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(Accredited by NAAC)

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GU/Acad –PG/BoS -NEP Engg. /2025/760 Date: 21.01.2025

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP Engg. /2024/636 dated 07.11.2024

In supersession to the above referred Circular the Syllabus of Semester II of the **Master of Engineering (Artificial Intelligence and Data Science)** Programme approved by the Academic Council in its meeting held on 06th December 2024 is attached herewith. The Syllabus Semester I approved earlier by the Academic Council in its meeting held on 22nd August 2024 is also attached.

The Dean, Faculty of Engineering and Principals of affiliated Colleges offering the **Master of Engineering (Artificial Intelligence and Data Science)** are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of affiliated Engineering Colleges.

Copy to,
1. The Director, Directorate of Technical Education, Govt. of Goa
2. The Chairperson, BoS in Computer Engineering.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar Examinations (Prof.), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

MASTER OF ENGINEERING (ARTIFICIAL INTELLIGENCE AND DATA SCIENCE)
RC 2024-25

TWO YEAR PROGRAMME STRUCTURE						
Semester I						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	EAD-500	Mathematical Foundations for AI and Data Science - I	4	0	0	4
2	EAD-501	Business Analytics	4	0	0	4
3	EAD-502	Advanced Data Structures and Algorithms	3	0	0	3
4	EAD-503	Advanced Data Structures and Algorithms Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	EAD-531	Fundamentals of AI and Data Science	3	0	0	3
6	EAD-532	Fundamentals of AI and Data Science Lab	0	0	1	1
OR						
7	EAD-533	High Performance and GPU Programming	3	1	0	4
Research Specific Elective (RSE) Courses						
8	REC-561	Engineering Research & Publications	3	1	0	4
OR						
9	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
		TOTAL	**17**	**2**	**2**	**20**
Semester II						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	EAD-504	Mathematical Foundations for AI & Data Science -II	3	0	0	3
2	EAD-505	Mathematical Foundations for AI & Data Science -II Lab	0	0	1	1
3	EAD-506	Applied Machine Learning	3	0	0	3
4	EAD-507	Applied Machine Learning Lab	0	0	1	1
5	EAD-508	Data Mining and Applications	3	0	0	3
6	EAD-509	Data Mining and Applications Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
7	EAD-534	Web Analytics	3	0	0	3
8	EAD-535	Web Analytics Lab	0	0	1	1
OR						
9	EAD-536	Pattern Recognition for AI & Data Science	3	0	0	3
10	EAD-537	Pattern Recognition for AI & Data Science Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
11	REC-563	Statistics and Data Analysis for Engineering Research	2	0	0	2
12	REC-564	Statistics And Data Analysis Lab	0	0	2	2
OR						
13	REC-565	Statistical Techniques for Engineering Research	2	0	0	2
14	REC-566	Probability & Statistical Analysis Lab	0	0	2	2
		TOTAL	**14**	**0**	**6**	**20**

Issued on: 21/01/2025

TWO YEAR PROGRAMME STRUCTURE						
Semester III						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	**EAD-600**	Applied Deep Learning	3	0	0	3
2	**EAD-601**	Applied Deep Learning Lab	0	0	1	1
3	**EAD-602**	Optimization Methods for AI & Data Science	3	0	0	3
4	**EAD-603**	Optimization Methods for AI & Data Science Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	**EAD-631**	Video Analytics using AI	3	0	0	3
6	**EAD-632**	Video Analytics using AI Lab	0	0	1	1
OR						
7	**EAD-633**	Natural Language Processing and Applications	3	0	0	3
8	**EAD-634**	Natural Language Processing and Applications Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
9	**EAD-661**	Research Directions in AI	2	0	0	2
10	**EAD-662**	Research Directions in AI Lab	0	0	2	2
OR						
11	**EAD-663**	Research Directions in Data Science	2	0	0	2
12	**EAD-664**	Research Directions in Data Science Lab	0	0	2	2
General Elective (GE) Courses						
13	**GEC-681**	Sustainability Principles and Practices	3	0	0	3
14	**GEC-682**	Sustainability Principles Lab	0	0	1	1
OR						
15	**GEC-683**	Project Management	3	0	0	3
16	**GEC-684**	Project Management Lab	0	0	1	1
		TOTAL	**14**	**0**	**6**	**20**
Semester IV						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
General Elective (GE) Courses						
1	**GEC-685**	Financial Management / NPTEL	4	0	0	4
OR						
2	**GEC-686**	Entrepreneurship / NPTEL	4	0	0	4
Program Specific Dissertation or Internship						
3	**EAD-698**	Dissertation	0	0	0	16
OR						
4	**EAD-699**	Internship	0	0	0	16
		TOTAL	**4**	**0**	**0**	**20**

Issued on: 21/01/2025

THREE YEAR PROGRAMME STRUCTURE						
Semester I						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	EAD-500	Mathematical Foundations for AI and Data Science - I	4	0	0	4
Programme Specific Elective (PSE) Courses						
2	EAD-531	Fundamentals of AI and Data Science	3	0	0	3
3	EAD-532	Fundamentals of AI and Data Science Lab	0	0	1	1
OR						
4	EAD-533	High Performance and GPU Programming	3	1	0	4
Research Specific Elective (RSE) Courses						
5	REC-561	Engineering Research & Publications	3	1	0	4
OR						
6	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
		TOTAL	**10**	**2**	**1**	**12**
Semester II						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	EAD-506	Applied Machine Learning	3	0	0	3
2	EAD-507	Applied Machine Learning Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
3	EAD-534	Web Analytics	3	0	0	3
4	EAD-535	Web Analytics Lab	0	0	1	1
OR						
5	EAD-536	Pattern Recognition for AI & Data Science	3	0	0	3
6	EAD-537	Pattern Recognition for AI & Data Science Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
7	REC-563	Statistics and Data Analysis for Engineering Research	2	0	0	2
8	REC-564	Statistics and Data Analysis Lab	0	0	2	2
OR						
9	REC-565	Statistical Techniques for Engineering Research	2	0	0	2
10	REC-566	Probability & Statistical Analysis Lab	0	0	2	2
		TOTAL	**8**	**0**	**4**	**12**

Issued on: 21/01/2025

Semester III						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	**EAD-501**	Business Analytics	4	0	0	4
2	**EAD-502**	Advanced Data Structures and Algorithms	3	0	0	3
3	**EAD-503**	Advanced Data Structures and Algorithms Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	**EAD-631**	Video Analytics using AI	3	0	0	3
6	**EAD-632**	Video Analytics using AI Lab	0	0	1	1
OR						
7	**EAD-633**	Natural Language Processing and Applications	3	0	0	3
8	**EAD-634**	Natural Language Processing and Applications Lab	0	0	1	1
		TOTAL	**10**	**0**	**2**	**12**

Semester IV						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	**EAD-504**	Mathematical Foundations for AI & Data Science –II	3	0	0	3
2	**EAD-505**	Mathematical Foundations for AI & Data Science -II Lab	0	0	1	1
3	**EAD-508**	Data Mining and Applications	3	0	0	3
4	**EAD-509**	Data Mining and Applications Lab	0	0	1	1
General Elective (GE) Courses						
5	**GEC-681**	Sustainability Principles and Practices	3	0	0	3
6	**GEC-682**	Sustainability Principles Lab	0	0	1	1
OR						
7	**GEC-683**	Project Management	3	0	0	3
8	**GEC-684**	Project Management Lab	0	0	1	1
		TOTAL	**9**	**0**	**3**	**12**

Semester V						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
Programme Specific Core (PSC) Courses						
1	**EAD-600**	Applied Deep Learning	3	0	0	3
2	**EAD-601**	Applied Deep Learning Lab	0	0	1	1
3	**EAD-602**	Optimization Methods for AI & Data Science	3	0	0	3
4	**EAD-603**	Optimization Methods for AI & Data Science Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
5	**EAD-661**	Research Directions in AI	2	0	0	2
6	**EAD-662**	Research Directions in AI Lab	0	0	2	2
OR						
7	**EAD-663**	Research Directions in Data Science	2	0	0	2
8	**EAD-664**	Research Directions in Data Science Lab	0	0	2	2
		TOTAL	**8**	**0**	**4**	**12**
Semester VI						
Sr. No.	**Course Code**	**Title of the Course**	**L**	**T**	**P**	**Credits**
General Elective (GE) Courses						
1	**GEC-685**	Financial Management / NPTEL	4	0	0	4
OR						
2	**GEC-686**	Entrepreneurship/ NPTEL	4	0	0	4
Program Specific Dissertation or Internship						
3	**EAD-698**	Dissertation	0	0	0	16
OR						
4	**EAD-699**	Internship	0	0	0	16
		TOTAL	**4**	**0**	**0**	**20**

Semester I
Programme Specific Core (PSC) Courses
Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-500
Title of the Course : Mathematical Foundations for AI and Data Science – I
Number of Credits : 04 (4L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic Knowledge of Applied Mathematics	
Course Objectives:	The course will enable the students to: 1. Introduce the students to the foundational concepts of Mathematics for Artificial Intelligence and Data Science, such as Linear Algebra, Matrix Calculus and Optimization. 2. Equip them with the analytical tools required to apply the concepts of Linear Algebra and Matrix Theory to applications arising in Artificial Intelligence and Data Science. 3. Expose them to Vector and Matrix Calculus, which is an essential tool for understanding and solving problems in artificial intelligence and data science. 4. Familiarize them with various optimization techniques required to solve problems related to Artificial Intelligence and Data Science.	
Content:		**No. of hours**
Unit - 1	**Linear Algebra**: Introduction, Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings. **Analytic Geometry:** Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Gram-Schmidt Orthogonalization, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions	**15**
Unit - 2	**Analytic Geometry:** Orthogonal Projections, Orthogonal Projection and the Normal Equation, Least Squares Problem, Rotations. **Decompositions**: Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.	**15**
Unit - 3	**Vector Calculus**: Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series.	**15**
Unit - 4	**Unconstrained Optimization**: Gradient Descent, Gradient Descent with momentum, Conjugate Gradient Descent. **Constrained Optimization**: Lagrange Multipliers, Convex Sets,	**15**

