BABU BANARASI DAS UNIVERSITY

School of Engineering

(School Code: 04)

Department of Computer Science & Engineering

University Branch Code: 42

M.Tech.- Computer Science and Engineering(Artificial Intelligence)

Evaluation Scheme

SEMESTER I									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
F	MAI1101	Mathematical Foundations of Artificial Intelligence	4	0	0	40	60	**100**	**4**
C	MAI1102	Advanced Data Structures and Algorithms	4	0	0	40	60	**100**	**4**
F	MAI1103	Principles of Artificial Intelligence	4	0	0	40	60	**100**	**4**
GE		Generic Elective I	4	0	0	40	60	**100**	**4**
C	MAI1151	Advanced Data Structures and Algorithms Lab	0	0	4	40	60	**100**	**2**
C	MAI1152	Artificial Intelligence Lab	0	0	4	40	60	**100**	**2**
C	MAI1153	Seminar	0	0	4	100	-	**100**	**2**
Total			**16**	**0**	**12**	**340**	**360**	**700**	**22**

SEMESTER II									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAI1201	Modern Machine Learning Architectures and Algorithms	4	0	0	40	60	**100**	**4**
C	MAI1202	Advanced Deep Learning and Generative Models	4	0	0	40	60	**100**	**4**
GE		Generic Elective II	4	0	0	40	60	**100**	**4**
GE		Generic Elective III	4	0	0	40	60	**100**	**4**
C	MAI1251	Machine Learning Lab	0	0	4	40	60	**100**	**2**
C	MAI1252	Deep Learning Lab	0	0	4	40	60	**100**	**2**
C	MAI1253	Seminar	0	0	4	100	-	**100**	**2**
Total			**16**	**0**	**12**	**340**	**360**	**700**	**22**

SEMESTER III									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
F	MAI1301	Research Methodology and IPR	4	0	0	40	60	100	4
GE		Generic Elective IV	4	0	0	40	60	100	4
C	MAI1351	Seminar	0	0	4	100	-	100	2
C	MAI1352	Dissertation I	2	-	-	400	-	400	10
Total			**10**	**-**	**4**	**580**	**120**	**700**	**20**

SEMESTER IV									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MAI1451	Dissertation II	-	-	32	200	800	1000	16
Total			**-**	**-**	**32**	**200**	**800**	**1000**	**16**

Legends:

L Number of Lecture Hours per week

T Number of Tutorial Hours per week

P Number of Practical Hours per week

CIA Continuous Internal Assessment

ESE End Semester Examination

Category of Courses:

F Foundation Course

C Core Course

GE Generic Elective

Generic Elective I

Course Code	Course Name	Credits
GE14211	Evolutionary Algorithms	4
GE14212	Computer Vision and Pattern Recognition	4
GE14213	Data Mining and Data Warehousing	4
GE14214	Natural Language Processing	4

Generic Elective II

Course Code	Course Name	Credits
GE14221	Blockchain Technologies	4
GE14222	Internet of Things	4
GE14223	Explainable AI	4
GE14224	Swarm Intelligence	4

Generic Elective III

Course Code	Course Name	Credits
GE14231	AI Policy and Governance	4
GE14232	Data Ethics in AI	4
GE14233	Responsible Artificial Intelligence	4
GE14234	AI for Cyber Security	4

Generic Elective IV

Course Code	Course Name	Credits
GE14241	Cloud Computing	4
GE14242	Distributed Systems	4
GE14243	Big Data Analytics	4
GE14244	Digital Twin Technology	4

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	I		
Course Name	Mathematical Foundations of Artificial Intelligence				
Code	MAI1101				
Course Type	Theory	**L**	**T**	**P**	**Credit**
Prerequisite	Basic Knowledge of Linear Algebra, Calculus, Probability and Statistics and Discrete Mathematics	4	0	0	4
Course Objectives	1. To introduce core mathematical concepts that form the foundation of Artificial Intelligence. 2. To develop a strong understanding of linear algebra and its role in AI models such as neural networks and dimensionality reduction. 3. To apply calculus for optimization and training of AI models through techniques such as gradient descent. 4. To explore probability and statistics for modeling uncertainty and learning from data. 5. To understand basic elements of discrete mathematics relevant to logic, reasoning, and graph-based algorithms.				
Course Outcomes					
CO1	Understand the fundamental concepts and motivation behind linear algebra and its applications in various fields.				
CO2	Understand the foundational concepts of probability, conditional probability, and Bayes' theorem, and apply them to model uncertain events.				
CO3	Understand the fundamental concepts of random variables and distribution functions in the context of stochastic processes.				
CO4	Understand the concept of periodic functions and represent them using trigonometric series.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Linear Algebra** Vectors and vector spaces**,** Matrices: operations, types, rank, inverse, and determinants**,** Eigenvalues, Eigenvectors, and diagonalization, Singular Value Decomposition (SVD)	9 Hours.	CO1
2	**Probability and Statistics** Introduction to Statistics and Probability, Probability and Conditioning, Conditional Probability, Baye's rule, Random variables, Expectation and Variance, Covariance, Discrete and Continuous Distributions- Uniform, Gaussian and Rayleigh distributions; Binomial, and Poisson distributions; Multivariate Gaussian distribution, Central Limit Theorem	9 Hours.	CO2
3	**Stochastic Process:** Random number, Distribution function, Interval estimation, Confidence intervals, Test of hypothesis, Markov process with special emphasis on Markov chain.	9 Hours.	CO3
4	**Integral Transform:** Fourier Series and Transform: Periodic functions, Trigonometric functions, Trigonometric Series,	9 Hours	CO4

	Fourier series, Dirichlet conditions, Euler formula for Fourier coefficients, Even and Odd functions, Half range series expansion, Parseval's formula. Fourier transform, Properties of Fourier transform, Fourier sine and cosine transform, Convolution theorem, First Fourier transform.		

Suggested Readings:

1. Kreyszig, E.(2011), Advanced engineering mathematics, Wiley India Pvt Ltd.
2. Grewal B.S.(2023), Higher Engineering Mathematics, Khanna Publishers
3. Ramana, B.V.(2010), Higher Engineering Mathematics, TMH, New Delhi.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc25_cs136/preview
2. https://onlinecourses.nptel.ac.in/noc24_ma61/preview
3. https://nptel.ac.in/courses/111107137

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	1	2	-	-	-	-	-	-	2	2
CO2	3	3	2	2	3	-	-	-	-	-	-	3	3
CO3	3	2	2	2	2	1	-	-	-	-	-	3	3
CO4	3	2	2	2	3	-	-	-	-	-	-	2	2

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	I		
Course Name	Advanced Data Structures and Algorithms				
Code	MAI1102				
Course Type	Theory	**L**	**T**	**P**	**Credit**
Prerequisite	Basic Knowledge of Data Structures and Algorithms	4	0	0	4
Course Objectives	1. To deepen students' understanding of complex data structures and their applications in solving advanced computational problems. 2. To explore advanced algorithmic techniques such as divide and conquer and backtracking. 3. To analyse and design efficient algorithms for problems involving graphs, trees. 4. To study and apply advanced data structures including trees, heaps, Priority Queue, hash tables, and Graphs.				
Course Outcomes					
CO1	Analyse the time and space complexity of algorithms and evaluate their efficiency.				
CO2	Learning simple and efficient implementations of priority queues using arrays and tree structures.				
CO3	Studying AVL Trees, including their single and double rotation techniques used to maintain balance after insertions and deletions.				
CO4	Apply graph algorithms to model and solve real-world problems such as scheduling, networking, and route optimization.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Role of algorithms in computing & complexity analysis:** Algorithms –Time and Space complexity of algorithms-Asymptotic analysis-Average and worst-case analysis-Asymptotic notation-Importance of efficient algorithms-Program performance measurement - Recurrences: The Substitution Method – The Recursion-Tree Method- Masters Theorem method	9 Hours.	CO1
2	**Priority Queues (Heaps)** – Model, Simple implementations, Binary Heap: Structure Property, Heap Order Property, Basic Heap Operations: insert, delete, Percolate down, Other Heap Operations. Binomial Queues: Binomial Queue Structure, Binomial Queue Operations, Implementation of Binomial Queue, Priority Queues in the Standard Library.	9 Hours.	CO2
3	**Trees** –Traversal, AVL: Single Rotation, Double Rotation, B-Trees. **Multi-way Search Trees** – 2-3 Trees: Searching for an Element in a 2-3 Tree, Inserting a New Element in a 2-3 Tree, Deleting an Element from a 2-3 Tree. **Red-Black Trees** – Properties of red-black trees, Rotations, Insertion, Deletion.	9 Hours.	CO3
4	**Hashing** – General Idea, Hash Function, Separate Chaining, Hash Tables without linked lists: Linear Probing, Quadratic	9 Hours	CO4

	Probing, Double Hashing, Rehashing, Hash Tables in the Standard Library, Universal Hashing, Extendible Hashing. **Graphs Algorithms** – Elementary Graph Algorithms: Topological sort, Single Source Shortest Path Algorithms: Dijkstra's, Bellman-Ford, All-Pairs Shortest Paths: Floyd-Warshall's Algorithm.		

Suggested Readings:

1. Adam Drozdex, "Data Structures and algorithms in C++", Cengage Learning, 4th Edition, 2013.
2. T.H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein, "Introduction to Algorithms", Prentice Hall of India, 3rd Edition, 2012.
3. Mark Allen Weiss, "Data Structures and Algorithms in C++", Pearson Education, 3rd Edition, 2009.

