



GU/Acad –PG/BoS -NEP Engg. /2025-26/502

Date: 18.10.2025

### CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP Engg. /2025/760 dated 21.01.2025

In supersession to the above referred Circular, the Syllabus of Semester III & IV of the **Master of Engineering (Artificial Intelligence and Data Science)** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24<sup>th</sup> & 25<sup>th</sup> July 2025 is attached. The Syllabus of Semester II approved by the Academic Council in its meeting held on 06<sup>th</sup> December 2024 and the Syllabus Semester I approved earlier by the Academic Council in its meeting held on 22<sup>nd</sup> 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**

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

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

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



Semester III						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
<b>Programme Specific Core (PSC) Courses</b>						
1	<a href="#">EAD-501</a>	Business Analytics	4	0	0	4
2	<a href="#">EAD-502</a>	Advanced Data Structures and Algorithms	3	0	0	3
3	<a href="#">EAD-503</a>	Advanced Data Structures and Algorithms Lab	0	0	1	1
<b>Programme Specific Elective (PSE) Courses</b>						
5	<a href="#">EAD-631</a>	Computer Vision and Image Processing	3	0	0	3
6	<a href="#">EAD-632</a>	Computer Vision and Image Processing Lab	0	0	1	1
<b>OR</b>						
7	<a href="#">EAD-633</a>	Natural Language Processing and Applications	3	0	0	3
8	<a href="#">EAD-634</a>	Natural Language Processing and Applications Lab	0	0	1	1
<b>TOTAL</b>			<b>10</b>	<b>0</b>	<b>2</b>	<b>12</b>
<b>Semester IV</b>						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
<b>Programme Specific Core (PSC) Courses</b>						
1	<a href="#">EAD-504</a>	Mathematical Foundations for AI & Data Science –II	3	0	0	3
2	<a href="#">EAD-505</a>	Mathematical Foundations for AI & Data Science -II Lab	0	0	1	1
3	<a href="#">EAD-508</a>	Data Mining and Applications	3	0	0	3
4	<a href="#">EAD-509</a>	Data Mining and Applications Lab	0	0	1	1
<b>General Elective (GE) Courses</b>						
5	<a href="#">GEC-681</a>	Sustainability - Principles & Practices	3	0	0	3
6	<a href="#">GEC-682</a>	Sustainability - Principles & Practices Lab	0	0	1	1
<b>OR</b>						
7	<a href="#">GEC-683</a>	Project Management	3	0	0	3
8	<a href="#">GEC-684</a>	Project Management Lab	0	0	1	1
<b>TOTAL</b>			<b>9</b>	<b>0</b>	<b>3</b>	<b>12</b>



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



## 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

<b>Pre-requisites for the Course:</b>	Basic Knowledge of Applied Mathematics	
<b>Course Objectives:</b>	<p>The course will enable the students to:</p> <ol style="list-style-type: none"> <li>1. Introduce the students to the foundational concepts of Mathematics for Artificial Intelligence and Data Science, such as Linear Algebra, Matrix Calculus and Optimization.</li> <li>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.</li> <li>3. Expose them to Vector and Matrix Calculus, which is an essential tool for understanding and solving problems in artificial intelligence and data science.</li> <li>4. Familiarize them with various optimization techniques required to solve problems related to Artificial Intelligence and Data Science.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Linear Algebra:</b> Introduction, Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings. <b>Analytic Geometry:</b> Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Gram-Schmidt Orthogonalization, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions	<b>15</b>
<b>Unit - 2</b>	<b>Analytic Geometry:</b> Orthogonal Projections, Orthogonal Projection and the Normal Equation, Least Squares Problem, Rotations. <b>Decompositions:</b> Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.	<b>15</b>
<b>Unit - 3</b>	<b>Vector Calculus:</b> 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.	<b>15</b>
<b>Unit - 4</b>	<b>Unconstrained Optimization:</b> Gradient Descent, Gradient Descent	

	with momentum, Conjugate Gradient Descent. <b>Constrained Optimization:</b> Lagrange Multipliers, Convex Sets, Convex Functions, Convex Optimization.	<b>15</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. David C. Lay: Linear Algebra and Its Applications, Third Edition, Pearson Education India, 2002.</li> <li>2. Lloyd N. Trefethen and David Bau III: Numerical Linear Algebra, Twenty-Fifth Anniversary Edition, SIAM-Society for Industrial and Applied Mathematics, 2022.</li> <li>3. Charu Agarwal: Linear Algebra and Optimization for Machine Learning, First Edition, Springer, 2021.</li> <li>4. Kaare Brandt Petersen, Michael Syskind Pedersen: The Matrix cookbook, Version 20121115, Technical University of Denmark, 2012.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong: Mathematics for Machine Learning, Cambridge University Press, 2020.</li> <li>2. Jay Dawani: Hands-On Mathematics for Deep learning, First Edition, Packt Publishing Ltd., 2020.</li> <li>3. Gilbert Strang: Introduction to Linear Algebra, Fifth Edition, Wellesley-Cambridge Press, 2016.</li> <li>4. Stephen Boyd, Lieven Vandenberghe: Introduction to applied linear algebra : Vectors, Matrices, and Least Squares, First Edition, Cambridge University Press, 2018.</li> <li>5. Stephen Boyd, Lieven Vandenberghe: Convex Optimization, First Edition, Cambridge University Press, 2004.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <p>CO1. Demonstrate a sound understanding of a range of mathematical tools and their role and importance in artificial intelligence and data science.</p> <p>CO2. Apply important concepts of linear algebra and matrix Calculus to applications arising in artificial intelligence and data science.</p> <p>CO3. Navigate the complex landscape of derivatives, gradients, and optimization techniques involving vectors and matrices.</p> <p>CO4. Employ various optimization techniques to solve problems arising in artificial Intelligence and data science applications.</p>	

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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

<b>Pre-requisites for the Course:</b>	A basic understanding of statistics and data analysis.	
<b>Course Objectives:</b>	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	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction to Business Analytics:</b> Overview of Business Analytics, Data-Driven Business Analytics, Models in Business Analytics, Problem Solving with Analytics, Introduction to Statistical Analysis and use of software. <b>Descriptive Analytics:</b> 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.	<b>15</b>
<b>Unit - 2</b>	<b>Descriptive Statistics:</b> 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. <b>Probability Distributions and Data Modelling:</b> 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	<b>15</b>
<b>Unit - 3</b>	<b>Trend lines and Regression Analysis:</b> Fundamentals of Linear Regression, Residual analysis and regression assumption, Multiple Linear Regression. <b>Forecasting Techniques Overview:</b> 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	<b>15</b>

	variables.	
<b>Unit – 4</b>	<p><b>Optimization Techniques:</b> 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.</p> <p><b>Simulation and Risk Analysis:</b> 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.</p>	<b>15</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. James R. Evans: Business Analytics: Methods, Models and Decisions, 3<sup>rd</sup> Edition, Pearson Education, 2021.</li> <li>2. Foster Provost, Tom Fawcett: Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, 1<sup>st</sup> Edition, O'Reilly Media, 2013.</li> <li>3. Dinesh Kumar U.: Business Analytics, The Science of Data-Driven Decision Making, 2<sup>nd</sup> Edition, Wiley, 2021.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Seema Acharya, Prasad R.N.: Fundamentals of Business Analytics, 2<sup>nd</sup> Edition, Wiley, 2016.</li> <li>2. Thomas H. Davenport, Jeanne G. Harris: Competing on Analytics, 1<sup>st</sup> Edition, Harvard Business Review Press, 2017.</li> <li>3. Eric Siegel: Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die, 2<sup>nd</sup> Edition, Wiley, 2016.</li> <li>4. Rick Sherman: Business Intelligence Guidebook: From Data Integration to Analytics, 1<sup>st</sup> Edition, Morgan Kaufmann, 2014.</li> <li>5. Nussbaumer Knaflic, Cole: Storytelling With Data: A Data Visualization Guide For Business Professionals 1<sup>st</sup> Edition, Wiley, 2015.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <p>CO1. Apply business analytics techniques to real-world business problems.</p> <p>CO2. Apply data-driven approaches to strategic decision-making.</p> <p>CO3. Demonstrate usage of analytics software and tools to manage databases, execute data queries, and utilize data visualization techniques.</p> <p>CO4. Apply analytics for business transformation.</p>	

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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

<b>Pre-requisites for the Course:</b>	Prior knowledge of basic data structures and a programming language.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Demonstrate proficiency in implementing and analyzing array-based sequences, stacks, and queues.</li> <li>2. Develop the ability to design efficient algorithms and data structures to solve complex problems.</li> <li>3. Understand various graph data structures.</li> <li>4. Develop Programming and Problem-Solving Skills.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction to Data Structures:</b> Types of Data Structures, Operations on Data Structures, Abstract Data Types, Big O Notation. <b>Arrays/Lists:</b> Declaration, Initialization, Operations, 2D Arrays/Lists: Declaration, Operations. <b>Stacks:</b> Operations, Implementation of Stack using Array/Lists and Linked List, Applications of Stack. <b>Queues:</b> Operations, Implementation of queue using Array/Lists and Linked List, Types of queues: Circular, Priority, De-queue.	<b>11</b>
<b>Unit - 2</b>	<b>Linked Lists:</b> Memory Allocation, Singly Linked List, Circular Linked List, Doubly Linked List, Header Linked List <b>Trees:</b> 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. <b>Multi-Way Search Trees:</b> B-Trees: Operations on a B-Tree, Insertion in a B-Tree, Deletion in a B-Tree, Application of a B-Tree, B+ Trees.	<b>12</b>
<b>Unit - 3</b>	<b>Maps and Dictionaries:</b> The Map ADT, Application: Counting Word Frequencies. <b>Hashing</b> : Difference between Hashing and Direct Addressing, Hash Tables, Hash Functions, Collision, Collision Resolution Techniques <b>Sets, Multisets, and Multimaps:</b> The Set ADT, Implementing Sets, Multisets, and Multimaps.	<b>11</b>
<b>Unit - 4</b>	<b>Sorting:</b> Merge-Sort, Array based implementation of merge sort, Quick-Sort implementation. <b>TextProcessing:</b> Pattern-Matching Algorithms: Brute Force, The	<b>11</b>

	<p>Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm.</p> <p><b>Graphs:</b> 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</p>	
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Malhotra Dheeraj, Malhotra Neha: Data Structures and Program Design Using Python, India, Mercury Learning and Information, 2020.</li> <li>2. Goodrich, Michael T, Tamassia, Roberto: Goldwasser, Michael H: Data Structures and Algorithms in Python. United States: Wiley, 2013.</li> <li>3. Miller, Bradley N., David L. Ranum: Problem-solving with algorithms and data structures using Python Second Edition. Franklin, Beedle &amp; Associates Inc., 2011.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Reema Thareja, S. Rama Sree: Advanced Data Structures, Oxford University Press, 2018.</li> <li>2. Baka, Benjamin: Python Data Structures and Algorithms. United Kingdom: Packt Publishing, 2017.</li> <li>3. Necaie, Rance D: Data Structures and Algorithms Using Python, India: Wiley, 2011.</li> <li>4. Vasudevan, Shriram K. Nagarajan, Abhishek S., Nanmaran, Karthick.: Data Structures Using Python. India: Oxford University Press, 2020.</li> <li>5. Lee, Kent D., Hubbard, Steve: Data Structures and Algorithms with Python. Germany: Springer International Publishing, 2015.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <p>CO1. Implement abstract data types (ADT) and data structures for stacks, queues and linked list.</p> <p>CO2. Demonstrate techniques and data structures to solve problems using trees, dictionaries, sets and hash tables.</p> <p>CO3. Apply data structures to solve computational problems involving text processing and dynamic programming.</p> <p>CO4. Apply and analyze graph algorithms for solving problems effectively.</p>	

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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

<b>Pre-requisites for the Course:</b>	Prior knowledge of basic data structures and a programming language.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Identify the appropriate data structure for a given problem.</li> <li>2. Understand trees and hash tables concepts.</li> <li>3. Understand data structures to solve computational problems involving text processing and dynamic programming.</li> <li>4. Understand various graph algorithms for solving problems effectively.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. Implementation of stack.</li> <li>2. Implementation of queue.</li> <li>3. Implementation of linked list.</li> <li>4. Write a program to implement the various operations on Binary Search Tree.</li> <li>5. Write program that use recursive and non-recursive functions to traverse the given binary tree in a)Preorder b) Inorder c) Postorder</li> <li>6. Implementation of AVL tree.</li> <li>7. Implementation of operations on Red-Black trees.</li> <li>8. Implementation of operations on B/B+-trees.</li> <li>9. Implementation of hash functions and its associated algorithms.</li> <li>10. Implementation of Bellman-Ford algorithm.</li> <li>11. Implementation of prim's algorithm for minimum spanning tree.</li> <li>12. Implementation of kruskals algorithm for minimum spanning tree.</li> <li>13. Implementation of graph traversal method.</li> <li>14. Write a program for implementing Knuth-Morris-Pratt pattern matching algorithm</li> <li>15. Write a program for implementing Brute Force pattern matching algorithm.</li> </ol> <p><b>Minimum 10 experiments to be performed from above list.</b></p>	<b>30 Hours</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Malhotra Dheeraj, Malhotra Neha: Data Structures and Program Design Using Python, India, Mercury Learning and Information, 2020.</li> <li>2. Goodrich, Michael T, Tamassia, Roberto Goldwasser, Michael H: Data Structures and Algorithms in Python. United States: Wiley, 2013.</li> </ol>	

