab - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
0	0	4	2

Course Objectives:

Knowledge on significance of cloud computing and its fundamental concepts and models.

Course Outcomes:

- Understand importance of cloud architecture
- Illustrating the fundamental concepts of cloud security
- Analyze various cloud computing mechanisms
- Understanding the architecture and working of cloud computing.

List of Experiments:

1. Install Virtualbox/VMware Workstation with different flavors of linux or windows OS on top of windows7 or 8.
2. Install a C compiler in the virtual machine created using virtual box and execute Simple Programs
3. Install Google App Engine. Create a hello world app and other simple web applications using python/java..
4. Find a procedure to transfer the files from one virtual machine to another virtual machine.
5. Find a procedure to launch virtual machine using trystack (Online Openstack Demo Version)
6. Install Hadoop single node cluster and run simple applications like word count.

E-Resources:

1. <https://www.iitk.ac.in/nt/fag/vbox.htm>
2. <https://www.google.com/urlsa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjqrNG0za73AhXZt1YBHZ21DWEQFnoECAMQAQ&url=http%3A%2F%2Fwww.cs.columbia.edu%2F~sedwards%2Fclasses%2F2015%2F1102-fall%2Flinuxvm.pdf&usq=AOvVaw3xZPuF5xVgk-AQnBRsTtHz>
3. <https://www.cloudsimtutorials.online/cloudsim/>
4. <https://edwardsamuel.wordpress.com/2014/10/25/tutorial-creating-openstack-instance-in-trystack/>
5. <https://www.edureka.co/blog/install-hadoop-single-node-hadoop-cluster>

Augmented Reality and Virtual Reality lab (Lab - IV)

M.Tech AI & DS I Year II Sem.

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- Understand augmented reality and Virtual reality to develop 3D virtual environment.

COURSE OUTCOMES:

1. Create and deploy a VR application.
2. Identify, examine and develop software that reflects fundamental techniques for the design and deployment of VR experiences.
3. Create 3D scenes with Unity and experiment with various user interface (UI) techniques that are used in VR applications.
4. Create a 2D game in Unity.
5. Choose, develop, explain and defend the use of particular designs for VR experiences.

List of Experiments:

1. Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same.
2. Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
3. Develop a scene in Unity that includes:
 - I. a cube, plane and sphere, apply transformations on the 3 game objects.
 - II. Add a video and audio source.
4. Develop a scene in Unity that includes a cube, plane and sphere. Create a new material and texture separately for three Game objects. Change the colour, material and texture of each Game object separately in the scene. Write a C# program in visual studio to change the colour and material /texture of the game objects dynamically on button click.
5. Develop a scene in Unity that includes a sphere and plane . Apply Rigid body component, material and Box collider to the game Objects. Write a C# program to grab and throw the sphere using vr controller.
6. Develop a simple UI(User interface) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene.
7. Create an immersive environment (living room/ battlefield/ tennis court) with only static game objects. 3D game objects can be created using Blender or use available 3D
8. Include animation and interaction in the immersive environment created in Week – 7.
9. Develop a VR Ball Game. The scene should contain a play area surrounded by four walls and a ball that acts as a player. The objective of the game is to keep the ball rolling without colliding with the walls. If it collides with either of the walls, the wall color should change and a text should display on the screen indicating the collision.
10. Develop a VR Golf Game. The scene should contain a play area (golf course), which consists of a series of cups/holes each having different scores. Display the score card.
11. Develop a VR game in Unity such that on each gun trigger click, destroy the cubes placed on the plane and gain a score point . Make a score UI and display it on the screen.
12. Develop a VR Basketball Game. The scene should contain a basketball court. The developed game should be a single player game. The objective of the game is to let the player put the ball in the basket maximum number of times. Display the score card.