	Convex Functions, Convex Optimization.	
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. David C. Lay: Linear Algebra and Its Applications, Third Edition, Pearson Education India, 2002. 2. Lloyd N. Trefethen and David Bau III: Numerical Linear Algebra, Twenty-Fifth Anniversary Edition, SIAM-Society for Industrial and Applied Mathematics, 2022. 3. Charu Agarwal: Linear Algebra and Optimization for Machine Learning, First Edition, Springer, 2021. 4. Kaare Brandt Petersen, Michael Syskind Pedersen: The Matrix cookbook, Version 20121115, Technical University of Denmark, 2012. **Reference Books** 1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong: Mathematics for Machine Learning, Cambridge University Press, 2020. 2. Jay Dawani: Hands-On Mathematics for Deep learning, First Edition, Packt Publishing Ltd., 2020. 3. Gilbert Strang: Introduction to Li near Algebra, Fifth Edition, Wellesley-Cambridge Press, 2016. 4. Stephen Boyd, Lieven Vandenberghe: Introduction to applied linear algebra : Vectors, Matrices, and Least Squares, First Edition, Cambridge University Press, 2018. 5. Stephen Boyd, Lieven Vandenberghe: Convex Optimization, First Edition, Cambridge University Press, 2004.	
Course Outcomes:	After taking this course, student will be able to: CO1. Demonstrate a sound understanding of a range of mathematical tools and their role and importance in artificial intelligence and data science. CO2. Apply important concepts of linear algebra and matrix Calculus to applications arising in artificial intelligence and data science. CO3. Navigate the complex landscape of derivatives, gradients, and optimization techniques involving vectors and matrices. CO4. Employ various optimization techniques to solve problems arising in artificial Intelligence and data science applications.	

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Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-501
Title of the Course : Business Analytics
Number of Credits : 4 (4L)
Effective from AY : 2024-25

Pre-requisites for the Course:	A basic understanding of statistics and data analysis.	
Course Objectives:	The course will enable the students to 1. Develop a strong foundation in business analytics techniques. 2. Learn to use data-driven approaches to strategic decision-making. 3. Gain hands-on experience with analytics software and tools. 4. Understand how to leverage analytics for business transformation	
Content:		**No. of hours**
Unit - 1	**Introduction to Business Analytics:** Overview of Business Analytics**,** Data-Driven Business Analytics, Models in Business Analytics, Problem Solving with Analytics, Introduction to Statistical Analysis and use of software. **Descriptive Analytics:** Data Visualization Techniques: Column, Bar, Line, Pie, Area, Scatter, Orbit, Bubble, Combination, Radar, Stock, Charts, Charts from Pivot tables, Geographic data, Colour scales, Icon sets, Sparklines and Dashboards, Driving business transformation with analytics.	**15**
Unit - 2	**Descriptive Statistics:** Frequency distributions, Measures of location, Measures of Dispersion, Chebyshev's Theorem, Measures of shape, Computing descriptive statistics for frequency distributions, Descriptive statistics for categorical data: the proportion, Measures of Association: Covariance, Correlation, Outliers, Use of Descriptive statistics to analyse survey data, Statistical thinking in business decisions. **Probability Distributions and Data Modelling:** Random Variables and Probability Distributions, Discrete Probability Distributions: Binomial distribution, Poisson distribution, and geometric distribution. Continuous Probability Distributions: Properties of probability density functions, uniform distribution, normal, exponential distribution.Types of Data Models: Conceptual Data Model, Logical Data Model, Physical Data Model	**15**
Unit – 3	**Trend lines and Regression Analysis:** Fundamentals of Linear Regression, Residual analysis and regression assumption, Multiple Linear Regression. **Forecasting Techniques Overview:** Qualitative and Judgemental Forecasting: Delphi method, Statistical Forecasting models: Time Series Analysis, Time Series with linear trend, Holt-Winters models for seasonality and no trend and Holt – Winters models with seasonality and trend, Regression Forecasting with causal	**15**

	variables.	
Unit – 4	**Optimization Techniques:** Developing Linear optimization models, decision variables, solving linear optimization models, Sensitivity analysis, Unbounded, solutions, Infeasibility, Application of linear optimisation models: Blending models, Portfolio investment models, Transportation models Multi-period, Multi-period financial planning models. Integer Linear Optimisation Models: Models with general Integer variables, Workforce-scheduling models, Alternative optimal solutions. Models with binary variables: using binary variables to model logical constraints, application in supply chain optimisation. **Simulation and Risk Analysis:** Understanding risk and uncertainty in decision-making, Monte Carlo simulation for risk assessment: profit model simulation, new product development, retirement planning, single-period purchase decisions, overbooking decisions, project management, Random sampling from probability distributions, Dynamic systems simulation, simulating waiting lines.	**15**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. James R. Evans: Business Analytics: Methods, Models and Decisions, 3rd Edition, Pearson Education, 2021. 2. Foster Provost, Tom Fawcett: Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, 1st Edition, O'Reilly Media, 2013. 3. Dinesh Kumar U.: Business Analytics, The Science of Data-Driven Decision Making, 2nd Edition, Wiley, 2021. **Reference Books** 1. Seema Acharya, Prasad R.N.: Fundamentals of Business Analytics, 2nd Edition, Wiley, 2016. 2. Thomas H. Davenport, Jeanne G. Harris: Competing on Analytics, 1st Edition, Harvard Business Review Press, 2017. 3. Eric Siegel: Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die, 2nd Edition, Wiley, 2016. 4. Rick Sherman: Business Intelligence Guidebook: From Data Integration to Analytics, 1st Edition, Morgan Kaufmann, 2014. 5. Nussbaumer Knaflic, Cole: Storytelling With Data: A Data Visualization Guide For Business Professionals 1st Edition, Wiley, 2015.	
Course Outcomes:	After taking this course, student will be able to: CO1. Apply business analytics techniques to real-world business problems. CO2. Apply data-driven approaches to strategic decision-making. CO3. Demonstrate usage of analytics software and tools to manage databases, execute data queries, and utilize data visualization techniques. CO4. Apply analytics for business transformation.	

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Name of the Programme : **Master of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-502**
Title of the Course : **Advanced Data Structures and Algorithms**
Number of Credits : **03 (3L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Prior knowledge of basic data structures and a programming language.	
Course Objectives:	The course will enable the students to: 1. Demonstrate proficiency in implementing and analyzing array-based sequences, stacks, and queues. 2. Develop the ability to design efficient algorithms and data structures to solve complex problems. 3. Understand various graph data structures. 4. Develop Programming and Problem-Solving Skills.	
Content:		**No. of hours**
Unit - 1	**Introduction to Data Structures:** Types of Data Structures, Operations on Data Structures, Abstract Data Types, Big O Notation. **Arrays/Lists:** Declaration, Initialization, Operations, 2D Arrays/Lists: Declaration, Operations. **Stacks:** Operations, Implementation of Stack using Array/Lists and Linked List, Applications of Stack. **Queues**: Operations, Implementation of queue using Array/Lists and Linked List, Types of queues: Circular, Priority, De-queue.	**11**
Unit - 2	**Linked Lists:** Memory Allocation, Singly Linked List, Circular Linked List, Doubly Linked List, Header Linked List **Trees**: Binary Tree: Types of Binary Trees, Memory Representation of Binary Trees, Binary Search tree: Operations on Binary Search Trees, Binary Tree Traversal Methods, Creating a Binary Tree Using Traversal Methods, AVL trees: Need for Height-Balanced Trees, Operations on an AVL Tree, Red Black Trees Operations. **Multi-Way Search Trees:** B-Trees: Operations on a B-Tree, Insertion in a B-Tree, Deletion in a B-Tree, Application of a B-Tree, B+ Trees.	**12**
Unit - 3	**Maps and Dictionaries:** The Map ADT, Application: Counting Word Frequencies. **Hashing :** Difference between Hashing and Direct Addressing, Hash Tables, Hash Functions, Collision, Collision Resolution Techniques **Sets, Multisets, and Multimaps:** The Set ADT, Implementing Sets, Multisets, and Multimaps.	**11**
Unit - 4	**Sorting:** Merge-Sort, Array based implementation of merge sort, Quick-Sort implementation. **TextProcessing:** Pattern-Matching Algorithms: Brute Force, The	**11**

	Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm. **Graphs:** Graph Representation: Adjacency Matrix Representation, Adjacency List Representation, Graph Traversal Techniques: Breadth-First Search, Depth-First Search, Topological Sort, Minimum Spanning Tree: Prim's Algorithm , Kruskal's Algorithm	
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. Malhotra Dheeraj, Malhotra Neha: Data Structures and Program Design Using Python, India, Mercury Learning and Information, 2020. 2. Goodrich, Michael T, Tamassia, Roberto: Goldwasser, Michael H: Data Structures and Algorithms in Python. United States: Wiley, 2013. 3. Miller, Bradley N., David L. Ranum: Problem-solving with algorithms and data structures using Python Second Edition. Franklin, Beedle & Associates Inc., 2011. **Reference Books** 1. Reema Thareja, S. Rama Sree: Advanced Data Structures, Oxford University Press, 2018. 2. Baka, Benjamin: Python Data Structures and Algorithms. United Kingdom: Packt Publishing, 2017. 3. Necaise, Rance D: Data Structures and Algorithms Using Python, India: Wiley, 2011. 4. Vasudevan, Shriram K. Nagarajan, Abhishek S., Nanmaran, Karthick.: Data Structures Using Python. India: Oxford University Press, 2020. 5. Lee, Kent D., Hubbard, Steve: Data Structures and Algorithms with Python. Germany: Springer International Publishing, 2015.	
Course Outcomes:	After taking this course, student will be able to: CO1. Implement abstract data types (ADT) and data structures for stacks, queues and linked list. CO2. Demonstrate techniques and data structures to solve problems using trees, dictionaries, sets and hash tables. CO3. Apply data structures to solve computational problems involving text processing and dynamic programming. CO4. Apply and analyze graph algorithms for solving problems effectively.	