	<p>3. Miller, Bradley N., David L. Ranum: Problem-solving with algorithms and data structures using Python Second Edition. Franklin, Beedle &amp; Associates Inc., 2011.</p> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Reema Thareja, S. Rama Sree: Advanced Data Structures, Oxford University Press, 2018.</li> <li>2. Baka, Benjamin: Python Data Structures and Algorithms. United Kingdom.: Packt Publishing, 2017.</li> <li>3. Necaie, Rance D: Data Structures and Algorithms Using Python, India.: Wiley, 2011.</li> <li>4. Vasudevan, Shriram K., Nagarajan, Abhishek S., Nanmaran, Karthick: Data Structures Using Python. India: Oxford University Press, 2020.</li> <li>5. Lee, Kent D., Hubbard, Steve: Data Structures and Algorithms with Python. Germany: Springer International Publishing, 2015.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO1. Solve problems using data structures such as arrays, linked lists, stacks, queues, linked list.</p> <p>CO2. Implement programs for various sorting techniques.</p> <p>CO3. Implement programs for trees, hash tables.</p> <p>CO4. Execute various graph traversal algorithms and string searching algorithms.</p>

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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

<b>Pre-requisites for the Course:</b>	Foundational understanding of programming and basic statistics.	
<b>Course Objectives:</b>	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.	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<p><b>Artificial Intelligence:</b> Introduction, Intelligent Agent: agents and Environments, The structure of Agents.</p> <p><b>Problem solving:</b> 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.</p> <p><b>Knowledge, Reasoning and Planning:</b> Logical Agents, First-Order Logic: syntax and semantics of first order logic, using first –Order Logic, Inference in First-Order Logic, Knowledge Representation.</p>	<b>12</b>
<b>Unit - 2</b>	<p><b>Machine Learning:</b> Learning from examples; forms of learning, supervised learning, Learning decision trees, evaluation and choosing the best hypothesis.</p> <p><b>Probabilistic Models:</b> Statistical Learning, Learning with complete data.</p> <p><b>Communicating, Perceiving and Acting:</b> Natural Language Processing: language models, text classification, Information retrieval,</p> <p><b>Perception:</b> Image formation, Image processing operations, Computer Vision.</p> <p><b>The Future of AI:</b> Agent Components, Agent Architecture.</p>	<b>11</b>
<b>Unit - 3</b>	<p><b>Introduction to Data Science:</b> What is Data Science, The data science Venn diagram, some more terminology.</p> <p><b>Types of Data:</b> Flavors of Data, Structured vs unstructured data, Quantitative vs qualitative data, Four levels of data- nominal, ordinal, interval, ratio</p> <p><b>The five steps of Data Science:</b> Overview of the five steps, Explore the data</p> <p><b>Communicating Data:</b> Identifying effective and ineffective visualizations – Scatter plots, Line graphs, Bar Charts, Histograms, Box plots. When graphs and statistics lie, Verbal communication.</p>	<b>11</b>

	<b>Beyond the essentials:</b> The bias variance trade-off.	
<b>Unit - 4</b>	<p><b>Data Visualization:</b> Introduction, How visualization works, positioning in the field</p> <p><b>From Graphics to Visualization :</b> A Simple Example, Graphics-Rendering Basics, Rendering the Height Plot, Texture Mapping, Transparency and Blending, Viewing</p> <p><b>Data Representation:</b> Continuous Data, Sampled Data, Discrete Datasets, Cell Types, Grid Types, Attributes, Computing Derivatives of Sampled Data, Advanced Data Representation</p> <p><b>The Visualization Pipeline:</b> Conceptual Perspective, Implementation Perspective, Algorithm Classification.</p>	<b>11</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning, Constructivist, collaborative, integrative and inquiry-based approach, Innovation-conducive pedagogy, digital pedagogical competency.	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Stuart J Russell, Peter Norvig: Artificial Intelligence - A Modern Approach, 4th Edition, Pearson Education, 2020.</li> <li>2. Sinan Ozdemir: Principles of Data Science, Packt Publishing, 2016.</li> <li>3. Alexandru C. Telea.:Data Visualization : Principles and Practice, 2nd Edition, CRC Press, 2014.</li> <li>4. Gypsy Nandi, Rupam Kumar Sharma.:Data Science Fundamentals and Practical Approaches, 1st Edition, BPB Publications, 2020.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. K.Knight, E. Rich, S.B. Nair.: Artificial Intelligence, 3rd Edition, Tata McGraw Hill Education, 2017.</li> <li>2. Joel Grus.: Data Science from Scratch, 2nd Edition, O'Reilly Media, 2019.</li> <li>3. Foster Provost &amp; Tom Fawcett.: Data Science for Business, 1st Edition, O'Reilly Media, 2013.</li> <li>4. Roger D. Peng &amp; Elizabeth Matsui.: The Art of Data Science, Lean Publishing, 2018.</li> <li>5. Anindita Das Bhattacharjee.: Artificial Intelligence and Soft Computing for Beginners, 4th Edition, Shroff Publications and Distributors, 2023.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <p>CO1. Demonstrate knowledge of the fundamental principles of Artificial Intelligence and Data Science.</p> <p>CO2. Analyse and compare the relative merits of different AI problem solving techniques.</p> <p>CO3. Apply basic tools (plots, graphs, summary statistics) to carry out exploratory data analysis.</p> <p>CO4. Create effective visualization of given data and Describe the Data Science Process and how its components interact.</p>	

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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

<b>Pre-requisites for the Course:</b>	Familiarity with basic programming concepts in Python and a foundational understanding of AI and data science.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. To provide the students with the basic knowledge of AI and Data Science.</li> <li>2. To introduce them to Python packages and their usability.</li> <li>3. To learn how to clean and prepare the data, apply AI algorithms, and interpret the results to influence decision-making.</li> <li>4. To make the students develop solutions using Data Science tools.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. Write a Program to Implement Breadth/Depth First Search using Python.</li> <li>2. Write a Program to Implement a Tic-Tac-Toe game using Python.</li> <li>3. Write a Program to implement an 8-Puzzle problem using Python.</li> <li>4. Write a Program to Implement Water-Jug problem using Python.</li> <li>5. Write a Program to Implement Travelling Salesman Problem using Python.</li> <li>6. Write a Program to Implement 8-Queens Problem using Python</li> <li>7. Case Study on Developing Machine Learning Systems</li> <li>8. Working with Numpy arrays</li> <li>9. Working with Pandas data frames</li> <li>10. Develop python program for Basic plots using Matplotlib</li> <li>11. Develop python program for Advance plots using Matplotlib</li> <li>12. Develop python program for Frequency distributions for words.</li> <li>13. Develop python program for Normal Curves.</li> <li>14. Develop python program for Correlation coefficient .</li> <li>15. Perform Exploratory data analysis on complex dataset.</li> </ol> <p><b>(Minimum 10 experiments to be performed from above list)</b></p>	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<b>Text Books</b> <ol style="list-style-type: none"> <li>1. Dr. Mohd. Abdul Hameed: Python for Data Science, Wiley, 1st Edition, 2021.</li> <li>2. Dr. R. Nageswara Rao: Core Python Programming, Dreamtech press, 3rd edition, 2018.</li> </ol>	

	<ol style="list-style-type: none"> <li>3. Taneja Sheetal, Kumar Naveen: Python Programming a modular approach, Pearson Education, 1st edition, 2017.</li> <li>4. Samir Madhavan: Mastering python for data science, Packt Publisher, 1st Edition, 2015.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Kenneth. A. Lambert: Fundamentals of Python First Programs, Cengage Learning, 2nd, 2019.</li> <li>2. Vamsi Kurama: Python Programming: A Modern Approach, Pearson India, 2017.</li> <li>3. Y. Daniel Liang: Introduction to Programming Using Python, Pearson Education, First edition, 2017.</li> <li>4. Stuart J Russell, Peter Norvig: Artificial Intelligence - A Modern Approach, 4th Edition, Pearson Education, 2020.</li> <li>5. Sinan Ozdemir: Principles of Data Science, Packt Publishing, 2016.</li> <li>6. Alexandru C. Telea: Data Visualization: Principles and Practice, 2nd Edition, CRC Press, 2014.</li> <li>7. Gypsy Nandi, Rupam Kumar Sharma: Data Science Fundamentals and Practical Approaches, 1st Edition, BPB Publications, 2020.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO1. Implement various techniques to solve AI problems.</li> <li>CO2. Apply AI techniques to solve difficult real-life problems.</li> <li>CO3. Explore functions of Python libraries &amp; packages.</li> <li>CO4. Implement Python code for data visualization.</li> </ol>

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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

<b>Pre-requisites for the Course:</b>	Basic knowledge of Programming Languages	
<b>Course Objectives:</b>	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.	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Modern Processors:</b> 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.	<b>15</b>
<b>Unit - 2</b>	<b>Basic optimization techniques for serial code</b> : 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.	<b>15</b>
<b>Unit – 3</b>	<b>Motivating Parallelism, Scope of Parallel Computing, Parallel Programming Platforms:</b> 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 <b>Principles of Parallel Algorithm Design:</b> Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models.	<b>15</b>

<p><b>Unit – 4</b></p>	<p>The Age of Parallel Processing, the Rise of GPU Computing, A Brief History of GPUs, Early GPU.  <b>GPU architectures and concepts:</b> CPU-GPU system, The GPU and thread engine, characteristics of GPU memory spaces.  <b>GPU programming model:</b> GPU programming abstractions, code structure for GPU programming model, Optimizing GPU resource usage.  <b>Directive based GPU programming:</b> GPU implementation process, Open ACC, OpenMP.</p>	<p><b>15</b></p>
<p><b>Pedagogy:</b> Inquiry Based Learning, Reflective, Integrative Learning</p>		
<p><b>References/ Readings:</b></p>	<p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Hager, Georg., Wellein, Gerhard: Introduction to High Performance Computing for Scientists and Engineers. Ukraine: CRC Press, 2010.</li> <li>2. Robey, Robert., Zamora, Yuliana: Parallel and High Performance Computing. United Kingdom: Manning, 2021.</li> <li>3. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar: Introduction to Parallel Computing, 2nd edition, Addison-Wesley, 2003, ISBN: 0-201-64865-2</li> </ol> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Levesque, John., Wagenbreth, Gene: High Performance Computing: Programming and Applications. United Kingdom: CRC Press, 2010.</li> <li>2. Robert D. Kent, Todd W. Sands: High Performance Computing Systems and Applications. Switzerland: Springer US, 2012.</li> <li>3. Hwang, Kai: Advanced Computer Architecture: Parallelism, Scalability, Programmability. Singapore: McGraw-Hill, 2000.</li> <li>4. Sterling, Thomas., Brodowicz, Maciej., Anderson, Matthew: High Performance Computing: Modern Systems and Practices. Germany: Elsevier Science, 2017.</li> <li>5. Sanders, Jason., Kandrot, Edward: CUDA by Example: An Introduction to General-Purpose GPU Programming. United Kingdom: Pearson Education, 2010.</li> </ol>	
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO1. Explain High Performance Computing (HPC) system architectures and various computational models.</p> <p>CO2. Apply parallel execution models and methodologies for parallel programming and parallel applications development.</p> <p>CO3. Explain different parallel computing paradigms, parallel architectures and parallel programming models</p> <p>CO4. Demonstrate programming using CUDA.</p>	

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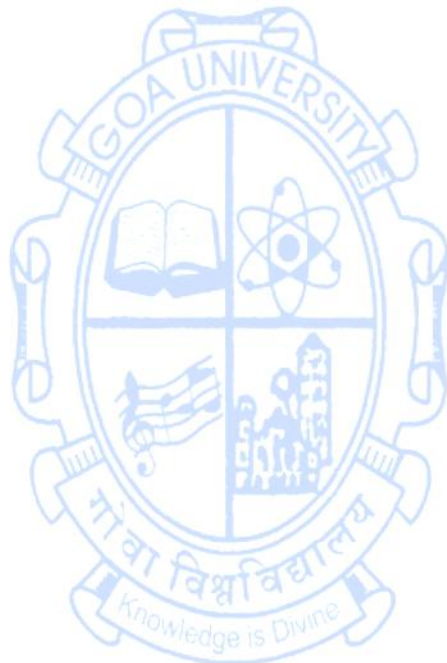
## Research Specific Elective (RSE) Courses

**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

<b>Pre-requisites for the Course:</b>	Knowledge of research requirements in real life	
<b>Course Objectives:</b>	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	
<b>Content:</b>		<b>No of Hours</b>
<b>Unit -1</b>	<b>Overview of scientific research in engineering</b> , 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	<b>11 + 4T</b>
<b>Unit -2</b>	<b>Purpose and Methodology of Literature Search and Review</b> 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	<b>11 + 4T</b>
<b>Unit -3</b>	<b>Quantitative and qualitative Data</b> – 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.	<b>12 + 4T</b>
<b>Unit- 4</b>	<b>Preparation of Publications-</b> 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	<b>11 + 3T</b>
<b>Pedagogy:</b>	Inquiry based learning, Integrative, Reflective Learning , Constructive learning and Collaborative learning	
<b>References/ Readings:</b>	1. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486.	