TEXT BOOKS

1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016.
2. Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002.
3. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.
4. Allan Fowler-AR Game Developmentll, 1st Edition, A press Publications, 2018, ISBN 978-1484236178.
5. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016),ISBN-10: 933257849

REFERENCE BOOKS

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging Real and Virtual Worlds", 2005.
4. Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003.
5. Designing for Mixed Reality, Kharis O'Connell Published by O'Reilly Media, Inc., 2016, ISBN:9781491962381.
6. Sanni Siltanen- Theory and applications of marker-based augmented reality. Julkaisija – Utgivare Publisher. 2012. ISBN 978-951-38-7449-0

Agentic AI (Professional Elective - V)

M.Tech AI & DS II Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives

- To introduce the fundamental concepts of intelligent agents, environments, and their properties
- To understand various agent architectures including reflex, model-based, goal-based, and utility-based models
- To explore knowledge management systems, memory models, and document retrieval techniques for agents
- To study learning mechanisms, feedback loops, and coordination strategies within multi-agent systems
- To analyze deliberative, reactive, and hybrid agent architectures along with real-world case studies

Course Outcomes

After completing this course, students will be able to:

1. Explain the concepts of agents, environments, rationality, and autonomy
2. Compare and contrast agent architectures including simple reflex, model-based, goal-based, and utility-based agents
3. Apply knowledge management techniques including memory systems, embeddings, similarity search, and RAG pipelines
4. Analyze cooperation, coordination, and task orchestration strategies in multi-agent systems
5. Design and evaluate deliberative, reactive, BDI, and hybrid agent architectures with reference to real-world applications

UNIT – I

Knowledge Management & Memory Systems: Introduction to AI agents and memory systems, types of memory: semantic, episodic, conversational, knowledge bases and document retrieval systems, embeddings and similarity search, Retrieval-Augmented Generation (RAG) pipelines, context injection and prompt engineering

UNIT – II

Feedback Loops & Self-Improvement: Concept of agent feedback loops, Reinforcement Learning from Human Feedback (RLHF) fundamentals, reward modeling and optimization, performance monitoring and error detection, iterative fine-tuning and continuous improvement, safety and alignment considerations

UNIT – III

Multi-Agent Systems: Overview of multi-agent systems and architectures, agent collaboration strategies and communication protocols, task delegation and orchestration, role-based agent systems (planner, executor, critic), emergent behavior and coordination challenges, multi-agent evaluation methods

UNIT – IV

Foundations of Agentic AI: Introduction to AI and agents, intelligent agents and their properties, types of environments including deterministic, stochastic, episodic, and dynamic, concept of rationality and autonomy, architectures for agents including simple reflex, model-based reflex, goal-based and utility-based agents.

UNIT – V

Agent Architectures and Design: Deliberative and reactive architectures, belief-desire-intention (BDI) model, hybrid agent architectures, case studies on practical implementation of agent architectures.

Textbooks:

1. M. Lanham, *AI Agents in Action*. Shelter Island, NY, USA: Manning Publications, 2024.
2. M. Wooldridge, *An Introduction to MultiAgent Systems*, 2nd ed. Hoboken, NJ, USA: Wiley, 2009.

Computer Vision and Robotics (Professional Elective - V)

M.Tech AI & DS II Year I Sem.

L	T	P	C
3	0	0	3

Pre Requisites: UG level Course in Linear Algebra and Probability.

Course Objectives:

- To understand the Fundamental Concepts Related To sources, shadows and shading
- To understand the The Geometry of Multiple Views

Course Outcomes:

1. Implement fundamental image processing techniques required for computer vision
2. Implement boundary tracking techniques
3. Apply chain codes and other region descriptors, Hough Transform for line, circle, and ellipse detections.
4. Apply 3D vision techniques and Implement motion related techniques.
5. Develop applications using computer vision techniques.

UNIT - I

CAMERAS: Pinhole Cameras

Radiometry – Measuring Light: Light in Space, Light Surfaces, Important Special Cases

Sources, Shadows, And Shading: Qualitative Radiometry, Sources and Their Effects, Local Shading Models, Application: Photometric Stereo, Interreflections: Global Shading Models

Color: The Physics of Color, Human Color Perception, Representing Color, A Model for Image Color, Surface Color from Image Color.

UNIT - II

Linear Filters: Linear Filters and Convolution, Shift Invariant Linear Systems, Spatial Frequency and Fourier Transforms, Sampling and Aliasing, Filters as Templates,

Edge Detection: Noise, Estimating Derivatives, Detecting Edges

Texture: Representing Texture, Analysis (and Synthesis) Using Oriented Pyramids, Application: Synthesis by Sampling Local Models, Shape from Texture.

