# SCHEME OF EXAMINATION
# &
# SYLLABI

## for

## Master of Technology (Two Year Degree Programme)
## (I and II Year)

## Offered by
## University School of Automation and Robotics (USAR)

## w.e.f. Academic Session 2026-27

GURU GOBIND SINGH
INDRAPRASTHA
UNIVERSITY

## Guru Gobind Singh Indraprastha University Sector 16C, Dwarka, Delhi – 110 078 [INDIA]
## www.ipu.ac.in

With effect from academic session 2026-27

## Introduction

This document describes the curriculum of the Master of Technology in Artificial Intelligence and Data Science that is offered at the University School of Automation and Robotics. The programme name is inline with the AICTE approved nomenclature of courses (Reference Sl. No. 28, Page 105, Approval Process Handbook 2022-23). In the event of any difficulty of implementation, and / or interpretation of any clause of the document, the same may be brought to the notice of Dean of the University School of Automation and Robotics. The decision of the Dean, University School of Automation and Robotics shall be final and implemented to resolve the issue. The same shall be put up in the subsequent meeting of the Board of Studies of the University School of Automation and Robotics for its approval. If the decision of the Board of Studies of the University School of Automation and Robotics is at variance with the decision taken earlier by the Dean of the School, the decision of the Board shall be effective from the date of the approval by the Board of Studies. In the interim period (between the approval of the Dean, of the School and the Board of Studies approval), the decision already taken by the Dean of the school shall stand.

**Course / Paper Group Codes:**

**BS:** Basic Science
**HS:** Humanities, social science, management
**PC:** Programme Core, that is course / paper offered in the discipline of the programme as a compulsory paper.
**PE:** Programme Elective, that is course / paper offered in the discipline of the programme as an elective paper.
**OA:** Open area elective offered by other school or other schools or Swayam /MOOCS

**Acronyms:**

APC: Academic programme committee comprising of all faculty of the school.
L: Number of Lecture hours per week
T/P: Number of Practical/Tutorial Hours per week
C: Number of credits assigned to a course / paper
NUES: An evaluation scheme in which evaluation is conducted by a committee, a teacher or a group of teacher as described in the scheme of study.
COE: Controller of Examinations of the Examinations Division of the University.

# M.Tech in Artificial Intelligence and Data Science (AI&DS)

## Programme Educational Objectives

The M.Tech(AI&DS) programme is meant to develop the students ability:-

PEO1: To demonstrate a deep understanding of the foundational principles, theories, and practices of artificial intelligence and data science, including machine learning, deep learning, natural language processing, and computer vision.

PEO2: To apply advanced statistical and computational methods to analyze, model, and extract insights from large and complex data sets, and to develop innovative solutions to challenging problems in a range of domains, such as healthcare, finance, marketing, and social media.

PEO3: To design and implement intelligent systems and applications that can learn, reason, and interact with humans and the environment.

PEO4: To communicate effectively, both orally and in writing, about technical concepts, research findings, and ethical considerations related to artificial intelligence and data science, and to engage in interdisciplinary discussions with stakeholders from diverse backgrounds and perspectives.

PEO5: To stimulate students for life-long learning with enthusiasm and commitment to improve knowledge and competence continuously.

## Program Specific Outcomes

PO1: Pursue further academic and research opportunities in related fields, as well as engage in continuous learning and professional development, to keep pace with the rapid advances and changing landscapes of artificial intelligence and data science.

PO2: An ability to design and implement intelligent systems and applications that can interact with humans and the environment, and that can learn, reason, and adapt to changing circumstances and user preferences.

PO3: Students should be able to demonstrate application of statistical and computational methods to process, clean, transform, and visualize large and heterogeneous data sets, and to extract insights, patterns, and trends that can inform decision-making and drive innovation.

PO4: Analyze, design, and develop advanced algorithms and models for machine learning, deep learning, natural language processing, and computer vision, and evaluate their performance in terms of accuracy, efficiency, and robustness.

PO5: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PSO-PEO Matrix*
Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

| Course Outcomes | PEO1 | PEO2 | PEO3 | PEO4 | PEO5 |
|---|---|---|---|---|---|
| **PO1** | 3 | 2 | 2 | 1 | 3 |
| **PO2** | 2 | 2 | 3 | 1 | 2 |
| **PO3** | 2 | 3 | 2 | 1 | 1 |
| **PO4** | 2 | 3 | 2 | 2 | 2 |
| **PO5** | 1 | 1 | 2 | 3 | 2 |

**Master of Technology**
**Artificial Intelligence and Data science**
**Regular Programme**

**First Semester**

| Group | Paper Code | Paper | L | T/ P | Credits |
|---|---|---|---|---|---|
| **Theory Papers (Core)** | | | | | |
| PC | MEAD601 | Advanced Data Structures and Algorithms | **3** | **-** | **3** |
| PC | MEAD603 | Mathematics for AI | **3** | **-** | **3** |
| PC | MEAD605 | Digital Image Processing and Computer Vision | **3** | **-** | **3** |
| PC | MEAD607 | Advanced Machine Learning | **3** | **-** | **3** |
| PC | MEAD609 | Statistical Methods for Data Science | **3** | **-** | **3** |
| **Open Area Electives** | | | | | |
| OA | MEAD611 | Open Electives- I #* | - | **-** | **2** |
| **Practical / Viva voce** | | | | | |
| PC | MEAD651 | Lab-I based on MEAD601 | - | **2** | **1** |
| PC | MEAD653 | Lab-II based on MEAD605 | - | **2** | **1** |
| PC | MEAD655 | Lab-III based on MEAD607 | - | **2** | **1** |
| PC | MEAD657 | Lab-IV based on MEAD609 | - | **2** | **1** |
| PC | MEAD659 | Term Paper -I* | - | - | **2** |
| | | TOTAL | **15** | **8** | **23** |

# Open Area electives offered on Swayam /MOOCS to be chosen in consultation with Dean/ Principal/ Director of University School/Department/ Institute and should be different from the courses offered under the programme

*****NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).

**Master of Technology**
**Artificial Intelligence and Data science**
**Regular Programme**

**Second Semester**

| Group | Paper Code | Paper | L | T/ P | Credits |
|---|---|---|---|---|---|
| **Theory Papers (Core)** | | | | | |
| PC | MEAD602 | Generative and Agentic AI | **3** | **-** | **3** |
| PC | MEAD604 | Neural Network and Deep Learning | **3** | **-** | **3** |
| **Elective 1 (Choose One)** | | | | | |
| PE | MEAD606 | Recommender Systems | **3** | **-** | **3** |
| PE | MEAD608 | Data Lakes, Warehousing and Analytics | **3** | **-** | **3** |
| PE | MEAD610 | Social Network Analysis | **3** | **-** | **3** |
| PE | MEAD612 | Speech and Language Processing | **3** | **-** | **3** |
| PE | MEAD614 | ML Ops and AI Deployment | **3** | **-** | **3** |
| **Elective 2 (Choose One)** | | | | | |
| PE | MEAD616 | Big Data Framework | **3** | **-** | **3** |
| PE | MEAD618 | Cloud computing | **3** | **-** | **3** |
| PE | MEAD620 | Intelligent Autonomous Systems | **3** | - | **3** |
| PE | MEAD622 | Adversarial Artificial Intelligence | **3** | **-** | **3** |
| PE | MEAD624 | Metaverse and Blockchain | **3** | **-** | **3** |
| **Open Area Electives** | | | | | |
| OA | MEAD618 | Open Electives - II #* | - | **-** | **2** |
| **Practical / Viva voce** | | | | | |
| PC | MEAD652 | Lab-V based on MEAD602 | - | **2** | **1** |
| PC | MEAD654 | Lab-VI based on MEAD604 | - | **2** | **1** |
| PE | MEAD656 | Lab-VII based on Elective 1 | - | **2** | **1** |
| PE | MEAD658 | Lab-VIII based on Elective 2 | - | **2** | **1** |
| PC | MEAD660 | Term Paper II* | **-** | **-** | **2** |

| | | | | | |
|---|---|---|---|---|---|
| | | **TOTAL** | **12** | **8** | **20** |

# Open Area electives offered on Swayam /MOOCS to be chosen in consultation with Dean/ Principal/ Director of University School/Department/ Institute should be different from the courses offered under the programme.