Online Resources

1. http://ocw.mit.edu/6-851S12 (MITOPENCOURSEWARE, Massachusetts Institute of Technology)
2. https://nptel.ac.in/courses/106/106/106106133

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	1	2	-	-	-	-	-	-	2	2
CO2	3	3	2	2	3	-	-	-	-	-	-	3	3
CO3	3	2	2	2	2	1	-	-	-	-	-	3	3
CO4	3	2	2	2	3	-	-	-	-	-	-	2	2

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	I		
Course Name	Principles of Artificial Intelligence				
Code	MAI1103				
Course Type	Theory	**L**	**T**	**P**	**Credit**
Prerequisite	Basic Knowledge of AI and Programming Concepts.	4	0	0	4
Course Objectives	1. To establish a comprehensive understanding of foundational Artificial Intelligence concepts, including its historical evolution, classifications, and the architecture of intelligent agent-based systems. 2. To develop critical analytical and problem-solving skills by applying search strategies, constraint satisfaction techniques, and game-theoretic approaches to AI problem formulations. 3. To strengthen logical reasoning and decision-making capabilities through the design and implementation of expert systems using structured knowledge representation and inference mechanisms. 4. To enable the application of advanced AI techniques such as natural language processing, reinforcement learning, and fuzzy logic for intelligent data analysis, autonomous decision-making and managing uncertainty in complex real-world environments.				
Course Outcomes					
CO1	Describe the core principles, history, and types of Artificial Intelligence, including intelligent agents and their environments.				
CO2	Apply uninformed and informed search techniques, game strategies, and constraint satisfaction methods to solve structured AI problems.				
CO3	Analyse and construct logical knowledge representations using propositional and first-order logic to perform intelligent reasoning and inference.				
CO4	Design intelligent systems using advanced AI techniques such as multi-agent systems, reasoning under uncertainty, probabilistic planning, and case-based reasoning to address complex real-world challenges, focusing on applications in robotics, expert systems, and human-AI interaction.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Foundations of Artificial Intelligence:** Definition, history, and evolution of AI, Types of AI: Narrow, General, Super AI, Turing Test, AI applications: NLP, computer vision, robotics, expert systems, Agents and Environments, Intelligent agent design: PEAS (Performance measure, Environment, Actuators, Sensors).	9 Hours.	CO1
2	**Problem Solving, Search, and Game Playing:** Problem formulation and state space**,** Uninformed search: BFS, DFS, Uniform Cost Search, Informed search: Greedy, Best-First, A* Algorithm**,** Heuristics: design and evaluation**,** Local search: Hill Climbing, Simulated Annealing**,** Adversarial	9 Hours.	CO2

	search: Game trees, Min-max, Alpha-Beta Pruning**,** Constraint Satisfaction Problems (CSPs)		
3	**Knowledge Representation, Reasoning, and Planning:** Approaches to knowledge representation, Propositional and First-Order Predicate Logic, Syntax, semantics, and inference techniques, Rule-based systems and expert systems, Semantic networks, frames, and ontologies, Probabilistic reasoning and Bayesian Networks, Classical and partial-order planning, Hierarchical Task Network (HTN) planning, Conditional and contingency planning, Decision theory, utility theory, Markov Decision Processes (MDPs)	9 Hours.	CO3
4	Advanced AI Techniques and Applications: **Reasoning Under Uncertainty**: Non-monotonic reasoning, Default logic and truth maintenance systems, Probabilistic logic and inference, **Planning Under Uncertainty and Dynamics**: Stochastic and probabilistic planning, **AI in Real-World Applications (Rule-based and Symbolic AI focused)**: AI in robotics: path planning, environment modeling, Expert systems in diagnostics (healthcare, automotive, legal domains), Symbolic AI in education and intelligent tutoring systems, Human-AI interaction and ethical reasoning in AI systems.	9 Hours	CO4

Suggested Readings:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, 4th Edition, Pearson Education: The most comprehensive and authoritative text on AI, covering search, logic, learning, planning, and real-world applications.
2. Elaine Rich, Kevin Knight & Shivashankar B. Nair, *Artificial Intelligence*, 3rd Edition, McGraw Hill: A foundational book offering clear insights into AI principles, expert systems, and problem-solving techniques.
3. Tom M. Mitchell, *Machine Learning*, McGraw Hill: A key resource for understanding the basics of machine learning algorithms and their mathematical foundations.

Online Resources:

1. https://nptel.ac.in/courses/112103280
2. https://onlinecourses.nptel.ac.in/noc22_cs56/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	1	2	-	1	-	-	-	-	2	2
CO2	3	3	3	2	2	-	-	-	-	-	-	3	2
CO3	3	3	3	2	3	1	-	-	-	-	-	3	3
CO4	3	3	3	3	3	2	2	2	1	-	2	3	3

Program	M. Tech (CSE-AI)				
Year	I	Semester		I	
Course Name	Advanced Data Structures and Algorithms Lab				
Code	MAI1151				
Course Type	Practical	L	T	P	Credit
Pre-Requisite	Basic Knowledge of computer fundamentals and Programming Concepts.	0	0	4	2
Course Objectives	**1.** To acquire the knowledge of using advanced tree structures **2.** To learn the usage of heap structures **3.** To understand the usage of graph structures and spanning trees **4.** To understand the problems such as matrix chain multiplication, activity selection and Huffman coding **5.** To understand the necessary mathematical abstraction to solve problems.				
Course Outcomes					
CO1	Design and implement basic and advanced data structures extensively				
CO2	Understand and implement Fibonacci Heaps for advanced heap operations with improved amortized complexity.				
CO3	Design algorithms using graph structures				
CO4	Develop efficient solutions for the Activity Selection problem using greedy algorithms.				

S. No.	List of Experiments	Mapped CO
1.	Implementation of Priority Queue	CO1
2.	Implementation of Binomial Queue	CO1
3.	Implementation of a AVL tree	CO1
4.	Implementation of Red-Black Tree	CO2
5.	Implementation of Multi-way Search	CO2
6.	Implementation of Fibonacci Heap	CO2
7.	Implementation of Tree Traversal	CO3
8.	Implementation of Graph Traversal	CO3
9.	Implementation of Shortest Path Algorithms(Dijkstra's algorithm)	CO3
10.	Implementation of All pairs shortest path	CO4

Online Resources

1. http://www.coursera.org/specializations/data-structures-algorithms
2. https://nptel.ac.in/courses/106102064

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	3	2	3	-	-	-	-	-	-	3	2
CO2	3	2	3	2	3	-	-	-	-	-	-	3	3
CO3	3	3	3	2	3	-	-	-	-	-	-	3	3
CO4	3	2	3	2	3	-	-	-	-	-	-	3	2

Program	M. Tech (CSE-AI)				
Year	I	Semester		I	
Course Name	Artificial Intelligence Lab				
Code	MAI1152				
Course Type	Practical	L	T	P	Credit
Pre-Requisite	Basic knowledge of programming, algorithms, and mathematics (linear algebra, probability, logic).	0	0	4	2
Course Objectives	**1.** Implement fundamental AI algorithms and understand their underlying principles. **2.** Develop problem-solving capabilities using techniques such as search, logic, and constraint satisfaction. **3.** Apply machine learning algorithms to real-world problems. **4.** Demonstrate the ability to design intelligent agents and apply AI methods to data-driven applications.				
Course Outcomes					
CO1	Implement AI techniques such as search algorithms and knowledge representation.				
CO2	Develop intelligent agents using rule-based and logic-based systems				
CO3	Apply fundamental machine learning techniques including supervised and unsupervised learning.				
CO4	Use Python libraries to build and evaluate AI models for real-world datasets.				

S. No.	List of Experiments	Mapped CO
1	Implement uninformed search algorithms: BFS, DFS.	CO1
2	Implement informed search algorithms: A*, Greedy Search.	CO2
3	Solve a constraint satisfaction problem (e.g., 8-Queens) using backtracking.	CO2
4	Develop a simple expert system using forward chaining and backward	CO2
5	Represent knowledge using propositional and first-order logic in Python.	CO2
6	Build a decision tree classifier using a dataset.	CO3
7	Implement a k-Nearest Neighbours (k-NN) algorithm from scratch.	CO4
8	Train and evaluate a Naïve Bayes classifier on textual data.	CO4
9	Use scikit-learn to apply Logistic Regression supervised learning algorithms.	CO3
10	Apply k-means clustering algorithmon a sample dataset using Python.	CO3

Online Resources

1. https://nptel.ac.in/courses/106105077

2. https://scikit-learn.org/stable/

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	2	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	II		
Course Name	Modern Machine Learning Architectures and Algorithms				
Code	MAI1201				
Course Type	Theory	**L**	**T**	**P**	**Credit**
Prerequisite	Basic Knowledge of computer fundamentals and Programming Concepts.	4	0	0	4
Course Objectives	**1.** To be able to define ML Model/Hypothesis and evaluation of model. **2.** To be able to understand classification algorithm and Dimensionality Reduction **3.** To be able to implement probabilistic algorithms and classification algorithm. **4.** To be able to understand and implement Reinforcement learning (RL)				
Course Outcomes					
CO1	Understand and define simple ML Model				
CO2	Analysis of classification algorithm and reduce dimensions of data.				
CO3	Develop Probabilistic algorithm.				
CO4	Apply Reinforcement learning (RL)				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction: Introduction to Machine Learning: Introduction. Different types of learning, Hypothesis space and inductive bias. Training and test sets, cross validation, Concept of over fitting, under fitting, Bias and Variance. Linear Regression: Introduction, Linear regression, Simple and Multiple Linear regression, Polynomial regression, evaluating regression fit.	9 Hours.	CO1
2	Decision tree learning: Introduction, Decision tree representation, appropriate problems for decision tree learning, the basic decision tree algorithm, hypothesis space search in decision tree learning, issues in decision tree learning, Ensamble Learning, Random Forest Instance based Learning: K nearest neighbour Algorithm. Curse of Dimensionality, Feature Selection: univariate, multivariate feature selection approach, Feature reduction: Principal Component Analysis, Independent Component Analysis(ICA) : Introduction, Cocktail Party Problem in ICA,Singular Value decomposition(SVD) Recommender System: Content based system, Collaborative filtering based System	9 Hours.	CO2
3	Probability and Bayes Learning: Bayesian Learning, Naïve Bayes, Python exercise on Naïve Bayes, Logistic Regression.	9 Hours.	CO3

	Support Vector Machine: Introduction, the Dual formulation, Maximum margin with noise, nonlinear SVM and Kernel function, solution to dual problem.		
4	Reinforcement learning (RL): Introduction, Agent and Environment, Actions and States, Rewards and Penalties, Learning, Policy, Trial and Error, Goal. Concepts of Value Function, Q-function, Model-Free RL vs. Model-Based RL	9 Hours	CO4

Suggested Readings:

1. Ethem Alpaydin,"Introduction to Machine Learning", MIT Press, Prentice Hall of India, Third Edition 2014
2. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar "Foundations of Machine Learning", MIT Press, 2012.