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-503**
Title of the Course : **Advanced Data Structures and Algorithms Lab**
Number of Credits : **01(1P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Prior knowledge of basic data structures and a programming language.	
Course Objectives:	The course will enable the students to: 1. Identify the appropriate data structure for a given problem. 2. Understand trees and hash tables concepts. 3. Understand data structures to solve computational problems involving text processing and dynamic programming. 4. Understand various graph algorithms for solving problems effectively.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Implementation of stack. 2. Implementation of queue. 3. Implementation of linked list. 4. Write a program to implement the various operations on Binary Search Tree. 5. Write program that use recursive and non-recursive functions to traverse the given binary tree in a)Preorder b) Inorder c) Postorder 6. Implementation of AVL tree. 7. Implementation of operations on Red-Black trees. 8. Implementation of operations on B/B+-trees. 9. Implementation of hash functions and its associated algorithms. 10. Implementation of Bellman-Ford algorithm. 11. Implementation of prim's algorithm for minimum spanning tree. 12. Implementation of kruskals algorithm for minimum spanning tree. 13. Implementation of graph traversal method. 14. Write a program for implementing Knuth-Morris-Pratt pattern matching algorithm 15. Write a program for implementing Brute Force pattern matching algorithm. **Minimum 10 experiments to be performed from above list.**	**30 Hours**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. Malhotra Dheeraj, Malhotra Neha: Data Structures and Program Design Using Python, India, Mercury Learning and Information, 2020. 2. Goodrich, Michael T, Tamassia, Roberto Goldwasser, Michael H: Data Structures and Algorithms in Python. United States: Wiley, 2013.	

	3. Miller, Bradley N., David L. Ranum: Problem-solving with algorithms and data structures using Python Second Edition. Franklin, Beedle & Associates Inc., 2011. **Reference Books** 1. Reema Thareja, S. Rama Sree: Advanced Data Structures, Oxford University Press, 2018. 2. Baka, Benjamin: Python Data Structures and Algorithms. United Kingdom.: Packt Publishing, 2017. 3. Necaise, Rance D: Data Structures and Algorithms Using Python, India.: Wiley, 2011. 4. Vasudevan, Shriram K., Nagarajan, Abhishek S., Nanmaran, Karthick: Data Structures Using Python. India: Oxford University Press, 2020. 5. Lee, Kent D., Hubbard, Steve: Data Structures and Algorithms with Python. Germany: Springer International Publishing, 2015.
Course Outcomes:	After taking this course, student will be able to: CO1. Solve problems using data structures such as arrays, linked lists, stacks, queues, linked list. CO2. Implement programs for various sorting techniques. CO3. Implement programs for trees, hash tables. CO4. Execute various graph traversal algorithms and string searching algorithms.

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Programme Specific Elective (PSE) Courses
Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-531
Title of the Course : Fundamentals of AI and Data Science
Number of Credits : 03 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Foundational understanding of programming and basic statistics.	
Course Objectives:	The course will enable the students to: 1. To understand the basic concepts of AI and Data science. 2. Ability to apply AI and Data Science in different domain. 3. Do exploratory analysis on a given data. 4. Cover various paradigms that come under the broad umbrella of AI and Data Science.	
Content:		**No. of hours**
Unit - 1	**Artificial Intelligence**: Introduction, Intelligent Agent: agents and Environments, The structure of Agents. **Problem solving**: Solving Problems by Searching: problem solving agents, search for solutions, uniform search strategies, heuristic search strategies. Adversarial Search, Games, Optimal decision in games, Alpha –Beta Pruning. **Knowledge, Reasoning and Planning**: Logical Agents, First-Order Logic: syntax and semantics of first order logic, using first -Order Logic, Inference in First-Order Logic, Knowledge Representation.	**12**
Unit - 2	**Machine Learning**: Learning from examples; forms of learning, supervised learning, Learning decision trees, evaluation and choosing the best hypothesis. **Probabilistic Models:** Statistical Learning, Learning with complete data. **Communicating, Perceiving and Acting**: Natural Language Processing: language models, text classification, Information retrieval, **Perception**: Image formation, Image processing operations, Computer Vision. **The Future of AI:** Agent Components, Agent Architecture.	**11**
Unit - 3	**Introduction to Data Science**: What is Data Science, The data science Venn diagram, some more terminology. **Types of Data**: Flavors of Data, Structured vs unstructured data, Quantitative vs qualitative data, Four levels of data- nominal, ordinal, interval, ratio **The five steps of Data Science**: Overview of the five steps, Explore the data **Communicating Data:** Identifying effective and ineffective visualizations – Scatter plots, Line graphs, Bar Charts, Histograms, Box plots. When graphs and statistics lie, Verbal communication.	**11**

	Beyond the essentials: The bias variance trade-off.	
Unit - 4	**Data Visualization:** Introduction, How visualization works, positioning in the field **From Graphics to Visualization** : A Simple Example, Graphics-Rendering Basics, Rendering the Height Plot, Texture Mapping, Transparency and Blending, Viewing **Data Representation:** Continuous Data, Sampled Data, Discrete Datasets, Cell Types, Grid Types, Attributes, Computing Derivatives of Sampled Data, Advanced Data Representation **The Visualization Pipeline:** Conceptual Perspective, Implementation Perspective, Algorithm Classification.	**11**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning, Constructivist, collaborative, integrative and inquiry-based approach, Innovation-conducive pedagogy, digital pedagogical competency.	
References/ Readings:	**Text Books** 1. Stuart J Russell, Peter Norvig: Artificial Intelligence - A Modern Approach, 4th Edition, Pearson Education, 2020. 2. Sinan Ozdemir: Principles of Data Science, Packt Publishing, 2016. 3. Alexandru C. Telea.:Data Visualization : Principles and Practice, 2nd Edition, CRC Press, 2014. 4. Gypsy Nandi, Rupam Kumar Sharma.:Data Science Fundamentals and Practical Approaches, 1st Edition, BPB Publications, 2020. **Reference Books** 1. K.Knight, E. Rich, S.B. Nair.: Artificial Intelligence, 3rd Edition, Tata McGraw Hill Education, 2017. 2. 2. Joel Grus.: Data Science from Scratch, 2nd Edition, O'Reilly Media, 2019. 3. 3. Foster Provost & Tom Fawcett.: Data Science for Business, 1st Edition, O'Reilly Media, 2013. 4. Roger D. Peng & Elizabeth Matsui.: The Art of Data Science, Lean Publishing, 2018. 5. Anindita Das Bhattacharjee.: Artificial Intelligence and Soft Computing for Beginners, 4th Edition, Shroff Publications and Distributors, 2023.	
Course Outcomes:	After taking this course, student will be able to: CO1. Demonstrate knowledge of the fundamental principles of Artificial Intelligence and Data Science. CO2. Analyse and compare the relative merits of different AI problem solving techniques. CO3. Apply basic tools (plots, graphs, summary statistics) to carry out exploratory data analysis. CO4. Create effective visualization of given data and Describe the Data Science Process and how its components interact.	

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Name of the Programme : **Master of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-532**
Title of the Course : **Fundamentals Of AI and Data Science Lab**
Number of Credits : **01 (1P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Familiarity with basic programming concepts in Python and a foundational understanding of AI and data science.	
Course Objectives:	The course will enable the students to: 1. To provide the students with the basic knowledge of AI and Data Science. 2. To introduce them to Python packages and their usability. 3. To learn how to clean and prepare the data, apply AI algorithms, and interpret the results to influence decision-making. 4. To make the students develop solutions using Data Science tools.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Write a Program to Implement Breadth/Depth First Search using Python. 2. Write a Program to Implement a Tic-Tac-Toe game using Python. 3. Write a Program to implement an 8-Puzzle problem using Python. 4. Write a Program to Implement Water-Jug problem using Python. 5. Write a Program to Implement Travelling Salesman Problem using Python. 6. Write a Program to Implement 8-Queens Problem using Python 7. Case Study on Developing Machine Learning Systems 8. Working with Numpy arrays 9. Working with Pandas data frames 10. Develop python program for Basic plots using Matplotlib 11. Develop python program for Advance plots using Matplotlib 12. Develop python program for Frequency distributions for words. 13. Develop python program for Normal Curves. 14. Develop python program for Correlation coefficient . 15. Perform Exploratory data analysis on complex dataset. **(Minimum 10 experiments to be performed from above list)**	**30**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. Dr. Mohd. Abdul Hameed: Python for Data Science, Wiley, 1st Edition, 2021. 2. Dr. R. Nageswara Rao: Core Python Programming, Dreamtech press, 3rd edition, 2018.	