*****NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).

**Electives shall be offered if at least 1/3rd of the total program strength opts for the course.**

**Master of Technology**
**Artificial Intelligence and Data science**
**Regular Programme**

**Third Semester**

| Group | Paper Code | Paper | L | T/ P | Credits |
|---|---|---|---|---|---|
| **Choose One** | | | | | |
| PC | MEAD751 | Dissertation Part – I** | - | - | **15** |
| PC | MEAD753 | Internship - I** | - | - | **15** |
| **Open Area Electives** | | | | | |
| OA | MEAD709 | Open Elective -III #* | - | - | **3** |
| OA | MEAD711 | Open Elective -IV #* | - | - | **3** |
| | | TOTAL | - | - | **21** |

# Open Area electives from relevant domain offered on Swayam /MOOCS to be chosen in consultation with Dean/ Principal/ Director of University School/Department/ Institute should be different from the courses offered under the programme

*****NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).

** The Dissertation/ Internship guidelines shall be issued separately by the school with the approval of the Dean, USAR

**Master of Technology**
**Artificial Intelligence and Data science**
**Regular Programme**

**Fourth Semester**

| Group | Paper Code | Paper | L/P | Credits |
|---|---|---|---|---|
| **Choose One** | | | | |
| PC | MEAD752 | Dissertation Part – II** | - | **20** |
| PC | MEAD754 | Internship - II** | - | **20** |
| | | **TOTAL** | - | **20** |

** The Dissertation/ Internship guidelines shall be issued separately by the school with the approval of the Dean, USAR

**NOTE:**

The total number of credits of the M. Tech. Programme is 84.

Each student shall be required to appear for examination in all courses, but for the award of the degree a student shall be required to earn the minimum of 80 credits out of 84.

**However, papers with evaluation on NUES basis may be dropped towards counting for total credits of 80 to award M. Tech. Degree.**

# DETAILED SYLLABUS

# FOR

# SEMESTER-I

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms

Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

## MEAD601 Advanced Data Structures and Algorithms

**Course Objectives:**

1. The course aims to teach students advanced data structures and algorithms like red-black trees, B-trees, AVL trees, graph algorithms, greedy, divide & conquer etc.
2. Students should be able to analyze the running time of algorithms and understand how to design efficient algorithms for a given problem.
3. Students should be able to apply advanced data structures and algorithms to solve complex problems in computer science and related fields.
4. The course aims to improve the student's programming skills.

**Course Outcomes:**

1. Ability to apply data structure in different problem scenarios
2. Ability to analyse the time complexity of algorithms
3. Ability to understand and apply different problems solving approaches using algorithms
4. Ability to implement heuristic search algorithms.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 2 | 1 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 1 | 1 | 2 | 1 | 3 |

**UNIT - I**

Elementary Data Structure: Arrays, Expressions, Linked list, Polynomials; Representation and Operations binary search Trees and operations, Red Black Trees and properties

**UNIT - II**

Overview of Divide-and-Conquer, Dynamic Programming and Greedy Algorithms, Comparison of dynamic programming and Greedy algorithm with Knapsack as case study Theoretical foundation of greedy algorithm,

**UNIT-III**

Graph representation and implementation, searching of a graph, application of BFS and DFS Data structure for Sets, Sorting and Searching techniques, Traversal algorithms, Spanning tree generation Algorithms

**UNIT - IV**

State Space Search, Heuristic search methods, Finding Optimal Paths: Branch & Bound, A*, Admissibility of A*, Informed Heuristic Functions, Problem Decomposition: Means Ends Analysis, Algorithm AO*

**Textbooks:**

1. T. H. Cormen, C. E. Leiserson, R.L. Rivest, C. Stein. Introduction to Algorithms, 3rd Edition, PHI, 2009
2. Deepak Khemani, Search Methods in Artificial Intelligence, Cambridge University Press, 2024.

**Reference books:**

1. Weiss, Mark Allen. Data structures and algorithm analysis. 2nd Edition, Pearson Education India,1996.
2. Stefan Edelkamp and Stefan Schroedl. Heuristic Search: Theory and Applications, Morgan Kaufmann, 2011.
3. Judea Pearl. Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley, 1984.

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms

Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

## MEAD603 Mathematics for AI

**Course Objectives:**

1. To understand the mathematical concepts and techniques necessary for working with AI algorithms and models.
2. To make students learn to apply linear algebra, calculus, probability theory, and graph theory to solve AI problems.
3. To learn about calculus and its application in AI, including optimization, derivatives, and gradients.
4. To develop critical thinking skills and the ability to evaluate and analyze mathematical concepts and techniques in the context of AI.

**Course Outcomes:**

1. Ability to use techniques necessary for working with AI algorithms and models.
2. Ability to apply linear algebra, calculus, probability theory, and graph theory to solve AI problems.
3. Ability to use mathematical tools and software for solving AI problems.
4. Students will be prepared to take advanced courses in AI, machine learning, and related fields.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 3 | 3 | 1 |
| **CO2** | 3 | 3 | 3 | 3 | 1 |
| **CO3** | 2 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 3 | 2 | 1 |

**UNIT - I**

Linear Algebra: Matrices and Determinants, Gauss Elimination, Linear Independence. Rank of a Matrix. Vector Space. Solutions of Linear Systems and concept of Existence, Uniqueness, Determinants. Cramer's Rule, Gauss–Jordan Elimination. The Matrix Eigenvalue Problem, Determining Eigenvalues and Eigenvectors, Eigenbases. Diagonalization. Quadratic Forms.Cayley – Hamilton Theorem

**UNIT - II**

Calculus: Continuity and differentiability, derivative of composite functions, chain rule, derivative of some common functions- logarithmic, exponential, trigonometric and inverse trigonometric**.** Applications of derivatives. Vector and matrix calculus, derivatives of scalar and vector valued functions, Gradient algorithms and convex functions

**UNIT - III**

Vector Calculus: Vector and Scalar Functions and Their Fields. Derivatives, Curves. Arc Length. Curvature. Torsion, Gradient of a Scalar Field. Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field, Line Integrals, Path Independence of Line Integrals, Double Integrals, Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals, Triple Integrals, Stokes Theorem. Divergence Theorem of Gauss.

**UNIT - IV**

Vector spaces: The n dimensional vectors, vector spaces, subspaces, spanning sets, linear dependence of vectors, basis and dimensions, linear transformation, null space and range space of a linear transformation, rank and nullity, rank and nullity theorem, inverse of a linear transformation, composition of linear map, matrices of a linear transformation and its transpose, the minimal polynomial

**Textbooks:**

1. Strang G. Linear algebra and its applications. Belmont, CA: Thomson, Brooks/Cole; 2006.
2. Deisenroth MP, Faisal AA, Ong CS. Mathematics for machine learning. Cambridge University Press; 2020.

**Reference books:**

1. Aggarwal CC, Aggarwal LF, Lagerstrom-Fife. Linear algebra and optimization for machine learning. Springer International Publishing; 2020.
2. Boyd S, Boyd SP, Vandenberghe L. Convex optimization. Cambridge university press; 2004.

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

## MEAD605 Digital Image Processing and Computer Vision

**Course Objectives:**

1. Familiarize students with the fundamental concepts and issues of Computer Vision and Image Processing, along with the major approaches developed to address them.
2. Introduce the principles of image acquisition, image formation models, and radiometric models, including how images are formed within a camera system.
3. Develop a strong understanding of core image processing concepts and techniques.
4. Impart knowledge of feature extraction and selection methods used for pattern classification and recognition.
5. Expose students to advanced topics in Computer Vision, including motion estimation and tracking, image classification, scene understanding, object classification and tracking, image fusion, and image registration.
6. Equip students with the skills needed to begin work in industry or pursue academic research in Computer Vision and Image Processing.

**Course Outcomes:**

1. Explain the fundamental concepts and issues of Computer Vision and Image Processing, and describe the major approaches used to address them.
2. Apply core image processing techniques to analyze and manipulate digital images.
3. Analyze and implement advanced Computer Vision techniques such as motion estimation and tracking, image classification, scene understanding, and object classification and tracking.
4. Apply Computer Vision and Image Processing concepts to formulate and solve real-world problems, demonstrating readiness for work in industry or academic research.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 2 | 3 | 1 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 2 |
| **CO3** | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 1 | 1 | 2 | 2 | 3 |

**UNIT - I**

Introduction: What is computer vision? Image formation: Geometric primitives and transformations, Photometric image formation, Digital camera

Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models. Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections.