Online Resources:

1. https://nptel.ac.in/courses/106106139
2. https://nptel.ac.in/courses/106105152

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	3	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	II		
Course Name	Advanced Deep Learning and Generative Models				
Code	MAI1202				
Course Type	Theory	**L**	**T**	**P**	**Credit**
Prerequisite	Concept of ANN, Deep Learning and Machine Learning	4	0	0	4
Course Objectives	1. To introduce the concepts of Deep learning 2. To solve real-world applications using Deep learning 3. Providing insight into recent Deep Learning architectures 4. To learn different knowledge representation techniques in Deep Learning				
Course Outcomes					
CO1	To understand basic concept of ANN and Deep Learning				
CO2	Know the concepts and techniques of Deep Learning and foster their abilities in designing and implementing Deep Learning based solutions for real-world and engineering problems.				
CO3	To understand a wide variety of learning representation techniques in Deep Learning visualize Convolutional Neural Network for real-world Applications and Other Neural Networks				
CO4	To distinguish different types of Advanced Neural Networks				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Neural Networks-I (Introduction & Architecture) :** Neural Networks-I (Introduction & Architecture) : Neuron, Nerve structure and synapse, Artificial Neuron and its model Activation functions, Sigmoid, Tanh and Relu Functions – Softmax The Neuron Expressing Linear Perceptrons as Neurons – Feed-Forward Neural Networks, Convergence rule, Auto-associative and Hetro-Associative memory.	9 Hours.	CO1
2	**Neural Networks-II (Backpropagation networks):** Architecture: perceptron Model, Solution, Single Layer Artificial Neural Network, Multilayer Perception Model; Backpropagation Learning Methods, Effect of Learning Rule Co-Efficient; Backpropagation Algorithm, Factors Affecting Backpropagation Training and Applications.	9 Hours.	CO2
3	**Deep Network :** Learning Platforms. A Probabilistic Theory of Deep Learning, Backpropagation and regularization, normalization, Stochastic Gradient Descent (SGD), Convolution Network Architecture, Deep Boltzmann Machine, Hidden Markov model, Deep Networks Vs. Shallow Networks Convolutional Networks- Auto Encoder and Semi-Supervised Learning	9 Hours.	CO3

4	**Advanced Neural Networks :** Population Based Methods, Spatial Transformer Networks- Recurrent networks, LSTM Recurrent Neural Network Language Models, Generator, Discriminator, Training, GAN variants; Autoencoder: Architecture, Denoising and Sparcity; DALL-E, DALL-E 2, ImageNet and AlexNet Structure	9 Hours	CO4

Suggested Readings:

1. Deep Learning: A Practitioner's Approach, Josh Patterson, Adam Gibson, O'Reilly Media, 2017
2. N. P. Padhy,"Artificial Intelligence and Intelligent Systems" Oxford University Press. Reference Books:
3. Stephen Marsland, ―Machine Learning: An Algorithmic Perspective, CRC Press, 2009

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_cs62/preview
2. https://nptel.ac.in/courses/106106201
3. https://onlinecourses.nptel.ac.in/noc25_cs93/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	3	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	2	2	-	-	-	-	-	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	Semester		II	
Course Name	Machine Learning Lab				
Code	MAI1251				
Course Type	Practical	L	T	P	Credit
Pre-Requisite	Basic knowledge of Python programming, and mathematics (linear algebra, probability, logic).	0	0	4	2
Course Objectives	1. Understand and apply fundamental machine learning algorithms such as regression, classification, clustering, and dimensionality reduction. 2. Develop proficiency in using programming tools and frameworks like Python, scikit-learn, Tensor Flow, or similar for machine learning. 3. Preprocess and analyze data effectively to prepare it for machine learning models. 4. Evaluate and compare model performance using appropriate metrics and techniques like cross-validation.				
Course Outcomes					
CO1	To learn the basic concepts of machine learning and types of machine learning.				
CO2	To design and analyze various machine learning algorithms and techniques with a modern outlook focusing on recent advances.				
CO3	Explore supervised and unsupervised learning paradigms of machine learning.				
CO4	To Outline predictions using machine learning algorithms.				

S. No.	List of Experiments	Mapped CO
1	Creation and Loading different types of datasets in Python using the required libraries. (a) Understanding and using Jupyter Notebook and Colab Notebook (b) Creation using pandas: Loading CSV dataset files using Pandas (c) Loading datasets using sklearn	CO1
2	Write a python program to (a) compute Mean, Median, Mode, Variance, Standard Deviation using Datasets (b) Demonstrate various data pre-processing techniques for a given dataset.	CO2
3	Implement Dimensionality reduction using Principle component Analysis method on a dataset iris	CO2
4	Write a program to demonstrate the working of the (a) Decision tree algorithm by considering a dataset. (b) Random Forest to predict the output class.	CO2

5	Write a Python program to implement Simple Linear Regression and plot the graph using Matplotlib and plot confusion matrix.	CO2
6	Build KNN Classification model for a given dataset. Vary the number of k values as follows and compare the results: 1,3,5,7,11	CO3
7	Implement Support Vector Machine for a dataset and compare the accuracy by applying the following kernel functions: i. Linear ii. Polynomial iii. RBF	CO4
8	Write a python program to implement K-Means clustering Algorithm. Vary the number of k values as follows and compare the results	CO4
9	implement a Naive Bayes classifier using Python	CO3
10	Implement any simple Reinforcement Algorithm.	CO3

Online Resources

1. https://nptel.ac.in/courses/106105077
2. https://scikit-learn.org/stable/

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**		II	
Course Name	Deep Leaning Lab				
Code	MAI1252				
Course Type	Practical	**L**	**T**	**P**	**Credit**
Prerequisite	Knowledge of ANN, Deep Leaning and Machine Learning Programming	0	0	4	2
Course Objectives	**1.** To introduce the basic concepts and techniques of Deep Learning and the need of Deep Learning techniques in real-world problems **2.** Develop analytical ability on different real world situations. **3.** To understand, learn and design Artificial Neural Networks of Supervised Learning for the selected problems and very the different parameters. **4.** Advanced Neural Networks :				
Course Outcomes					
CO1	Understand and basic concept of graph representation of the Dataset program using Numpy and Pandas				
CO2	Analysis of conditions in a problem and implement it in a program.				
CO3	To understand the concept of CNN, RNN, GANs, Auto-encoders				
CO4	Execute your task in the laboratory, and record the results / output in the lab observation notebook, and get certified by the concerned faculty.				

S. No.	List of Experiments	Mapped CO
1	Design a single unit perceptron for classification of a linearly separable binary dataset without using pre-defined models. Use the Perceptron() from sklearn.	CO1
2	Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets. Vary the activation functions used and compare the results.	CO1
3	Design and implement an Image classification model to classify a dataset of images using Deep Feed Forward NN. Record the accuracy corresponding to the number of epochs. Use the MNIST, CIFAR-10 datasets.	CO2
4	Design and implement a CNN model (with 2 layers of convolutions) to classify multi category image datasets. Record the accuracy corresponding to the number of epochs. Use the MNIST, CIFAR-10 datasets. computer vision problems Applying the Convolution Neural Network on computer vision problems	CO2
5	Implement the standard VGG-16 & 19 CNN architecture model to classify multi category image dataset and check the accuracy.	CO3
6	Use the concept of Data Augmentation to increase the data size from a single image.	CO3
7	Implement RNN for sentiment analysis on movie reviews.	CO3

8	Implement Bidirectional LSTM for sentiment analysis on movie reviews.	CO3
9	Implement Generative Adversarial Networks to generate realistic Images. Use MNIST, Fashion MNIST or any human face datasets.	CO3
10	Implement Auto encoders for image denoising on MNIST, Fashion MNIST or any suitable dataset	CO4

Online Resources

1. https://onlinecourses.nptel.ac.in/noc24_cs59/preview
2. https://archive.nptel.ac.in/courses/106/106/106106184/

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	3	2	3	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	2	2	2	2	2	3	-	2	2	2	2	2	2

Program	M. Tech (CSE-AI)				
Year	II	**Semester**	III		
Course Name	Research Methodology and IPR				
Code	MAI1301				
Course Type	Theory	**L**	**T**	**P**	**Credit**
Prerequisite	Basic Knowledge of Statistics and Mathematics	4	0	0	4
Course Objectives	1. To understand the basic concepts and significance of research. 2. To equip students with skills to design and implement research studies. 3. To develop the ability to analyse and interpret data. 4. To provide an overview of various types of IPR. 5. To educate students on the legal aspects and procedures of IPR protection.				
Course Outcomes					
CO1	Understand the basic principles, purpose, and process of conducting scientific research.				
CO2	Understand basic of Correlatioin, Regression and Probability Distribution and Sampling Methods				
CO3	Apply effective strategies for conducting and analysing literature studies relevant to their research area.				
CO4	Explain the concept, significance, and classification of various forms of Intellectual Property Rights (IPR)..				

Module	Course Contents	Contact Hrs.	Mapped CO
1	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.	9 Hours.	CO1
2	Correlation-Scatter diagram, Karl Pearson's coefficient of correlation, spearman's rank correlation coefficient. Regression-Finding regression equations, regression coefficients, prediction based on regression equations. Binomial distributions, Poisson distribution, Normal distribution and their applications. Sampling methods: Population and sample, Probability and non-probability sampling methods, determination of sample size	9 Hours.	CO2
3	Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	9 Hours.	CO3
4	**Introduction to Intellectual Property Rights (IPR):** Concept of Property: Understanding the nature of tangible and intangible property, including intellectual property. Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and	9 Hours	CO4

	Development: technological research, innovation, patenting, development. India's National IPR Policy: Understanding the overall policy framework for IPR in India. **International Scenario:** International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT. India's National IPR Policy: Understanding the overall policy framework for IPR in India.		

