ATMANIRBHAR BHARAT
SWAYAMPURNA GOA

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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP Engg. /2024/636 Date: 07.11.2024

CIRCULAR

The University has notified Ordinance OA-43 governing the Master of Engineering Degree and Post-Graduate Engineering Certificate from the Academic Year 2024-2025 onwards.

The Syllabus of Semester I of the **Master of Engineering (Artificial Intelligence and Data Science)** Programme approved by the Academic Council in its meeting held on 22nd August 2024 is 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 VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.11.07 16:14:46 +05'30'

(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.
6.

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**

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**

Issued on: 07/11/2024

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.	**11**

	TextProcessing: Pattern-Matching Algorithms: Brute Force, The 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	**15**

	for Containing Interaction Overheads, Parallel Algorithm Models.	
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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