**UNIT - II**

Image processing: Image Transforms, Image Enhancement, Image Filtering, Colour Image Processing, Image Segmentation. Point operators, Linear filtering, Neighborhood operators, Fourier transforms, Pyramids and wavelets, Geometric transformations, Global optimization
Segmentation: Active Contours, Split and merge, mean shift and mode finding
Feature-based Alignment: 2D and 3D based alignment, Pose estimation and Geometrics intrinsic Calibration
Structure from motion: Triangulation, two frame structure from motion, factorisation and bundle adjustment, constrained structure and motion.

**UNIT - III**

Feature detection and matching: Points and patches, Texture Descriptors, Colour Features, Edges/Boundaries
Object Boundary and Shape Representations.Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency

**UNIT - IV**

Dense Motion Estimation: Translational alignment, parametric and spline based motion, optical flow layered motion
Image Stiching and Computational Photography
Stereo correspondence, Image based rendering, 3D constructions and Object recognition, Gesture Recognition and Object Tracking

**Textbooks:**

1. Forsyth DA, Ponce J. Computer vision: a modern approach. prentice hall professional technical reference; 2002.
2. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing 3rd Edition, Prentice Hall; August 2007

**Reference books:**

1. Prince SJ. Computer vision: models, learning, and inference. Cambridge University Press; 2012.
2. Bradski G, Kaehler A. Learning OpenCV: Computer vision with the OpenCV library. O'Reilly Media, Inc.; 2008.
3. Szeliski R. Computer vision: algorithms and applications. Springer Nature; 2022.

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

## MEAD607 Advanced Machine Learning

**Course Objectives:**

1. The course aims to introduce students to the fundamental concepts of machine learning, including supervised and unsupervised learning, reinforcement learning, and deep learning.
2. To make students learn different types of machine learning algorithms, such as decision trees, logistic regression, support vector machines, k-nearest neighbours, and neural networks.
3. To understand principles of model selection, evaluation, and optimization, including cross-validation, regularization, and hyperparameter tuning.
4. To use different machine learning tools and software, such as scikit-learn, TensorFlow, or PyTorch, to implement machine learning algorithms and evaluate their performance.

**Course Outcomes:**

1. Ability to apply different machine learning algorithms to solve real-world problems.
2. Ability to evaluate and optimize machine learning models using different evaluation metrics and techniques.
3. Ability to use different machine learning tools and software to implement machine learning algorithms and evaluate their performance.
4. Students will be prepared to use machine learning techniques for solving real-world problems in various fields.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 3 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 1 |
| **CO3** | 2 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 1 | 3 | 3 |

**UNIT - I**

Introduction: Definition of learning systems, Goals and applications of machine learning, Aspects of developing a learning system, Concept Learning and general to specific ordering]

Decision Tree Learning: Decision Tree representation, appropriate problems for decision tree learning, decision tree learning algorithm, Issues in decision tree learning, Picking the best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity. Occam's razor. Overfitting, noisy data, and pruning

Ensemble Learning: Using committees of multiple hypotheses. Bagging, boosting, and DECORATE. Active learning with ensembles.

**UNIT - II**

Experimental Evaluation of Learning Algorithms: Measuring the accuracy of learned hypotheses. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis testing

Computational Learning Theory: Models of learnability: learning in the limit; probably approximately correct (PAC) learning. Sample complexity: quantifying the number of examples needed to PAC learn. Computational complexity of training. Sample complexity for finite hypothesis spaces. PAC results for learning conjunctions, kDNF, and kCNF. Sample complexity for infinite hypothesis spaces, Vapnik-Chervonenkis dimension

Rule Learning: Propositional and First-Order: Translating decision trees into rules. Heuristic rule induction using separate and conquer and information gain. First-order Horn-clause induction (Inductive Logic Programming) and Foil. Learning recursive rules. Inverse resolution, Golem, and Progol.

**UNIT - III**

Artificial Neural Networks: Neurons and biological motivation, Linear threshold units, Perceptrons: representational limitation and gradient descent training, Multilayer networks and back propagation, Hidden layers and constructing intermediate, distributed representations, Overfitting, learning network structure, recurrent networks.

Support Vector Machines: Maximum margin linear separators. Quadratic programming solution to finding maximum margin separators. Kernels for learning non-linear functions.

Bayesian Learning: Probability theory and Bayes rule. Naive Bayes learning algorithm. Parameter smoothing. Generative vs. discriminative training. Logisitic regression. Bayes nets and Markov

**UNIT - IV**

Instance-Based Learning: Constructing explicit generalizations versus comparing to past specific examples. k-Nearest-neighbor algorithm. Case-based learning.

Clustering and Unsupervised Learning: Learning from unclassified data. Clustering. Hierarchical Aglomerative Clustering. k-means partitional clustering. Expectation maximization (EM) for soft clustering. Semi-supervised learning with EM using labeled and unlabled data.

Reinforcement Learning: Q learning, non deterministic rewards and actions, Temporal difference learning

**Textbooks:**

1. Mitchell TM. Machine learning. New York: McGraw-hill; 2007.
2. Zhou ZH. Machine learning. Springer Nature; 2021.

**Reference books:**

1. Bishop CM, Nasrabadi NM. Pattern recognition and machine learning. New York: springer; 2006.
2. Mohri M, Rostamizadeh A, Talwalkar A. Foundations of machine learning. MIT, 2018

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms

Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

## MEAD609 Statistical Methods for Data Science

**Course Objectives:**

1. To understand the fundamental concepts of statistics, including probability theory, random variables, probability distributions, and statistical inference.
2. To learn about the different types of data and how to describe and summarize data using graphical and numerical methods.
3. To understand the principles of statistical hypothesis testing and how to test hypotheses using appropriate tests and procedures.
4. To develop critical thinking skills and the ability to evaluate statistical claims and arguments in data science.

**Course Outcomes:**

1. Ability to describe and summarize data using appropriate statistical methods.
2. Ability to design experiments and test hypotheses using appropriate statistical methods.
3. Ability to analyze data using regression models and other statistical techniques.
4. Students will develop solid foundation in statistical methods and be prepared to take more advanced courses in data science or related fields.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 3 | 3 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 3 | 2 | 2 |

**UNIT - I**

Introduction and types of Data - Basic definitions, Introduction and types of Data: Understanding data, Classification of data, Scales of measurement, Describing Categorical Data - Frequency distributions, Charts of categorical data, Mode and Median
Describing Numerical Data - Frequency Tables for numerical data, Mean, Median and Mode, Measures of dispersion- Range, variance and standard deviation, Percentiles, Quartiles, and Interquartile range
Association between two categorical variables, Relative frequencies, Association between two numerical variables - Scatterplot, Describing association, Covariance, Correlation, Fitting a line, Association between categorical and numerical variables

**UNIT - II**

Permutation and Combination, Basic Principles of Counting, Probability: Basic Definition, Properties of Probability, Independent exhaustive events, Conditional and Joint Probability, Random Variables, Probability Distribution: discrete and Continuous, Probability Mass Function, Discrete random variables - Cumulative distribution function

**UNIT - III**

Multiple random variables: Two random variables, Multiple random variables and distributions, Independence, Functions of random variables - Visualization, functions of multiple random variables, Expected value of a random variable, Scatter plots and spread, Variance and standard deviation, Covariance and correlation, Inequalities, Multiple continuous random variables, Jointly Gaussian random variables Probability models for data

**UNIT - IV**

Estimation and Inference, Bayesian estimation, Hypothesis testing, Time series based Forecasting: Introduction to Time Series, Time Series Analysis, Time Series Forecasting Methods

**Textbooks:**

1. James G, Witten D, Hastie T, Tibshirani R. An introduction to statistical learning. New York: springer; 2013.
2. Casella G, Berger RL. Statistical inference. Cengage Learning; 2021.