Suggested Readings:

1. Research Methodology by C.R.KOTHARI, New Age.
2. Business Statistics, Sharma J K, Pearson Education 2nd Edition.
3. Research Methodology, 2nd edition, Pearson Education , Ranjit Kumar (2009)

Online Resources:

1. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview
2. https://onlinecourses.nptel.ac.in/noc23_ge36/preview
3. https://archive.nptel.ac.in/courses/110/105/110105139/

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	2	1	-	-	-	-	2	2	2	2
CO2	3	3	2	3	3	-	-	-	-	-	-	2	2
CO3	3	2	3	2	2	-	-	-	2	3	3	3	2
CO4	2	1	2	1	1	-	2	2	-	2	2	2	2

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	I		
Course Name	Evolutionary Algorithms				
Code	GE14211				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Prior knowledge of programming, mathematics, algorithms, optimization, and basic AI/ML is required.	4	0	0	4
Course Objectives	1. Conduct a comprehensive review of recent developments and trends in Genetic Algorithms and Evolutionary Computing. 2. Develop and implement evolutionary algorithms that balance robustness with computational simplicity and ease of programming. 3. Enhance the efficiency of evolutionary algorithms for solving a wide range of optimization problems in practical applications. 4. Explore novel approaches to solving complex optimization problems without relying on intricate mathematical models or formulations.				
Course Outcomes					
CO1	Explain the fundamental principles of Evolutionary Algorithms and demonstrate their use in solving complex optimization problems.				
CO2	Analyse common design and implementation challenges in Genetic Algorithms and propose effective solutions.				
CO3	Illustrate the structure and role of Differential Evolution algorithms in solving real-world optimization tasks.				
CO4	Describe key concepts of Swarm Intelligence techniques and their applications in optimization.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Evolutionary Algorithms for Complex Optimization :** Introduction, Natural evolution as inspiration for computation, Fundamentals of population-based optimization, Introduction to EA techniques and workflows, Evolutionary methods in solving AI problems, Different forms and variants of EAs, Self-adaptive optimization techniques, Mutation-driven evolutionary modelling, Components and flow of an evolutionary process, Comparing stochastic and deterministic search, Advantages in flexibility and complex problem-solving.	9 Hours.	CO1
2	**Introduction to Genetic Algorithms:** Basic Structure of GA, Genetic Operators, GA Cycle, Elitism and generational gap, Convergence analysis, Fitness Landscape and Schema Theory, Adaptive and self-adaptive strategies, Types of Genetic Algorithms, Constraints Handling, Hybrid Genetic	9 Hours.	CO2

	Algorithms, Multi-Objective Genetic Algorithms (MOGA), Dynamic/Adaptive Gas, Real-World Applications of GA.		
3	**Introduction to Genetic Programming:** Fitness evaluation, sub-tree crossover, mutation, Selection mechanisms , Bloat control, Symbolic regression, Automatically Defined Functions, GP in classification and ML, Multi-objective GP, Evolving neural networks using GP. **Introduction to Differential Evolution:** Vector-based representation, Mutation strategy, Crossover and scaling factor, Selection mechanism, Control parameter tuning, DE variants and convergence behaviour, Self-adaptive DE, Hybrid DE, Multi-objective DE, Constraint handling in DE, Parallel/Distributed DE.	9 Hours.	CO3
4	**Bio-Inspired Swarm Algorithms and Multi-Objective Optimization:** Introduction to Swarm Intelligence, decentralization, self-organization, Introduction to multi-objective problems, Pareto optimality and dominance, Objective space vs. decision space, Performance metrics, Swarm Algorithms Methods: PSO, ACO, ABC, WOA, GWA. NSGA-II, SPEA2, MOEA/D. Dynamic MOO, Preference-based optimization, Decision-making from Pareto fronts.	9 Hours	CO4

Suggested Readings:

1. Goldberg, D. E., "Genetic Algorithms in Search, Optimization, and Machine Learning", Addison-Wesley,1989
2. Fogel, D. B., "Evolutionary Computation: Principles and Practice for Signal Processing", Wiley-IEEE Press, 2006
3. Eiben, A. E., & Smith, J. E., "Introduction to Evolutionary Computing", (2nd ed.). Springer, 2015

Online Resources

1. https://archive.nptel.ac.in/courses/112/103/112103301/

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	3	2	3	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	2	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	2	3	3	3	-	-	-	-	-	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	I		
Course Name	Computer Vision and Pattern Recognition				
Code	GE14212				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Prior knowledge of programming, mathematics,algorithms, optimization, and basic AI/ML is required.	4	0	0	4
Course Objectives	1. To have a strong foundation on computer algorithms to perform image processing on digital images 2. Develop analytical ability on how computers can be made for gaining high-level understanding from digital images or videos 3. Easy mapping and respective conversion of real world problem to image processing 4. Computer vision tasks include methods for acquiring, processing, analyzing and understanding digital images.				
Course Outcomes					
CO1	To have a strong foundation on computer algorithms to perform image processing on digital images				
CO2	Develop analytical ability on how computers can be made for gaining high-level understanding from digital images or videos				
CO3	Easy mapping and respective conversion of real world problem to image processing				
CO4	Computer vision tasks include methods for acquiring, processing, analysing and understanding digital images.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	Principles of Pattern Recognition: Introduction and Uses, Basic Mathematics of computer vision ,Classification and Bayes Decision Rule, Clustering vs. Classification, Relevant Basics of Linear Algebra, Vector Spaces, Eigen Value and Eigen Vectors, Vector Spaces Rank of Matrix and SVD, Types of Errors, Examples of Bayes Decision Rule.	9 Hours.	CO1
2	Normal Distribution and Parameter Estimation, Training Set, Test Set, Standardization, Normalization, Clustering and Metric Space, Normal Distribution and Decision Boundaries Normal Distribution and Decision Boundaries II, Bayes Theorem, Linear Discriminate Function and Perceptron, Perceptron Learning and Decision Boundaries, Linear and Non-Linear Decision Boundaries-NN Classifier	9 Hours.	CO2
3	Principal Component Analysis (PCA),Fisher's LDA, Gaussian Mixture Model(GMM),Basics of Clustering, Similarity/Dissimilarity Measures, Clustering Criteria's-Means Algorithm and Hierarchical Clustering, K-Medoids and DBSCAN ,Feature Selection : Problem statement and	9 Hours.	CO3

	Uses, Branch and Bound Algorithm, Sequential Forward and Backward Selection.		
4	Cauchy Schwartz Inequality, Probabilistic Separability Based, Interclass Distance Based, Principal Components Comparison Between Performance of Classifiers, Basics of Statistics, Covariance, and their Properties, Data Condensation, Feature Clustering, Data Visualization, Probability Density Estimation, Visualization and Aggregation.	9 Hours	CO4

Suggested Readings:

1. Robert Haralick and Linda Shapiro, "Computer and Robot Vision", Vol I, II, Addison Wesley, 1993
2. David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach" Pearson
3. Milan Sonka,Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision" Thomson Learning.

Online Resources

1. https://nptel.ac.in/courses
2. https://www.cse.iitb.ac.in

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	3	2	3	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	2	-	3	3
CO3	3	3	3	2	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3

Program	M. Tech(CSE-AI)				
Year	I	**Semester**	I		
Course Name	DATA MINING AND DATA WAREHOUSING				
Code	GE14213				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	To understand mathematics and statistics, programming skills and Data Warehousing Concepts	4	0	0	4
Course Objectives	1. To characterize the kinds of patterns that can be discovered by association rule mining. 2. To implement classification techniques on large datasets. 3. To analyse various clustering techniques in real world applications. 4. To get exposed to the concepts of data warehousing architecture and implementation.				
Course Outcomes					
CO1	Identify data mining techniques in building intelligent model.				
CO2	Illustrate association mining techniques on transactional databases.				
CO3	Apply classification and clustering techniques in real world applications.				
CO4	Design, create and maintain data warehouses.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**DATA MINING & ASSOCIATION RULE MINING** Data Mining– Concepts, Data Discretization and Concept Hierarchy Generation Introduction to Association rules – Association Rule Mining – Mining Frequent Itemsets with and without Candidate Generation –Classification versus Prediction – Data Preparation for Classification and Prediction	9 Hours.	CO1
2	**CLASSIFICATION AND PREDICTION TECHNIQUES** Classification by Decision Tree – Bayesian Classification – Rule Based Classification – Bayesian Belief Networks – Classification by Backpropagation – Support Vector Machines – K-Nearest Neighbor Algorithm – Linear Regression, Nonlinear Regression	9 Hours.	CO2
3	**CLUSTERING TECHNIQUES** Cluster Analysis – Partitioning Methods: k-Means and k-Medoids – Hierarchical Methods: Agglomerative and Divisive –Model Based Clustering Methods: Fuzzy clusters and Expectation-Maximization Algorithm	9 Hours.	CO3
4	**DATA WAREHOUSE** Need for Data Warehouse – Database versus Data Warehouse – Multidimensional Data Model –	9 Hours	CO4

	Schemas for Multidimensional Databases – OLAP operations – OLAP versus OLTP – Data Warehouse Architecture – Extraction, Transformation and Loading (ETL)		

Suggested Readings:

1. Jiawei Han, Micheline Kamber, "Data Mining Concepts and Techniques", Third Edition,Elsevier, 2012.
2. K. P. Soman, Shyam Diwakar, V. Ajay, "Insight into Data mining Theory and Practice",Easter Economy Edition, Prentice Hall of India, 2009.
3. Data Warehousing, Data Mining, & OLAP – Alex Berson, Stephen Smith, TMHill,2008.
4. David L. Olson Dursun Delen, "Advanced Data Mining Techniques," Springer-Verlag Berlin Heidelberg, 2008
5. G. K. Gupta, "Introduction to Data Min Data Mining with Case Studies", Eastern Economy Edition, Prentice Hall of India, Third Edition, 2014

Online Resources

1. https://onlinecourses.nptel.ac.in/noc21_cs06/preview
2. https://archive.nptel.ac.in/courses

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	3	2	3	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	3	2
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	2	-	3	3