UNIT - III

The Geometry of Multiple Views: Two Views

Stereopsis: Reconstruction, Human Stereopsis, Binocular Fusion, Using More Cameras

Segmentation by Clustering: What Is Segmentation?, Human Vision: Grouping and Gestalt, Applications: Shot Boundary Detection and Background Subtraction, Image Segmentation by Clustering Pixels, Segmentation by Graph-Theoretic Clustering,

UNIT - IV

Segmentation by Fitting a Model:

The Hough Transform, Fitting Lines, Fitting Curves, Fitting as a Probabilistic Inference Problem, Robustness

Segmentation and Fitting Using Probabilistic Methods:

Missing Data Problems, Fitting, and Segmentation, The EM Algorithm in Practice,

Tracking With Linear Dynamic Models:

Tracking as an Abstract Inference Problem, Linear Dynamic Models, Kalman Filtering, Data Association, Applications and Examples

UNIT - V

Geometric Camera Models: Elements of Analytical Euclidean Geometry, Camera Parameters and the Perspective Projection, Affine Cameras and Affine Projection Equations

Geometric Camera Calibration: Least-Squares Parameter Estimation, A Linear Approach to Camera Calibration, Taking Radial Distortion into Account, Analytical Photogrammetry,

Case study: Mobile Robot Localization

Model- Based Vision:Initial Assumptions, Obtaining Hypotheses by Pose Consistency, Obtaining Hypotheses by pose Clustering, Obtaining Hypotheses Using Invariants, Verification, Case study: Registration In Medical Imaging Systems, Curved Surfaces and Alignment.

Text Books:

1. David A. Forsyth and Jean Ponce: Computer Vision – A Modern Approach, PHI Learning (Indian Edition), 2009.

References

1. E. R. Davies: Computer and Machine Vision – Theory, Algorithms and Practicalities, Elsevier (Academic Press), 4th edition, 2013.
2. R. C. Gonzalez and R. E. Woods “Digital Image Processing” Addison Wesley 2008.
3. Richard Szeliski “Computer Vision: Algorithms and Applications” Springer-Verlag London Limited 2011.

Nature Inspired Computing (Professional Elective - V)

M.Tech AI & DS II Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives:

Knowledge on significance of intelligence, genetic algorithms Ant Colony algorithms

Course Outcomes:

1. Familiar with Genetic algorithm and its applications.
2. Compare different Ant Colony Optimization algorithmic models.
3. Compare different Artificial Bee Colony Optimization algorithmic models.
4. Illustrate Particle swarm optimization algorithm with an example.

UNIT - I

Models of Life and Intelligence - Fundamentals of bio-inspired models and bio-inspired computing. Evolutionary models and techniques, Swarm models and its self-organization, swarm and evolutionary algorithms. Optimisation problems – single and multi-objective optimisation, heuristic, meta-heuristic and hyper heuristic functions.

UNIT - II

Genetic algorithms - Mathematical foundation, Genetic problem solving, crossover and mutation. genetic algorithms and Markov process, applications of genetic algorithms

UNIT - III

Ant Colony Algorithms - Ant colony basics, hybrid ant system, ACO in combinatorial optimisation, variations of ACO, case studies.

UNIT - IV

Particle Swarm algorithms - particles moves, particle swarm optimisation, variable length PSO, applications of PSO, case studies. Artificial Bee Colony algorithms - ABC basics, ABC in optimisation, multi-dimensional bee colony algorithms, applications of bee algorithms, case studies.

UNIT - V

Selected nature inspired techniques - Hill climbing, simulated annealing, Gaussian adaptation, Cuckoo search, Firey algorithm, SDA algorithm, bat algorithm, case studies. Other nature inspired techniques - Social spider algorithm, Cultural algorithms, Harmony search algorithm, Intelligent water drops algorithm, Artificial immune system, Flower pollination algorithm, case studies.