**Reference books:**

1. Gelman A, Carlin JB, Stern HS, Dunson DB, Vehtari A, Rubin DB. Bayesian data analysis. CRC press; 2013.
2. Levin RI. Statistics for management. Pearson Education India; 2011.

# DETAILED SYLLABUS

# FOR

# SEMESTER-II

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms

Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

## MEAD602 Generative and Agentic AI

**Course Objectives:**

1. Introduce the foundational concepts of Generative AI and the deep learning architectures (embeddings, RNNs, LSTMs, attention).
2. Develop an understanding of Generative Adversarial Networks (GANs), their training framework, and advanced/specialized GAN architectures.
3. Build practical skills in designing and developing AI agents using frameworks.
4. Familiarize students with the ethical, monitoring, and responsible AI considerations involved in deploying agentic systems.

**Course Outcomes:**

1. Explain the fundamental concepts of Generative AI, deep learning foundations, and sequence modeling architectures used in generative systems.
2. Design and analyze GAN-based architectures for image and cross-domain generation tasks.
3. Develop intelligent agentic systems using LangGraph and AutoGen, incorporating memory, tool integration, multi-agent collaboration, and Agentic RAG architectures.
4. Evaluate transformer-based foundation models and apply principles of monitoring, observability, and ethical responsibility while deploying generative and agentic AI systems.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 1 | 1 | 3 | 1 |
| **CO2** | 1 | 2 | 2 | 3 | 1 |
| **CO3** | 2 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | 2 | 1 | 3 | 3 |

**UNIT - I**

Introduction to Generative AI- Evolution of Artificial Intelligence, Discriminative vs Generative Models, Introduction to Generative AI, Applications of Generative AI in text, image, audio, video, and code generation, Foundation Models and Emergent Capabilities, Overview of Large Language Models, Generative AI Ecosystem and Tools.
Deep Learning Foundations for Generative AI : Neural Networks Review, Representation Learning Word Embeddings: Word2Vec, GloVe, FastText, Sequence Modeling using RNNs, LSTMs, and GRUs Encoder-Decoder Architecture, Attention Mechanism, Limitations of Recurrent Architectures

**UNIT - II**
Generative Adversarial Networks (GANs): Introduction to GANs, Generator and Discriminator Networks, Adversarial Learning Framework, Training Procedure of GANs, Challenges in GAN Training.
Advanced GAN Architectures and Specialized GAN Models: Deep Convolutional GAN (DCGAN), Conditional GAN (cGAN), Auxiliary Classifier GAN (AC-GAN), Least Squares GAN (LSGAN), Wasserstein GAN (WGAN), CycleGAN, Pix2Pix, StyleGAN, Progressive GANs, Super-Resolution GAN (SRGAN), Text-to-Image GANs, Image-to-Image Translation.

**UNIT - III**
Building Agents with LangGraph : Introduction to LangGraph, agent workflows and state management, message trimming and filtering, short-term and long-term memory, external memory and memory schemas, integrating tools and APIs,
deployment concepts in LangGraph, use cases of LangGraph-based agents. Traditional RAG vs Agentic RAG, architecture and components of Agentic RAG, adaptive retrieval mechanisms, variants and applications of Agentic RAG, introduction to LlamaIndex for Agentic RAG, multi-agent systems concepts, coordination and collaboration among agents, workflow design for multi-agent systems.

**UNIT - IV**
Transformer Architecture, Self-Attention and Multi-Head Attention, Positional Encoding, Encoder-only, Decoder-only, and Encoder-Decoder Models, BERT, GPT, T5, LLaMA, Gemini and other foundation models, Tokenization Techniques, Scaling Laws and Emergent Abilities, Training Large Language Models.
Introduction to AutoGen, roles and conversation patterns, developing collaborative AI agents, deploying agentic systems, monitoring and evaluation of AI agents, observability and AgentOps concepts,
Introduction to LangSmith for agent monitoring, ethical issues in agentic AI: autonomy, bias, accountability, safety and responsible AI practices.

**Textbooks:**

1. Fregly, C., Barth, A., & Eigenbrode, S. ,Generative AI on AWS: Build production-ready applications with foundation models and large language models. O'Reilly Media, 2024
2. Gale, E., Mastering AI Agents: From Design to Deployment of Autonomous Systems, 2025.

**Reference books:**

1. Raschka, S., Build a Large Language Model (From Scratch), Manning Publications, 2024.
2. Padgham, L., & Winikoff, M. (2005). Developing intelligent agent systems: A practical guide. John Wiley & sons.

# MEAD604 Neural Networks and Deep Learning

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

**Course Objectives:**

1. The course aims to introduce students to the concepts of neural networks and deep learning.
2. To make students learn about different neural network architectures, such as feedforward neural networks, convolutional neural networks, and recurrent neural networks.
3. To understand principles of deep learning, such as backpropagation, regularization, and optimization.
4. To understand the applications of neural networks and deep learning in various fields, such as healthcare, finance, and robotics.

**Course Outcomes:**

1. Ability to understand and apply different neural network architectures to solve real-world problems.
2. Ability to apply different deep learning techniques to train neural networks for different applications.
3. Ability to evaluate and analyze different neural network and deep learning techniques for different applications.
4. Students will develop understanding of the applications of neural networks and deep learning in various fields.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 2 | 2 | 3 | 1 |

**UNIT-I**

Basic principles of Artificial Neural Network (ANN): Principles of ANN design, Basic network structure, Perceptron's input output principles, the Adaline.
The perceptron: single layer, multilayer perceptron, Madaline, Back propagation learning procedure, derivation of BP algorithms, modified BP algorithm, Case study of XOR, character recognition.
Hopfield networks: Binary Hopfield networks, Bidirectional associative memory principle, Walsh function, Network stability, continuous Hopfield models

**UNIT-II**

Counter Propagation NN: Kohonen self-organising map layer and Grossberg Layer, Training of layers, application of Counter Propagation NN in character recognition
LAMSTAR Network: Basic principle, detailed outline of LAMSTAR Network, Forgetting Feature, LAMSTAR as data analysis tool
Adaptive Resonance Theory NN (ART NN): The ART network structure, setting up of the ART network, Properties of ART
Statistical training of NN: Annealing methods, Simulated annealing by Boltzman training of weights, Stochastic determination, Cauchy training of NN

**UNIT-III**

Deep Feedforward Networks: Regularization for Deep Learning, Optimization for training Deep Models
Convolutional Neural Networks: Convolution operation, motivation behind CNN, Pooling, Variants of basic convolution function, Efficient convolution algorithms, unsupervised features, Neuroscientific basis for Convolution networks
Sequence Modelling: Recurrent Neural Networks (RNNs), Bidirectional RNNs, Encoder-decoder sequence-to-sequence architecture, Deep recurrent networks, Recursive NN, Challenges of long term dependencies, Echo state networks, leaky units, Long Short Term Memory, Gated Recurrent Units,

**UNIT-IV**

Linear Factor models, Autoencoders, Representational learning, Structures probabilistic models for Deep learning, Montecarlo methods, Deep Generative Models, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning

**Textbooks:**

1. Bengio Y, Goodfellow I, Courville A. Deep learning. Cambridge, MA, USA: MIT press; 2017.
2. Géron A. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media, Inc.; 2022.

**Reference Books:**

1. Buduma N, Buduma N, Papa J. Fundamentals of deep learning. " O'Reilly Media, Inc."; 2022.
2. Aggarwal C., Neural Networks and Deep Learning: A Textbook, Springer; 1st ed. 2018.

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## MEAD606 Recommender System

**Course Objectives:**

1. The course aims to introduce students to the concepts of recommender systems.
2. To make students learn about different types of recommender systems, such as collaborative filtering, content-based filtering, and hybrid recommender systems.
3. To understand principles of recommendation algorithms, such as matrix factorization, clustering, and association rule mining and different evaluation metrics for recommender systems, such as precision, recall, and F1 score.
4. To understand applications of recommender systems in various fields, such as e-commerce, entertainment, and social media.