	3. Taneja Sheetal, Kumar Naveen: Python Programming a modular approach, Pearson Education, 1st edition, 2017. 4. Samir Madhavan: Mastering python for data science, Packt Publisher, 1st Edition, 2015. **Reference Books** 1. Kenneth. A. Lambert: Fundamentals of Python First Programs, Cengage Learning, 2nd, 2019. 2. Vamsi Kurama: Python Programming: A Modern Approach, Pearson India, 2017. 3. Y. Daniel Liang: Introduction to Programming Using Python, Pearson Education, First edition, 2017. 4. Stuart J Russell, Peter Norvig: Artificial Intelligence - A Modern Approach, 4th Edition, Pearson Education, 2020. 5. Sinan Ozdemir: Principles of Data Science, Packt Publishing, 2016. 6. Alexandru C. Telea: Data Visualization: Principles and Practice, 2nd Edition, CRC Press, 2014. 7. Gypsy Nandi, Rupam Kumar Sharma: Data Science Fundamentals and Practical Approaches, 1st Edition, BPB Publications, 2020.
Course Outcomes:	After taking this course, student will be able to: CO1. Implement various techniques to solve AI problems. CO2. Apply AI techniques to solve difficult real-life problems. CO3. Explore functions of Python libraries & packages. CO4. Implement Python code for data visualization.

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Name of the Programme : **Master of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-533**
Title of the Course : **High Performance and GPU Programming**
Number of Credits : **4 (3L+1T)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Programming Languages	
Course Objectives:	The course will enable the students to 1. Introduce fundamentals of high-performance computing using their architectures and corresponding programming environments. 2. Apply parallel execution models and methodologies for parallel programming and parallel application development. 3. Provide foundations for developing, analyzing, and implementing parallel algorithms using parallelization paradigms. 4. Introduce the fundamental parallel algorithms through the GPU.	
Content:		**No. of hours**
Unit - 1	**Modern Processors:** Stored Program Computer Architecture General purpose cache- based microprocessor-Performance based metrics and benchmarks- Moore's Law- Pipelining Superscalarity SIMD- Memory Hierarchies Cache- mapping- prefetch- Multicore processors. Multithreaded processors- Vector Processors- Design Principles- Maximum performance estimates- Programming for vector architecture.	**15**
Unit - 2	**Basic optimization techniques for serial code** : scalar profiling function and line based runtime profiling- hardware performance counters- common sense optimizations- simple measures, large impact- elimination of common subexpressions- avoiding branches using simd instruction sets- the role of compilers - general optimization options- inlining - aliasing- computational accuracy register optimizations- using compiler logs- c++ optimizations - temporaries dynamic memory management- loop kernels and iterators data access optimization: balance analysis and light speed estimates- storage order- case study: Jacobi algorithm and dense matrix transpose.	**15**
Unit – 3	**Motivating Parallelism, Scope of Parallel Computing, Parallel Programming Platforms**: Implicit Parallelism, Trends in Microprocessor and Architectures, Limitations of Memory, System Performance, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines **Principles of Parallel Algorithm Design:** Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models.	**15**

Unit – 4	The Age of Parallel Processing, the Rise of GPU Computing, A Brief History of GPUs, Early GPU. **GPU architectures and concepts:** CPU-GPU system, The GPU and thread engine, characteristics of GPU memory spaces. **GPU programming model:** GPU programming abstractions, code structure for GPU programming model, Optimizing GPU resource usage. **Directive based GPU programming**: GPU implementation process, Open ACC, OpenMP.	**15**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books:** 1. Hager, Georg., Wellein, Gerhard: Introduction to High Performance Computing for Scientists and Engineers. Ukraine: CRC Press, 2010. 2. Robey, Robert., Zamora, Yuliana: Parallel and High Performance Computing. United Kingdom: Manning, 2021. 3. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar: Introduction to Parallel Computing, 2nd edition, Addison-Wesley, 2003, ISBN: 0-201-64865-2 **Reference Books:** 1. Levesque, John., Wagenbreth, Gene: High Performance Computing: Programming and Applications. United Kingdom: CRC Press, 2010. 2. Robert D. Kent, Todd W. Sands: High Performance Computing Systems and Applications. Switzerland: Springer US, 2012. 3. Hwang, Kai: Advanced Computer Architecture: Parallelism, Scalability, Programmability. Singapore: McGraw-Hill, 2000. 4. Sterling, Thomas., Brodowicz, Maciej., Anderson, Matthew: High Performance Computing: Modern Systems and Practices. Germany: Elsevier Science, 2017. 5. Sanders, Jason., Kandrot, Edward: CUDA by Example: An Introduction to General-Purpose GPU Programming. United Kingdom: Pearson Education, 2010.	
Course Outcomes:	After taking this course, student will be able to: CO1. Explain High Performance Computing (HPC) system architectures and various computational models. CO2. Apply parallel execution models and methodologies for parallel programming and parallel applications development. CO3. Explain different parallel computing paradigms, parallel architectures and parallel programming models CO4. Demonstrate programming using CUDA.	

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Research Specific Elective (RSE) Courses

Name of the Programme : Master of Engineering (Artificial Intelligence and Data Science)
Course code : REC-561
Title of the course : Engineering Research & Publication
Number of credits : 4(3L+1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of research requirements in real life	
Course Objectives:	The course will enable the students to 1. Understand the importance of literature review, defining the research objectives. 2. Explain qualitative and quantitative methods of data analyses and its importance. 3. Classify research publications, select appropriate journals based on research areas. 4. Practice ethics in publication and academic integrity	
Content:		**No of Hours**
Unit -1	**Overview of scientific research in engineering**, foundational and fundamental concepts like types of research and considerations for research in specific domains, motivation to do research, critical thinking, assumptions and hypotheses, basic and applied research, importance of formulation of broad research objectives	**11 + 4T**
Unit -2	**Purpose and Methodology of Literature Search and Review** of the scientific and engineering publications. Sources such as scholarly databases, public domain, open access, current literature, review articles, critical review and gap analysis, defining research objectives	**11 + 4T**
Unit -3	**Quantitative and qualitative Data –** importance of data in research, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	**12 + 4T**
Unit- 4	**Preparation of Publications-** Elements of research publications, types of publications, writing for journal publications, basic requirements for publication, selection of journals, journal quality indicators, peer review, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity	**11 + 3T**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning , Constructive learning and Collaborative learning	
References/ Readings:	1. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486. 2. Michael Jay Katz, 'From Research to Manuscript', Springer Publication,	

	2009, ISBN:9781402094668. 3. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work', Springer Publications, 2022, ISBN:9783030900243 4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.
Course Outcomes:	CO 1. Understand the importance of literature review, defining the research objectives. CO 2. Explain qualitative and quantitative methods of data analyses and its importance. CO 3. Classify research publications, select appropriate journals based on research areas. CO 4. Practice ethics in publication and academic integrity

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Name of the Programme : Master of Engineering (Artificial Intelligence and Data Science)
Course code : REC-562
Title of the course : Literature Review & Technical Writing for Engineers
Number of credits : 4(3L + 1T)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basics of Technical writing skills.	
Course Objectives:	The course will enable the students to 1. Understand the importance of literature review and writing a review paper. 2. Explain the method to be followed to write a review paper. 3. Classify data for qualitative and quantitative analysis 4. Demonstrate technical writing for conference.	
Content:		**No of Hours**
Unit -1	**Overview on Literature Review**, difference between objectives of literature review and research objectives; types of literature review, qualitative and quantitative reviews, search strategies, primary and secondary sources, database search strategies, field search, root search, complimentary search, meta-analysis	**12 + 4T**
Unit -2	**Database management of literature reviews**, bibliometric analysis, importance of writing a review paper, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity; public domain, open access, current literature.	**11 + 4T**
Unit -3	**Technical writing on a specific research topic**, structure of the paper, abstract, introduction, experimental, simulation, analysis, discussion, inferences, title, acknowledgment, referencing, presentation of tables, figures, graphs, equations; comparison between technical writing for conference papers and journal paper	**11 + 4T**
Unit- 4	**Importance of data in research**, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	**11 + 3T**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work – Multidisciplinary Guide to Systematic Approaches', Springer Publications, 2022, ISBN:9783030900243. 2. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668. 3. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486. 4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for	

	Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of literature review and writing a review paper. CO 2. Explain the method to be followed to write a review paper. CO 3. Classify data for qualitative and quantitative analysis CO 4. Demonstrate technical writing for conference.

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Semester II
Programme Specific Core (PSC) Courses
Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-504
Title of the Course : Mathematical Foundations for AI and Data Science – II
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of elementary probability theory and basic theory of random variables.	
Course Objectives:	The course will enable the students to: 1. Acquaint themselves with the foundational concepts of Probability and Statistics for Artificial Intelligence and Data Science. 2. Equip themselves with the analytical tools required to apply these concepts to applications arising in Artificial Intelligence and Data Science. 3. Familiarize themselves with various notions of convergence of random variables, limit theorems and their applications. 4. Gain exposure to various Bayesian inference models and prediction functions.	
Content:		**No. of hours**
Unit - 1	**Discrete Random Variables**: Review of Discrete Random Variables and Some Special Distributions (Bernoulli, Binomial, and Poisson distributions), Joint Distribution Functions of Multiple Discrete Random Variables, Marginal Distributions, Independence, Probability Generating Function, Moment Generating Function, Functions of Multiple Random Variables, Conditioning, Baye's Rule, Covariance and Correlation.	**10**
Unit - 2	**Continuous Random Variables:** Review of Continuous Random Variables and Some Special Distributions(Exponential, Uniform, and Gaussian distributions), Joint Distribution Functions of Multiple Continuous Random Variables, Marginal Distributions, Independence, Multivariate Gaussian Distribution, Probability Generating Function, Moment Generating Function, Conditioning, the Continuous Bayes' Rule, Derived Distributions, Covariance and Correlation, Sum of Independent Random Variables, Exponential family.	**11**
Unit - 3	**Limit Theorems, Convergence and Inequalities:** Markov and Chebyshev Inequalities, Chernoff Bounds, Cauchy Schwarz inequality, Jensen's Inequality, The Weak Law of Large Numbers, The Strong Law of Large Numbers, The Central Limit Theorem, Convergence in distribution, Convergence in probability, Convergence in mean and almost sure convergence, applications.	**10**
Unit - 4	**Bayesian Statistics-Bayesian Inference:** Bayesian Parametric Models, The Prior Distribution, The Likelihood, The Posterior Distribution, The Conjugate Prior, Bayesian Estimators - Minimum	**14**

