MANIPAL
ACADEMY of HIGHER EDUCATION
(Institution of Eminence Deemed to be University)

Master of Engineering - ME (Artificial Intelligence and Machine Learning)

Syllabus

July 2024 Onwards

MANIPAL SCHOOL OF INFORMATION SCIENCES
MANIPAL ACADEMY OF HIGHER EDUCATION
MANIPAL – 576104, KARNATAKA, INDIA.

Program Educational Objectives / Outcomes (PEOs)

PEO 1: Acquire solid mathematical and computational skills essential for understanding, applying, and developing modern artificial intelligence and machine learning algorithms.

PEO 2: Produce industry-ready graduates with practical experience in structuring machine learning projects using state-of-the-art software.

PEO 3: Address multi-disciplinary challenges through coursework and projects by adapting to the rapidly advancing developments in artificial intelligence and machine learning approaches.

Program Objectives / Outcomes (POs)

PO 1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO 2: An ability to write and present a substantial technical report/document.

PO 3: Demonstrate a degree of mastery over the area as per the specialization of the program which should be at a level higher than the requirements in an appropriate bachelor program.

PO 4: Identify appropriate and efficient algorithmic approaches for solving real-life challenges using artificial intelligence and machine learning principles and state-of-the art software prevalent in industry and academia.

PO 5: Develop teamwork and leadership skills for addressing challenges of social importance for sustainable societal development using ethical artificial intelligence and machine learning approaches.

Program Structure

Semester 1	Semester 2
Course Name	Course name
Algorithms and Data Structures for Big Data	Advanced Applications of Probability & Statistics
Applied Linear Algebra	Deep Learning
Applied Machine Learning	Machine Learning Principles & Applications
Applied Probability and Statistics	Reinforcement Learning
Elective – I	Elective – II
Mini Project – I	Mini Project – II
Professional Skill Development – I	Professional Skill Development – II
Semester III & IV	Project Work
Elective-1	**Elective-2**
Course Name	Course name
Applications of Graph Theory	Applied Mathematics for Machine Learning
Architecture of Big Data Systems	Convolutional Neural Networks for Computer Vision
Principles of Data Visualization	Natural Language Processing Principles & Applications
	Entrepreneurship

SEMESTER I

BDA 5101: Algorithms and Data Structures for Big Data

Course Outcome

1. Analyse recursive programs, solve a general class of recurrence relations
2. Design programs for implementation of linked lists, stack, queues and binary search tree.
3. Design programs for dictionary, hash tables, graphs and shortest path techniques, sorting and searching.
4. Design string and text processing programs

Algorithm specification and analysis techniques, Elementary data structures, Sorting & Searching, Hash Tables, Graph, String and text processing techniques, Data stream algorithms

AML 5101: Applied Linear Algebra

Course Outcome

1. Develop a solid understanding of matrix-vector operations and relate them to real-life calculations.
2. Apply and analyse algorithms constructed using matrix-vector principles.
3. Develop models for real-life applications using the least squares technique and interpret the results from a practical perspective.

Conceptual introduction to vectors, Matrices, Linear Least Squares.

AML 5102: Applied Machine Learning

Course Outcome

1. Apply different types of supervised and unsupervised machine learning algorithms to practical problems.
2. Analyse different types of machine learning paradigms.
3. Evaluate the performance of machine learning algorithms.

Introduction to Machine Learning, Linear Model; Introduction to Clustering and Dimension Reduction, Ensemble Methods; Probabilistic Models for Supervised Learning; Generative AI with Large Language Models.

AML 5103: Applied Probability and Statistics

Course Outcome

1. Model random phenomena using random variables.
2. Construct Bayesian models for quantifying uncertainty in practical problems.
3. Use sample information and perform hypothesis-test analysis using an appropriate statistical technique to explain attributes of a population.

Counting; Probability Concepts; Conditional Probability, Random Variables, Sampling and Parameter Estimation.

ELECTIVES - SEMESTER I

AML 5131: Applications of Graph Theory

Course Outcome

1. Develop a thorough understanding of fundamental graph theoretic concepts and apply them to understanding practical problems.
2. Relate a real-life problem to an appropriate graph theoretic setup.
3. Describe how graph theory can be used for machine learning applications.

Graphs; Euler Tours and Hamilton Cycles, Flow in Networks; Matchings; Colouring Problems, Random walks and Applications; Spectral Clustering and Applications.

BDA 5102: Architecture of Big Data Systems

Course Outcome

1. Apply various techniques to examine different types of data and understand lambda architecture.
2. Apply different tools and frameworks of Hadoop eco-system.
3. Apply Spark engine to process real-time data.
4. Design applications to handle batch and streaming data using Hadoop and Spark tools.

Classifying Big Data Characteristics and Big Data processing - the Lambda architecture, Batch layer, Serving layer and Speed layer, Spark: Alternatives to MapReduce, Stream Processing and Machine Learning using Spark.