**Course Outcomes:**

1. Ability to different types of recommender systems to recommend items to users.
2. Ability to understand and apply different recommendation algorithms to generate recommendations.
3. Ability to evaluate and analyze different recommender system techniques using appropriate evaluation metrics.
4. Ability to develop critical thinking skills and to evaluate and analyze different recommender system techniques.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 3 | 3 | 3 | 3 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 1 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 2 |

**UNIT-I**

Introduction to Recommender Systems (RS): Goals of RS, Basic models of RS, Challenges in RS
Collaborative filtering: Key properties of rating matrices, user and item based nearest recommendation, predicting ratings, neighborhood-based methods (clustering, dimensionality reduction, regression modelling and graph models), Model based collaborative filtering, Content-based, knowledge based, ensemble based and hybrid recommender system

**UNIT-II**

Evaluating Recommender Systems: Explanations in recommender systems, General properties of evaluation research, popular evaluation designs, goals of evaluation design design issues in offline recommender evaluation, accuracy metrics in offline evaluation.
Context, time and location sensitive RS: Multidimensional approach, context pre-filtering, post filtering, contextual modelling, temporal collaborative filtering, discrete temporal models, location aware recommender systems

**UNIT-III**

Structural recommendations in networks Ranking algorithms, recommendations by collective classification, recommending friends: link prediction, social influence analysis and viral marketing
Social and trust centric RS: Multidimensional models for social context, network centric and trust centric methods, user interaction in social recommenders

**UNIT-IV**

Attack-resistant RS: Trade-offsAttack models, Types of attacks, detecting attacks on RS, strategies for robust RS, Online consumer decision making
Learning to rank, multi-armed bandit algorithms, group RS, multi criteria RS, Active learning in RS, privacy in RS, Recommender systems and the next-generation web

**Textbooks:**

1. Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press, 1st ed., 2011.
2. Aggarwal CC. Recommender systems. Cham: Springer International Publishing; 2016.

**Reference books:**

1. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer; 2013.

2. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer; 2011.

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## MEAD608 Data Lakes, Warehousing and Analytics

**Course Objectives:**

1. The students would made to understand the concepts, principles, and techniques of data warehousing, including data modelling, schema design, and data integration
2. The course aims to teach the process of ETL (Extract, Transform, Load) and its role in populating a data warehouse.
3. Students would be exposed to data mining techniques, including classification, clustering, association rules, and anomaly detection.
4. The course aims to teach the students, the ethical, legal, and social implications of data warehousing and data mining, including privacy, security, and data protection.

**Course Outcomes:**

1. Ability to understand data modelling, schema design, and data integration
2. Ability to populate a data warehouse and apply the process of ETL
3. Ability to apply data mining techniques on large data sets
4. Ability to appreciate the ethical, legal and social implications of data warehousing and importance of data privacy.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 1 | 2 | 1 | 1 |
| **CO2** | 1 | 2 | 3 | 2 | 1 |
| **CO3** | 2 | 2 | 3 | 2 | 1 |
| **CO4** | 2 | 1 | 3 | 1 | 3 |

**UNIT - I**

Data Warehousing and Business Analysis: - Data warehousing Components, Building a Data warehouse, Data Warehouse Architecture, DWH Schemas for Decision Support, Data Extraction-Cleaning-Transformation Tools, Metadata, Reporting, Query tools and Applications, Online Analytical Processing (OLAP), OLAP and Multidimensional Data Analysis, OLAP vs OLTP.

Discovering Storage and Compute Data Lakes: Introducing data lakes, Discovering data lake architectures, Data Warehouse Vs Datalakes.

**UNIT - II**

Data Engineering on Microsoft Azure: Introducing data engineering in Azure, Performing data engineering in Microsoft Azure-Self-managed data, engineering services (IaaS), Azure-managed data engineering services (PaaS), Data processing services in Microsoft Azure, Data engineering as a service (SaaS), Data cataloging and sharing services in Microsoft Azure; Opening a free account with Microsoft Azure

Understanding Data Pipelines: Exploring data pipelines, Process of creating a data pipeline, Running a data pipeline, Sample lakehouse project Data Collection Stage – The Bronze Layer: Case Study-Architecting the Electroniz data lake, Understanding the bronze layer, Configuring data sources, Configuring data destinations, Building the ingestion pipelines.

**UNIT - III**

Understanding Delta Lake: Understanding how Delta Lake enables the lakehouse, Understanding Delta Lake, Creating a Delta Lake table, Changing data in an existing Delta Lake table, Performing time travel, Performing upserts of data, Understanding isolation levels, Understanding concurrency control, Cleaning up Azure resources

Data Curation Stage – The Silver Layer: The need for curating raw data, The process of curating raw data, Developing a data curation pipeline, Running the pipeline for the silver layer, Verifying curated data in the silver layer

**UNIT - IV**

Data Aggregation Stage – The Gold Layer : The need to aggregate data, The process of aggregating data, Developing a data aggregation pipeline, Running the

aggregation pipeline, Understanding data consumption, Verifying aggregated data in the gold layer, Meeting customer expectations.

Data Engineering Challenges and Effective Deployment Strategies, governance, Infrastructure Provisioning.

**Textbooks:**

1. Manoj Kukreja,, Data Engineering with Apache Spark, Delta Lake, and Lakehouse, Packt Publishing, 2021.
2. Ponniah P. Data warehousing fundamentals for IT professionals. John Wiley & Sons; 2011.
3. Scott Haines, Modern Data Engineering with Apache Spark: A Hands-On Guide for Building Mission-Critical Streaming Applications, Apress, 2022

**Reference books:**

1. Berson A, Smith SJ. Data warehousing, data mining, and OLAP. McGraw-Hill, Inc.; 1997.
2. Soman KP, Diwakar S, Ajay V. Data mining: theory and practice. PHI Learning Pvt. Ltd.; 2006.
3. Lee, D., Wentling, T., Haines, S., & Babu, P., Delta Lake: The definitive guide: Modern data lakehouse architectures with data lakes. " O'Reilly Media, Inc." 2024

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## MEAD610 Social Network Analysis

**Course Objectives:**

1. The course aims to introduce students to different network metrics, such as centrality, clustering coefficient, and degree distribution.
2. To make students understand the principles of network visualization and modelling.
3. To learn about different social network analysis techniques, such as community detection, link prediction, and influence analysis.
4. To understand the applications of social network analysis in various fields, such as sociology, marketing, and healthcare.

**Course Outcomes:**

1. Ability to apply different network metrics to analyze social networks.
2. Ability to visualize and model social networks using appropriate tools and techniques.
3. Ability to different social network analysis techniques to detect communities, predict links, and analyze influence.
4. Students will be prepared for advanced courses and research in application of Social Network Analysis

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 1 |
| **CO3** | 3 | 3 | 3 | 2 | 3 |
| **CO4** | 3 | 2 | 2 | 2 | 3 |

**UNIT-I**

Basic Concepts of Social Networks: The social networks perspective, historical and theoretical foundation, fundamental concepts in network analysis, analysing relationships, from relationships to networks, social networks vs Link analysis, power of informal networks, Social network data
Mathematical representations of Social Networks: Notation for social network data, Graph and matrices

**UNIT-II**

Structural and Locational Properties: Centrality and Prestige, Non-directional and directional Structural balance and Transitivity, clusterability, generalisation of clusterability, Cohesive subgroups, Affiliations and overlapping subgroups

**UNIT-III**

Roles and Positions: Structural equivalence, Positional analysis, Block models
Analysing relations association among relations: Relational Algebra, Network Positions and Roles

**UNIT-IV**

Dyadic and Triadic Methods: Dyads, simple distribution, statistical analysis of number of arcs, conditional uniform distribution, Statistical analysis of number of mutuals, Triads, Distribution of triads census, Testing structural hypothesis.
Statistical Dyadic interaction models: Statistical analysis of single relational networks, Stochastic block models and Goodness-of-fit indices

**Textbooks:**

1. Wasserman, Stanley, and Katherine Faust. Social network analysis: Methods and applications. Cambridge University Press; 1994.
2. Borgatti SP, Everett MG, Johnson JC. Analyzing social networks. Sage; 2018.

**Reference books:**

1. Hanneman, Robert A. and Mark Riddle. Introduction to social network methods. University of California, Riverside; 2005.