	Mean-Square-Error Estimation, Maximum-a-Posteriori Estimation, Minimizing the Probability Error, Comparison between the Bayesian Estimators, Bayesian Linear Regression.	
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Carlos Fernandez-Granda, "Lecture Notes : Probability and Statistics for Data Science", Center for Data Science in NYU, 2017. 2. Dimitri Bertsekas, John N. Tsitsiklis, "Introduction to Probability", Second Edition, Athena Scientific, 2008. 3. Larry Wasserman, "All of Statistics : A Concise Course in Statistical Inference", First Edition, Springer New-York, 2010. 4. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", First Edition, Cambridge University Press, 2020. **Reference Books** 1. Hossein Pishro-Nik, "Introduction to Probability, Statistics and Random Processes", First Edition, Kappa Research LLC, Massachusetts, USA, 2014. 2. Jay Dawani," Hands-On Mathematics for Deep learning", First Edition, Packt Publishing Ltd., 2020. 3. Marc Deisenroth, Stefanos Zafeiriou, Lecture Notes : "Mathematics for Inference and Machine Learning", Imperial College London, Department of Computing, 2017. 4. Marco Taboga, "Lectures on Probability Theory and Mathematical Statistics", Third Edition, CreateSpace Independent Publishing Platform, 2017. 5. Trevor Hastie, Robert Tibshirani ,Jerome Friedman, "The Elements of Statistical Learning: Data Mining", Inference, and Prediction, Second Edition, Springer, 2013.	
Course Outcomes:	After taking this course, student will be able to: CO 1. Demonstrate a sound understanding of a range of statistical tools and their role and importance in artificial intelligence and data science. CO 2. Apply important concepts of probability and statistics to applications arising in artificial intelligence and data science. CO 3. Apply various notions of convergence of random variables and limit theorems to various situations arising in artificial intelligence and data science. CO 4. Build inference models and prediction functions.	

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Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-505
Title of the Course : Mathematical Foundations for AI & DATA SCIENCE -II LAB
Number of Credits : 1 (1P)
Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of Python programming	
Course Objectives:	The course will enable the students to: 1. Acquaint themselves with the usage of Python Libraries such as Numpy, SymPy, Matplotlib, Pandas, SciPy, Scikit Learn and their functionalities, along with Basics of Python. 2. Understand how to create data visualizations using python modules. 3. Gain exposure to different computational tools through python programming, for analysis of data. 4. Develop proficiency in the use of python libraries and its various functionalities to implement Baye's rule, central limit theorem, law of large numbers, maximum a posteriori estimation and Bayesian regression.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Program to generate Binomial random variables and visualize the probability mass function. 2. Program to generate Poisson random variables and visualize the probability mass function. 3. Program to generate and plot the Gaussian distribution. 4. Program to implement conditional probability distribution. 5. Program to implement marginal probability distribution. 6. Program to verify statistical independence of random variables. 7. Program to compute the upper bounds of the Markov inequality. 8. Program to compute the upper bounds of Chebyshev's inequality. 9. Program to compute the upper bounds of Chernoff's inequality. 10. Program to verify central limit theorem. 11. Program to illustrate the weak law of large numbers. 12. Program to compute a conjugate prior given a distribution. 13. Program to estimate the posterior distribution given the prior and the data. 14. Program to implement maximum - a-posteriori estimation. 15. Program to implement Minimum Mean-Square-Error Estimation. Minimum 10 experiments to be performed from above list.	**30**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. Dr. R. Nageswara Rao; Core Python Programming, Third edition,	

	Dreamtech Press, 2018. 2. Nathan George, Practical Data Science with Python: Learn tools and techniques from hands-on examples to extract insights from data, First Edition, Packt Publishing Ltd, 2021. 3. Samir Madhavan, Mastering Python for Data Science, First Edition, Packt Publishing Ltd., 2015. 4. Taneja Sheetal & Kumar Naveen, Python Programming a 5. Modular Approach, First edition, Pearson Education, 2017. **Reference Books** 1. Kenneth. A. Lambert, Fundamentals of Python: First Programs, Second Edition, Course Technology Cengage Learning, 2019. 2. Vamsi Kurama, Python Programming: A Modern Approach, First Edition, Pearson India, 2017. 3. Y. Daniel Liang, Introduction to Programming Using Python, First Edition, Pearson Education, 2017.
Course Outcomes:	After taking this course, student will be able to: CO 1. Demonstrate proficiency in applying relevant Python's tools and techniques for data analytics. CO 2. Implement Baye's rule, central limit theorem, law of large numbers, maximum a posteriori estimation and Bayesian regression using Python. CO 3. Create data visualizations using Python modules. CO 4. Write complex Python programs to solve artificial intelligence and data science problems

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-506**
Title of the Course : **Applied Machine Learning**
Number of Credits : **3 (3L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence.	
Course Objectives:	The course will enable the students to: 1. Understand the basic concepts of Machine learning. 2. Learn about Mc-Culloch Pitts neuron model, logic functions, linear and non-linear separability concept and different training rules. 3. Learn various supervised learning algorithms. 4. Understand data clustering, transformation and dimensionality reduction techniques.	
Content:		**No. of hours**
Unit - 1	**Introduction:** Towards Intelligent Machines, Well-Posed Machine Learning Problems, Examples of Applications in Diverse Fields, Data Representation, Domain Knowledge for Productive use of Machine Learning, Diversity of Data: Structured/Unstructured, Forms of Learning. **Supervised Learning:** Learning from Observations, Bias and Variance, Computational Learning Theory, Occam's Razor Principle and Overfitting Avoidance, Heuristic Search in Inductive Learning, Estimating Generalization Errors, Metrics for Assessing Regression accuracy, Metrics for Assessing Classification accuracy, An Overview of the Design Cycle and Issues in Machine Learning.	**11**
Unit - 2	**Statistical Learning**: Naive Bayes Classifier, k-Nearest Neighbor (k-NN) Classifier, Linear and Logistic regression. **Decision Tree Learning**: Introduction, Example of a Classification Decision Tree, Measures of Impurity for Evaluating Splits in Decision Trees, ID3 and C4.5 Decision Trees, Pruning the Tree, Strengths and Weaknesses of Decision-Tree Approach, Random Forest algorithm.	**11**
Unit - 3	**Data Clustering and Data Transformations**: Clustering, Engineering the Data, Different Clustering Methods such as Partitional Clustering, Hierarchical Clustering, Clustering using Self-Organizing Maps, Fuzzy K-Means Clustering, Expectation-Maximization (EM) Algorithm, Data transformation techniques. **Reinforcement Learning**: Principle of working. Characteristics, types and elements of reinforcement learning	**12**
Unit - 4	**Artificial Neural Networks**: Introduction to neural networks, structure of biological neuron, Mc-Culloch Pitts neuron model, Logic network realization by using Mc-Culloch Pitts neuron model, Neuron modelling for artificial neuron systems.	**11**

	Single layer network: Concept of linear separability and non-linear separability. **Training rules**: Hebbian learning rule, perceptron learning rule, Delta learning rule and related problems.	
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, "Elements of Artificial Neural Network", Penram Publications, 2nd Edition, 1995. 2. M. Gopal, "Applied Machine Learning|2nd Edition", Mc Graw Hill Publication, 2nd Edition, 2021. 3. Siddhanta Bhatta, "Applied Machine Learning Solutions with Python", BPB Publication, 2nd Edition, 2021. 4. Tom M Mitchell, Machine Learning, Indian edition, McGraw Hill Publication, 1997. **Reference Books** 1. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Prentice Hall of India, 4th Edition, 2020. 2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications. 3. Satish Kumar, "Neural Networks A Classroom Approach", VISIONIAS Publication, 2nd Edition, 2020.	
Course Outcomes:	**After taking this course, student will be able to:** CO 1. Explain concepts of Machine learning. CO 2. Demonstrate usage of logic functions, linear and non-linear separability concept and different training rules. CO 3. Apply data clustering, transformation and dimensionality reduction techniques for various applications. CO 4. Develop solutions to real world applications using supervised learning algorithms.	

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Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-507
Title of the Course : Applied Machine Learning Lab
Number of Credits : 1 (1P)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of python programming.	
Course Objectives:	The course will enable the students to: 1. Understand the concepts of Machine learning and learn about Python libraries. 2. Demonstrate the knowledge of various supervised learning algorithms. 3. Implement Python programs for data clustering, transformation and dimensionality reduction techniques. 4. Illustrate knowledge of logic functions, linear and non-linear separability concept and different training rules.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Study experiment on Machine learning. 2. Study of various Python machine learning libraries. 3. Implementation of KNN classifier. 4. Implementation of Naive Bayes Classifier. 5. Implementation of Decision tree classifier ID3. 6. Implementation of Decision tree classifier C4.5. 7. Implementation of Random Forest algorithm for application 1. 8. Implementation of Hierarchical clustering algorithm 1. 9. Implementation of Hierarchical clustering algorithm 2. 10. Implementation of clustering using SOM for application 1 11. Implementation of K-Means clustering for application 1 12. Implementation of Neural network-based Logic functions I. 13. Implementation of Neural network perceptron learning rule. 14. Implementation of Hebbian learning rule. 15. Mini project. **Minimum 10 experiments to be performed from above list.**	**30**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, “Elements of Artificial Neural Network”, Penram Publications, 2nd Edition, 1995. 2. M. Gopal, “Applied Machine Learning|2nd Edition”, Mc Graw Hill Publication, 2nd Edition, 2021. 3. Siddhanta Bhatta, “Applied Machine Learning Solutions with Python”, BPB Publication, 2nd Edition, 2021. 4. Tom M Mitchell, Machine Learning, Indian edition, McGraw Hill Publication, 1997. **Reference Books** 1. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press,	

	Prentice Hall of India, 4th Edition, 2020. 2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications. 3. Satish Kumar, "Neural Networks A Classroom Approach", VISIONIAS Publication, 2nd Edition, 2020.
Course Outcomes:	After taking this course, student will be able to: CO 1. Demonstrate the knowledge of Machine learning and Python libraries. CO 2. Implement solutions to real world applications using supervised learning algorithms. CO 3. Demonstrate usage of data clustering, transformation and dimensionality reduction techniques for various applications CO 4. Implement logic functions, linear and non-linear separability concept and different neural network training rules.