BDA 5132: Principles of Data Visualization

Course Outcome

1. Implement web scrapping techniques to extract data from websites.
2. Organize raw data for analysis using data manipulation techniques.
3. Use powerBI for preparation and modelling of data for analysis.
4. Interpret data using various data visualization techniques.
5. Report data for analytics and to manage workspace using Power BI

Web scraping, Data Analysis: Data structures for analysis, Data Visualization.

MPT 5100: Mini Project - I

Course Outcome

1. Identify the real-world and socially relevant problems and perform feasibility analysis for finding solutions.
2. Organize work effectively as a member in a team, examine, experiment, and communicate technical information constructively.
3. Develop and implement solutions to the identified problems by applying research methodology and development life cycle with appropriate documentation by incorporating ethical standards.

Problem identification, literature survey, formation of detailed specifications. Design and implementation of the proposed system architecture. Demonstrate an ability to present and defend project work carried out to a panel of experts.

PSD 5100: Professional Skill Development - I

Course Outcome

1. Identify and synthesize important themes in the field of engineering which transform socio-economic ecosystem.
2. Develop competence to communicate effectively in oral and written forms.
3. Effective management of time, involve in reflective learning and adhere to the professional code of conduct.

Report writing involves identifying the topic of interest from current issues in the domain of engineering and technology or inter disciplinary domains, then framing the order in the report, writing abstract, deciding on the content itself, conclusion and future scope of the topic and properly citing the references from bibliography. Presenting in classroom to audience where content spoken, the conceptual knowledge and presentation skills (like audibility, eye contact, memory) of speaker is assessed.

SEMESTER II

AML 5201: Advanced Applications of Probability and Statistics

Course Outcome

1. Apply linear and logistic regression models for practical problems and assess model performance.
2. Interpret the output of principal component analysis (PCA) applied to multivariate data for dimension reduction.
3. Identify multivariate data with mixed data type features and cluster using an appropriate technique.
4. Understand the basics of time series modelling and apply to real-life problems

Multivariate Distributions, Linear and Logistic Regression, Principal Component Analysis; Cluster Analysis, Bootstrapping; Time Series Analysis.

AML 5202: Deep Learning

Course Outcome

1. Gain a solid understanding of the mathematical basis of neural networks.
2. Build and analyse deep learning models for application problems.
3. Devise techniques for improving the way neural networks learn.
4. Develop skills to choose an appropriate deep learning model.

Introduction to Deep Learning; Matrix Calculus; Logistic Regression, Shallow Neural Network, Deep Neural Network; Improving the Way neural Networks Learn, Hyperparameter Tuning; Recurrent Neural Networks; Advanced Deep Learning Models

AML 5203: Machine Learning Principles and Applications

Course Outcome

1. Differentiate between discriminative and generative algorithms for supervised machine learning.
2. Evaluate machine learning algorithms for accuracy and performance.
3. Devise techniques for dealing with practical difficulties in applying machine learning techniques to real-life problems.
4. Develop low dimensional models of application problems.

Kernel Methods; Linear Regression, Generative Learning Algorithms, Feature & Model Selection; Imbalanced Data; Expectation Maximization; Dimension Reduction; Independent Component Analysis

AML 5204: Reinforcement Learning

Course Outcome

1. Define the key features of reinforcement learning that distinguishes it from AI and non-interactive machine learning.
2. Understand how ideas such as temporal difference learning and dynamic programming fit in the framework of learning from interaction to achieve goals.
3. Decide if an application problem can be formulated as a reinforcement learning problem and choose an appropriate algorithm.
4. Understand and implement commonly used reinforcement learning algorithms.

Introduction to the Reinforcement Learning Problem; Reinforcement Learning Framework; Dynamic Programming, Model Free Reinforcement Learning, Approximate Solution Methods.

ELECTIVES - SEMESTER II

AML 5231: Applied Mathematics for Machine Learning

Course Outcome

1. Develop a solid understanding of fundamentals of matrix decomposition techniques and apply them to practical problems.
2. Describe the role of derivatives in machine learning and understand different methods for computing them.
3. Acquire solid foundation in understanding the principles behind state-of-the-art optimization algorithms used in machine learning libraries.

Matrix Decompositions and Applications, Computing Derivatives, Continuous Optimization.

AML 5232: Convolutional Neural Networks for Computer Vision

Course Outcome

1. Identify and apply appropriate image processing operation for a problem-solving task.
2. Analyze a real-life problem involving computer vision and solve it using CNNs.
3. Develop and design CNN architectures using the basic building blocks of CNN
4. Investigate use of an existing CNN architecture for an application problem.

Introduction to Computer Vision; Features; Neural Networks Basics, Convolutional Neural Networks (CNN), CNN Training, CNN Architectures; Applications of CNNs in Computer Vision

AML 5233: Natural Language Processing Principles and Applications

Course Outcome

1. Develop an in-depth understanding of both algorithms for processing linguistic information and the underlying computational properties of natural languages.
2. Analyse word-level, syntactic, and semantic processing from both a linguistic and an algorithmic perspective.
3. Formulate deep learning approaches for natural language processing tasks.