Program	M. Tech(CSE-AI)				
Year	I	**Semester**	I		
Course Name	Natural Language Processing				
Code	GE14214				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Basic knowledge of computers, programming, data structures, linguistics, and statistics.	4	0	0	4
Course Objectives	1. To learn the basics of linguistics, probability, and statistics. 2. To study how statistics are applied in NLP, including sequence labeling, and to learn different parsing methods. 3. To understand the meaning of words and how to label their roles in sentences. 4. To learn about analysing conversations, answering questions, and building chat-bots.				
Course Outcomes					
CO1	Understand the basics of linguistics, probability, and statistics associated with Natural Language Processing (NLP).				
CO2	Implement a Part-of-Speech (POS) tagger and design a sequence labeling solution for a given domain.				
CO3	Implement semantic processing tasks and develop a simple document indexing and search system using NLP concepts.				
CO4	Implement a simple chatbot using dialogue system concepts.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Introduction:** Natural Language Processing, Components , Basics of Linguistics and Probability & Statistics (Words , Tokenization, Morphology, Finite State Automata). **Morphology:** Inflectional Morphology, Derivational Morphology, Finite-State Morphological Parsing, Combining an FST Lexicon and Rules, and the Porter Stemmer.	9 Hours.	CO1
2	**Statistical Natural Language Processing:** N-grams and Language Models, Smoothing Techniques, Text Classification using Naïve, Bayes Classifier, Evaluation Metrics for NLP Models, Vector Semantics, Term Frequency-Inverse Document Frequency (TF-IDF), Word2Vec Embeddings, Evaluation of Vector-Based Semantic Models. **Sequence Tagging Techniques:**	9 Hours.	CO2

	Sequence Labelling Fundamentals, Part-of-Speech (POS) Tagging, Named Entity Recognition (NER) and Tagging, Transformation-Based Tagging Methods.		
3	**Parsing:** Top-down, Earley Parsing, Feature Structures, Probabilistic Context, Free Grammars Representing Meaning, Meaning Structure of Language, First Order Predicate Calculus Representing Linguistically Relevant Concepts, Syntax, Driven Semantic Analysis.	9 Hours.	CO3
4	**Computational Semantics:** Semantic parsing, Word Sense Disambiguation (WSD), discourse structure and coherence, reference resolution, and Question Answering (QA) models. **Dialogue Systems**: Dialog acts, interpretation, language generation, discourse planning, and machine translation using rule-based and statistical methods (e.g., interlingua, transfer metaphor).	9 Hours	CO4

Suggested Readings:

1. Daniel Jurafsky and James H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition (Prentice Hall Series in Artificial Intelligence), 2020.
2. Christopher D. Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, MIT Press, 2009.
3. James Allen, Natural Language Understanding, Addison-Wesley, 1994.

Online Resources

1. https://nptel.ac.in/courses/106105158
2. https://onlinecourses.nptel.ac.in/noc20_cs87/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	2	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	-	-	3	3
CO3	3	2	3	2	2	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	2	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	II		
Course Name	Blockchain Technologies				
Code	GE14221				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Computer Networks, Cryptography, Distributed Systems	4	0	0	4
Course Objectives	1. To understand the fundamental principles and architecture of blockchain technology. 2.To study consensus mechanisms and smart contracts in blockchain systems. 3.To provide hands-on knowledge of Ethereum and Hyperledger platforms. 4. To explore real-world blockchain use cases and challenges.				
Course Outcomes					
CO1	Understand the architecture, structure, and key components of blockchain systems.				
CO2	Analyse different consensus mechanisms and their roles in distributed trust.				
CO3	Develop and deploy smart contracts and DApps on Ethereum and Hyperledger.				
CO4	Evaluate blockchain applications and address their legal, ethical, and scalability challenges.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Introduction to Blockchain:**Distributed systems and ledgers, cryptographic hash functions, Merkle trees, digital signatures, blocks and transactions, blockchain structure. **Types of Blockchains:** Public, private, and consortium. **Blockchain Applications:** Cryptocurrency, digital identity, smart assets.	9 Hours.	CO1
2	**Consensus Mechanisms and Blockchain Security:** Proof-of-Work (PoW), Proof-of-Stake (PoS), Delegated PoS, Practical Byzantine Fault Tolerance (PBFT). Forks, block finality, Sybil attacks, 51% attack, scalability trilemma.	9 Hours.	CO2
3	**Smart Contracts and Ethereum Ecosystem:** Ethereum architecture, accounts, gas, EVM. Solidity language: syntax, functions, modifiers, events, mappings, inheritance. Tools: MetaMask, Truffle, Remix IDE. ERC standards (ERC-20, ERC-721).	9 Hours.	CO3
4	**Enterprise Blockchain & Use Cases:** Hyperledger Fabric architecture, peers, chain code, channels, endorsement. Comparison of blockchain platforms. Real-world applications: finance, supply chain, healthcare, voting systems. Challenges: scalability, interoperability, regulation	9 Hours	CO4

Suggested Readings:

1. Narayanan, Arvind, et al. Bitcoin and Cryptocurrency Technologies, Princeton University Press, 2016.
2. Antonopoulos, Andreas M. Mastering Bitcoin, O'Reilly Media, 2017.
3. Bashir, Imran. Mastering Blockchain, Packt Publishing, 2017.

Online Resources

1. https://archive.nptel.ac.in/courses/106/105/106105235/
2. https://onlinecourses.swayam2.ac.in/aic21_ge01/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	2	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	2	-	3	3
CO3	3	3	3	3	3	-	-	-	-	2	-	3	3
CO4	3	2	3	3	2	2	-	-	-	2	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	Semester		II	
Course Name	Internet of Things				
Code	GE14222				
Course Type	GE	L	T	P	Credit
Prerequisite	Basics of IoT.	4	0	0	4
Course Objectives	1. To study the fundamentals about IoT. 2. To study the design methodology and different IoT hardware platforms. 3. To study the basics of IoT Data Analytics and supporting services. 4. To study about various IoT case studies and industrial applications.				
Course Outcomes					
CO1	Explain the fundamental concepts, principles, and challenges in different domain.				
CO2	Explain the properties and working principles of various devices used in building smart application.				
CO3	Explain the structure and working principles of communication protocols used in building smart application.				
CO4	Build smart application for the given environment using relevant technologies.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Introduction to Internet of Things:** Vision, Definition, Conceptual Framework, Architectural view, technology behind IoT, Sources of the IoT, M2M Communication, IoT Examples. **Design Principles for Connected Devices**: IoT/M2M systems layers and design standardization, communication technologies, data enrichment and consolidation, ease of designing and affordability	9 Hours.	CO1
2	**Hardware for IoT:** Sensors, Digital sensors, actuators, radio frequency identification (RFID) technology, wireless sensor networks, participatory sensing technology. **Embedded Platforms for IoT:** Embedded computing basics, Overview of IOT supported Hardware platforms such as Arduino, NetArduino, Setup the IDE, Using Arduino Software, Arduino Simulation Environment, Raspberry pi, Beagle Bone, Intel Galileo boards and ARM cortex.	9 Hours.	CO2
3	**Network & Communication aspects in IoT:** Wireless Medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination. Application Layer Protocols: CoAP and MQTT. **Wireless Communication Protocols:** Bluetooth, Wi-Fi, Zigbee, LoRaWAN, NFC, RFID, 6LoWPAN, NBIoT. **Wired Communication Protocols:** UART, SPI, I2C, CAN, Interfacing ESP32CAM module with ESP32 microcontroller.	9 Hours.	CO3

4	**Challenges in IoT Design challenges:** Development Challenges, Security Challenges, Other challenges IoT. **Case Study**: Weather Monitoring, Smart Traffic Management, Pollution Monitoring, Smart Home Automation, Accident Detection and Alert.	9 Hours	CO4

Suggested Readings:

1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017
2. Internet of Things – A hands-on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press, 2015
3. Internet of Things: Architecture, Design Principles And Applications, Rajkamal, McGraw Hill Higher Education.

Online Resources

1. https://archive.nptel.ac.in/courses/106/105/106105166/
2. https://onlinecourses.swayam2.ac.in/ntr24_ed01/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	2	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	2	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	2	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	II		
Course Name	Explainable AI				
Code	GE14223				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Basic Knowledge of computer fundamentals and Programming Concepts.	4	0	0	4
Course Objectives	1. To build a strong foundation in Artificial Intelligence concepts, including its history, types, and intelligent agent-based systems. 2. To develop analytical and problem-solving skills using search algorithms, constraint satisfaction, and game theory techniques 3. To enhance reasoning and decision-making abilities through expert systems and logical knowledge representation. 4. To apply NLP, reinforcement learning, and fuzzy logic techniques for intelligent analysis, decision-making, and handling uncertainty in real-world scenarios.				
Course Outcomes					
CO1	Understand the fundamental concepts of Artificial Intelligence.				
CO2	Analyse various problem-solving strategies in AI and implement searching algorithms, game theory, and constraint satisfaction techniques in practical scenarios.				
CO3	Apply knowledge-based systems and logical reasoning techniques using propositional and first-order logic to model intelligent decision-making.				
CO4	Apply Natural Language Processing techniques for analysing and processing human language data.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	Introduction to AI**,** History of AI, Strong AI & Weak AI, Turing Test, Agents and its Types, Environments, and Intelligent Agents.	9 Hours.	CO1
2	Problem-Solving, Solving Problems by Searching, Search in Complex Environments, Types of searching algorithms, Informed Searching, Uninformed Searching and its types, Constraint Satisfaction Problem Adversarial Search, local search problems, and game playing, game theory: ALPHA-BETA PRUNING and Min Max algorithm.	9 Hours.	CO2
3	Expert System, Knowledge, Reasoning, and Planning, Logical Agents, First-Order Logic, Propositional Logic, Inference in First-Order Logic, Quantifiers.	9 Hours.	CO3

4	Natural Language Processing, Sentimental Analysis, NLP Components, NLP Applications, Text Vectorization, and NLP Pipeline. Reinforcement Learning and its components, Model-based and model-free learning, Markov Decision Process (MDP), value functions, state value functions, state value action functions, Bellman equations, optimal value functions, and Q-learning, SARSA, MONTE CARLO, Temporal Difference Learning, Dynamic Programming. Fuzzy Inference System (FIS), Fuzzy Logic, Membership Functions, Fuzzification and Defuzzification, Types of Fuzzy Systems.	9 Hours	CO4

Suggested Readings:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson Education, 2020.