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Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-508
Title of the Course : Data Mining and Applications
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Database management systems	
Course Objectives:	The course will enable the students to: 1. Analyze data in terms of mining tasks, kinds of knowledge to be mined, kinds of technologies used and kinds of applications targeted. 2. Implement various preprocessing techniques on data. 3. Implement algorithms for classification and regression applications. 4. Implement algorithms for clustering, anomaly detection and pattern matching applications.	
Content:		**No. of hours**
Unit - 1	**Introduction:** Definition, types of data that can be mined, kinds of patterns that can be mined and technologies used, issues in data mining. **Getting to know your data:** Data Objects and Attribute types, basic statistical descriptions of data, data visualization, measuring data similarity and dissimilarity. **Data Preprocessing**: Overview, data cleaning, data integration, data reduction, data transformation and data discretization.	**11**
Unit - 2	**Data Warehousing and Online Analytical Processing:** Basic Concepts, data warehouse modelling: data cube and OLAP, data warehouse design and usage, Data warehouse implementation. **Classification:** Basic Concepts, Decision Tree Induction, Bayes Classification methods, Rule based Classification, Lazy Learners, Model evaluation and selection, Techniques for improving classification accuracy.	**12**
Unit - 3	**Cluster Analysis:** basic concepts and methods, cluster analysis, partitioning methods, hierarchical methods, density-based methods, grid- based methods, evaluation of clustering. **Mining Frequent Patterns, Associations and Correlations:** Basic concepts and methods, frequent itemset mining methods, pattern evaluation methods.	**11**
Unit - 4	**Outlier Detection:** Outliers and Outlier analysis, Outlier detection methods, Statistical approaches, proximity-based approaches, clustering-based approaches, classification-based approaches. **Data Mining Applications:** Data Mining for Financial data analysis, Data mining for retail and telecommunication industries, Data mining in science and engineering, Data mining for intrusion detection and prevention, Data mining and recommender systems.	**11**

Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning
References/ Readings:	**Text Books** 1. Jiawen Han, Micheline Kamber, Jian Pei, "Data Mining: Concepts and Techniques", 4th Edition, Elsevier Science, 2022. 2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, "Introduction to Data Mining", Second edition, Pearson, 2021. **Reference Books** 1. K.P. Soman, Shyam Diwakar, V. Ajay, "Insight into data mining theory and practice", First Edition, PHI, 2006. 2. Aurelien Geron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow", Second Edition, O'Reily Media, 2017. 3. Arun K Pujari, "Data Mining Techniques", Fourth Edition, Universities Press, 2016. 4. Charu C Aggarwal, "Data Mining: The Textbook", Springer, 2015. 5. Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, "Data Mining Practical Machine Learning Tools and Techniques", Morgan Kaufmann, 2017.
Course Outcomes:	After taking this course, student will be able to: CO 1. Evaluate data in terms of types and quality and investigate data preprocessing activities. CO 2. Apply the concept of measures of similarity and dissimilarity of data attributes. Explore data in terms of summary statistics and data visualization, store and analyze data in a multidimensional array. CO 3. Implement classification algorithms for solving problems in data mining. CO 4. Apply algorithms for efficient pattern mining and solve clustering problems in data mining and anomaly detection.

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-509**
Title of the Course : **Data Mining and Applications Lab**
Number of Credits : **1 (1P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic programming knowledge.	
Course Objectives:	The course will enable the students to: 1. Perform preprocessing techniques on raw data. 2. Implement various data mining algorithms on varied datasets. 3. Apply various post processing techniques for visualization of data mining results. 4. Validate the results of data mining tasks.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Implementation of techniques for Data Pre-processing and cleaning. 2. Implementation of techniques of Data Reduction. 3. Implementation of Data Transformation. 4. Implementation of Apriori Association rule mining algorithm. 5. Implementation of FP Growth Association rule mining algorithm. 6. Implementation of Decision Tree using ID3. 7. Implementation of Decision Tree using C4.5. 8. Implementation of Bayesian Classifier. 9. Perform k-NN on a real-world dataset (like Iris or MNIST) and analyze the effect of different values of k. 10. Implementation of Linear Regression for prediction. 11. Implementation of algorithms for Cluster Analysis. 12. Implementation of t-Distributed Stochastic Neighbor Embedding (t-SNE) for data visualization. 13. Implementation of algorithms for Outlier detection. 14. Implementation of applications for text mining. 15. Implementation of application for web classification. **Minimum 10 experiments to be performed from above list.**	**30**
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. Jiawen Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques Fourth Edition, Elsevier Science, 2022. 2. Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, Data Mining Practical Machine Learning Tools and Techniques, Morgan Kaufmann, 2016. **Reference Books** 1. K.P. Soman, Shyam Diwakar, V. Ajay, “Insight into data mining theory and practice”, First Edition, PHI, 2006.	

	2. Aurelien Geron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow”, Second Edition, O’Reily Media, 2017. 3. Arun K Pujari, “Data Mining Techniques”, Fourth Edition, Universities Press, 2016. 4. Charu C Aggarwal, “Data Mining: The Textbook”, Springer, 2015. 5. Jesus Salcedo, “Machine Learning for Data Mining: Improve your data mining capabilities with advanced predictive modelling”, Packt, 2019.
Course Outcomes:	After taking this course, student will be able to: CO 1. Demonstrate appropriate data preprocessing for a given mining task. CO 2. Apply algorithms for mining useful information from data. CO 3. Perform evaluation of mining algorithms and model selection. CO 4. Draw meaningful insights from data.

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Programme Specific Elective (PSE) Courses
Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : EAD-534
Title of the Course : Web Analytics
Number of Credits : 3 (3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of data science.	
Course Objectives:	The course will enable the students to: 1. Gain knowledge on the fundamental Web analytics. 2. Gain of the Features, Benefits, and Limitations and the data stream used 3. Comprehend Web analytics in Customizations and Real-World Tasks. 4. Understand the principles of metrics of web and related Web analytics versions in existence.	
Content:		**No. of hours**
Unit - 1	**Introduction: Measuring success** : Website Measurement, Web Analytics Information, Decisions Web Analytics, TROI of Web Analytics, Web Analytics and Web Traffic, Google Analytics Different **Available Methodologies and their Accuracy**: Page Tags and Log files, Cookies in Web Analytics, Data Accuracy, Visitor Data Accuracy for Logfiles, Visitor Data from Page Tags, Visitor Data When Using Cookies, Data from Different Vendors	**11**
Unit - 2	**Google Analytics Features, Benefits, and Limitations:** Key Features and Capabilities, Standard Features, Advanced Features, Google Analytics Works, Google Analytics Tracking Code What is Not Tracked by Default, Default Attribution Model, Google Analytics Limits. **Google Analytics Reports and Interface:** Discoverability and Initial Report Access, Report Layout, Metrics, Data Table, Date Range Selector. Real time reporting, Flow visualization, Top standard reports, creating google analytic account, Tracking ecommerce transaction, Tracking events.	**11**
Unit - 3	**Google Analytics Customizations:** Why Customize an Existing Product?, Custom Reports, Day-on-Day Custom Report, Unique Visitors by Page, Affiliate Performance, Managing Custom Reports. **Focusing on Key Performance Indicators**: Setting Objectives and Key Results, Selecting and Preparing KPIs, What is a KPI?, Preparing KPIs, Presenting Your KPIs, Presenting Hierarchical KPIs via Segmentation.	**12**
Unit - 4	**Web Analytics 2.0:** State of the Analytics Union, State of the Industry, Web Analytics 2.0, Web Analytics 2.0, Multiple Outcomes Analysis, Competitive Intelligence, Strategic Imperative.	**11**

	Web Metrics: Common metrics: Visits and Visitors, Time on Page and Time on Site, Bounce Rate, and Conversion Rate.	
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. Brian Clifton.: Advanced Web Metrics with Google Analytics, 3rd Edition, Wiley Publishing, 2012. 2. Avinash Kaushik.: Web Analytics 2.0: The Art of Online Accountability and Science of Customer Centricity, 2009. 3. Grigor Yovov.: Google Analytics Kickstarter Guide, 2020 **Reference Books** 1. Sterne J., Web Metrics: Proven methods for measuring web site success, John Wiley and Sons, 2002. 2. Jerri L. Ledford, Joe Teixeira, Mary E. Tyler.: Google Analytics, John Wiley and Sons, 2011. 3. Anand Rajaraman, Jure Leskovec, and Jeffrey D. Ullman.: Mining of Massive Datasets, 2nd edition, Cambridge University Press, 2014. 4. Michael Beasley.: Practical Web Analytics for User Experience, Newnes, 2013. 5. Avinash Kaushik .: Web Analytics: An hour a day, 2007.	
Course Outcomes:	After going through this course, the students will be able to: CO 1. Explain the fundamentals and concepts of Web analytics. CO 2. Illustrate the Benefits of Google Analytics Reports and Interface. CO 3. Illustrate Web analytics in Customizations and Real-World Tasks. CO 4. Analyze Website traffic and web metrics in Web analytics.	