Introduction to Natural Language Processing (NLP); Regular Expressions; N-gram Language Models, Naive Bayes and Sentiment Classification; Vector Semantics and Embeddings, NLP with Deep Learning; Applications of Natural Language Processing

ENP 5230: Entrepreneurship

1. Explain the importance of entrepreneurship and entrepreneurial development model, social responsibilities of business
2. Describe Entrepreneurial Traits and Factors affecting Entrepreneurship processent
3. Discuss Business Start-up Process
4. Summarize a business and marketing plan for entrepreneurs.

Introduction to Entrepreneurship, Entrepreneurial Traits, Process of Entrepreneurship, Business Start-up Process, Business Plan writing, Case studies.

MPT 5200 Mini project - II

Course Outcome

1. Identify the real-world and socially relevant problems and perform feasibility analysis for finding solutions.
2. Organize work effectively as a member in a team, examine, experiment, and communicate technical information constructively.
3. Develop and implement solutions to the identified problems by applying research methodology and development life cycle with appropriate documentation by incorporating ethical standards.

Problem identification, literature survey, formation of detailed specifications, Design and implementation of the proposed system architecture, demonstrate an ability to present and defend project work carried out to a panel of experts.

PSD 5200: Professional Skill Development - II

Course Outcome

1. Develop the skills needed for approaching technical and HR interviews.
2. Use mathematical, reasoning, and domain specific skills to solve objective questionnaires in time.
3. Demonstrate depth of knowledge in the chosen field of study.

Peer interviews, mock interviews, Logical reasoning, mathematical aptitude, domain specific problem solving skills, Conduction of domain specific knowledge test.

AML 6098: Project Work

Course Outcome

1. Undertake innovative industry/research oriented projects and perform feasibility analysis for finding solutions.
2. Implement and test the proposed design using appropriate framework, programming language and tools.
3. Demonstrate an ability to present and defend project work carried out to a panel of experts.

Problem identification, literature survey, formation of detailed requirement specification document, Design and implementation of the proposed modules with specific test cases, Detailed report of the work carried out, present, and defend the project work carried out to a panel of experts.

Program Outcome and Course Outcome Mapping

Sl. No.	Course Code	Course Name	Credits	PO1	PO2	PO3	PO4	PO5
1	BDA 5101	Algorithms and Data Structures for Big Data	3			*	*	
2	AML 5101	Applied Linear Algebra	3	*			*	
3	AML 5102	Applied Machine Learning	3	*			*	*
4	AML 5103	Applied Probability and Statistics	3			*		*
5	AML 5131	Applications of Graph Theory	3	*		*	*	
	BDA 5102	Architecture of Big Data Systems	3			*	*	*
	BDA 5132	Principles of Data Visualization	3			*		*
6	BDA 5151	Algorithms and Data Structures for Big Data Lab	1			*	*	
7	AML 5151	Applied Linear Algebra Lab	1	*			*	
8	AML 5152	Applied Machine Learning Lab	1	*			*	*
9	AML 5153	Applied Probability and Statistics Lab	1			*		*
10	AML 5181	Applications of Graph Theory Lab	1	*		*	*	
	BDA 5152	Architecture of Big Data Systems Lab	1			*	*	*
	BDA 5182	Principles of Data Visualization Lab	1			*		*
11	MPT 5100	Mini Project – I	4	*	*	*	*	*
12	PSD 5100	Professional Skill Development – I	1	*	*			
13	AML 5201	Advanced Applications of Probability and Statistics	3			*		*
14	AML 5202	Deep Learning	3	*			*	*
15	AML 5203	Machine Learning Principles and Applications	3	*			*	*
16	AML 5204	Reinforcement Learning	3	*			*	*
17	AML 5231	Applied Mathematics for Machine Learning	3	*		*		

Sl. No.	Course Code	Course Name	Credits	PO1	PO2	PO3	PO4	PO5
	AML 5232	Convolutional Neural Networks for Computer Vision	3	*			*	*
	AML 5233	Natural Language Processing Principles and Applications	3	*			*	*
	ENP 5230	Entrepreneurship	3			*	*	
18	AML 5251	Advanced Applications of Probability and Statistics Lab	1			*		*
19	AML 5252	Deep Learning Lab	1	*			*	*
20	AML 5253	Machine Learning Principles and Applications Lab	1	*			*	*
21	AML 5254	Reinforcement Learning Lab	1	*			*	*
22	AML 5281	Applied Mathematics for Machine Learning Lab	1	*		*		
	AML 5282	Convolutional Neural Networks for Computer Vision Lab	1	*			*	*
	AML 5283	Natural Language Processing Principles and Applications Lab	1	*			*	*
	ENP 5280	Entrepreneurship Lab	1			*	*	
23	MPT 5200	Mini Project – II	4	*	*	*	*	*
24	PSD 5200	Professional Skill Development – II	1			*	*	*
25	AML 6098	Project Work	25	*	*	*	*	*