2. Elaine Rich, Kevin Knight, and Shivashankar B. Nair, Artificial Intelligence, 3rd Edition, Tata McGraw-Hill, 2009.

Online Resources

1. https://www.coursera.org/specializations/explainable-artificial-intelligence-xai
2. https://www.udemy.com/course/xai-explain-ml-models/?srsltid=AfmBOooJ37lrNTnp58EcPXNBerJlHIQD5AIY8qswxAkQbvrtvkQTwH5Y&couponCode=PMNVD2025

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	2	2	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	2	-	3	3
CO3	3	3	3	3	3	-	-	-	-	2	-	3	3
CO4	3	2	3	3	3	-	-	-	-	2	-	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	II		
Course Name	Swarm Intelligence				
Code	GE14224				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Basic understanding of AI, algorithms, and optimization techniques is required.	4	0	0	4
Course Objectives	1. **Introduce the fundamentals of Swarm Intelligence (SI)** by exploring its biological inspirations and comparing it with traditional and nature-inspired AI techniques. 2. **Explain core properties** of swarm-based systems such as self-organization, decentralization, robustness, and scalability. 3. **Provide in-depth knowledge of Ant Colony Optimization (ACO)**, including its biological basis, algorithmic structure, variants, and real-world applications. 4. **Develop a strong understanding of Particle Swarm Optimization (PSO) and explore additional swarm based algorithms** including its behavioral models, algorithmic implementation, and practical use in optimization problems. Bee Algorithm, Firefly Algorithm, Cuckoo Search, and Bat Algorithm, highlighting their design principles and comparative effectiveness.				
Course Outcomes					
CO1	Formulate and assess problems in evolutionary computation and swarm intelligence. Evaluate the strengths and weaknesses of alternative approaches to evolutionary and swarm-based methods.				
CO2	Determine and analyse the key commonalities and differences in various evolutionary and swarm-based models.				
CO3	Advance techniques in evolutionary computation and swarm intelligence on problems such as optimization, automatic programming, control, machine learning, and modelling.				
CO4	Develop a proposal for an extended research project. Design and conduct an experiment in evolutionary computation.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Unit 1: Introduction to Swarm Intelligence** Definition and overview of swarm intelligence (SI),Natural inspirations: Ant colonies, bird flocking, fish schooling, bee hives, Key properties: Self-organization, decentralization, robustness, scalability, Comparison with traditional AI and other nature-inspired computing techniques, Applications of SI in optimization, robotics, and distributed systems	9 Hours.	CO1
2	**Ant Colony Optimization (ACO)** Introduction to Ant Colony Optimization, Biological background: Foraging behaviour of real ants, ACO algorithm components: Pheromone updating, probability transition rule ,Variants of ACO: Ant System, Ant Colony System, MAX-	9 Hours.	CO2

	MIN ACO, Applications: Traveling Salesman Problem (TSP), scheduling, routing, etc. Case studies and simulation using Python/Matlab **Particle Swarm Optimization (PSO)** Introduction to Particle Swarm Optimization, Biological background: Bird flocking and fish schooling, PSO algorithm: Velocity and position updates, inertia weight, personal/global best, Variants of PSO: Constriction factor, hybrid PSO, Applications: Function optimization, neural network training, feature selection, Implementation and parameter tuning		
3	**Other Swarm-Based Algorithms** Bee Algorithm and Artificial Bee Colony (ABC),Firefly Algorithm, Cuckoo Search Algorithm, Bat Algorithm, Comparative analysis of algorithms: Strengths and weaknesses, Implementation examples and real-world use cases	9 Hours.	CO3
4	**Applications and Research Trends** Swarm robotics: Coordination, control, and navigation, Multi-agent systems and distributed problem solving ,SI in wireless sensor networks, IoT, smart grids, Recent research trends and future directions in SI, Project work, case studies, and open-source tools (e.g., NetLogo, Swarm, MATLAB)Ethical and practical considerations in deploying SI systems	9 Hours	CO4

Suggested Readings:

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

Online Resources

1. https://www.udemy.com/course/an-introduction-to-swarm-algorithms-for-business/?srsltid=AfmBOopWLd_bWJ19d7Y9P5s5DJJjJuRKSAfO4lr0ZlDZHhhw6UBGVyM1&couponCode=NVDIN35

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	3	3	2	2	-	-	-	-	2	-	3	2
CO2	3	3	3	2	3	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	2	-	-	2	2	2	3	3

Program	M. Tech (CSE-AI)				
Year	I	**Semester**	II		
Course Name	AI Policy and Governance				
Code	GE14231				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Basic knowledge of core AI, Data Science, Machine learning, Ethics in AI.	4	0	0	4
Course Objectives	1. To develop a comprehensive understanding of AI technologies. 2. To understand and analyse the ethical implications of AI. 3. To equip students to apply research methodologies on AI policy and governance. 4. To design and implement effective AI governance frameworks. 5. To prepare students to navigate the ethical challenges and governance policies surrounding AI applications.				

Course Outcomes	
CO1	Understand the complex interplay of AI development and regulatory practices, comprehending how emerging technologies influence and are influenced by public norms and values.
CO2	Apply interdisciplinary approaches integrating knowledge from the humanities, social sciences, and public policy to evaluate the social impact of emerging AI applications in real world scenarios.
CO3	Analyse emerging AI governance strategies, critically assessing their origins, applications, and effectiveness for responsible AI management and regulation.
CO4	Identify and remember core principles, challenges and developments in AI governance, including essential policy milestones and landmark case studies.

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	**AI Ethics and Responsible AI:** Overview of ethical theories, Ethical considerations in AI development, Core ethical principles (fairness, accountability, transparency, privacy, safety, human oversight), Understanding Bias in AI algorithm systems (data bias, algorithmic bias, societal implications), Explainable AI (XAI) and interpretability, Ethical frameworks for AI development and deployment, Case studies of ethical dilemmas in AI like autonomous vehicles, facial recognition, predictive policing and decision making.	9 Hours.	CO1
2	**AI Law and Regulation:** Introduction to Legal Frameworks Governing AI, Intellectual property rights in AI, GDPR and other data protection regulations, Legal requirements for explainable AI, Liability issues, and regulatory challenges.	9 Hours.	CO2

	Regulatory approaches to AI as EU AI Act, US approaches, Indian policy landscape, International AI governance initiatives, Cyber security and AI (AI for security, security of AI systems), Challenges in regulating AI technologies, and Policy recommendations for AI regulation.		
3	**AI Policy and Governance Framework development:** National AI strategies, Role of governments, industry, civil society, and academia in AI governance, Standardization and certification for AI systems, Public engagement and stakeholder participation in AI policy, Future of work and AI's impact on society. **Privacy, Bias and Fairness:-** Ethical guidelines and frameworks for AI design, Ethical considerations in AI research and development, Responsible AI engineering practices, Ethical and legal implications of data collection and usage in AI, Privacy-enhancing technologies, Fairness metrics, and evaluation methods, mitigating bias in AI systems.	9 Hours.	CO3
4	**Algorithmic Governance and Society:** Impact of AI on democracy, human rights, and social justice, Regulation of AI in specific sectors (e.g., healthcare, finance, defense), AI for public good and sustainable development goals, AI in public administration and smart cities. **Societal Impacts and Ethical Decision-Making:** Ethical implications of AI on employment, inequality, AI and the future of work, International and national efforts for AI governance, Strategies for Addressing Societal Concerns, Ethical decision-making frameworks in AI, and practical exercises on ethical AI design and deployment.	9 Hours	CO4

Suggested Readings:

1. Müller, Vincent C. Ethics of Artificial Intelligence. The Routledge Social Science Handbook of AI (London: Routledge), 2021.
2. Calo, Ryan, A. Michael Froomkin, and Ian Kerr. Robot Law. Edward Elgar Publishing, 2016.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc25_lw12/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	2	3	2	2	2	3	3	3	-	2	2	2	2
CO2	2	3	3	2	2	3	3	3	2	3	2	2	2
CO3	3	3	3	2	3	3	3	3	-	2	2	3	3
CO4	2	2	2	1	2	3	3	3	-	2	2	2	2

Program	M. Tech(CSE-AI)				
Year	I	Semester		II	
Course Name	Data Ethics in AI				
Code	GE14232				
Course Type	GE	L	T	P	Credit
Prerequisite	Basic understanding of Artificial Intelligence, Machine Learning, Programming fundamentals (preferably Python), and ethical awareness related to technology and society.	4	0	0	4
Course Objectives	1. To introduce ethical concepts and their relevance in AI and robotics. 2. To examine global ethical initiatives, standards, and regulatory frameworks in AI. 3. To understand roboethics and moral responsibilities in robotic applications. 4. To analyze ethical challenges and opportunities in real-world AI implementations.				
Course Outcomes					
CO1	Explain ethical principles and analyze AI's societal, legal, psychological, and environmental impacts.				
CO2	Evaluate ethical concerns and regulatory standards through real-world AI case studies.				
CO3	Interpret roboethics frameworks and professional ethical responsibilities in robotics.				
CO4	Assess ethical issues and policy strategies in AI applications across industries.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Introduction:** definition of morality and ethics in ai, impact on society, impact on human psychology-impact on the legal system, impact on the environment and the planet, impact on trust.	9 Hours.	CO1
2	**ETHICAL INITIATIVES IN AI:** international ethical initiatives, ethical harms and concerns, **Case study:** healthcare robots, autonomous vehicles, warfare and weaponization. **AI STANDARDS AND REGULATION:** model process for addressing ethical concerns during system design, transparency of autonomous systems, data privacy process, algorithmic bias considerations, ontological standard for ethically driven robotics and automation systems	9 Hours.	CO2
3	**ROBOETHICS: SOCIAL AND ETHICAL IMPLICATION OF ROBOTICS:** robot-roboethics, ethics	9 Hours.	CO3

	and morality, moral theories, ethics in science and technology, ethical issues in an ict society, harmonization of principles, ethics and professional responsibility roboethics taxonomy.		
4	**AI AND ETHICS- CHALLENGES AND OPPORTUNITIES:** challenges, opportunities, ethical issues in artificial intelligence, societal issues concerning the application of artificial intelligence in medicine, decision-making role in industries, national and international strategies on ai.	9 Hours	CO4

Suggested Readings

1. Eleanor Bird, Jasmin Fox-Skelly, Nicola Jenner, Ruth Larbey, Emma Weitkamp and Alan Winfield ,"The ethics of artificial intelligence: Issues and initiatives", EPRS | European Parliamentary Research Service Scientific Foresight Unit (STOA) PE 634.452 – March 2020
2. . Patrick Lin, Keith Abney, George A Bekey," Robot Ethics: The Ethical and Social Implications of Robotics", The MIT Press- January 2014.