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-535**
Title of the Course : **Web Analytics Lab**
Number of Credits : **1 (1P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of python programming and web development tools.	
Course Objectives:	This course will enable students to: 1. Understand and use web analytics tools, their features, interfaces, and metrics. 2. Configure, collect, analyze and interpret web analytics data including traffic trends and set up demo sites and implement tracking codes. 3. Assess website usability and analyze user behavior using tools like Hotjar and survey responses. 4. Use competitive analysis platforms like SEMrush and understand the evolution of analytics tools, focusing on advanced metrics.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Explore features, functionalities and compare Google Analytics and Adobe Analytics tools 2. Analyze reports from web analytics platforms, and classify metrics into offsite and onsite categories 3. Demonstrate, configuring tracking for different traffic sources. 4. Extract and analyse historical data from Google Analytics. 5. Import sample data sets and implement characterization of content 6. Demonstrate the simulation and analyzation of logs from website 7. Set up Google Tag Manager and analyse the collected data in Google Analytics. 8. Demonstrate beacon in a webpage and monitor its interactions using Chrome DevTools. 9. Analyse eCommerce, brand advocacy data, interpreting data patterns using Google Analytics 10. Evaluation website usability using checklists and heatmaps (Hotjar). 11. Analyze user paths, clicks, and interactions using Hotjar 12. Use survey tools to create and deploy post-visit surveys. 13. Analyze web traffic and server logs, for data accuracy and completeness. 14. Demonstrate the use of metrics like bounce rate, page views, in Google Analytics. 15. A case study to illustrate the transition from Google Analytics 1.0 to 2.0. Minimum 10 experiments to be performed from above list.	**30**

Pedagogy:	Constructive, Collaborative and Inquiry Based Learning
References/ Readings:	**Text Books** 1. Weber J., Broadley C., Practical Google Analytics and Google Tag Manager for Developers, APress Publishing, 1st Edition, 2015 2. Karlins D., Matisoff E.: Adobe Analytics For Dummies, Wiley Publishing, 1st Edition, 2019 3. Kaushik A.: Web Analytics 2.0, The Art of Online Accountability and Science of Customer Centricity, Wiley Publishing, Inc. 1st Edition, 2010 **Reference Books** 1. Sponder M., Khan G: Digital Analytics for Marketing, Routledge Publishing, Inc. 1st Edition, 2017 2. Haridass T., Learning Google BigQuery: A beginner's guide to mining massive datasets through interactive analysis , Packt Publishing, Inc. 1st Edition, 2017 3. Mark Edmondson.: Learning Google Analytics: Creating Business Impact and Driving Insights, 2022
Course Outcomes:	This course will enable students to: CO 1. Demonstrate and Identify Different Data Collection and Web Analytics Strategies CO 2. Analyze and process the web analytics data with demonstration CO 3. Apply Different Web Analytics Tools like Hotjar CO 4. Analyze Various Google Analytics platforms and testing

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-536**
Title of the Course : **Pattern Recognition for AI & Data Science**
Number of Credits : **3 (3L)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence and Applied mathematics.	
Course Objectives:	The course will enable the students to: 1. Utilize various data structures and similarity measures for pattern representation and clustering. 2. Apply Bayesian decision theory for accurate classification using discriminant functions and decision surfaces. 3. Analyze nearest neighbor classifiers using data reduction and prototype selection techniques. 4. Evaluate decision trees and SVMs through model selection, feature choice, and kernel functions for handling complex data.	
Content:		**No. of hours**
Unit - 1	**Introduction**- Introduction to Pattern Recognition, Different paradigms for Pattern Recognition. **Representation- Data Structures for Pattern Representation**: Patterns as Vectors, Patterns as Strings, Logical Descriptions, Patterns as Trees and Graphs. Representation of Clusters. Proximity Measures: Distance Measure, Weighted Distance measure, Non-Metric Similarity function, Edit Distance, **Size of Patterns**: Normalization of Data, Use of appropriate similarity measures. Feature Extraction: Fisher's Linear Discriminant, Principal Component Analysis. Feature Selection: Exhaustive Search, Branch and Bound Search, Max-Min approach to feature selection.	**15**
Unit - 2	**Bayesian Decision Theory**- continuous features: two category classification, Minimum error rate classification: minimax criterion, neyman-pearson criterion, discriminant functions, **Decision surfaces**: the multicategory case, two category case, The normal density: Univariate density, multivariate density, discriminant functions for the Normal density: case 1,2,3,	**10**
Unit - 3	**Nearest Neighbour Based Classifiers**- Nearest Neighbour Algorithm. Variants of Nearest Neighbour Algorithm: k-Nearest Neighbour (kNN)algorithm, Modified k-Nearest neighbour (MkNN) algorithm, **Efficient Algorithms**: The Branch & Bound algorithm, The Cube algorithm, Searching for Nearest Neighbour by Projection, Ordered Partitions.	**10**

Unit - 4	**Decision trees**: Classification and Regression Trees (CART), Number of splits, query election and node impurity, when to stop splitting, pruning, assignment of leaf node labels, multivariate decision trees, ID3, C4.5 **Support Vector Machines**- Introduction: Linear Discriminant Functions. Learning the Linear Discriminant Function: Learning the weight vector, Multi-class problems	**10**
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	**Text Books** 1. M. Narasimha Murty, Dr. V SusheelaDevi," Pattern Recognition An Algorithmic Approach", Springer - ISBN 978-0-85729-494-4 ,2011. 2. R.O.Duda, P.E.Hart, D.G.Stork,"Pattern Classification", John Wiley, 2001. 3. Sá, J. P. Marques de," Pattern Recognition: Concepts, Methods, and Applications", Germany, Springer, 2001. **Reference Books** 1. Christopher M. Bishop,"Pattern Recognition and Machine Learning", Springer -ISBN-10: 0- 387-31073-8,2006. 2. Sankar K. Pal, Amita Pal,"Pattern recognition From Classical to Modern Approaches", World Scientific Publishing Company - ISBN 981-02-4684-6, 2002. 3. Sing-Tze Bow, Marcel Dekker,"Pattern Recognition and Image Preprocessing", 2nd Edition - 2002. 4. Theodoridis, Sergios., Koutroumbas, Konstantinos," Pattern Recognition". Netherlands: Elsevier Science, 2003. 5. Fu, King-Sun,"Applications of Pattern Recognition", United States: CRC Press, 2019. 6. Trevor Hastie, Robert Tibshirani, Jerome Friedman," The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, 2009. 7. Nello Cristianini, John Shawe-Taylor," An Introduction to Support Vector Machines and Other Kernel-based Learning Methods", Cambridge University Press, 2000. 8. Kevin P. Murphy," Machine Learning: A Probabilistic Perspective", MIT Press, 2012.	
Course Outcomes:	After taking this course, student will be able to: CO 1. Utilize various data structures and similarity measures for pattern representation and clustering. CO 2. Apply Bayesian decision theory for accurate classification using discriminant functions and decision surfaces. CO 3. Analyze nearest neighbor classifiers using data reduction and prototype selection techniques. CO 4. Evaluate decision trees and SVMs through model selection, feature choice, and kernel functions for handling complex data.	

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **EAD-537**
Title of the Course : **Pattern Recognition for AI & Data Science Lab**
Number of Credits : **1 (1P)**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of python programming.	
Course Objectives:	The course will enable the students to: 1. Understand the fundamental concepts of pattern recognition, used for representation and clustering of patterns. 2. Apply pattern recognition techniques, such as Bayesian decision theory and nearest neighbor classifiers, to solve practical classification and clustering problems in real-world scenarios. 3. Evaluate the performance of classifiers like decision trees and support vector machines through cross-validation and statistical measures to determine their effectiveness. 4. Design and implement integrated pattern recognition systems that combine multiple techniques to effectively address complex data challenges and improve classification outcomes.	
Content:	**List of Programs /Experiments**	**No. of hours**
	1. Development of Pattern Recognition Using Data Structures and Similarity Measures: Investigate data structures (vectors, strings, trees, and graphs) and similarity measures for effective pattern representation and clustering. 2. Data Preprocessing and Feature Extraction for Enhanced Classification Accuracy: Apply Principal Component Analysis (PCA) and Fisher's Linear Discriminant to preprocess data and enhance classification accuracy. 3. Feature Selection Methods and Evaluation of Classifiers: Implement exhaustive search and sequential selection methods to evaluate the performance of classifiers on benchmark datasets. 4. Bayesian Decision Theory and Classification: Apply Bayesian decision theory for classification tasks, analyzing decision surfaces and discriminant functions with continuous features. 5. Application of Bayesian Networks for Classification: Implement a Bayesian network for a multi-class classification problem, demonstrating how conditional dependencies between features can be utilized to make predictions. 6. Nearest Neighbour Classifiers Implementation: Implement the k-Nearest Neighbour (kNN) algorithm and analyze its application in real-world classification tasks. 7. Comparison of Nearest Neighbour Classifiers with Different	**30**