	<ol style="list-style-type: none"> <li>2. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668.</li> <li>3. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work', Springer Publications, 2022, ISBN:9783030900243</li> <li>4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research &amp; Technical Writing for Science and Engineering', Taylor &amp; Francis Publications, 2022, ISBN:9781003139058.</li> </ol>
<b>Course Outcomes:</b>	<p>CO 1. Understand the importance of literature review, defining the research objectives.</p> <p>CO 2. Explain qualitative and quantitative methods of data analyses and its importance.</p> <p>CO 3. Classify research publications, select appropriate journals based on research areas.</p> <p>CO 4. Practice ethics in publication and academic integrity</p>

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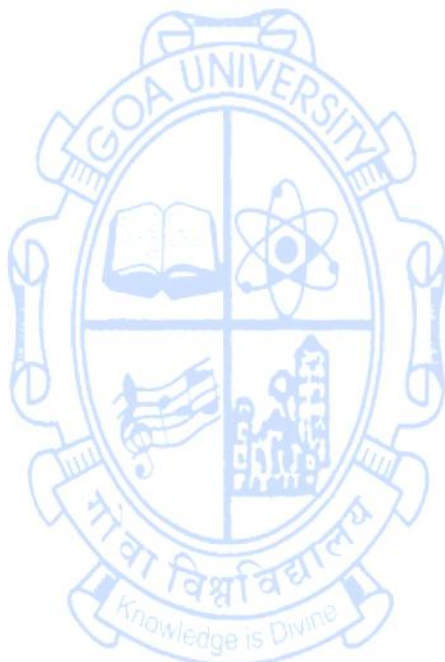


**Name of the Programme** : Master of Engineering (Artificial Intelligence and Data Science)  
**Course code** : REC-562  
**Title of the course** : Literature Review & Technical Writing for Engineers  
**Number of credits** : 4(3L + 1T)  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basics of Technical writing skills.	
<b>Course Objectives:</b>	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.	
<b>Content:</b>		<b>No of Hours</b>
<b>Unit -1</b>	<b>Overview on Literature Review</b> , 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	<b>12 + 4T</b>
<b>Unit -2</b>	<b>Database management of literature reviews</b> , 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.	<b>11 + 4T</b>
<b>Unit -3</b>	<b>Technical writing on a specific research topic</b> , 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	<b>11 + 4T</b>
<b>Unit- 4</b>	<b>Importance of data in research</b> , 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.	<b>11 + 3T</b>
<b>Pedagogy:</b>	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
<b>References/ Readings:</b>	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.
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <p>CO 1. Understand the importance of literature review and writing a review paper.</p> <p>CO 2. Explain the method to be followed to write a review paper.</p> <p>CO 3. Classify data for qualitative and quantitative analysis</p> <p>CO 4. Demonstrate technical writing for conference.</p>

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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

<b>Pre-requisites for the Course:</b>	Knowledge of elementary probability theory and basic theory of random variables.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Acquaint themselves with the foundational concepts of Probability and Statistics for Artificial Intelligence and Data Science.</li> <li>2. Equip themselves with the analytical tools required to apply these concepts to applications arising in Artificial Intelligence and Data Science.</li> <li>3. Familiarize themselves with various notions of convergence of random variables, limit theorems and their applications.</li> <li>4. Gain exposure to various Bayesian inference models and prediction functions.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Discrete Random Variables:</b> 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.	<b>10</b>
<b>Unit - 2</b>	<b>Continuous Random Variables:</b> 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.	<b>11</b>
<b>Unit - 3</b>	<b>Limit Theorems, Convergence and Inequalities:</b> 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.	<b>10</b>
<b>Unit - 4</b>	<b>Bayesian Statistics-Bayesian Inference:</b> Bayesian Parametric	<b>14</b>

	Models, The Prior Distribution, The Likelihood, The Posterior Distribution, The Conjugate Prior, Bayesian Estimators - Minimum Mean-Square-Error Estimation, Maximum-a-Posteriori Estimation, Minimizing the Probability Error, Comparison between the Bayesian Estimators, Bayesian Linear Regression.	
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Carlos Fernandez-Granda, "Lecture Notes : Probability and Statistics for Data Science", Center for Data Science in NYU, 2017.</li> <li>2. Dimitri Bertsekas, John N. Tsitsiklis, "Introduction to Probability", Second Edition, Athena Scientific, 2008.</li> <li>3. Larry Wasserman, "All of Statistics : A Concise Course in Statistical Inference", First Edition, Springer New-York, 2010.</li> <li>4. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", First Edition, Cambridge University Press, 2020.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Hossein Pishro-Nik, "Introduction to Probability, Statistics and Random Processes", First Edition, Kappa Research LLC, Massachusetts, USA, 2014.</li> <li>2. Jay Dawani, "Hands-On Mathematics for Deep learning", First Edition, Packt Publishing Ltd., 2020.</li> <li>3. Marc Deisenroth, Stefanos Zafeiriou, Lecture Notes : "Mathematics for Inference and Machine Learning", Imperial College London, Department of Computing, 2017.</li> <li>4. Marco Taboga, "Lectures on Probability Theory and Mathematical Statistics", Third Edition, CreateSpace Independent Publishing Platform, 2017.</li> <li>5. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition, Springer, 2013.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO 1. Demonstrate a sound understanding of a range of statistical tools and their role and importance in artificial intelligence and data science.</li> <li>CO 2. Apply important concepts of probability and statistics to applications arising in artificial intelligence and data science.</li> <li>CO 3. Apply various notions of convergence of random variables and limit theorems to various situations arising in artificial intelligence and data science.</li> <li>CO 4. Build inference models and prediction functions.</li> </ol>	

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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

<b>Pre-requisites for the Course:</b>	Knowledge of Python programming	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>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.</li> <li>2. Understand how to create data visualizations using python modules.</li> <li>3. Gain exposure to different computational tools through python programming, for analysis of data.</li> <li>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.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. Program to generate Binomial random variables and visualize the probability mass function.</li> <li>2. Program to generate Poisson random variables and visualize the probability mass function.</li> <li>3. Program to generate and plot the Gaussian distribution.</li> <li>4. Program to implement conditional probability distribution.</li> <li>5. Program to implement marginal probability distribution.</li> <li>6. Program to verify statistical independence of random variables.</li> <li>7. Program to compute the upper bounds of the Markov inequality.</li> <li>8. Program to compute the upper bounds of Chebyshev's inequality.</li> <li>9. Program to compute the upper bounds of Chernoff's inequality.</li> <li>10. Program to verify central limit theorem.</li> <li>11. Program to illustrate the weak law of large numbers.</li> <li>12. Program to compute a conjugate prior given a distribution.</li> <li>13. Program to estimate the posterior distribution given the prior and the data.</li> <li>14. Program to implement maximum - a-posteriori estimation.</li> <li>15. Program to implement Minimum Mean-Square-Error Estimation.</li> </ol> <p>Minimum 10 experiments to be performed from above list.</p>	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<b>Text Books</b> 1. Dr. R. Nageswara Rao; Core Python Programming, Third edition,	

	<p>Dreamtech Press, 2018.</p> <ol style="list-style-type: none"> <li>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.</li> <li>3. Samir Madhavan, Mastering Python for Data Science, First Edition, Packt Publishing Ltd., 2015.</li> <li>4. Taneja Sheetal &amp; Kumar Naveen, Python Programming a</li> <li>5. Modular Approach, First edition, Pearson Education, 2017.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Kenneth. A. Lambert, Fundamentals of Python: First Programs, Second Edition, Course Technology Cengage Learning, 2019.</li> <li>2. Vamsi Kurama, Python Programming: A Modern Approach, First Edition, Pearson India, 2017.</li> <li>3. Y. Daniel Liang, Introduction to Programming Using Python, First Edition, Pearson Education, 2017.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO 1. Demonstrate proficiency in applying relevant Python's tools and techniques for data analytics.</li> <li>CO 2. Implement Baye's rule, central limit theorem, law of large numbers, maximum a posteriori estimation and Bayesian regression using Python.</li> <li>CO 3. Create data visualizations using Python modules.</li> <li>CO 4. Write complex Python programs to solve artificial intelligence and data science problems</li> </ol>

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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

<b>Pre-requisites for the Course:</b>	Basic knowledge of Artificial Intelligence.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Understand the basic concepts of Machine learning.</li> <li>2. Learn about Mc-Culloch Pitts neuron model, logic functions, linear and non-linear separability concept and different training rules.</li> <li>3. Learn various supervised learning algorithms.</li> <li>4. Understand data clustering, transformation and dimensionality reduction techniques.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction:</b> 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. <b>Supervised Learning:</b> 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.	<b>11</b>
<b>Unit - 2</b>	<b>Statistical Learning:</b> Naive Bayes Classifier, k-Nearest Neighbor (k-NN) Classifier, Linear and Logistic regression. <b>Decision Tree Learning:</b> 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.	<b>11</b>
<b>Unit - 3</b>	<b>Data Clustering and Data Transformations:</b> 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. <b>Reinforcement Learning:</b> Principle of working. Characteristics, types and elements of reinforcement learning	<b>12</b>
<b>Unit - 4</b>	<b>Artificial Neural Networks:</b> 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.	<b>11</b>

	<p><b>Single layer network:</b> Concept of linear separability and non-linear separability.</p> <p><b>Training rules:</b> Hebbian learning rule, perceptron learning rule, Delta learning rule and related problems.</p>	
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, "Elements of Artificial Neural Network", Penram Publications, 2nd Edition, 1995.</li> <li>2. M. Gopal, "Applied Machine Learning 2nd Edition", Mc Graw Hill Publication, 2nd Edition, 2021.</li> <li>3. Siddhanta Bhatta, "Applied Machine Learning Solutions with Python", BPB Publication, 2nd Edition, 2021.</li> <li>4. Tom M Mitchell, Machine Learning, Indian edition, McGraw Hill Publication, 1997.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Prentice Hall of India, 4th Edition, 2020.</li> <li>2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications.</li> <li>3. Satish Kumar, "Neural Networks A Classroom Approach", VISIONIAS Publication, 2nd Edition, 2020.</li> </ol>	
<b>Course Outcomes:</b>	<p><b>After taking this course, student will be able to:</b></p> <ol style="list-style-type: none"> <li>CO 1. Explain concepts of Machine learning.</li> <li>CO 2. Demonstrate usage of logic functions, linear and non-linear separability concept and different training rules.</li> <li>CO 3. Apply data clustering, transformation and dimensionality reduction techniques for various applications.</li> <li>CO 4. Develop solutions to real world applications using supervised learning algorithms.</li> </ol>	

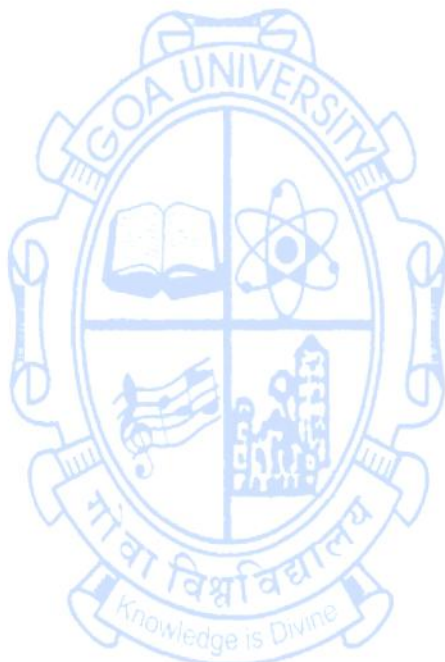
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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-507  
**Title of the Course** : Applied Machine Learning Lab  
**Number of Credits** : 1 (1P)  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic knowledge of python programming.	
<b>Course Objectives:</b>	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.	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	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. <b>Minimum 10 experiments to be performed from above list.</b>	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<b>Text Books</b> 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. <b>Reference Books</b> 1. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press,	

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

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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

<b>Pre-requisites for the Course:</b>	Basic knowledge of Database management systems	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Analyze data in terms of mining tasks, kinds of knowledge to be mined, kinds of technologies used and kinds of applications targeted.</li> <li>2. Implement various preprocessing techniques on data.</li> <li>3. Implement algorithms for classification and regression applications.</li> <li>4. Implement algorithms for clustering, anomaly detection and pattern matching applications.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction:</b> Definition, types of data that can be mined, kinds of patterns that can be mined and technologies used, issues in data mining. <b>Getting to know your data:</b> Data Objects and Attribute types, basic statistical descriptions of data, data visualization, measuring data similarity and dissimilarity. <b>Data Preprocessing:</b> Overview, data cleaning, data integration, data reduction, data transformation and data discretization.	<b>11</b>
<b>Unit - 2</b>	<b>Data Warehousing and Online Analytical Processing:</b> Basic Concepts, data warehouse modelling: data cube and OLAP, data warehouse design and usage, Data warehouse implementation. <b>Classification:</b> Basic Concepts, Decision Tree Induction, Bayes Classification methods, Rule based Classification, Lazy Learners, Model evaluation and selection, Techniques for improving classification accuracy.	<b>12</b>
<b>Unit - 3</b>	<b>Cluster Analysis:</b> basic concepts and methods, cluster analysis, partitioning methods, hierarchical methods, density-based methods, grid-based methods, evaluation of clustering. <b>Mining Frequent Patterns, Associations and Correlations:</b> Basic concepts and methods, frequent itemset mining methods, pattern evaluation methods.	<b>11</b>
<b>Unit - 4</b>	<b>Outlier Detection:</b> Outliers and Outlier analysis, Outlier detection methods, Statistical approaches, proximity-based approaches, clustering-based approaches, classification-based approaches. <b>Data Mining Applications:</b> 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.	<b>11</b>