Online Resources

1. https://swayam-plus.swayam2.ac.in/courses/course-details?id=P_INTEL_02
2. https://onlinecourses.nptel.ac.in/noc25_lw12/preview

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	2	2	2	1	2	3	3	3	-	2	2	2	2
CO2	3	2	2	2	2	3	3	3	2	3	2	2	2
CO3	2	2	2	2	2	3	3	3	-	2	2	2	2
CO4	2	2	2	2	2	3	3	3	1	2	2	2	2

Program	M. Tech(CSE-AI)				
Year	I	**Semester**	II		
Course Name	Responsible AI				
Code	GE14233				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Basic knowledge of Artificial Intelligence/Machine Learning, programming skills in Python, and fundamental concepts of probability and statistics. Prior exposure to data analysis and awareness of ethical issues in technology is beneficial but not mandatory.	4	0	0	4
Course Objectives	1. Understand the principles and challenges of Responsible AI. **2.** Learn to identify and mitigate bias in AI systems. **3.** Explore methods for explainability and interpretability in AI. **4.** Study AI safety, security, and privacy techniques.				
Course Outcomes					
CO1	Describe key principles and challenges of Responsible AI, including fairness and safety.				
CO2	Detect and mitigate bias using fairness metrics and tools				
CO3	Apply explainability and interpretability techniques in AI models.				
CO4	Analyze and address safety, security, and privacy in AI systems.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**INRODUCTION TO RESPONSIBLE AI:** Overview of AI, Common misconception of AI, Introduction to Responsible AI, Characteristics of Responsible AI, Key principles of responsible AI, Challenges in implementing responsible AI, ELSI Framework and AI, Safety and Alignment, Fairness and Privacy.	9 Hours.	CO1
2	**FAIRNESS AND BIAS:** Human Bias, Types of biases, Effects of biases on different demographics, Bias vs Fairness, Sources of Biases, Exploratory data analysis, Bias Mitigation Techniques, Pre-processing techniques, In-processing techniques, post-processing techniques, Bias detection tools, Overview of fairness in AI, Group fairness and Individual fairness, Counterfactual fairness, Fairness metrics, Bias and disparity mitigation with Fairlearn.	9 Hours.	CO2
3	**EXPLAINABILITY & INTERPRETABILITY:** Importance of Explainability and Interpretability – Challenges, Interpretability through simplification and visualization, Intrinsic interpretable methods, Post Hoc interpretability, Interpretability Evaluation methods, Explainability through causality, Model agnostic Interpretation,	9 Hours.	CO3

4	**SAFETY, SECURITY, AND PRIVACY:** Overview of safety – security – privacy - resilience - Taxonomy of AI safety and Security - Adversarial attacks and mitigation - Model and data security - The ML life cycle - Adopting an ML life cycle MLOps and ModelOps - Model drift - Data drift, Concept drift, Privacy-preserving AI techniques, Differential privacy, Federated learning.	9 Hours	CO4

Suggested Readings:

1. M. Sridhar, Abhijeet Chavan, "Responsible AI: Implementing AI with Trustworthiness and Fairness", Wiley, 2023. – Covers fairness, accountability, transparency, safety, and real-world applications.
2. Sandra Wachter, Brent Mittelstadt, "The Ethics of Artificial Intelligence", Oxford University Press (Forthcoming), Preprint articles available online. – Deep dive into ELSI, legal frameworks, and AI governance.
3. Suresh Venkatasubramanian & Solon Barocas, "Fairness and Machine Learning: Limitations and Opportunities" (2023, online). https://fairmlbook.org (Free and open resource) – Comprehensive resource on bias, fairness metrics, and mitigation techniques.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc24_cs132/preview
2. https://onlinecourses.nptel.ac.in/noc25_lw12/preview

Course Articulation Matrix

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	3	3	3	-	2	2	3	2
CO2	3	3	3	2	3	3	3	3	2	2	2	3	3
CO3	3	3	3	2	3	3	3	3	-	2	2	3	3
CO4	3	3	3	2	3	3	3	3	2	2	2	3	3

Program	M. Tech				
Year	I	**Semester**		II	
Course Name	AI for Cyber Security				
Code	GE14234				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	AI Basics and Security	4	0	0	4
Course Objectives	1. To give an overview of different AI and Machine Learning models in Cyber Security 2. To study Various attack on ML models 3. To study Machine Learning and Privacy 4. To study of assisted intelligence in Artificial Intelligence and Cybercrime in mobile platform and Procedural Issues Duty of Care in cyber security laws				
Course Outcomes					
CO1	Introduction: Role of AI in Cyber Security and Security Framework: Artificial Intelligence in Cyber Security				
CO2	Understand the concepts in Machine Learning				
CO3	An Introduction of Cyber Security Mechanisms Using Deep Learning Algorithms				
CO4	The concept of cybercrime with Artificial Intelligence in Cyber Security:				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Artificial Intelligence** and **Cyber Security**: Artificial Intelligence: Basic concepts of AI; Intelligent agents; solving problems by searching –Uniformed search, Informed search; Logical agents; first-order logic; knowledge representations. **Introduction to Cyber Security:** Basic Cyber Security Concepts, layers of security, Vulnerability, threat, Harmful acts, Internet Governance – Challenges and Constraints, Computer Criminals, Security Models, Cyber Crime, Cyber terrorism, Cyber Espionage, Comprehensive Cyber Security Policy etc.	9 Hours.	CO1
2	**Machine Learning in Security:** Introduction to Machine Learning, Applications of Machine Learning in Cyber Security Domain, Machine Learning: tasks and Approaches, Anomaly Detection, Privacy Preserving Nearest Neighbour Search, Machine Learning for Malware detection and classification, Malware detection and classification, Online Learning Methods for Detecting Malicious Executables	9 Hours.	CO2
3	**Deep Learning in Security:** Introduction to deep learning, Cyber Security Mechanisms Using Deep Learning Algorithms, Applying deep learning in various use cases, Network Cyber Threat Detection	9 Hours.	CO3

4	**Cybercrime:** Mobile and Wireless Devices: Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile **Artificial Intelligence in Cyber Security:** Model Stealing & Watermarking, Network Traffic Analysis, Malware Analysis Critically assess the strengths, limitation and potential vulnerable of AI-ML techniques in Cybersecurity application multiple AI and ML technoques to detect, classify and mitigate a range of cyber threats across different domain	9 Hours	CO4

Suggested Readings:

1. Nina Godbole and Sunit Belpure, Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley
2. B. B. Gupta, D. P. Agrawal, Haoxiang Wang, Computer and Cyber Security: PrinciplesAlgorithm, Applications, and Perspectives, CRC Press, ISBN 9780815371335, 2018.
3. Russell, S. and Norvig, P, Artificial Intelligence: A Modern Approach, Third Edition, PrenticeHall, 2010.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc23_cs127/preview
2. https://www.youtube.com/watch?v=wRUiRm3dK3U

Course Articulation Matrix													
PO-PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	2	2	3	3	3	-	2	2	3	2
CO2	3	3	3	2	3	3	2	2	-	2	2	3	3
CO3	3	3	3	2	3	3	2	2	-	2	2	3	3
CO4	2	2	2	2	2	3	3	3	2	2	2	3	2

Program	M. Tech				
Year	II	**Semester**	III		
Course Name	Cloud Computing				
Code	GE14241				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Operating Systems, Computer Networks,	4	0	0	4
Course Objectives	To introduce the basic concepts and evolution of Cloud Computing. To explain the architectural models and virtualization techniques that power cloud environments. To impart knowledge about security, compliance, and performance challenges in cloud-based systems. To provide hands-on experience in using popular cloud platforms to design and deploy applications.				
Course Outcomes					
CO1	Explain the core principles, service models, and deployment types in Cloud Computing.				
CO2	Illustrate how cloud architectures and virtualization enable scalable and efficient resource utilization.				
CO3	Assess key security, privacy, and performance concerns related to cloud services.				
CO4	Apply cloud tools and platforms to build and deploy basic cloud-based applications.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to Cloud Computing**: Definition and characteristics of Cloud Computing, Evolution from Grid to Cloud, Service Models: IaaS, PaaS, SaaS, Deployment Models: Public, Private, Hybrid, Community, Comparison with traditional IT infrastructure, Benefits and challenges of cloud adoption	9 Hours.	CO1
2	**Cloud Architecture and Virtualization**: Cloud reference architecture (NIST Model), Virtualization: Concepts, Types (Full, Para, OS-level), Hypervisors: Type 1 and Type 2, Containers vs. Virtual Machines, Storage virtualization and cloud data management, Resource pooling and elasticity	9 Hours.	CO2
3	**Cloud Security and Performance**: Security issues in cloud: Data breaches, multi-tenancy risks, Authentication, Authorization, and Identity Management, Regulatory compliance and legal issues (GDPR, HIPAA, etc.), Cloud performance metrics, Monitoring tools and SLAs (Service Level Agreements), Risk assessment and mitigation.	9 Hours.	CO3
4	**Cloud Platforms and Applications:** Overview of public cloud providers: AWS, Azure, GCP, Working with Compute (EC2, App Engine), Storage (S3, Blob), Sample deployment of a web app on a cloud platform, Use cases: Cloud in Education, Business, Healthcare, Introduction to Serverless, Edge, and Multi-cloud computing, Future trends: AI in Cloud, Green Cloud,	9 Hours	CO4

Suggested Readings:

1. Rajkumar Buyya et al., *Mastering Cloud Computing*, McGraw Hill
2. Thomas Erl, *Cloud Computing: Concepts, Technology & Architecture*, Pearson

Online Resources

1-https://onlinecourses.nptel.ac.in/noc21_cs14/preview

2-https://archive.nptel.ac.in/courses/106/105/106105167/

Course Articulation Matrix														
PO- PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO 6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO11**	**PO1 2**	**PSO1**	**PSO2**
CO1	3	2	2	2	1	-	-	-	-	-	-	-	2	3
CO2	3	3	3	2	2	-	-	-	-	-	-	-	2	3
CO3	3	3	3	3	2	-	-	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3

Program	M. Tech				
Year	II	**Semester**	III		
Course Name	Distributed Systems				
Code	GE14242				
Course Type	GE	**L**	**T**	**P**	**Credit**
Prerequisite	Operating Systems, Computer Networks, Basics of Algorithms & Data Structures	4	0	0	4
Course Objectives	1. Understand the fundamental principles and models that govern distributed systems, including architectural and communication frameworks. 2. Explore the design of algorithms and synchronization techniques for distributed coordination, mutual exclusion, and consistency. 3. Analyze techniques for fault tolerance, transaction processing, and recovery in distributed environments. 4. Examine real-world distributed file systems and database systems, and explore current frameworks like MapReduce and Spark. 5. Apply distributed algorithms and consistency models in the design of scalable and fault-tolerant systems.				
Course Outcomes					
CO1	Understand the design principles, models, and communication mechanisms of distributed systems.				
CO2	Apply synchronization, coordination, and election algorithms in distributed environments.				
CO3	Analyze transaction processing, fault tolerance, and recovery mechanisms in distributed systems.				
CO4	Implement distributed system components and evaluate fault tolerance mechanisms.				