	Distance Metrics: Analyze the performance of k-Nearest Neighbour (kNN) and m-Nearest Neighbour (m-kNN) classifiers using Euclidean, Manhattan, and Cosine similarity distance metrics. 8. Decision Trees Construction and Evaluation: Construct decision trees using the ID3 and C4.5 algorithms, evaluate their performance, and implement pruning techniques to enhance accuracy. 9. Hyperparameter Tuning of Decision Trees and Support Vector Machines: Implement hyperparameter tuning for decision trees using Classification and Regression Trees (CART) and support vector machines, assessing the impact of parameters on model performance. 10. Support Vector Machines for Classification: Implement SVMs with linear and non-linear kernels, and evaluate their performance on datasets while adjusting hyperparameters for optimal results. 11. Evaluation of Classifiers Using Cross-Validation Techniques: Apply k-fold cross-validation techniques to assess the performance of classifiers on benchmark datasets. 12. Data Reduction Techniques in Pattern Recognition: Implement PCA and Random Sampling data reduction techniques to simplify datasets while preserving essential information. 13. Advanced Decision Tree Techniques: Evaluate the performance of Random Forest and Gradient Boosting Machines across different classification tasks. 14. Ensemble Methods for Improving Classification Performance: Implement bagging and boosting ensemble methods to evaluate their impact on classifier performance through comparative analysis. 15. Analysis of Temporal Patterns in Time Series Data: Implement ARIMA (AutoRegressive Integrated Moving Average) and seasonal decomposition techniques to recognize patterns in time series data and extract meaningful trends, seasonal effects, and residuals for deeper analysis. Minimum 10 experiments to be performed from above list.	
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	**Text Books** 1. M. Narasimha Murty, Dr. V Susheela Devi," Pattern Recognition An Algorithmic Approach", Springer - ISBN 978-0-85729-494-4, 2011. 2. Richard O. Duda, Peter E. Hart, David G. Stork," Pattern Classification", Wiley-Interscience, 2nd Edition, 2001. 3. Ian H. Witten, Eibe Frank, Mark A. Hall,"Data Mining: Practical Machine Learning Tools and Techniques", Morgan Kaufmann, 4th Edition, 2016. **Reference Books**	

	1. J. D. Gibbons," Nonparametric Statistical Inference", Marcel Dekker, 2nd Edition, 1985. 2. Trevor Hastie, Robert Tibshirani, Jerome Friedman," The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, 2nd Edition, 2009. 3. Christopher M. Bishop," Pattern Recognition and Machine Learning", Springer, 1st Edition, 2006.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand fundamental concepts of pattern recognition, for pattern representation and clustering. CO 2. Apply techniques like Bayesian decision theory and nearest neighbor classifiers to tackle classification and clustering challenges. CO 3. Evaluate classifiers such as decision trees and support vector machines using cross-validation and statistical measures to assess their effectiveness. CO 4. Design and implement pattern recognition systems that integrate multiple techniques to effectively tackle complex data challenges and improve classification results.

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Research Specific Elective (RSE) Courses

Name of the Programme : Master Of Engineering (Artificial Intelligence and Data Science)
Course Code : REC-563
Title of the Course : Statistics and Data Analysis for Engineering Research
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic Knowledge of Statistics	
Course Objectives:	The course will enable the students to 1. Explain the different types of data and parameter estimations 2. Explain standard probability distributions 3. Select the appropriate parameter estimation & distribution method 4. Co-relate different Hypotheses	
Content:		**No of Hours**
Unit -1	**Data Analysis:** Types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, experimental data, Qualitative data collection, questioners, rating scale, conducting survey. Statistical Modeling and Graphical Diagnostics - Scatter Plot, Stem-and-Leaf Plot, Histogram, Box Plot **Correlation and Regression Modeling:** Basic concept and numericals.	**9**
Unit -2	**Probability distributions and Sampling distributions:** Basic introduction to Bernoulli, Binomial and Normal distribution. Basic introduction to Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	**7**
Unit -3	**Parameter estimation:** Point Estimation – Concept, unbiased estimator, method of maximum likelihood. Parameter estimation of standard distributions- Binomial and Normal. Confidence Interval Estimation - Concept, Confidence interval on mean of single normal population with variance known, Confidence interval on the ratio of variances of two normal distributions	**7**
Unit- 4	**Tests of Hypotheses:** Introduction, Type I and type II errors, significance level and power of the test, Test of hypotheses - on mean of single normal population with variance known, on variance of single normal population.	**7**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. D. V Thiel, 'Research Methods for Engineers', Cambridge Press, 2014, ISBN:978-110-70-3-488 2. T. Mustafy, T. U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4	

	4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Explain the different types of data and probability distributions. CO 2. Select the appropriate parameter estimation & distribution method CO 3. Apply estimators for the given situations. CO 4. Evaluate Hypotheses based on the statistical considerations.

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **REC-564**
Title of the Course : **Statistics and Data Analysis Lab**
Number of Credits : **2**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic Knowledge of Statistics	
Course Objectives:	The course will enable the students to 1. Apply the different types of data and parameter estimations 2. Analyze standard probability distributions 3. Demonstrate parameter estimation & distribution methods 4. Co-relate different Hypotheses	
Content:		**No of Hours**
	Using open-source software like libreoffice or any proprietary software perform following experiments: 1. Obtain measures of central tendency and dispersion. 2. Obtain Quartiles, Percentiles and prepare Box-and-Whisker Diagram 3. Develop Pie chart, Bar Chart, Histogram and Stem-and-Leaf Plot, 4. Develop_correlation using Pearson's Correlation Coefficient and showing Scatter Diagrams and Trendlines 5. Develop Linear and Nonlinear Regression Models 6. Obtain probability values involving probability distributions – Binomial and Normal 7. Obtain values of Normal, t-distribution, Chi-square and F-statistic. 8. Develop confidence interval for single population and two populations with variance known. 9. Develop confidence interval on the ratio of variances of two normal distributions. 10. Perform test of hypotheses on mean/variance of single/ two population(s).	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. D. V Thiel, 'Research Methods for Engineers', Cambridge Press, 2014, ISBN:978-110-70-3-488 2. T. Mustafy, T. U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4 4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition,	

	John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply the different types of data and parameter estimations CO 2. Analyze standard probability distributions CO 3. Demonstrate parameter estimation & distribution methods CO 4. Co-relate different Hypotheses

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **REC-565**
Title of the Course : **Statistical Techniques for Engineering Research**
Number of Credits : **2**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	The course will enable the students to 1. Understand the importance of statistical methods for research 2. Select the appropriate factorial design method for a given set of experimental plan. 3. Apply basic probability theorems and draw relevant inferences. 4. Analyze suitable probability model for given set of data	
Content:		**No of Hours**
Unit-1	**Overview on Statistical methods**, collection of data, one dimensional and two-dimensional statistical analysis, computation of central tendency and dispersion for grouped and ungrouped data, correlation preliminary, understanding variability in data.	**6**
Unit-2	**Design of Experiments**, Preparation of experimental plan, full factorial design, fractional factorial design, identification of parameters and levels, randomization, replication, blocking, interaction; numerical; Optimization methods for two parameters.	**9**
Unit-3	**Probability Preliminary**: Introduction to Probability, definition, Sample Space, Events, Conditional Probability, Theorem on total probability, Bayes' theorem. Random Variable: Introduction, Discrete and Continuous distribution, Characteristics- Mean, Variance and distribution function.	**8**
Unit-4	**Probability and Sampling Distribution**: Bernoulli, Binomial, Exponential, Normal, distribution. Mean, variance and distribution function, important properties, approximations and applications. Statistic and Sampling Distribution: Population and Sample. Statistic, Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	**7**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Tahvir Mustafy, Tauhid U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 2. Jiju Antony, 'Design of Experiments for Engineers & Scientists', Elsevier, 2023, ISBN 978-044-315-1736 3. Douglas Montgomery, 'Design and Analysis of Experiments', Wiley India, Eighth Edition, 2013, 9788126540501 4. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010, ISBN: 9788126523504	

	5. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015, ISBN 978-1-292-17601-7 6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Understand the importance of statistical methods for research CO 2. Select the appropriate factorial design method for a given set of experimental plans. CO 3. Apply basic probability theorems and draw relevant inferences. CO 4. Analyze suitable probability model for given set of data

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Name of the Programme : **Master Of Engineering (Artificial Intelligence and Data Science)**
Course Code : **REC-566**
Title of the Course : **Probability & Statistical Analysis Lab**
Number of Credits : **2**
Effective from AY : **2024-25**

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	The course will enable the students to 1. Apply basic probability theorems and draw relevant inferences. 2. Analyze suitable probability model for given set of data 3. Demonstrate factorial design methods 4. Synthesize fractional and full factorial experimental design data	
Content:		**No of Hours**
	Using open-source software like libreoffice or any proprietary software perform following experiments: 1. Obtain probability values involving discrete probability distributions - Bernoulli, Binomial. 2. Obtain probability values involving continuous probability distributions - Exponential and Normal distributions. 3. Obtain values of Normal, t-distribution, Chi-square and F-statistic. 4. Obtain values of Mean, Variance and distribution function of Bernoulli and Binomial distribution. 5. Obtain values of Mean, Variance and distribution function of Exponential and Normal distributions. 6. Obtain values of central tendency of grouped and ungrouped data. 7. Obtain values of dispersion of grouped and ungrouped data. 8. Analyse experimental output using full factorial design. 9. Analyse experimental output using fractional factorial design. 10. Analyse a full case study in involving full factorial design or fractional factorial design.	**60**
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	1. Tahvir Mustafy, Tauhid U Rahman, 'Statistics & Data Analysis for Engineers and Scientists', Springer, 2024, ISBN:9789819946600. 2. Jiju Antony, 'Design of Experiments for Engineers & Scientists', Elsevier, 2023, ISBN 978-044-315-1736 3. Douglas Montgomery, 'Design and Analysis of Experiments', Wiley India, Eighth Edition, 2013, 9788126540501 4. J. Ravichandran, Probability and Statistics for Engineers, Wiley India, 2010, ISBN: 9788126523504 5. R. Johnson, Probability and Statistics for engineers, Eighth Edition, Prentice Hall of India, New Delhi, 2015, ISBN 978-1-292-17601-7 6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition,	

	John Wiley & Sons, 2022.
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply basic probability theorems and draw relevant inferences. CO 2. Analyze suitable probability model for given set of data CO 3. Demonstrate factorial design methods CO 4. Synthesize fractional and full factorial experimental design data

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