<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Jiawen Han, Micheline Kamber, Jian Pei, “Data Mining: Concepts and Techniques”, 4th Edition, Elsevier Science, 2022.</li> <li>2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, “Introduction to Data Mining”, Second edition, Pearson, 2021.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. K.P. Soman, Shyam Diwakar, V. Ajay, “Insight into data mining theory and practice”, First Edition, PHI, 2006.</li> <li>2. Aurelien Geron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow”, Second Edition, O’Reily Media, 2017.</li> <li>3. Arun K Pujari, “Data Mining Techniques”, Fourth Edition, Universities Press, 2016.</li> <li>4. Charu C Aggarwal, “Data Mining: The Textbook”, Springer, 2015.</li> <li>5. Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, “Data Mining Practical Machine Learning Tools and Techniques”, Morgan Kaufmann, 2017.</li> </ol>
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO 1. Evaluate data in terms of types and quality and investigate data preprocessing activities.</li> <li>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.</li> <li>CO 3. Implement classification algorithms for solving problems in data mining.</li> <li>CO 4. Apply algorithms for efficient pattern mining and solve clustering problems in data mining and anomaly detection.</li> </ol>

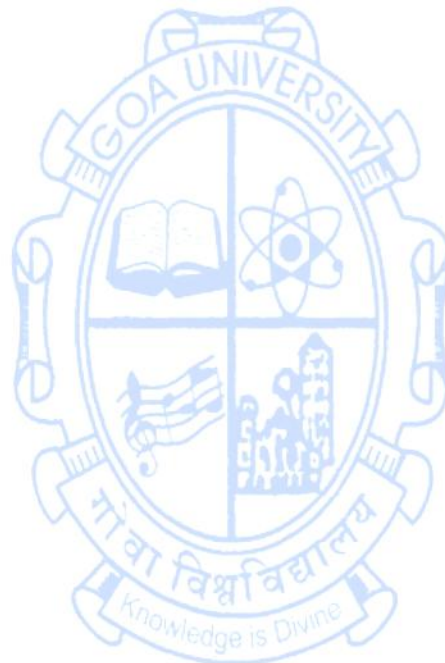
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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-509  
**Title of the Course** : Data Mining and Applications Lab  
**Number of Credits** : 1 (1P)  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic programming knowledge.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Perform preprocessing techniques on raw data.</li> <li>2. Implement various data mining algorithms on varied datasets.</li> <li>3. Apply various post processing techniques for visualization of data mining results.</li> <li>4. Validate the results of data mining tasks.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. Implementation of techniques for Data Pre-processing and cleaning.</li> <li>2. Implementation of techniques of Data Reduction.</li> <li>3. Implementation of Data Transformation.</li> <li>4. Implementation of Apriori Association rule mining algorithm.</li> <li>5. Implementation of FP Growth Association rule mining algorithm.</li> <li>6. Implementation of Decision Tree using ID3.</li> <li>7. Implementation of Decision Tree using C4.5.</li> <li>8. Implementation of Bayesian Classifier.</li> <li>9. Perform k-NN on a real-world dataset (like Iris or MNIST) and analyze the effect of different values of k.</li> <li>10. Implementation of Linear Regression for prediction.</li> <li>11. Implementation of algorithms for Cluster Analysis.</li> <li>12. Implementation of t-Distributed Stochastic Neighbor Embedding (t-SNE) for data visualization.</li> <li>13. Implementation of algorithms for Outlier detection.</li> <li>14. Implementation of applications for text mining.</li> <li>15. Implementation of application for web classification.</li> </ol> <p><b>Minimum 10 experiments to be performed from above list.</b></p>	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Jiawen Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques Fourth Edition, Elsevier Science, 2022.</li> <li>2. Ian H. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pal, Data Mining Practical Machine Learning Tools and Techniques, Morgan Kaufmann, 2016.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. K.P. Soman, Shyam Diwakar, V. Ajay, "Insight into data mining theory and practice", First Edition, PHI, 2006.</li> </ol>	

	<ol style="list-style-type: none"> <li>2. Aurelien Geron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow”, Second Edition, O’Reilly Media, 2017.</li> <li>3. Arun K Pujari, “Data Mining Techniques”, Fourth Edition, Universities Press, 2016.</li> <li>4. Charu C Aggarwal, “Data Mining: The Textbook”, Springer, 2015.</li> <li>5. Jesus Salcedo, “Machine Learning for Data Mining: Improve your data mining capabilities with advanced predictive modelling”, Packt, 2019.</li> </ol>
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO 1. Demonstrate appropriate data preprocessing for a given mining task.</li> <li>CO 2. Apply algorithms for mining useful information from data.</li> <li>CO 3. Perform evaluation of mining algorithms and model selection.</li> <li>CO 4. Draw meaningful insights from data.</li> </ol>

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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

<b>Pre-requisites for the Course:</b>	Basic knowledge of data science.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Gain knowledge on the fundamental Web analytics.</li> <li>2. Gain of the Features, Benefits, and Limitations and the data stream used</li> <li>3. Comprehend Web analytics in Customizations and Real-World Tasks.</li> <li>4. Understand the principles of metrics of web and related Web analytics versions in existence.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction: Measuring success</b> : Website Measurement, Web Analytics Information, Decisions Web Analytics, TROI of Web Analytics, Web Analytics and Web Traffic, Google Analytics Different <b>Available Methodologies and their Accuracy:</b> 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	<b>11</b>
<b>Unit - 2</b>	<b>Google Analytics Features, Benefits, and Limitations:</b> 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. <b>Google Analytics Reports and Interface:</b> 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.	<b>11</b>
<b>Unit - 3</b>	<b>Google Analytics Customizations:</b> Why Customize an Existing Product?, Custom Reports, Day-on-Day Custom Report, Unique Visitors by Page, Affiliate Performance, Managing Custom Reports. <b>Focusing on Key Performance Indicators:</b> Setting Objectives and Key Results, Selecting and Preparing KPIs, What is a KPI?, Preparing KPIs, Presenting Your KPIs, Presenting Hierarchical KPIs via Segmentation.	<b>12</b>
<b>Unit - 4</b>	<b>Web Analytics 2.0:</b> State of the Analytics Union, State of the Industry, Web Analytics 2.0, Web Analytics 2.0, Multiple Outcomes	<b>11</b>

	Analysis, Competitive Intelligence, Strategic Imperative. <b>Web Metrics:</b> Common metrics: Visits and Visitors, Time on Page and Time on Site, Bounce Rate, and Conversion Rate.	
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Brian Clifton.: Advanced Web Metrics with Google Analytics, 3rd Edition, Wiley Publishing, 2012.</li> <li>2. Avinash Kaushik.: Web Analytics 2.0: The Art of Online Accountability and Science of Customer Centricity, 2009.</li> <li>3. Grigor Yovov.: Google Analytics Kickstarter Guide, 2020</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Sterne J., Web Metrics: Proven methods for measuring web site success, John Wiley and Sons, 2002.</li> <li>2. Jerri L. Ledford, Joe Teixeira, Mary E. Tyler.: Google Analytics, John Wiley and Sons, 2011.</li> <li>3. Anand Rajaraman, Jure Leskovec, and Jeffrey D. Ullman.: Mining of Massive Datasets, 2nd edition, Cambridge University Press, 2014.</li> <li>4. Michael Beasley.: Practical Web Analytics for User Experience, Newnes, 2013.</li> <li>5. Avinash Kaushik .: Web Analytics: An hour a day, 2007.</li> </ol>	
<b>Course Outcomes:</b>	<p>After going through this course, the students will be able to:</p> <p>CO 1. Explain the fundamentals and concepts of Web analytics.</p> <p>CO 2. Illustrate the Benefits of Google Analytics Reports and Interface.</p> <p>CO 3. Illustrate Web analytics in Customizations and Real-World Tasks.</p> <p>CO 4. Analyze Website traffic and web metrics in Web analytics.</p>	

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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

<b>Pre-requisites for the Course:</b>	Basic knowledge of python programming and web development tools.	
<b>Course Objectives:</b>	This course will enable students to: <ol style="list-style-type: none"> <li>1. Understand and use web analytics tools, their features, interfaces, and metrics.</li> <li>2. Configure, collect, analyze and interpret web analytics data including traffic trends and set up demo sites and implement tracking codes.</li> <li>3. Assess website usability and analyze user behavior using tools like Hotjar and survey responses.</li> <li>4. Use competitive analysis platforms like SEMrush and understand the evolution of analytics tools, focusing on advanced metrics.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. Explore features, functionalities and compare Google Analytics and Adobe Analytics tools</li> <li>2. Analyze reports from web analytics platforms, and classify metrics into offsite and onsite categories</li> <li>3. Demonstrate, configuring tracking for different traffic sources.</li> <li>4. Extract and analyse historical data from Google Analytics.</li> <li>5. Import sample data sets and implement characterization of content</li> <li>6. Demonstrate the simulation and analyzation of logs from website</li> <li>7. Set up Google Tag Manager and analyse the collected data in Google Analytics.</li> <li>8. Demonstrate beacon in a webpage and monitor its interactions using Chrome DevTools.</li> <li>9. Analyse eCommerce, brand advocacy data, interpreting data patterns using Google Analytics</li> <li>10. Evaluation website usability using checklists and heatmaps (Hotjar).</li> <li>11. Analyze user paths, clicks, and interactions using Hotjar</li> <li>12. Use survey tools to create and deploy post-visit surveys.</li> <li>13. Analyze web traffic and server logs, for data accuracy and completeness.</li> <li>14. Demonstrate the use of metrics like bounce rate, page views, in Google Analytics.</li> <li>15. A case study to illustrate the transition from Google Analytics 1.0 to 2.0.</li> </ol> <p>Minimum 10 experiments to be performed from above list.</p>	<b>30</b>

<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Weber J., Broadley C., Practical Google Analytics and Google Tag Manager for Developers, APress Publishing, 1st Edition, 2015</li> <li>2. Karlins D., Matisoff E.: Adobe Analytics For Dummies, Wiley Publishing, 1st Edition, 2019</li> <li>3. Kaushik A.: Web Analytics 2.0, The Art of Online Accountability and Science of Customer Centricity, Wiley Publishing, Inc. 1st Edition, 2010</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Sponder M., Khan G: Digital Analytics for Marketing, Routledge Publishing, Inc. 1st Edition, 2017</li> <li>2. Haridass T., Learning Google BigQuery: A beginner's guide to mining massive datasets through interactive analysis , Packt Publishing, Inc. 1st Edition, 2017</li> <li>3. Mark Edmondson.: Learning Google Analytics: Creating Business Impact and Driving Insights, 2022</li> </ol>
<b>Course Outcomes:</b>	<p>This course will enable students to:</p> <p>CO 1. Demonstrate and Identify Different Data Collection and Web Analytics Strategies</p> <p>CO 2. Analyze and process the web analytics data with demonstration</p> <p>CO 3. Apply Different Web Analytics Tools like Hotjar</p> <p>CO 4. Analyze Various Google Analytics platforms and testing</p>

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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

<b>Pre-requisites for the Course:</b>	Basic knowledge of Artificial Intelligence and Applied mathematics.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Utilize various data structures and similarity measures for pattern representation and clustering.</li> <li>2. Apply Bayesian decision theory for accurate classification using discriminant functions and decision surfaces.</li> <li>3. Analyze nearest neighbor classifiers using data reduction and prototype selection techniques.</li> <li>4. Evaluate decision trees and SVMs through model selection, feature choice, and kernel functions for handling complex data.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction-</b> Introduction to Pattern Recognition, Different paradigms for Pattern Recognition. <b>Representation- Data Structures for Pattern Representation:</b> 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, <b>Size of Patterns:</b> 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.	<b>15</b>
<b>Unit - 2</b>	<b>Bayesian Decision Theory-</b> continuous features: two category classification, Minimum error rate classification: minimax criterion, neyman-pearson criterion, discriminant functions, <b>Decision surfaces:</b> the multicategory case, two category case, The normal density: Univariate density, multivariate density, discriminant functions for the Normal density: case 1,2,3,	<b>10</b>
<b>Unit - 3</b>	<b>Nearest Neighbour Based Classifiers-</b> Nearest Neighbour Algorithm. Variants of Nearest Neighbour Algorithm: k-Nearest Neighbour (kNN)algorithm, Modified k-Nearest neighbour (MkNN) algorithm, <b>Efficient Algorithms:</b> The Branch & Bound algorithm, The Cube algorithm, Searching for Nearest Neighbour by Projection, Ordered Partitions.	<b>10</b>