TEXT BOOKS:

1. Albert Y.Zomaya - "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006
2. Floreano, D. and C. Mattiussi - "Bio-Inspired Artificial Intelligence: Theories, methods, and Technologies" IT Press, 2008

REFERENCES:

1. Leandro Nunes de Castro - " Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007
2. Marco Dorigo, Thomas Stutzle - " Ant Colony Optimization", Prentice Hall of India, New Delhi, 2005
3. Vinod Chandra S S, Anand H S - "Machine Learning: A Practitioner's Approach", Prentice Hall of India, New Delhi, 2020

Quantum Computing (Professional Elective - V)

M.Tech AI & DS II Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives

- To introduce the fundamentals of quantum computing
- The problem solving approach using finite dimensional mathematics

Course Outcomes

1. Understand basics of quantum computing
2. Understand physical implementation of Qubit
3. Understand Quantum algorithms and their implementation
4. Understand The Impact of Quantum Computing on Cryptography

UNIT - I

Introduction to Essential Linear Algebra

Some Basic Algebra, Matrix Math, Vectors and Vector Spaces, Set Theory

Complex Numbers

Definition of Complex Numbers, Algebra of Complex Numbers, Complex Numbers Graphically, Vector Representations of Complex Numbers, Pauli Matrices, Transcendental Numbers

UNIT - II

Basic Physics for Quantum Computing

The Journey to Quantum, Quantum Physics Essentials, Basic Atomic Structure, Hilbert Spaces, Uncertainty, Quantum States, Entanglement

Basic Quantum Theory

Further with Quantum Mechanics, Quantum Decoherence, Quantum Electrodynamics, Quantum Chromodynamics, Feynman Diagram Quantum Entanglement and QKD, Quantum Entanglement, Interpretation, QKE

UNIT - III

Quantum Architecture

Further with Qubits, Quantum Gates, More with Gates, Quantum Circuits, The D-Wave Quantum Architecture

Quantum Hardware

Qubits, How Many Qubits Are Needed? Addressing Decoherence, Topological Quantum Computing, Quantum Essentials

UNIT - IV

Quantum Algorithms

What Is an Algorithm? Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Shor's Algorithm, Grover's Algorithm

UNIT - V

Current Asymmetric Algorithms: RSA, Diffie-Hellman, Elliptic Curve

The Impact of Quantum Computing on Cryptography: Asymmetric Cryptography, Specific Algorithms, Specific Applications

Textbooks:

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press
2. Dr. Chuck Easttom, Quantum Computing Fundamentals, Pearson

References:

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. Basic Concepts, Vol
3. Basic Tools and Special Topics, World Scientific. Pittenger A. O., An Introduction to Quantum Computing Algorithms

Fundamentals of Data Science (Open Elective)

M.Tech AI & DS II Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives:

- Learn concepts, techniques and tools they need to deal with various facets of data science practice, including data collection and integration
- Understand the basic types of data and basic statistics
- Identify the importance of data reduction and data visualization techniques

Course Outcomes:

1. Understand basic terms of statistical modeling and data science
2. Implementation of R programming concepts
3. utilize R elements for data visualization and prediction

UNIT - I Introduction

Definition of Data Science- Big Data and Data Science hype – and getting past the hype - Datafication - Current landscape of perspectives - Statistical Inference - Populations and samples - Statistical modeling, probability distributions, fitting a model – Over fitting.

Basics of R: Introduction, R-Environment Setup, Programming with R, Basic Data Types.

UNIT - II Data Types & Statistical Description

Types of Data: Attributes and Measurement, Attribute, The Type of an Attribute, The Different Types of Attributes, Describing Attributes by the Number of Values, Asymmetric Attributes, Binary Attribute, Nominal Attributes, Ordinal Attributes, Numeric Attributes, Discrete versus Continuous Attributes.

Basic Statistical Descriptions of Data: Measuring the Central Tendency: Mean, Median, and Mode, Measuring the Dispersion of Data: Range, Quartiles, Variance, Standard Deviation, and Interquartile Range, Graphic Displays of Basic Statistical Descriptions of Data.

UNIT - III

Vectors: Creating and Naming Vectors, Vector Arithmetic, Vector sub setting,

Matrices: Creating and Naming Matrices, Matrix Sub setting, Arrays, Class.