MEAD612 Speech and Language Processing

**Marking Scheme:**
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**Course Objectives:**

1. To make students learn about different text analytics techniques, such as text classification, sentiment analysis, and information extraction.
2. To make students understand the principles of natural language processing, such as part-of-speech tagging, syntactic parsing, and semantic analysis.
3. To understand the applications of text analytics and natural language processing in various fields, such as customer service, social media analysis, and healthcare.
4. To develop critical thinking skills and the ability to evaluate and analyze different text analytics and natural language processing techniques.

**Course Outcomes:**

1. Ability to understand and apply different text analytics techniques to analyze and classify text data.
2. Ability to apply different natural language processing techniques to process and understand natural language text.
3. Ability to evaluate and analyze different text analytics and natural language processing techniques for different applications.
4. Students will be prepared for advanced courses and research in natural Language processing and text analysis.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 2 | 2 | 3 | 3 |
| **CO4** | 3 | 2 | 1 | 2 | 3 |

**UNIT - I**

Language in Cognitive Science: Definitions of language, Language as a rule-governed dynamic system, Knowledge of language, Modes of language: spoken and written, Language system as expression and content
Language Analysis and Computational Linguistics: What is Language Analysis?, Form, Function and Meaning in Language Analysis, Levels of Linguistic Analysis: Phonetics, Phonology, Morphology, Syntax, Semantics, Discourse, Pragmatics, Lexicology
Shallow Parsing and Tools for NLP: Morphological Analysis, Tokenization & PoS Tagging, Chunking & Multi word expression (MWE), Named-Entity Recognition, Lemmatizer & Stemming, Morphological Synthesis
Deep Parsing and Tools for NLP: Syntactic Parsing Techniques and algorithms, Semantic Parsing, Information Extraction, Automatic Summarization, Anaphora Resolution, Pragmatics and Discourse analysis

**UNIT - II**

Text Classification: Bag of words representation. Vector space model and cosine similarity. Relevance feedback and Rocchio algorithm. Versions of nearest neighbor and Naive Bayes for text, Text Classification Using Support Vector Machine (SVM), Statistical Parsing
Language Learning: Classification problems in language: word-sense disambiguation, sequence labelling. Hidden Markov models (HMM's). Veterbi algorithm for determining most-probable state sequences, Training the parameters of HMM's. Use of HMM's for speech recognition.

**UNIT - III**

NLP with ANN: Issues in using ANN with text, understanding word and sentence embedding, Introduction to NLTK, Binary encoding, TF, TF-IDF encoding, Latent Semantic analysis encoding, Latent Dirichlet Allocation, Word2Vec models (Skip-gram, CBOW, Glove, one hot Encoding), Sequence-to-sequence models (Seq2Seq) - GloVe: Global Vectors for Word Representation

**UNIT - IV**

Speech Processing: Articulatory Phonetics, Speech Sounds and Phonetic Transcription, Acoustic Phonetics, Phonology, Computational Phonology, Automatic Speech Recognition (ASR), Speech Recognition Approaches, Text to Speech (TTS) system, Speech Synthesis Approaches
NLP Applications: Lexicon, Dictionaries, thesaurus, Transliteration, Spell Checker, Grammar Checker, Domain identification, Language identification, Auto suggest/ Auto complete, Machine Translation, Question answering & dialogue agents, OCR, Hand Writing Recognition, Sentiment analysis

**Textbooks:**

1. Bird S, Klein E, Loper E. Natural language processing with Python: analyzing text with the natural language toolkit. " O'Reilly Media, Inc."; 2009.
2. Thanaki J. Python natural language processing. Packt Publishing Ltd; 2017.

**Reference books:**

1. Hardeniya N, Perkins J, Chopra D, Joshi N, Mathur I. Natural language processing: python and NLTK. Packt Publishing Ltd; 2016.
2. Srinivasa-Desikan B. Natural Language Processing and Computational Linguistics: A practical guide to text analysis with Python, Gensim, spaCy, and Keras. Packt Publishing Ltd; 2018.

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MEAD614 ML Ops and AI Deployment

**Course Objectives:**

1. Introduce the foundations of MLOps, including the machine learning lifecycle, data management practices, data versioning, experiment tracking, and the role of feature stores in machine learning and generative AI applications.
2. Develop an understanding of machine learning pipeline development, including feature engineering, model training and evaluation, hyperparameter tuning, experiment tracking, and model lineage management using tools such as MLflow.
3. Familiarize students with model deployment architectures and serving strategies.
4. Build competency in the operational, governance, and ethical aspects of deployed machine learning systems.

**Course Outcomes:**

1. Understand MLOps fundamentals, machine learning lifecycle, data management, experiment tracking, and feature store concepts
2. Apply MLOps pipelines for model development, training, evaluation, versioning, and lifecycle management
3. Apply model deployment architectures, serving techniques, and deployment strategies for machine learning applications
4. Analyze deployed machine learning systems with respect to monitoring, performance optimization, security, governance, and ethical considerations

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 2 | 2 | 3 | 3 |

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| CO\PO | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO4 | 3 | 2 | 1 | 2 | 3 |

**UNIT - I**

MLOps Foundations and Data Lifecycle: Introduction to MLOps and its significance, challenges in managing machine learning systems in production, comparison of traditional software development,
DevOps and MLOps, machine learning lifecycle from data to deployment readiness, key components of MLOps, MLOps workflows and tooling landscape. Data management for machine learning systems, data acquisition and preprocessing pipelines, data versioning concepts, reproducibility and experiment
tracking, overview of DVC. Feature stores, motivation and role of feature stores in machine learning and generative AI applications, benefits of feature stores for MLOps, overview of Feast.

**UNIT - II**

MLOps Pipelines and Model Lifecycle Management:Machine learning model development workflows, feature engineering pipelines, training and evaluation processes, comparison of development of small models and large models including large language models, hyperparameter tuning and optimization, experiment tracking and model lineage, overview of MLflow. Continuous integration

**UNIT - III**

Model Deployment Architectures and Serving:Concept of model deployment, deployment architectures for machine learning systems, batch inference and real time inference, online and offline deployment modes, model serving patterns, REST API based model serving, containerization concepts,
introduction to Docker for model deployment, orchestration overview, deployment strategies for cloud, edge and on premises environments.

**UNIT - IV**

Model Deployment Operations and Governance:Operational aspects of deployed models, monitoring and logging of deployed machine learning systems, performance optimization and scaling strategies, model performance monitoring, detection of model drift and data drift, deployment strategies including
blue green deployment, canary deployment and rollback mechanisms. Security considerations in model deployment, introduction to MLSecOps, governance and compliance, model explainability and ethical considerations, bias detection and tracking, deployment considerations for large language models, overview of advanced topics such as federated learning and edge inferencing.

**Textbooks:**

1. Huyen, C., Designing machine learning systems.O'Reilly Media, Inc, 2022.
2. Lakshmanan, V ., Robinson, S., & Munn, Machine learning design patterns. O'Reilly Media, 2020

**Reference books:**

1. Ameisen, E., Building machine learning powered applications: Going from idea to product, O'Reilly Media, Inc, 2020
2. Wilson, B., Machine learning engineering in action. Simon and Schuster., 2022
3. Chen, C., Murphy, N. R., & Srinivasan, K., Reliable machine learning. O'Reilly Media, 2023
4. Kleppmann, M., Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems, O'Reilly Media, Inc. 2019

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## MEAD616 Big Data Frameworks

**Course Objectives:**

1. The course aims to introduce students to the fundamental concepts of big data, including the three Vs (volume, velocity, and variety), and the challenges of big data processing and analysis.
2. To make students learn about different big data frameworks, such as Hadoop, and Spark and their architecture and components.
3. To learn to use different big data tools and software, such as Hadoop MapReduce, Spark SQL, and Hive, to process and analyze big data.
4. To develop critical thinking skills and the ability to evaluate and analyze different big data frameworks and their effectiveness.