<b>Unit - 4</b>	<p><b>Decision trees:</b> 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</p> <p><b>Support Vector Machines-</b> Introduction: Linear Discriminant Functions. Learning the Linear Discriminant Function: Learning the weight vector, Multi-class problems</p>	<b>10</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. M. Narasimha Murty, Dr. V SusheelaDevi," Pattern Recognition An Algorithmic Approach", Springer - ISBN 978-0-85729-494-4 ,2011.</li> <li>2. R.O.Duda, P.E.Hart, D.G.Stork,"Pattern Classification", John Wiley, 2001.</li> <li>3. Sá, J. P. Marques de," Pattern Recognition: Concepts, Methods, and Applications", Germany, Springer, 2001.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Christopher M. Bishop,"Pattern Recognition and Machine Learning", Springer -ISBN-10: 0- 387-31073-8,2006.</li> <li>2. Sankar K. Pal, Amita Pal,"Pattern recognition From Classical to Modern Approaches", World Scientific Publishing Company - ISBN 981-02-4684-6, 2002.</li> <li>3. Sing-Tze Bow, Marcel Dekker,"Pattern Recognition and Image Preprocessing", 2nd Edition - 2002.</li> <li>4. Theodoridis, Sergios., Koutroumbas, Konstantinos," Pattern Recognition". Netherlands: Elsevier Science, 2003.</li> <li>5. Fu, King-Sun,"Applications of Pattern Recognition", United States: CRC Press, 2019.</li> <li>6. Trevor Hastie, Robert Tibshirani, Jerome Friedman," The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, 2009.</li> <li>7. Nello Cristianini, John Shawe-Taylor," An Introduction to Support Vector Machines and Other Kernel-based Learning Methods", Cambridge University Press, 2000.</li> <li>8. Kevin P. Murphy," Machine Learning: A Probabilistic Perspective", MIT Press, 2012.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO 1. Utilize various data structures and similarity measures for pattern representation and clustering.</li> <li>CO 2. Apply Bayesian decision theory for accurate classification using discriminant functions and decision surfaces.</li> <li>CO 3. Analyze nearest neighbor classifiers using data reduction and prototype selection techniques.</li> <li>CO 4. Evaluate decision trees and SVMs through model selection, feature choice, and kernel functions for handling complex data.</li> </ol>	

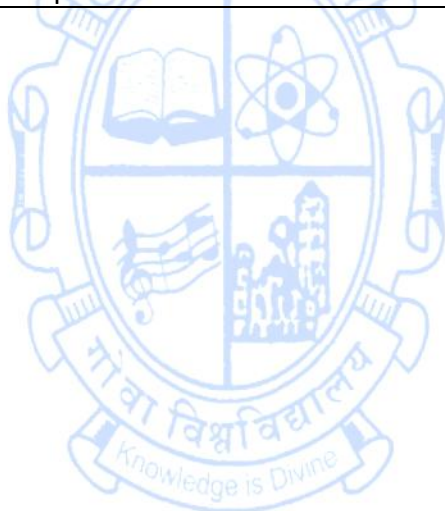
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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-537  
**Title of the Course** : Pattern Recognition for AI & Data Science Lab  
**Number of Credits** : 1 (1P)  
**Effective from AY**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

<b>Pre-requisites for the Course:</b>	Basic knowledge of python programming.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Understand the fundamental concepts of pattern recognition, used for representation and clustering of patterns.</li> <li>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.</li> <li>3. Evaluate the performance of classifiers like decision trees and support vector machines through cross-validation and statistical measures to determine their effectiveness.</li> <li>4. Design and implement integrated pattern recognition systems that combine multiple techniques to effectively address complex data challenges and improve classification outcomes.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>3. Feature Selection Methods and Evaluation of Classifiers: Implement exhaustive search and sequential selection methods to evaluate the performance of classifiers on benchmark datasets.</li> <li>4. Bayesian Decision Theory and Classification: Apply Bayesian decision theory for classification tasks, analyzing decision surfaces and discriminant functions with continuous features.</li> <li>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.</li> <li>6. Nearest Neighbour Classifiers Implementation: Implement the k-Nearest Neighbour (kNN) algorithm and analyze its application in real-world classification tasks.</li> <li>7. Comparison of Nearest Neighbour Classifiers with Different</li> </ol>	<b>30</b>

	<p>Distance Metrics:</p> <p>Analyze the performance of k-Nearest Neighbour (kNN) and m-Nearest Neighbour (m-kNN) classifiers using Euclidean, Manhattan, and Cosine similarity distance metrics.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>11. Evaluation of Classifiers Using Cross-Validation Techniques: Apply k-fold cross-validation techniques to assess the performance of classifiers on benchmark datasets.</p> <p>12. Data Reduction Techniques in Pattern Recognition: Implement PCA and Random Sampling data reduction techniques to simplify datasets while preserving essential information.</p> <p>13. Advanced Decision Tree Techniques: Evaluate the performance of Random Forest and Gradient Boosting Machines across different classification tasks.</p> <p>14. Ensemble Methods for Improving Classification Performance: Implement bagging and boosting ensemble methods to evaluate their impact on classifier performance through comparative analysis.</p> <p>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.</p> <p>Minimum 10 experiments to be performed from above list.</p>	
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. M. Narasimha Murty, Dr. V Susheela Devi, "Pattern Recognition An Algorithmic Approach", Springer - ISBN 978-0-85729-494-4, 2011.</li> <li>2. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", Wiley-Interscience, 2nd Edition, 2001.</li> <li>3. Ian H. Witten, Eibe Frank, Mark A. Hall, "Data Mining: Practical Machine Learning Tools and Techniques", Morgan Kaufmann, 4th Edition, 2016.</li> </ol> <p><b>Reference Books</b></p>	

	<ol style="list-style-type: none"> <li>1. J. D. Gibbons," Nonparametric Statistical Inference", Marcel Dekker, 2nd Edition, 1985.</li> <li>2. Trevor Hastie, Robert Tibshirani, Jerome Friedman," The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, 2nd Edition, 2009.</li> <li>3. Christopher M. Bishop," Pattern Recognition and Machine Learning", Springer, 1st Edition, 2006.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO 1. Understand fundamental concepts of pattern recognition, for pattern representation and clustering.</p> <p>CO 2. Apply techniques like Bayesian decision theory and nearest neighbor classifiers to tackle classification and clustering challenges.</p> <p>CO 3. Evaluate classifiers such as decision trees and support vector machines using cross-validation and statistical measures to assess their effectiveness.</p> <p>CO 4. Design and implement pattern recognition systems that integrate multiple techniques to effectively tackle complex data challenges and improve classification results.</p>



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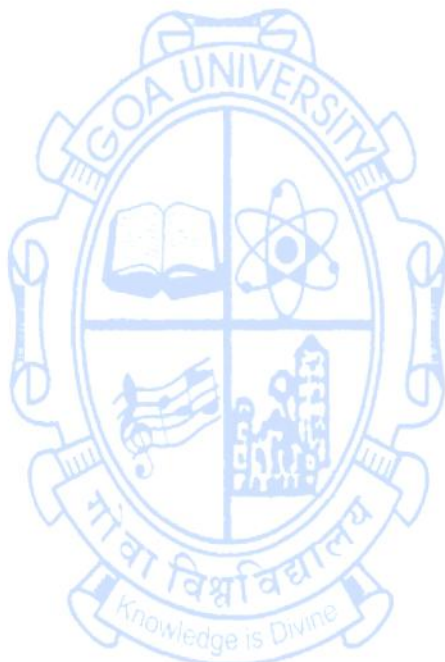
## Research Specific Elective (RSE) Courses

**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

<b>Pre-requisites for the Course:</b>	Basic Knowledge of Statistics	
<b>Course Objectives:</b>	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	
<b>Content:</b>		<b>No of Hours</b>
<b>Unit -1</b>	<b>Data Analysis:</b> Types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, experimental data, Qualitative data collection, questioners, rating scale, conducting survey. <b>Statistical Modeling and Graphical Diagnostics</b> - Scatter Plot, Stem-and-Leaf Plot, Histogram, Box Plot <b>Correlation and Regression Modeling:</b> Basic concept and numericals.	<b>9</b>
<b>Unit -2</b>	<b>Probability distributions and Sampling distributions:</b> Basic introduction to Bernoulli, Binomial and Normal distribution. Basic introduction to Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	<b>7</b>
<b>Unit -3</b>	<b>Parameter estimation:</b> 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	<b>7</b>
<b>Unit- 4</b>	<b>Tests of Hypotheses:</b> 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.	<b>7</b>
<b>Pedagogy:</b>	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
<b>References/ Readings:</b>	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	

	<p>Engineers', 6<sup>th</sup> Edition, Wiley India, 2016, ISBN 0-471-20454-4</p> <p>4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9<sup>th</sup> Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1</p> <p>5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5<sup>th</sup> Edition, John Wiley &amp; Sons, 2022.</p>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO 1. Explain the different types of data and probability distributions.</p> <p>CO 2. Select the appropriate parameter estimation &amp; distribution method</p> <p>CO 3. Apply estimators for the given situations.</p> <p>CO 4. Evaluate Hypotheses based on the statistical considerations.</p>

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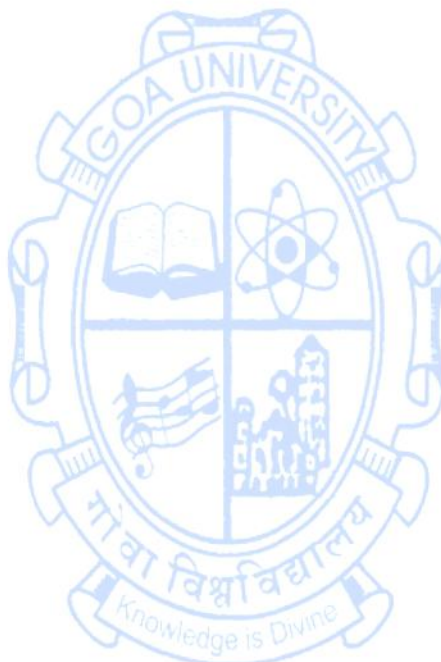


**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : REC-564  
**Title of the Course** : Statistics and Data Analysis Lab  
**Number of Credits** : 2  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic Knowledge of Statistics	
<b>Course Objectives:</b>	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	
<b>Content:</b>		<b>No of Hours</b>
	<b>Using open-source software like libreoffice or any proprietary software perform following experiments:</b> 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).	<b>60</b>
<b>Pedagogy:</b>	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
<b>References/ Readings:</b>	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', 6 <sup>th</sup> 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 ,9 <sup>th</sup> Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5 <sup>th</sup> Edition,	

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

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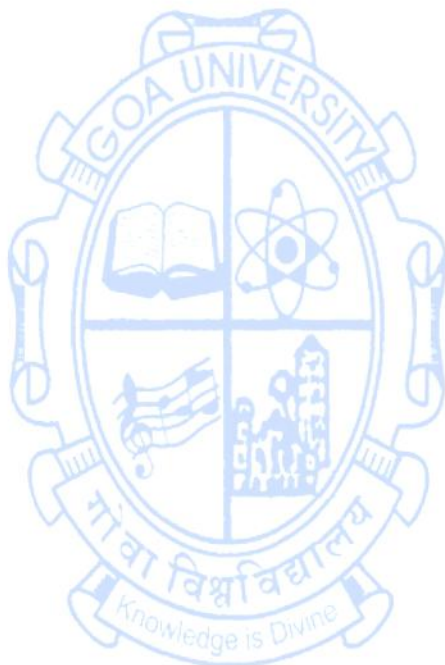


**Name of the Programme** : Master of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : REC-565  
**Title of the Course** : Statistical Techniques for Engineering Research  
**Number of Credits** : 2  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic knowledge of Statistics and Probability	
<b>Course Objectives:</b>	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	
<b>Content:</b>		<b>No of Hours</b>
<b>Unit-1</b>	<b>Overview on Statistical methods</b> , 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.	<b>6</b>
<b>Unit-2</b>	<b>Design of Experiments</b> , 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.	<b>9</b>
<b>Unit-3</b>	<b>Probability Preliminary:</b> 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.	<b>8</b>
<b>Unit-4</b>	<b>Probability and Sampling Distribution:</b> 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.	<b>7</b>
<b>Pedagogy:</b>	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
<b>References/ Readings:</b>	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	

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

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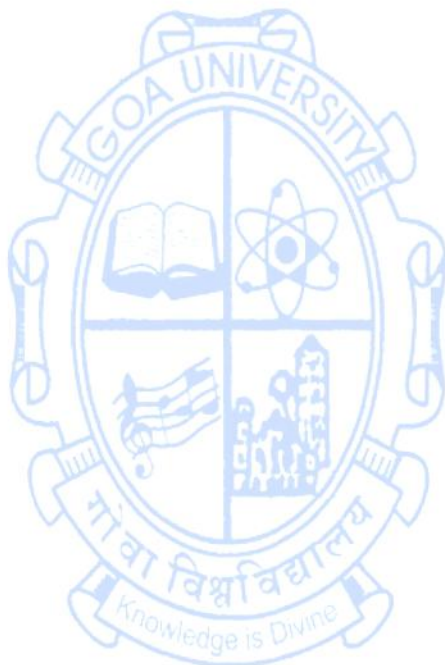


**Name of the Programme** : Master of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : REC-566  
**Title of the Course** : Probability & Statistical Analysis Lab  
**Number of Credits** : 2  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic knowledge of Statistics and Probability	
<b>Course Objectives:</b>	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	
<b>Content:</b>		<b>No of Hours</b>
	<b>Using open-source software like libreoffice or any proprietary software perform following experiments:</b> 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.	<b>60</b>
<b>Pedagogy:</b>	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
<b>References/ Readings:</b>	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, 5 <sup>th</sup> Edition,	