Factors and Data Frames: Introduction to Factors: Factor Levels, Summarizing a Factor, Ordered Factors, Comparing Ordered Factors, Introduction to Data Frame, subsetting of Data Frames, Extending Data Frames, Sorting Data Frames.

Lists: Introduction, creating a List: Creating a Named List, Accessing List Elements, Manipulating List Elements, Merging Lists, Converting Lists to Vectors

UNIT - IV

Conditionals and Control Flow: Relational Operators, Relational Operators and Vectors, Logical Operators, Logical Operators and Vectors, Conditional Statements.

Iterative Programming in R: Introduction, While Loop, For Loop, Looping Over List.

Functions in R: Introduction, writing a Function in R, Nested Functions, Function Scoping, Recursion, Loading an R Package, Mathematical Functions in R.

UNIT - V

Charts and Graphs: Introduction, Pie Chart: Chart Legend, Bar Chart, Box Plot, Histogram, Line Graph: Multiple Lines in Line Graph, Scatter Plot.

Regression: Linear Regression Analysis, Multiple Linear regression

TEXT BOOKS:

1. Doing Data Science, Straight Talk from The Frontline. Cathy O'Neil and Rachel Schutt, O'Reilly, 2014 .
2. K G Srinivas, G M Siddesh, "Statistical programming in R", Oxford Publications.

REFERENCE BOOKS:

1. Jiawei Han, Micheline Kamber and Jian Pei. Data Mining: Concepts and Techniques, 3rd ed. The Morgan Kaufmann Series in Data Management Systems.
2. Introduction to Data Mining, Pang-Ning Tan, Vipin Kumar, Michael Steinbach, Pearson Education.
3. John S. Everitt, "A Handbook of Statistical Analysis Using R", Second Edition, CRC, 2014.
4. Dalgaard, Peter, "Introductory statistics with R", Springer Science & Business Media, 2008.
5. Paul Teetor, "R Cookbook", O'Reilly, 2011.

R Programming (Open Elective)

M.Tech AI & DS II Year I Sem.

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Course Objectives:

- Understanding and being able to use basic programming concepts
- Automate data analysis
- Working collaboratively and openly on code
- Knowing how to generate dynamic documents
- Being able to use a continuous test-driven development approach

Course Outcomes:

1. Understand to use and program in the programming language R
2. Understand to use R to solve statistical problems
3. Implement and describe Monte Carlo the technology
4. Implement minimize and maximize functions using R

UNIT – I

Introduction: Overview of R, R data types and objects, reading and writing data, sub setting R Objects, Essentials of the R Language, Installing R, Running R, Packages in R, Calculations, Complex numbers in R, Rounding, Arithmetic, Modulo and integer quotients, Variable names and assignment, Operators, Integers, Factors, Logical operations

UNIT – II

Control structures, functions, scoping rules, dates and times, Introduction to Functions, preview of Some Important R Data Structures, Vectors, Character Strings, Matrices, Lists, Data Frames, Classes Vectors: Generating sequences, Vectors and subscripts, Extracting elements of a vector using subscripts, Working with logical subscripts, Scalars, Vectors, Arrays, and Matrices, Adding and Deleting Vector Elements, Obtaining the Length of a Vector, Matrices and Arrays as Vectors Vector Arithmetic and Logical Operations, Vector Indexing, Common Vector Operations

UNIT – III

Lists: Creating Lists, General List Operations, List Indexing Adding and Deleting List Elements, Getting the Size of a List, Extended Example: Text Concordance Accessing List Components and Values Applying Functions to Lists, DATA FRAMES, Creating Data Frames, Accessing Data Frames, Other Matrix-Like Operations

UNIT - IV

Factors And Tables: Factors and Levels, Common Functions Used with Factors, Working with Tables, Matrix/Array-Like Operations on Tables , Extracting a Subtable, Finding the Largest Cells in a Table, Math Functions, Calculating a Probability, Cumulative Sums and Products, Minima and Maxima, Calculus, Functions for Statistical Distributions

UNIT - V

Graphics: Creating Graphs, Customizing Graphs, Saving Graphs to Files, Customizing Graphs, Creating Three-Dimensional Plots.