Module	**Course Contents**	**Contact Hrs.**	**Mapped CO**
1	**Foundations of Distributed Systems**: Introduction to Distributed Systems, Types and Architecture; Characteristics: Transparency, Fault Tolerance, Scalability; System Models: Architectural & Fundamental; Interprocess Communication: Sockets, Message Passing, Remote Procedure Calls (RPC), Remote Method Invocation (RMI); High-level Communication Models; Publish-Subscribe Systems.	9 Hours.	CO1
2	**Time, Coordination, and Agreement**: Logical Clocks (Lamport, Vector Clocks), Clock Synchronization (Cristian's and Berkeley Algorithms), Global State and Snapshot Algorithms, Distributed Mutual Exclusion (Ricart-Agrawala, Token-based), Group Mutual Exclusion, Leader Election (Bully, Ring), Deadlock Detection, Termination Detection, Consensus Algorithms (Paxos, Raft).	9 Hours.	CO2
3	**Data Management in Distributed Systems**: Distributed File Systems: Architecture and Case Studies (Google File System, HDFS, Dropbox), Distributed Databases: Design, Replication Techniques, Partitioning; Consistency Models: Data-Centric and Client-Centric, Quorum-based Systems; Case Studies: Bigtable, Amazon Aurora, Spanner.	9 Hours.	CO3
4	**Fault Tolerance & Advanced Systems:** Fault Models, Failure Detection, Agreement, Checkpointing, Recovery; Commit Protocols (2PC, 3PC), Voting; Concurrency Control (Locking, OCC, Timestamp), Distributed Recovery; Distributed Shared Memory (IVY, Munin), MapReduce, Spark, RDD, Kafka, Blockchain Basics, Web Services.	9 Hours	CO4

Suggested Readings:

1. Andrew S. Tanenbaum and Maarten van Steen, Distributed Systems: Principles and Paradigms, Publisher: Pearson / Prentice Hall, 2nd Edition, 2007
2. Ajay D. Kshemkalyani and Mukesh Singhal, Distributed Computing: Principles, Algorithms and Systems, Publisher: Cambridge University Press, 2011
3. George Coulouris, Jean Dollimore, Tim Kindberg, and Gordon Blair, Distributed Systems: Concepts and Design, Publisher: Pearson Education, 5th Edition, 2017

Online Resources

1-https://archive.nptel.ac.in/courses/106/106/106106168/

2-https://onlinecourses.nptel.ac.in/noc21_cs87/preview

Course Articulation Matrix														
PO- PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO 6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO11**	**PO1 2**	**PSO1**	**PSO2**
CO1	3	2	2	2	1	-	-	-	-	-	-	2	3	2
CO2	3	3	3	2	2	-	-	-	-	-	-	2	3	3
CO3	3	3	3	3	2	-	-	-	-	-	-	2	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3	3

Program	M. Tech				
Year	II	Semester	III		
Course Name	Big Data Analytics				
Code	GE14243				
Course Type	GE	L	T	P	Credit
Prerequisite	Data Mining, Databases, Programming in Python/Java	4	0	0	4
Course Objectives	1. To introduce the fundamental concepts and techniques of big data analytics. 2. To understand Hadoop architecture and its ecosystem components such as HDFS, MapReduce, Pig, Hive, Spark, MongoDB. 3. To implement big data storage and processing using modern tools. 4. To perform real-time analytics using R, Spark, and other frameworks. 5. To explore NoSQL databases for handling semi-structured and unstructured data.				
Course Outcomes					
CO1	Understand the architecture and ecosystem of Big Data platforms and their use cases.				
CO2	Apply HDFS and MapReduce paradigms to process large-scale datasets.				
CO3	Design and query semi-structured data using Pig, Hive, and MongoDB tools.				
CO4	Implement advanced analytics using Spark, R, and explore web and text data analysis.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	**Big Data Fundamentals & Hadoop Introduction**: Types of Digital Data; Evolution, Definition, and Characteristics of Big Data; Big Data vs Traditional BI; Big Data Analytics – Types and Importance; Hadoop Introduction: History, Architecture, Components, HDFS Basics, YARN, Hadoop Ecosystem Overview (Hive, Pig, Spark, HBase, Flume, Sqoop).	9 Hours.	CO1
2	**HDFS and MapReduce Programming**: HDFS Architecture, Block Structure, Commands, File Read/Write Flow, Fault Tolerance; MapReduce Programming Model: Mapper, Reducer, Combiner, Partitioner; Execution Phases; Data Compression, Input/Output Formats, Failures and Recovery.	9 Hours.	CO2
3	**Big Data Tools – Pig, Hive, MongoDB**: Pig Latin Syntax and Operators, UDFs, Pig Execution Modes; Hive Architecture, HiveQL, Tables, Querying, UDFs, RC Files; MongoDB: Architecture, BSON, CRUD Operations, Query Language, Indexing, Replication.	9 Hours.	CO3
4	**Advanced Analytics – Spark, R & Web Analytics**: Introduction to Apache Spark – RDDs, Transformations, Actions, SparkSQL; Big Data Analytics using R – Supervised & Unsupervised Learning; Case Study on Collaborative Filtering; Web and Text Mining – Web Content, Structure, and Link Analytics.	9 Hours	CO4

Suggested Readings:

1. Tom White, Hadoop: The Definitive Guide, O'Reilly, 4th Edition, 2015.
2. Viktor Mayer-Schönberger & Kenneth Cukier, Big Data: A Revolution That Will Transform How We Live, Work, and Think, Houghton Mifflin Harcourt.
3. Jure Leskovec, Anand Rajaraman, and Jeff Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd Edition.

Online Resources

1. https://hadoop.apache.org/
2. https://spark.apache.org/
3. https://www.mongodb.com/

Course Articulation Matrix														
PO- PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO 6**	**PO7**	**PO8**	**PO9**	**PO1 0**	**PO11**	**PO1 2**	**PSO1**	**PSO2**
CO1	3	2	2	2	2	–	–	–	1	2	–	1	3	2
CO2	3	3	3	3	2	–	–	–	2	2	–	1	3	2
CO3	3	3	3	3	2	–	–	–	2	2	–	1	3	2
CO4	3	3	3	3	3	–	–	–	2	3	–	2	3	3

Program	M.Tech CSE				
Year	II	**Semester**	III		
Course Name	Digital Twin Technology				
Code	GE14244				
Course Type		**L**	**T**	**P**	**Credit**
Prerequisite	Basics of IoT, Data Analytics, and AI	4	0	0	4
Course Objectives	5. To introduce the fundamental concepts and architecture of Digital Twin systems. 6. To understand integration of physical systems with real-time data and simulations. 7. To explore applications in smart manufacturing, healthcare, transportation, and infrastructure. 8. To design and implement basic digital twin prototypes using simulation and real-world data.				
Course Outcomes					
CO1	Understand the principles and architecture of digital twin systems.				
CO2	Design and simulate real-time virtual models for physical systems.				
CO3	Integrate AI/ML models with digital twin for decision-making.				
CO4	Apply digital twin concepts to real-world domains and assess feasibility.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction to Digital Twins, Definition and evolution of digital twins, Digital Twin vs. Simulation vs. Cyber-Physical Systems, Components: Physical asset, virtual model, data connection, Types of Digital Twins (Product, Process, System, etc.) Use-cases across industries	30 Hours.	CO1
2	Architecture and Technologies, Digital Twin architecture layers, Sensors and IoT infrastructure, Real-time data integration and telemetry, Communication protocols (MQTT, OPC-UA, REST APIs), Cloud, edge, and fog computing for twins.	30 Hours.	CO2
3	Modeling, Simulation & AI Integration, Simulation models (physics-based, data-driven), Tools: MATLAB, Simulink, AnyLogic, Unity, TwinCAT, Integration with AI/ML for prediction, optimization, Data assimilation, time-series analysis, and feedback loops, Introduction to Digital Twin standards (DAML, ISO, etc.), Reinforcement learning for control system.	30 Hours.	CO3
4	Applications & Challenges, Digital Twin in Smart Manufacturing, Healthcare, Robotics and Autonomous system, Smart Cities, Predictive maintenance, performance optimization, BIM and Digital Twins in infrastructure, Security, privacy, and data governance, Scalability and interoperability challenges.	30 Hours	CO4

Suggested Readings:

1. Michael Grieves, Digital Twin: Manufacturing Excellence through Virtual Factory Replication.
2. Rajkumar Buyya, Fog and Edge Computing.

Online Resources

1- https://www.sw.siemens.com/en-US/digital-twin/

2-https://www.ibm.com/topics/digital-twin

Course Articulation Matrix														
PO- PSO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	
CO1	3	2	-	-	-	-	-	-	-	-	-	3	2	-
CO2	3	2	3	2	3	-	-	-	-	-	-	3	2	-
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3	-
CO4	2	3	3	2	2	2	-	-	2	2	2	2	3	-