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

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## SEMESTER III

### Programme Specific Core Courses

**Name of the Programme** : Master of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-600  
**Title of the Course** : Applied Deep Learning  
**Number of Credits** : 3 (3L)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Basics of Machine Learning.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Understand the concept of Error Back Propagation algorithm and Deep Learning.</li> <li>2. Learn architecture, working and applications of Convolutional Neural Networks and Recurrent Neural Networks.</li> <li>3. Understand the concept of Recursive Neural Networks and Auto encoders.</li> <li>4. Study various Deep Generative models.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Neural Networks:</b> Basic architectures of Neural network, Multilayer Neural Network, Back propagation algorithm, setting of parameter values and design considerations, practical issues with neural network training. <b>Deep Neural Network (DNN):</b> Introduction to DNN, Neural network Vs. DNN, types of DNN, Applications of DNN.	<b>11</b>
<b>Unit - 2</b>	<b>Convolutional Neural Networks (CNN):</b> Introduction to CNN, Correlation and Convolution, CNN architecture, layers of CNN, CNN with example, Case studies of CNN. <b>Recurrent Neural Networks (RNN):</b> Recurrent neural networks (RNN) architecture, vanishing gradient and exploding gradient problems in RNN, Applications of RNN in the real world.	<b>11</b>
<b>Unit - 3</b>	<b>Recursive Neural Networks:</b> Introduction, Simple GRU, Full gated recurrent unit, GRU to LSTM transition, LSTM architecture, Applications of LSTM, Variants of LSTM. <b>Auto encoders:</b> Under complete autoencoder, autoencoder Vs. PCA, sparse autoencoder, denoising autoencoder, contractive and convolutional autoencoder.	<b>12</b>
<b>Unit - 4</b>	<b>Deep Generative Models:</b> Deep Belief networks, Boltzmann Machines, Deep Boltzmann Machine. <b>Generative AI:</b> Basics of generative models, Generative Adversarial Networks (GAN) architecture, types of GAN (Vanilla GANs, Deep Convolutional GANs, Conditional GANs, and Cycle GANs), applications of GAN.	<b>11</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	

<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Dr. Rajkumar Tekchandani, Dr. Neeraj Kumar, “Applied Deep Learning”, 1<sup>st</sup> Edition, BPB Publications, April 2023, ISBN: 978-9355513724.</li> <li>2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016, ISBN: 978-0262035613.</li> <li>3. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, “Elements of Artificial Neural Network”, 2<sup>nd</sup> Edition, Penram Publications, 1995, ISBN: 978-8187972204.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Charu C. Aggarwal, “Neural Networks and Deep learning- A Textbook”, 1<sup>st</sup> Edition, Springer Publications, 2019, ISBN: 978-3319944623.</li> <li>2. J. Zurada, “Introduction to Artificial neural network”, 1<sup>st</sup> Edition, Jaico Publications, 1996, ISBN: 978-8125914259.</li> <li>3. Patterson J.,Gibson A., “Deep Learning: A Practitioner’s Approach”, 1<sup>st</sup> Edition, O’Reilly Publications, 2017, ISBN: 978-9352136049.</li> </ol>
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO1. Explain Error Back Propagation algorithm to solve practical problems.</li> <li>CO2. Illustrate the architecture, working and applications of Convolutional Neural Networks and Recurrent Neural Networks.</li> <li>CO3. Explain the architecture, working and applications of Recursive Neural Networks and Auto encoders.</li> <li>CO4. Demonstrate the solutions to real world problems using Deep Generative Models.</li> </ol>

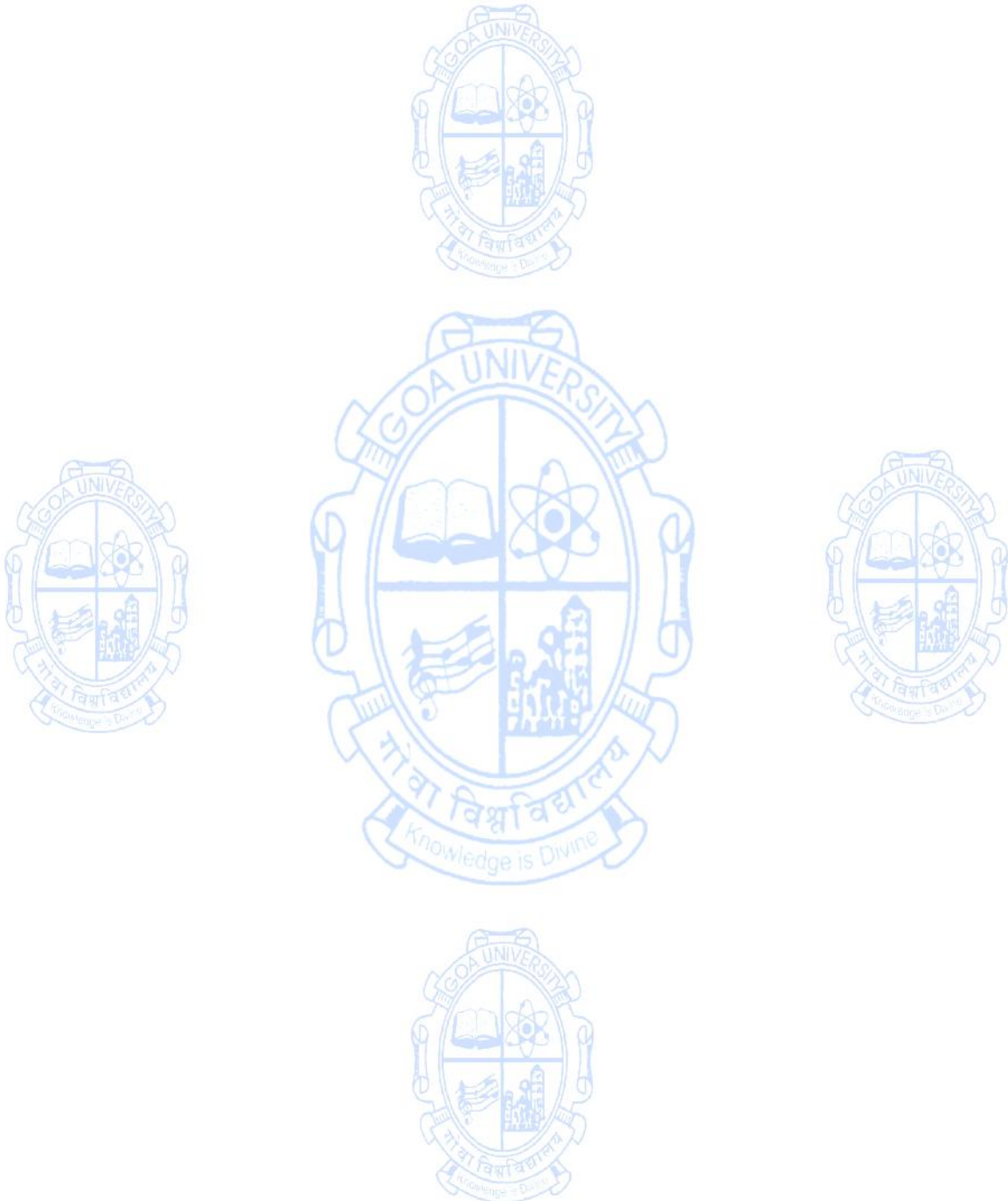
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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-601  
**Title of the Course** : Applied Deep Learning Lab  
**Number of Credits** : 1 (2P)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Python programming.	
<b>Course Objectives:</b>	The course will enable the students to: 1. Understand knowledge of Error Back Propagation algorithm and Deep Learning. 2. Describe Convolutional Neural Networks and Recurrent Neural Networks in Python. 3. Demonstrate knowledge of Recursive Neural Networks in Python. 4. Implement Python programs for various Auto encoders and Deep Generative models.	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	1. Study experiment on Neural Networks and DNN 2. Introduction to various Python Deep Learning libraries. 3. Implementation of Error Back Propagation algorithm for application 4. Implementation of CNN using architecture 1 5. Implementation of CNN using architecture 2 6. Implementation of RNN for application 7. Implementation of LSTM for application 8. Implementation of Auto encoder type 9. Implementation of Deep Generative Model1. 10. Mini project.	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<b>Text Books</b> 1. Dr. Rajkumar Tekchandani, Dr. Neeraj Kumar, "Applied Deep Learning", 1 <sup>st</sup> Edition, BPB Publications, April 2023, ISBN: 978-9355513724. 2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016, ISBN: 978-0262035613. <b>Reference Books</b> 1. Charu C. Aggarwal, "Neural Networks and Deep learning- A Textbook", Springer Publications, 1 <sup>st</sup> Edition, 2019, ISBN: 978-3319944623. 2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications, 1 <sup>st</sup> Edition, 1996, ISBN: 978-8125914259.	
<b>Course Outcomes:</b>	After taking this course, student will be able to: CO1. Apply Error Back Propagation algorithm to solve practical problems. CO2. Develop solutions to real world applications using CNN and RNN. CO3. Implement Recursive Neural Networks for various applications.	

	CO4. Apply problem solving techniques to real world problems using Auto encoders and Deep Generative Models.
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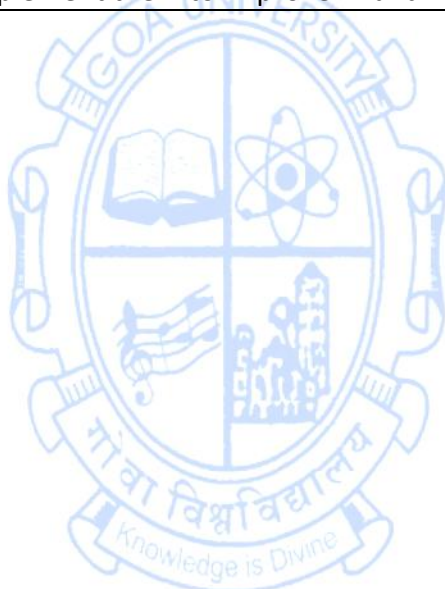


**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-602  
**Title of the Course** : Optimization Methods for AI & Data Science  
**Number of Credits** : 3 (3L)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Mathematical Foundations for Artificial Intelligence and Data Science-I & II	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Gain a comprehensive understanding of concepts and principles of optimization relevant to AI and Data Science.</li> <li>2. Familiarize themselves with various optimization techniques relevant to AI and Data Science.</li> <li>3. Explore the application of optimization methods in AI and Data Science contexts.</li> <li>4. Analyze complex problems to determine appropriate optimization strategies and methods.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction:</b> Optimization problems and existence of optimal solutions, concepts from geometry, line segments, hyperplanes, convex sets and convex functions. <b>Linear programming:</b> Standard form of linear programming problem, Simplex algorithm, visualization (graphical representation of two variable problem), duality in linear programming, solving the dual, overview of sensitivity analysis.	<b>10</b>
<b>Unit - 2</b>	<b>Unconstrained optimization:</b> Basics of Set-Constrained and Unconstrained Optimization, gradients and stationary points, gradient descent method, gradient descent method with momentum, Newton's method, conjugate gradient method, solving linear equations.	<b>13</b>
<b>Unit - 3</b>	<b>Constrained optimization:</b> Equality constraints, inequality constraints, convex functions, convex optimization and duality, projected gradient descent method, Lagrange's method and KKT conditions, penalty method, applications.	<b>13</b>
<b>Unit - 4</b>	<b>Optimization in AI and Data Science</b> : AI and Data Science Problems and Feature Engineering, Stochastic Gradient Descent Algorithm, Linear Regression and its variants.	<b>09</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<b>Textbooks:</b> <ol style="list-style-type: none"> <li>1. E. K. P. Chong, Wu-Sheng Lu and S. H. Zak, "An Introduction to Optimization with applications to machine learning", 5<sup>th</sup> Edition, John Wiley and Sons Pvt. Ltd., 2023, ISBN:978-1119877639.</li> <li>2. D. G. Luenberger, Y. Ye, "Linear and Nonlinear Programming", 4<sup>th</sup> Edition, Springer, 2016, ISBN: 978-3319188416.</li> <li>3. Jorge Nocedal, Stephen J. Wright, "Numerical optimization", 2<sup>nd</sup></li> </ol>	

	<p>Edition, Springer, 2006, ISBN: 978-0387303031.</p> <p><b>References:</b></p> <ol style="list-style-type: none"> <li>1. S. Boyd, L. Vandenberghe, "Convex Optimization", International edition(Soft Cover), Cambridge India, 2016, ISBN: 0521833787.</li> <li>2. Dimitri P. Bertsekas, "Nonlinear programming", 3<sup>rd</sup> Edition, Athena Scientific, 2016, ISBN: 978-1886529052.</li> <li>3. Stephen J. wright, Benjamin Recht, "Optimization for Data Analysis", 1st Edition, Cambridge University Press, 2022, ISBN:978-1009004282.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO1. Recall and explain fundamental concepts and principles of optimization relevant to AI and Data Science.</p> <p>CO2. Apply various optimization techniques to solve practical problems in AI and Data Science.</p> <p>CO3. Analyze optimization models and algorithms to determine their suitability and effectiveness for specific applications.</p> <p>CO4. Evaluate the performance of optimization methods and implement them to improve AI and Data Science solutions.</p>