Debugging: Fundamental Principles of Debugging, Why Use a Debugging Tool?, Using R Debugging Facilities, Moving Up in the World: More Convenient Debugging Tools, Ensuring Consistency in Debugging Simulation Code, Syntax and Runtime Errors, Running GDB on R Itself.

TEXT BOOKS:

1. The Art of R Programming by Norman Matloff Cengage Learning India.

References:

1. R Programming for Data Science by Roger D. Peng

2. Hadley Wickham, Garrett Grolemund, R for Data Science: Import, Tidy, Transform, Visualize, and Model Data 1st Edition, O'Reilly
3. Tilman M. Davies, The book of R a first course in programming and statistics, no starch press

Intrusion Detection Systems (Open Elective)

M.Tech AI & DS II Year I Sem.

L	T	P	C
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Prerequisites: Computer Networks, Computer Programming

Course Objectives:

- Compare alternative tools and approaches for Intrusion Detection through quantitative analysis to determine the best tool or approach to reduce risk from intrusion.
- Identify and describe the parts of all intrusion detection systems and characterize new and emerging IDS technologies according to the basic capabilities all intrusion detection systems share.

Course Outcomes:

1. Understand fundamental knowledge of intrusion detection and prevention
2. Understand different types of attacks in network layer and code injection human layer
3. Analyze different anomaly detection algorithms

UNIT - I

The state of threats against computers, and networked systems-Overview of computer security solutions and why they fail-Vulnerability assessment, firewalls, VPN's -Overview of Intrusion Detection and Intrusion Prevention, Network and Host-based IDS

UNIT - II

Classes of attacks - Network layer: scans, denial of service, penetration Application layer: software exploits, code injection-Human layer: identity theft, root access-Classes of attackers-Kids/hackers/sop Hesitated groups-Automated: Drones, Worms, Viruses

UNIT - III

A General IDS model and taxonomy, Signature-based Solutions, Snort, Snort rules, Evaluation of IDS, Cost sensitive IDS

UNIT - IV

Anomaly Detection Systems and Algorithms-Network Behavior Based Anomaly Detectors (rate based)-Host-based Anomaly Detectors-Software Vulnerabilities-State transition, Immunology, Payload Anomaly Detection

UNIT - V

Attack trees and Correlation of alerts- Autopsy of Worms and Botnets-Malware detection -Obfuscation, polymorphism- Document vectors. Email/IM security issues-Viruses/Spam-From signatures to thumbprints to zero day detection-Insider Threat issues-Taxonomy-Masquerade and Impersonation Traitors, Decoys and Deception-Future: Collaborative Security

TEXT BOOKS:

1. Peter Szor, The Art of Computer Virus Research and Defense, Symantec Press ISBN 0-321-30545-3.
2. Markus Jakobsson and Zulfikar Ramzan, Crimeware, Understanding New Attacks and Defenses.

REFERENCE BOOKS:

1. Saiful Hasan, Intrusion Detection System, Kindle Edition.
2. Ankit Fadia, Intrusion Alert: An Ethical Hacking Guide to Intrusion Detection.

Online Websites/Materials:

1. <https://www.intechopen.com/books/intrusion-detection-systems/>

Online Courses:

1. <https://www.sans.org/course/intrusion-detection-in-depth>
2. <https://www.cybrary.it/skill-certification-course/ids-ips-certification-training-course>

Digital Forensics (Open Elective)

M.Tech AI & DS II Year I Sem.

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Pre-Requisites: Cybercrime and Information Warfare, Computer Networks

Course Objectives:

1. provides an in-depth study of the rapidly changing and fascinating field of computer forensics.
2. Combines both the technical expertise and the knowledge required to investigate, detect and prevent digital crimes.
3. Knowledge on digital forensics legislations, digital crime, forensics processes and procedures, data acquisition and validation, e-discovery tools
4. E-evidence collection and preservation, investigating operating systems and file systems, network forensics, art of steganography and mobile device forensics

Course Outcomes: On completion of the course the student should be able to

1. Understand relevant legislation and codes of ethics.
2. Computer forensics and digital detective and various processes, policies and procedures.
3. E-discovery, guidelines and standards, E-evidence, tools and environment.
4. Email and web forensics and network forensics.