**Course Outcomes:**

1. Ability to apply different big data frameworks to process and analyze large datasets.
2. Ability to design and implement big data applications that can scale to handle large datasets.
3. Ability to use different big data tools and software to process and analyze big data.
4. Students will be prepared to use big data frameworks for solving real-world problems in various fields.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 1 |
| **CO3** | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 2 | 2 | 2 | 2 |

**UNIT - I**

Introduction to Big Data: Principles of Big data, Challenges of processing big data, Big data skill and sources of Big Data, Data Acquisitions: web APIs, open data sources, Data APIs and Web scrapping, Data quality and transformation: Data imputation, Data Transformations, outlier and anomalies

**UNIT - II**

Introduction to Hadoop: evolution of Hadoop, Hadoop and its components, comparison with other systems, Hadoop distribution and vendors, Hadoop releases, HDFS, HDFS architecture, Hadoop Architecture, Hadoop installation and cluster configuration

**UNIT-III**

Map Reduce: Map reduce framework, Map and reduce task, partitioners and combiners, Map reduce programming, map only and reduce only program, Map reduce streaming, Map reduce on image dataset, Introduction to HBase, HBase Admin
Introduction to Hive: the hive data-ware house, working with Hive QL

**UNIT-IV**

Introduction to Apache spark: Apache spark APIs for large scale data processing, Resilient distributed databases, Map reduce with spark, working of spark with and without Hadoop, Spark SQL
Introduction to Kafka: Working with Kafka using spark, spark streaming architecture, setting up Kafka Producer and Consumer.

**Textbooks:**

1. White T. Hadoop: The definitive guide. O'Reilly Media, Inc.; 2012.
2. Kienzler R. Mastering Apache Spark 2. x. Packt Publishing Ltd; 2017.

**Reference books:**

1. Bengfort B, Kim J. Data analytics with Hadoop: an introduction for data scientists. O'Reilly Media, Inc.; 2016.
2. Minni S. Apache Kafka Cookbook. Packt Publishing Ltd; 2015.

# MEAD618 Cloud Computing

**Marking Scheme:**
**Teachers Continuous Evaluation and End Term Theory Examination:** As per per university examination norms from time to time
**Instruction to Paper Setters:** **Maximum Marks**: As per University norms Question No. 1 should be compulsory and cover the entire syllabus. This question may have objective or short answer type questions. Apart from Question No. 1, rest of the paper shall consist of four sections as per the units given in the syllabus. Every section should have two questions. However, student may be asked to attempt only 1 question from each section.

**Course Objectives:**

1. The course aims to introduce students to the fundamental concepts, advantages, and novel applications of cloud computing. Provide an overview of different cloud types and their characteristics.
2. To make students explore cloud computing architecture and virtualization.
3. To make students learn identity and access management in the cloud and challenges related to identity and access management (IAM) in cloud services. Introduce relevant IAM standards and protocols .
4. To develop critical thinking skills and the ability to evaluate and analyze security management and privacy issues in the cloud and to understand audit, compliance, and security-as-a-cloud

**Course Outcomes:**

1. Ability to describe the concepts, benefits, and novel applications of cloud computing. Identify different types of clouds and their characteristics.
2. Students will be able to evaluate risk and challenges associated with cloud computing.
3. Ability to comply with the security management standards in the cloud.
4. Ability to assess security considerations at various levels including infrastructure, network, host, application and data security

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 3 | 2 | 2 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 2 | 2 | 3 | 2 |
| **CO4** | 3 | 2 | 1 | 2 | 2 |

**UNIT - I**

Introduction to Cloud Computing Online Social Networks and Applications, Cloud introduction and overview, Different clouds, Risks, Novel applications of cloud computing
Cloud Computing Architecture Requirements, Introduction Cloud computing architecture, On Demand Computing Virtualization at the infrastructure level, Security in Cloud computing environments, CPU Virtualization, A discussion on Hypervisors Storage Virtualization Cloud Computing Defined, The SPI Framework for Cloud Computing, The Traditional Software Model, The Cloud Services Delivery Model

**UNIT - II**

Cloud Deployment Models Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise
Security Issues in Cloud Computing: Infrastructure Security, Infrastructure Security: The Network Level, The Host Level, The Application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security
Identity and Access Management: Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services, IAM Practices in the Cloud, Cloud Authorization Management

**UNIT-III**

Security Management in the Cloud Security Management Standards, Security Management in the Cloud, Availability Management: SaaS, PaaS, IaaS Privacy Issues Privacy Issues, Data Life Cycle, Key Privacy Concerns in the Cloud, Protecting Privacy, Changes to Privacy Risk Management and Compliance in Relation to Cloud Computing, Legal and Regulatory Implications, U.S. Laws and Regulations, International Laws and Regulations

**UNIT-IV**

Audit and Compliance Internal Policy Compliance, Governance, Risk, and Compliance (GRC), Regulatory/External Compliance, Cloud Security Alliance, Auditing the Cloud for Compliance, Security-as-a-Cloud

Advanced Topics: Recent developments in hybrid cloud and cloud security.

**Textbooks:**

1. Buyya, Rajkumar, James Broberg, and Andrzej M. Goscinski, eds. Cloud computing: Principles and paradigms. John Wiley & Sons, 2010.

2. Erl, Thomas, Ricardo Puttini, and Zaigham Mahmood. Cloud computing: concepts, technology & architecture. Pearson Education, 2013.

**Reference books:**

1. John Rhoton. Cloud Computing Explained: Implementation Handbook for Enterprises, Recursive Limited. 2nd ed.; 2009.
2. Tim Mather. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice). O'Reilly Media; 2009.

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## MEAD620 Intelligent Autonomous Systems

**Course Objectives:**

1. Introduce the fundamental concepts of autonomous and intelligent systems, levels of autonomy, embedded intelligence, and the sensing technologies.
2. Develop an understanding of localization and mapping techniques, coordinate transformations, multi-sensor fusion, and planning/decision-making methods, along with practical exposure to ROS2, Gazebo, and OpenCV tools.
3. Familiarize students with autonomous control, navigation, and guidance approaches, human-machine interaction, and tracking systems, supported by case studies of autonomous rotorcraft using PX4 and ArduPilot.
4. Expose students to emerging autonomous technologies such as cooperative multi-agent control and swarm intelligence, and their application to UAV/UGV missions and intelligent industrial robotics.

**Course Outcomes:**

1. Explain the fundamental concepts of autonomous systems, levels of autonomy, and apply sensor characterization.
2. Apply localization and mapping techniques, including sensor fusion and AI-based methods, and design path/trajectory planning and decision-making algorithms
3. Design and analyze autonomous control, navigation, and guidance strategies for autonomous platforms.
4. Analyze emerging autonomous technologies, including multi-agent cooperative control and swarm intelligence, and apply them to real-world UAV, UGV, and industrial robotics applications.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| **CO\PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** |
| **CO1** | 2 | 2 | 2 | 2 | 1 |
| **CO2** | 1 | 3 | 2 | 3 | 1 |
| **CO3** | 2 | 3 | 1 | 3 | 2 |

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| CO\PO | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO4 | 3 | 3 | 1 | 2 | 2 |

**UNIT - I**

Introduction to Autonomous Systems: Evolution of autonomous and intelligent systems; Levels of autonomy; Autonomous agents; Embedded intelligence; Applications in UAVs, UGVs, autonomous vehicles, industrial automation, and aerospace systems.
Sensors and Environment Modelling: Fundamentals of sensing systems; IMU, GPS/GNSS, LiDAR, Radar, ultrasonic sensors and cameras; Sensor characteristics and calibration; Sensor error modeling; Environmental modelling;

**UNIT - II**

Simultaneous Localization and Mapping: Coordinate frames and transformations; Inertial navigation concepts; Localization techniques; Visual-inertial navigation; Multi sensor fusion methods; quantum navigation with AI.
Planning and Decision Making: Mission planning concepts; Graph-based path Trajectory generation; Obstacle avoidance; AI based decision making.
Introduction to ROS2, Gazebo and OpenCV

**UNIT-III**

Autonomous Control: Autonomous control approach; Autonomous navigation and guidance; Human-machine interaction; Autonomous tracking systems.
Case study of rotorcraft as autonomous system using PX4 and Ardupilot

**UNIT-IV**
Emerging Autonomous Technologies: Cooperative control of multi-agent systems; Swarm intelligence;
Applications and Case Studies: UAV and UGV simulations for intelligent autonomous mission execution; Intelligent industrial robotics motion control and automation applications.