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-603  
**Title of the Course** : Optimization Methods for AI & Data Science Lab  
**Number of Credits** : 1 (2P)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Knowledge of Python programming.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Gain a comprehensive understanding of Python Libraries and functionalities that are used to implement optimization techniques.</li> <li>2. Acquire hands-on experience in algorithmic thinking, by implementing various optimization methods.</li> <li>3. Compare the performance of different optimization methods, through practical coding assignments.</li> <li>4. Gain exposure to various Python libraries, to create visualizations of optimization algorithms, to effectively communicate their findings and insights.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. Write a Python program to visualize line segments, hyperplanes, and convex sets using libraries such as Matplotlib. Include functionality to check if a point is inside a convex set.</li> <li>2. Implement the Simplex algorithm from scratch to solve a linear programming problem.</li> <li>3. Write a program that takes a linear programming problem and computes its dual.</li> <li>4. Implement the gradient descent algorithm with and without momentum for a function, and compare the convergence rates.</li> <li>5. Implement Newton’s method for finding stationary points of multivariable functions. Compare the performance of Newton’s method with gradient descent on a given function.</li> <li>6. Write a Python program to implement the conjugate gradient descent method. Test it on quadratic functions and comment on its convergence.</li> <li>7. Implement the projected gradient method for optimization with convex constraints. Provide visual output to showcase the constraint projection process.</li> <li>8. Write a program to implement the method of Lagrange multipliers for constrained optimization problems and provide an example.</li> <li>9. Implement penalty methods for solving constrained optimization problems.</li> <li>10. Implement stochastic gradient descent method on a linear</li> </ol>	<b>30</b>

	regression model.
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning
<b>References/ Readings:</b>	<p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. Rupesh Kumar Tipu, Vandna Batra, Suman Punia, "Efficient Coding with Python: Mastering Optimization Techniques", 1st Edition, Lambert Academic Publishing, 2024, ISBN: 978-6207474097.</li> <li>2. Nathan George, "Practical Data Science with Python: Learn tools and techniques from hands-on examples to extract insights from data", 1<sup>st</sup> Edition, Packt Publishing Ltd, 2021, ISBN: 978-1801071970.</li> <li>3. Samir Madhavan, "Mastering Python for Data Science", 1<sup>st</sup> Edition, Packt Publishing Ltd., 2015, ISBN: 978-1784390150.</li> </ol> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Dr. R. Nageswara Rao; "Core Python Programming", 3<sup>rd</sup> Edition, Dreamtech Press, 2018, ISBN: 978-9390457151</li> <li>2. Kenneth. A. Lambert," Fundamentals of Python: First Programs", 2<sup>nd</sup> Edition, Course Technology Cengage Learning, 2019, ISBN: 978-1111822705.</li> <li>3. Vamsi Kurama, "Python Programming: A Modern Approach", 1<sup>st</sup> Edition, Pearson India, 2017.</li> </ol>
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO1. Have a deeper understanding of problem-solving approaches to optimization problems, through Python programming.</li> <li>CO2. Implement fundamental optimization algorithms in Python to solve mathematical problems arising in AI and Data Science.</li> <li>CO3. Apply different optimization methods in Python, and analyse their effectiveness in solving various mathematical problems.</li> <li>CO4. Utilize relevant Python libraries to build and solve optimization models using Python.</li> </ol>

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## Programme Specific Elective (PSE) Courses

**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-631  
**Title of the Course** : Computer Vision and Image Processing  
**Number of Credits** : 3 (3L)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Image processing concepts, machine learning, artificial intelligence	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Understand the fundamental principles of computer vision, including image formation, radiometric models, and basic digital image operations such as geometric transformations and histogram-based techniques.</li> <li>2. Explore spatial and frequency domain image processing techniques for filtering, enhancement, and transformation using both theoretical and practical frameworks.</li> <li>3. Implement machine learning and deep learning algorithms in real-world computer vision applications such as medical image segmentation, object tracking, facial and gesture recognition, and image fusion.</li> <li>4. Apply techniques for noise detection and restoration, as well as morphological operations for shape and region-based image analysis using Python and relevant libraries.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Introduction to Computer Vision and Basic Concepts of Image Formation:</b> Introduction and Goals of Computer Vision, Image Formation and radiometry, Geometric Transformation, Geometric Camera models, Image Reconstruction from series of projections. <b>Playing with Digital Images:</b> Playing with pixel and patches, Neighborhood of a pixel, Histogram Processing, Histogram matching, Basic Transformations in images, color models	<b>12</b>
<b>Unit - 2</b>	<b>Spatial Domain Processing:</b> Signals in one dimension, System in one direction, Graphical illustration of one-dimensional convolution, One dimensional filter design intuition, concept of two-dimensional filtering of images, Smoothing filters, Sharpening filters, Convolution vs. correlation. <b>Frequency Domain Image Processing:</b> One Dimensional analog signal in time and frequency domain, One dimensional discrete time signal in time and frequency domain, Two – dimensional Fourier Transform, Filtering of images in frequency domain	<b>12</b>
<b>Unit - 3</b>	<b>Noise and Image:</b> Noise and degradation model, Restoration in presence of noise only, Detection of noise in images, Measurement of noise in images using PSNR, Classical methods of noise removal, Adaptive filtering	<b>11</b>

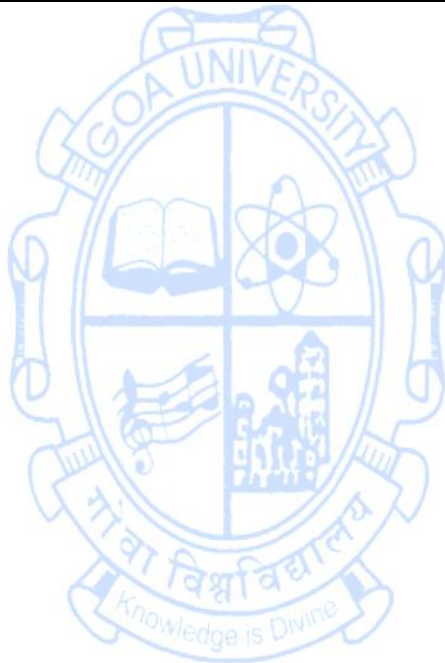
	<b>Binary Morphology:</b> Erosion, Dilation, Erosion dilation duality, Opening and closing, Hit and Miss transformation, Boundary extraction, Hole filling, Region filling, Connected component analysis, Connected component analysis using skimage library, convex hull, Thinning, Thickening.	
<b>Unit - 4</b>	<b>Applications of Computer Vision:</b> Machine Learning Algorithms and their Applications in Medical Image Segmentation, Motion estimation and Object Tracking, face and Facial Expression Recognition, Gesture Recognition, Image Fusion	<b>10</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Textbooks:</b></p> <ol style="list-style-type: none"> <li>1. Manas Kamal Bhuyan, "Computer Vision and Image Processing: Fundamentals and Applications", 1<sup>st</sup> Edition, CRC Press, 2019, ISBN: 978-0815370840 .</li> <li>2. Dr. Manish Kashyap, " Digital Image Processing Using Python", 1<sup>st</sup> Edition, bpb Publications, 2024, ISBN: 978-9365898910.</li> <li>3. Sandipan Dey, " Image Processing Masterclass with Python", 1<sup>st</sup> Edition, bpb Publications, 2021, ISBN:978-9389898644.</li> </ol> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", 4<sup>th</sup> edition, Pearson Edition, 2018, ISBN: 978-9353062989 .</li> <li>2. Prince, S. J. D., "Computer Vision: Models, Learning, and Inference", 1<sup>st</sup> edition, Cambridge University Press, 2017 ISBN: 978-1107011793.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <p>CO1. Analyze image formation processes, geometric transformations, and perform fundamental image processing operations including histogram equalization and color space conversion.</p> <p>CO2. Compare spatial and frequency domain filtering techniques using convolution, correlation, and Fourier Transform for image enhancement.</p> <p>CO3. Apply morphological operations such as erosion, dilation, boundary extraction, and region filling for structural analysis.</p> <p>CO4. Design and evaluate computer vision solutions using machine learning and deep learning approaches for practical applications such as face recognition, object tracking, gesture detection, and medical image segmentation.</p>	

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-632  
**Title of the Course** : Computer Vision and Image Processing Lab  
**Number of Credits** : 1 (2P)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Python Programming.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Understand techniques for image acquisition, enhancement, transformation, and basic analysis using Python libraries such as OpenCV and skimage.</li> <li>2. Discuss and evaluate features, perform morphological operations, and process images in both spatial and frequency domains.</li> <li>3. Implement filtering, denoising, and restoration operations on degraded images.</li> <li>4. Apply computer vision and deep learning techniques for real-world applications such as face recognition, tracking, and medical imaging.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. To load, display, and analyze digital images using OpenCV and matplotlib.</li> <li>2. To implement basic geometric transformations: translation, rotation, scaling, flipping, and affine transforms.</li> <li>3. To perform histogram equalization and histogram matching for contrast enhancement.</li> <li>4. To explore different color models (RGB, HSV, Grayscale) and apply color space conversion.</li> <li>5. To reconstruct an image from noisy projections using inverse transform and interpolation methods.</li> <li>6. To apply spatial filters (mean, median, Gaussian, Laplacian) for image smoothing and sharpening.</li> <li>7. To apply frequency domain filtering for noise reduction and enhancement using ideal and Butterworth filters.</li> <li>8. To compare spatial vs. frequency domain results for edge enhancement and noise filtering.</li> <li>9. To implement morphological operations like erosion, dilation, opening, and closing using skimage and OpenCV.</li> <li>10. To extract and analyze object boundaries and regions using connected component analysis and region filling.</li> </ol>	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<b>Text Books</b> <ol style="list-style-type: none"> <li>1. Sandipan Dey, "Image Processing Masterclass with Python", 1st Edition, bpb Publications, 2021, ISBN:978-9389898644.</li> <li>2. Dr. Manish Kashyap, "Digital Image Processing Using Python", 1st Edition, bpb Publications, 2025, ISBN: 978-9365898910.</li> </ol>	

	<p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", 4<sup>th</sup> edition, Pearson Edition, 2018, ISBN: 978-9353062989 .</li> <li>2. Prince, S. J. D. "Computer Vision: Models, Learning, and Inference", 1<sup>st</sup> Edition, Cambridge University Press, 2017, ISBN: 978-1107011793.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO1. Explain concept of restoration noisy images, and perform morphological operations for object structure extraction.</li> <li>CO2. Demonstrate spatial and frequency domain filtering techniques using convolution, correlation, and Fourier analysis.</li> <li>CO3. Implement fundamental image processing techniques including geometric transformation, color space conversion, and histogram-based operations.</li> <li>CO4. Develop computer vision applications using deep learning and pretrained models for face, expression, and object recognition.</li> </ol>



**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-633  
**Title of the Course** : Natural Language Processing and Applications  
**Number of Credits** : 3 (3L)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Fundamentals of Artificial Intelligence and Pattern recognition.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. Explain the principles of automatic speech recognition and synthesis.</li> <li>2. Demonstrate algorithms used for processing natural linguistic information.</li> <li>3. Illustrate the semantics and pragmatics of the English language for processing.</li> <li>4. Apply the fundamental concepts and techniques of natural language processing (NLP).</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Getting started with NLP:</b> Importance and challenges of NLP, Tokenization, stemming, Lemmatization, and stop word removal, Term frequency, Inverse document frequency. Pipeline creation, Part-of-speech tagging, Text summarization, Sentiment analysis, Word sense disambiguation. <b>Text Processing and Cleaning:</b> Text processing techniques, Advanced text normalization, addressing typos and spelling errors, filtering out punctuation and special characters, dealing with case sensitivity, stripping extra whitespace, Segmenting text into sentences, Preparing text for machine learning models.	<b>11</b>
<b>Unit - 2</b>	<b>Semantic Representation:</b> Semantic representation technique, TF-IDF techniques, N-gram modeling techniques, word and sentence embeddings, BERT, Semantic role labeling, one-hot encoding, Semantic clustering, Cosine similarity, relationship extraction. <b>Part-of-speech Tagging and Named Entity Recognition:</b> POS tagging and NER techniques, POS tagging technique, Entity recognition, Entity classification and extraction, Custom NER Training, NER post-processing, Entity disambiguation, Entity visualization, NER integration, NER evaluation.	<b>12</b>
<b>Unit - 3</b>	<b>Text Classification:</b> Importance of text classification in NLP, Text categorization, Spam detection, Sentiment classification, Topic assignment, Content moderation, Text ML classification, Deep learning classification, Classification metrics. <b>Advanced Techniques for Topic Modeling:</b> Topic modeling technique, Document clustering, analyzing topic evolution, Extracting topics from short texts, Multilingual topic modeling technique, Topic modeling with neural networks.	<b>11</b>

<b>Unit - 4</b>	<p><b>Building a Chatbot:</b> Designing a conversational interface, training a chatbot with intents and entities, implementing dialog management, personalizing chatbot responses, evaluating chatbot performance, securing chatbot conversations, Enhancing chatbot intelligence with Machine Learning.</p> <p><b>Natural language Generation:</b> Salient issues in natural language generation, Components of natural language generator, Functions of NLG System, Applications of NLG systems.</p>	<b>11</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Rosario Moscato, Alessio Ligios, Corrado Silvestri, " Natural Language Processing", 1st Edition, bpb Publications, 2025, ISBN: 9365893046.</li> <li>2. Ela Kumar, "Natural Language Processing", 1st Edition, Dreamtech Press publishers, 2019, ISBN: 978-9389307597.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Eisenstein Jacob, "Introduction to Natural Language Processing", MIT Press, 2019, ISBN 9780262042840.</li> <li>2. Dan Jurafsky, "Speech and Language Processing", 2nd edition, Gamma Publications, 2025, ISBN- 9332518416.</li> </ol>	
<b>Course Outcomes:</b>	<p>After going through this course, the students will be able to:</p> <p>CO 1. Explain the need for Natural Language Processing and various approaches to Text preprocessing.</p> <p>CO 2. Illustrate approaches and ways of morphological analysis in NLP.</p> <p>CO 3. Demonstrate the machine learning techniques used in NLP.</p> <p>CO 4. Apply techniques of Information extraction in NLP.</p>	