UNIT - I

Digital Forensics Science: Forensics science, computer forensics, and digital forensics.

Computer Crime: Criminalistics as it relates to the investigative process, analysis of cyber criminalistics area, holistic approach to cyber-forensics

UNIT - II

Cyber Crime Scene Analysis:

Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation.

UNIT - III

Evidence Management & Presentation:

Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, Explain what the normal case would look like, Define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause.

UNIT - IV

Computer Forensics: Prepare a case, Begin an investigation, Understand computer forensics workstations and software, Conduct an investigation, Complete a case, Critique a case,

Network Forensics: open-source security tools for network forensic analysis, requirements for preservation of network data.

UNIT - V

Mobile Forensics: mobile forensics techniques, mobile forensics tools.

Legal Aspects of Digital Forensics: IT Act 2000, amendment of IT Act 2008.

Recent trends in mobile forensic technique and methods to search and seizure electronic evidence

TextBooks:

1. John Sammons, The Basics of Digital Forensics, Elsevier
2. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications

References

1. William Oettinger, Learn Computer Forensics: A beginner's guide to searching, analyzing, and securing digital evidence, Packt Publishing; 1st edition (30 April 2020), ISBN : 1838648178.
2. Thomas J. Holt , Adam M. Bossler, Kathryn C. Seigfried-Spellar , Cybercrime and Digital Forensics: An Introduction, Routledge.

Optimization Techniques (Open Elective)

M.Tech AI & DS II Year I Sem.

L	T	P	C
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Prerequisite: Mathematics –I, Mathematics –II

Course Objectives:

- To introduce various optimization techniques i.e classical, linear programming, transportation problem, simplex algorithm, dynamic programming
- Constrained and unconstrained optimization techniques for solving and optimizing electrical and electronic engineering circuits design problems in real world situations.
- To explain the concept of Dynamic programming and its applications to project implementation.

Course Outcomes:

1. Explain the need of optimization of engineering systems
2. Understand optimization of electrical and electronics engineering problems
3. Apply classical optimization techniques, linear programming, simplex algorithm, transportation problem
4. Apply unconstrained optimization and constrained non-linear programming and dynamic programming
5. Formulate optimization problems.

UNIT - I

Introduction and Classical Optimization Techniques: Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surface - classification of Optimization problems.

Linear Programming: Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm.

UNIT - II

Transportation Problem: Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems. Degeneracy.

Assignment problem – Formulation – Optimal solution - Variants of Assignment Problem; Traveling Salesman problem.

UNIT - III

Classical Optimization Techniques: Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints: Solution by method of Lagrange multipliers – Multivariable Optimization with inequality constraints: Kuhn – Tucker conditions.

Single Variable Nonlinear Unconstrained Optimization: Elimination methods: Uni Model function-its importance, Fibonacci method & Golden section method.

UNIT - IV

Multi variable nonlinear unconstrained optimization: Direct search methods – Univariate method, Pattern search methods – Powell's, Hooke - Jeeves, Rosenbrock's search methods. Gradient methods: Gradient of function & its importance, Steepest descent method, Conjugate direction methods: Fletcher-Reeves method & variable metric method.

UNIT - V

Dynamic Programming: Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

TEXT BOOKS:

1. Optimization Techniques & Applications by S.S.Rao, New Age International.
2. Optimization for Engineering Design by Kalyanmoy Deb, PHI

REFERENCE BOOKS:

1. George Bernard Dantzig, Mukund Narain Thapa, “Linear programming”, Springer series in Operations Research 3rd edition, 2003.
2. H. A. Taha, “Operations Research: An Introduction”, 8th Edition, Pearson/Prentice Hall, 2007.
3. Optimization Techniques by Belegundu & Chandrupatla, Pearson Asia.
4. Optimization Techniques Theory And Practice by M.C.Joshi, K.M.Moudgalya, Narosa Publications

Cyber Physical Systems (Open Elective)

M.Tech AI & DS II Year I Sem.