**Textbooks:**

1. Sebastian Thrun, Wolfram Burgard and Dieter Fox, Probabilistic Robotics, MIT Press, 2006
2. Steven M. LaValle, Planning Algorithms, Cambridge University Press, 2006

**Reference books:**

1. Peter Corke, Robotics, Vision and Control, Springer, 2011
2. Mohinder S. Grewal et al., Global Positioning Systems, Inertial Navigation and Integration, Wiley, 2nd Edition, 2007

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## MEAD622 Adversarial Artificial Intelligence

**Course Objectives:**

1. Introduce the fundamental concepts of adversarial machine learning, adversarial settings, and the importance of adversarial robustness in AI applications.
2. Develop an understanding of methods to evaluate adversarial attacks and design defense mechanisms.
3. Familiarize students with vulnerabilities in deep learning architectures, with emphasis on adversarial examples in computer vision and their generation/defense techniques.
4. Expose students to real-world applications of adversarial machine learning

**Course Outcomes:**

1. Explain the fundamental concepts of adversarial machine learning and differentiate between types of adversarial attacks, including evasion and poisoning attacks.
2. Evaluate the effectiveness of adversarial attacks using appropriate metrics, and design defense mechanisms such as adversarial training, data sanitization, and robust learning algorithms to mitigate them.
3. Analyze vulnerabilities in deep neural network architectures and apply techniques to generate and defend against adversarial examples in computer vision applications.
4. Analyze real-world applications of adversarial machine learning in domains such as cybersecurity, finance, and healthcare, and evaluate the ethical, legal, and societal implications of adversarial AI practices.

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| CO\PO | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 1 | 2 | 2 | 1 |
| CO2 | 2 | 2 | 3 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 3 | 1 |
| CO4 | 2 | 1 | 1 | 1 | 3 |

**UNIT - I**

Introduction to Adversarial ML: Overview of machine learning and adversarial settings, Importance of adversarial machine learning in AI applications.
Types of Adversarial Attacks: Overview of adversarial attacks (decision-time attacks vs. training- time attacks)Evasion Attacks, Poisoning Attacks

**UNIT - II**

Evaluation of Adversarial Attacks, Metrics for assessing the effectiveness of adversarial attacks, Analysis of attack success rates. Defense Mechanisms Against Evasion Attacks: Techniques for enhancing model robustness, Adversarial training and its implications. Defense Mechanisms Against Poisoning Attacks: Data sanitization techniques, Robust learning algorithms.

**UNIT-III**

Deep Learning in Adversarial Settings: Overview of deep learning architectures, Vulnerabilities in deep neural networks.
Adversarial Examples in Computer Vision: Techniques for generating and defending against adversarial examples in image processing, Applications in facial recognition and object detection.

**UNIT-IV**

Real-World Applications of Adversarial Machine Learning: Applications in cybersecurity, finance, and healthcare, Case studies from industry.
Ethical Considerations in Adversarial Machine Learning, Discussing the ethical implications of adversarial strategies, Legal and societal responsibilities in AI practices.

**Textbooks:**

1. Vorobeychik, Y., & Kantarcioglu, M., Adversarial Machine Learning. Morgan & Claypool Publishers, 2018.
2. Joseph, A. D., Nelson, B., Rubinstein, B. I. P., & Tygar, J. D., Adversarial Machine Learning, Cambridge University Press, 2019

**Reference books:**

1. Liu, B., Liu, W., Zhou, W., & Yang, X., Adversarial Machine Learning: Attack surfaces, defence mechanisms, learning theories in artificial intelligence. Springer Nature Switzerland AG, 2023

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## MEAD624 Metaverse and Blockchain

**Course Objectives:**

1. Introduce the fundamental concepts of the Metaverse, its evolution, defining characteristics, layered architecture, and enabling technologies (AR/VR/XR/MR, digital twins, spatial computing).
2. Develop an understanding of blockchain fundamentals, distributed ledger technology, consensus mechanisms, cryptographic principles, and smart contract development.
3. Familiarize students with immersive virtual world design, avatar creation, digital identity, and interoperability concepts, along with the integration of AI and blockchain-based identity verification within Metaverse environments.
4. Build competency in Metaverse economic and governance models (NFTs, DAOs, DeFi), and equip students to evaluate the security, privacy, legal, ethical, and sustainability implications of Metaverse-blockchain ecosystems

**Course Outcomes:**

1. Explain the fundamental concepts, evolution, layers, and enabling technologies of the Metaverse, and describe its applications across various industry domains.
2. Apply blockchain fundamentals, including consensus mechanisms, cryptographic principles, and smart contract development.
3. Design immersive virtual world experiences using 3D world-building platforms, and implement digital identity and interoperability solutions.
4. Analyze Metaverse economic and governance models (NFTs, DAOs, DeFi)

| Mapping of Course Outcome to Programme Outcome ((scale 1: low, 2: Medium, 3: High) | | | | | |
|---|---|---|---|---|---|
| CO\PO | PO1 | PO2 | PO3 | PO4 | PO5 |
| CO1 | 2 | 2 | 1 | 1 | 1 |
| CO2 | 2 | 3 | 1 | 3 | 1 |
| CO3 | 1 | 3 | 1 | 2 | 1 |
| CO4 | 2 | 2 | 2 | 1 | 3 |

**UNIT - I**

Introduction to Metaverse and Foundational Technologies: Evolution of the Metaverse concept, defining characteristics of the Metaverse (persistence, interoperability, immersion, real-time interaction), historical milestones from virtual worlds to Web3-based Metaverse, layers of the Metaverse (infrastructure, hardware, virtualization, experience), Metaverse ecosystem stakeholders. Enabling technologies overview: AR, VR, XR, MR, digital twins, spatial computing, edge computing for Metaverse, 5G/6G connectivity requirements. Applications of Metaverse across gaming, education, healthcare, retail, real estate, and enterprise collaboration.

**UNIT - II**

Blockchain Fundamentals and Decentralized Infrastructure: Introduction to blockchain technology, distributed ledger concepts, structure of a blockchain (blocks, hashes, Merkle trees), types of blockchain (public, private, consortium, hybrid), consensus mechanisms (Proof of Work, Proof of Stake, Delegated Proof of Stake, Practical Byzantine Fault Tolerance), cryptographic foundations (hashing, digital signatures, public-private key cryptography). Smart contracts: concepts, lifecycle, and platforms (Ethereum, Solana, Polygon), introduction to Solidity programming, decentralized applications (DApps), tokenization concepts (fungible and non-fungible tokens), token standards (ERC-20, ERC-721, ERC-1155), wallets and crypto-economic principles, decentralized storage solutions (IPFS, Filecoin) for Metaverse assets.

**UNIT-III**

Immersive Technologies, Virtual Worlds, and Digital Identity: 3D virtual world design principles, world-building engines and platforms (Unity, Unreal Engine, Decentraland, The Sandbox), avatar creation and customization, digital identity and self-sovereign identity (SSI) concepts, identity verification using blockchain, interoperability standards across virtual platforms, asset portability between Metaverse platforms. Human-computer interaction in immersive environments, haptics and sensory feedback, social and collaborative experiences in shared virtual spaces, content creation and user-generated content (UGC) economies, integration of AI (avatars, NPCs, generative content) within Metaverse environments.

**UNIT-IV**

NFT marketplaces and digital asset ownership, virtual real estate and digital land economics, play-to-earn and creator economy models, decentralized autonomous organizations (DAOs) for Metaverse governance, DeFi integration within Metaverse platforms, cross-chain interoperability and bridges.

Security challenges in blockchain and Metaverse (smart contract vulnerabilities, wallet security, identity theft, virtual asset fraud), privacy concerns in immersive data collection, regulatory and legal challenges (digital property rights, jurisdiction, taxation of virtual assets), ethical considerations (digital addiction, accessibility, inclusivity, misinformation in virtual spaces), sustainability and energy concerns of blockchain infrastructure, emerging trends and future directions of Metaverse-blockchain convergence.

**Textbooks:**

1. Ball, M., The metaverse: and how it will revolutionize everything. Liveright Publishing, 2022
2. Bashir, I., Mastering blockchain, Packt Publishing Ltd, 2020

**Reference books:**

1. Dieter Schmalstieg and Tobias Höllerer,, Augmented Reality: Principles and Practice, Addison-Wesley Professional, 2016
2. Gabriel René and Dan Mapes, The Spatial Web: How Web 3.0 Will Connect Humans, Machines and AI to Transform the World. 2019