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Course Objective: To learn about design of cyber-physical systems

Course Outcomes: Upon the Successful Completion of the Course, the Students would be able to:

1. Understand the core principles behind CPS
2. Identify Security mechanisms of Cyber physical systems
3. Understand Synchronization in Distributed Cyber-Physical Systems

UNIT - I

Symbolic Synthesis for Cyber-Physical Systems

Introduction and Motivation, Basic Techniques - Preliminaries, Problem Definition, Solving the Synthesis Problem, Construction of Symbolic Models, Advanced Techniques: Construction of Symbolic Models, Continuous-Time Controllers, Software Tools

UNIT - II

Security of Cyber-Physical Systems

Introduction and Motivation, Basic Techniques - Cyber Security Requirements, Attack Model, Countermeasures, Advanced Techniques: System Theoretic Approaches

UNIT - III

Synchronization in Distributed Cyber-Physical Systems: Challenges in Cyber-Physical Systems, A Complexity-Reducing Technique for Synchronization, Formal Software Engineering, Distributed Consensus Algorithms, Synchronous Lockstep Executions, Time-Triggered Architecture, Related Technology, Advanced Techniques

UNIT - IV

Real-Time Scheduling for Cyber-Physical Systems

Introduction and Motivation, Basic Techniques - Scheduling with Fixed Timing Parameters, Memory Effects, Multiprocessor/Multicore Scheduling, Accommodating Variability and Uncertainty

UNIT - V

Model Integration in Cyber-Physical Systems

Introduction and Motivation, Causality, Semantic Domains for Time, Interaction Models for Computational Processes, Semantics of CPS DSMLs, Advanced Techniques, ForSpec, The Syntax of CyPhyML, Formalization of Semantics, Formalization of Language Integration.

Text Books:

1. Raj Rajkumar, Dionisio De Niz , and Mark Klein, Cyber-Physical Systems, Addison-Wesley Professional.
2. Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015

Graph Analytics (Open Elective)

M.Tech AI & DS II Year I Sem.

L	T	P	C
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Course Objectives:

- To explore the concept of Graphs and related algorithms.
- To learn new ways to model, store, retrieve and analyze graph-structured data.
- To be aware of advanced concepts in graph analytic techniques and its applications.

Course Outcomes: Upon the Successful Completion of the Course, the Students would be able to:

1. Understand Large-scale Graph and its Characteristics
2. Analyze Breadth-First Search Algorithm
3. Illustrate Recent Advances in Scalable Network Generation

UNIT - I

Introduction and Application of Large-scale Graph: Characteristics, Complex Data Sources - Social Networks, Simulations, Bioinformatics; Categories- Social, Endorsement, Location, Co-occurrence graphs; Graph Data structures, Parallel, Multicore and Graph Algorithms

UNIT - II

Algorithms: Search and Paths

A Work-Efficient Parallel Breadth-First Search Algorithm (or How To Cope With the Nondeterminism of Reducers), Multi-Objective Shortest Paths

UNIT - III

Algorithms: Structure

Multicore Algorithms for Graph Connectivity Problems, Distributed Memory Parallel Algorithms for Massive Graphs, Massive-Scale Distributed Triangle Computation and Applications

UNIT - IV

Models

Recent Advances in Scalable Network Generation, Computational Models for Cascades in Massive Graphs, Executing Dynamic Data-Graph Computations Deterministically Using Chromatic Scheduling.

UNIT - V

Frameworks and Software

Graph Data Science Using Neo4j, A Cloud-Based Approach to Big Graphs, Interactive Graph Analytics at Scale in Arkouda

Text Books:

1. David A. Bader, Massive Graph Analytics, CRC Press

References:

1. Stanley Wasserman, Katherine Faust, "Social Network Analysis: Methods and Applications", (Structural Analysis in the Social Sciences), Cambridge University Press, 1995.
2. Matthew O. Jackson, "Social and Economic Networks", Princeton University Press, 2010.
3. Tanja Falkowski, "Community Analysis in Dynamic Social Networks", (Dissertation), University Magdeburg, 2009.