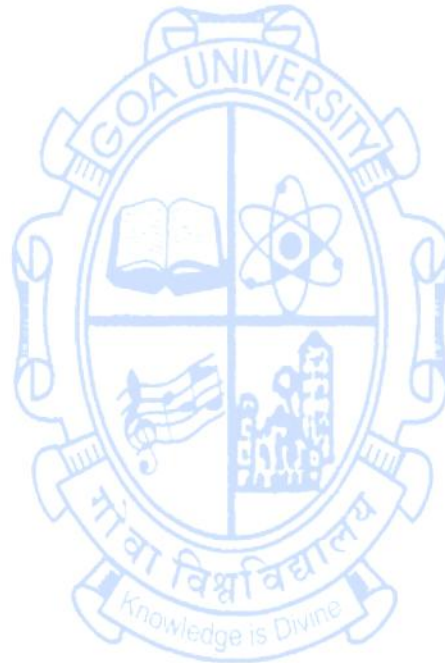
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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-634  
**Title of the Course** : Natural Language Processing and Applications Lab  
**Number of Credits** : 1 (2P)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Knowledge of python.	
<b>Course Objectives:</b>	This course will enable students to: 1. Understanding and implementing algorithms for processing linguistic information. 2. Analyse the knowledge of semantics in languages for processing. 3. Apply the techniques of natural language processing. 4. Apply principles of automatic speech recognition and synthesis in NLP.	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	1. Implement a Python program for Word Tokenization. 2. Implement a Python program Sentence Tokenization. 3. Implement a Python program for Removing Stop words. 4. Implement a Python program for Part-of-Speech (POS) Tagging. 5. Implement a Python program for Stemming. 6. Implement a Python program for Lemmatization. 7. Implement a Python program for Word Frequency Count. 8. Implement a Python program for Text Preprocessing. 9. Implement a Python program for Named Entity Recognition (NER). 10. Implement a Python program for Term Frequency - Inverse Document Frequency.	<b>30</b>
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<b>Text Books</b> 1. Rosario Moscato, Alessio Ligios, Corrado Silvestri, " Natural Language Processing", 1st Edition, bpb Publications, 2025, ISBN-9365893046 2. Steven Bird , Ewan Klein , " Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit", 1st Edition, O'Reilly Media, 2009, ISBN-0596516495. <b>Reference Books</b> 1. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, "Practical natural language processing", O'Reilly publications, 2020, ISBN- 1492054054. 2. Dan Jurafsky, "Speech and Language Processing", 2nd edition, Gamma Publications, 2025, ISBN- 9332518416.	
<b>Course Outcomes:</b>	After going through this course, students will be able to CO 1. Describe different algorithms and approaches for NLP tasks to different domains CO 2. Analyse different NLP applications using machine learning and deep	

	<p>learning methods</p> <p>CO 3. Apply programming techniques using various approaches to Text preprocessing.</p> <p>CO 4. Apply the techniques for Information extraction &amp; named entities recognition in NLP.</p>
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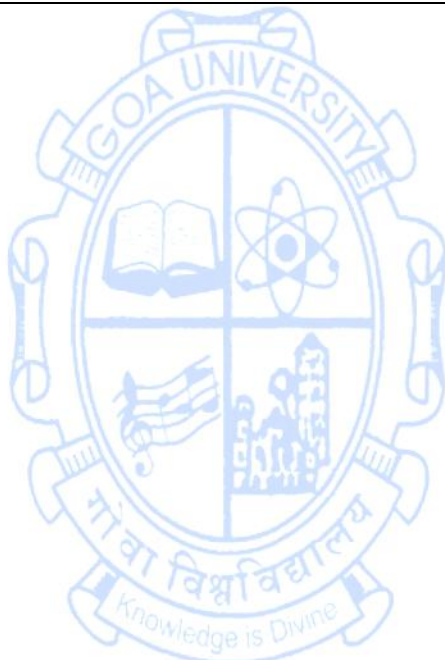
## Research Specific Elective (RSE) Courses

**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-661  
**Title of the Course** : Research Directions in AI  
**Number of Credits** : 2 (2L)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Basic knowledge of AI	
<b>Course Objectives:</b>	The course will enable the students to: 1. Explore computer vision for object detection, classification and segmentation. 2. Learn to build custom image classifiers and Biomedical Systems. 3. Understand the process of training and tuning Biomedical Systems and GANs. 4. Learn the concepts of Explainable AI, Edge AI, TinyML.	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Physiological Biometrics:</b> Introduction, Types of Biometric Recognitions, Recognition Systems, Principal Component Analysis, Linear Discriminant Analysis, RBF, Face Recognition, Hand Geometry.	<b>7</b>
<b>Unit - 2</b>	<b>Localization and Object Detection:</b> Computer Vision, Image Classification using CNN, Image Segmentation, YOLO algorithm, Encoding bounding boxes in YOLO, CNN for object detection. <b>Biomedical Systems:</b> Introduction, ANN Classifiers- Breast Cancer, Thyroid, Skin Disease.	<b>8</b>
<b>Unit - 3</b>	<b>Biomedical Systems:</b> Skin disease, Diabetes and Heart Disease. <b>Training and Developing Generative Adversarial Networks:</b> Generative Adversarial Training, Generating MNIST data - Basic GAN implementation), Issues during training a GANs, Case Study - Common practical implementation of GANs.	<b>7</b>
<b>Unit - 4</b>	<b>Explainable AI:</b> Introduction, types of explanations, overview of techniques. <b>Edge AI:</b> Introduction, characteristics, Use cases, hardware platforms, tools, real-world applications, federated learning. <b>TinyML:</b> Introduction, characteristics, Use cases, hardware platforms, tools, real-world applications.	<b>8</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning, Constructivist, collaborative, integrative.	
<b>References/ Readings:</b>	<b>Textbooks</b> 1. Anupam Shukla, Ritu Tiwari, Rahul Kala, "Real Life Applications of Soft Computing", CRC Press, 2016, ISBN: 978-1439822876. 2. Pete Warden, Daniel Situnayake, "TinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers", 1 <sup>st</sup> Edition, O'Reilly, 2020, ISBN: 978-9352139606.	

	<p>3. Christoph Molnar, "Interpretable Machine Learning", 2<sup>nd</sup> Edition, Shroff Publication, 2024, ISBN: 978-9355428370.</p> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016, ISBN: 978-0262035613.</li> <li>2. Nikhil Buduma &amp; Joe Papa, "Fundamentals of Deep Learning", 2<sup>nd</sup> Edition, O'REILLY, 2022, ISBN: 978-9355420121.</li> <li>3. Patterson J. and Gibson A., "Deep Learning: A Practitioner's Approach", 1<sup>st</sup> Edition, O'Reilly, 2017, ISBN: 978-9352136049.</li> </ol>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO1. Explain concepts of Explainable AI, Edge AI, TinyML.</p> <p>CO2. Illustrate object detection, classification and segmentation using YOLO algorithm.</p> <p>CO3. Develop Biomedical Systems and GANs for practical scenarios.</p> <p>CO4. Develop object classifiers and biomedical systems.</p>

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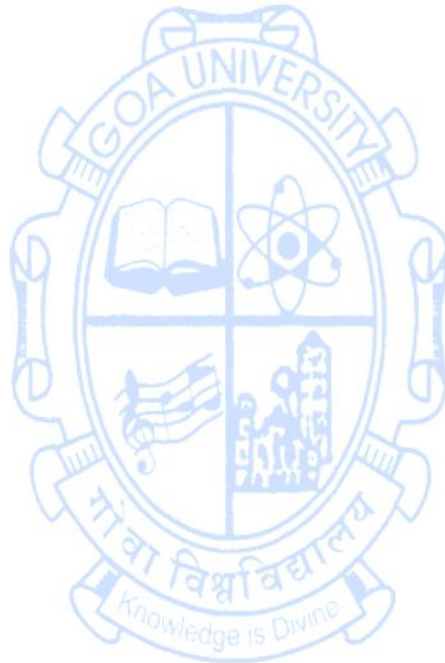


**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : EAD-662  
**Title of the Course** : Research Directions in AI Lab  
**Number of Credits** : 2 (4P)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Basics of python programming	
<b>Course Objectives:</b>	The course will enable the students to: 1. Explore the libraries and physiological biometric systems using AI. 2. Learn to build custom image classifiers and Biomedical Systems. 3. Understand the process of training and tuning Biomedical Systems and GANs. 4. Learn the concepts of Explainable AI, Edge AI, TinyML	
<b>Content:</b>		<b>No. of hours</b>
	<b>List of Programs /Experiments</b> 1. Study of Tensor Flow 2. Study of Keras 3. Implementation of Thyroid classification. 4. Implementation of Heart disease detection. 5. Implementation of Skin disease detection. 6. Implementation of Diabetes detection 7. Implementation of a CNN for application1. 8. Implementation of a CNN for application2. 9. Implementation of a CNN for application3. 10.Implementation of Explainable AI for application1 11.Implementation of Explainable AI to application2. 12.Implementation of Explainable AI to application3. 13.Implementation of a GAN application1. 14.Implementation of GAN application2. 15.Study experiment on Edge AI, TinyML.	<b>60</b>
<b>Pedagogy:</b>	Inquiry Based Learning, Reflective, Integrative Learning, Constructivist, collaborative, integrative	
<b>References/ Readings:</b>	<b>Text Books</b> 1. Dr. Rajkumar Tekchandani, Dr. Neeraj Kumar, "Applied Deep Learning", BPB, 1 <sup>st</sup> Edition 1, April 2023, , ISBN: 978-9355513724. 2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016, ISBN: 978-0262035613. 3. Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, "Elements of Artificial Neural Network", 2 <sup>nd</sup> Edition, Penram Publications, 1995, ISBN: 978-8187972204.  <b>Reference Books</b> 1. Charu C. Aggarwal, "Neural Networks and Deep learning- A Textbook", 1 <sup>st</sup> Edition, Springer Publications, 2019, ISBN: 978-3319944623. 2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications,	

	<p>1<sup>st</sup> Edition, 1996, ISBN: 978-8125914259.</p> <p>3. Patterson J.,Gibson A., “Deep Learning: A Practitioner’s Approach”, O’Reilly, 1<sup>st</sup> Edition, 2017, ISBN: 978-9352136049.</p>
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO1. Explain concepts of Explainable AI, Edge AI, TinyML.</p> <p>CO2. Demonstrate object classifiers and biomedical systems.</p> <p>CO3. Implement object detection, classification and segmentation using YOLO algorithm.</p> <p>CO4. Develop Biomedical Systems and GANs for practical scenarios.</p>

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : REC-663  
**Title of the Course** : Research Directions in Data Science  
**Number of Credits** : 2 (2L)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Basics of Data Science.	
<b>Course Objectives:</b>	The course will enable the students to: <ol style="list-style-type: none"> <li>1. To explore the foundational tools, technologies, and applications of Big Data, emphasizing its integration with Cloud Computing and IoT in domains like healthcare and smart agriculture.</li> <li>2. To examine real-world applications of data analytics using machine learning techniques and to understand the role of IoT in healthcare and intelligent systems such as traffic management.</li> <li>3. To understand business intelligence fundamentals and develop proficiency in using Power BI for data modeling, transformation, and expression using DAX functions.</li> <li>4. To Illustrate advanced visualization techniques in Power BI, explore AI-enhanced reporting features, and understand report publishing and dashboard creation in the Power BI service.</li> </ol>	
<b>Content:</b>		<b>No. of hours</b>
<b>Unit - 1</b>	<b>Big Data and Big Data Analytics:</b> A review of Tool and its applications <b>Emerging Trends of Big Data in Cloud Computing</b> <b>Big Data in Cloud computing</b> <b>Big Data Analytics in Healthcare:</b> A developing Country Survey <b>Big Data with IoT for Smart Farming</b>	<b>7</b>
<b>Unit - 2</b>	<b>Data Analytics and Its Applications</b> A study on self-regulating traffic Light Control Using RFID and machine Learning algorithm Heart Disease Prediction Using Decision tree and random Forest Classification Techniques Technologies and Applications of Internet of Things (IoT) in Healthcare.	<b>7</b>
<b>Unit - 3</b>	<b>Understanding the Basics:</b> Understanding business intelligence, Concepts of the star and snowflake schema, Power BI as a business intelligence application, Different users of Power BI, Development life cycle in Power BI desktop. <b>Optimize Data Model:</b> Introduction to data modeling, Review and create relationships, Combining queries in Power BI. <b>Data Analysis Expressions:</b> Introduction to DAX, Calculated columns and measures, Mathematical functions, Count functions, Information functions, Logical functions, Filter functions, Date and time functions	<b>8</b>

<p><b>Unit - 4</b></p>	<p><b>Visualizations in Power BI:</b> Introduction to Power BI reports, Standardizing report Development, Creating multi-page reports using visualizations, Filters and slicers.</p> <p><b>Drill Through and Drill Down Reports:</b> Drill through &amp; Drill Down report in Power BI.</p> <p><b>Artificial Intelligence in Power:</b> Why AI visuals are used, AI visuals in Power BI desktop, Narrative Visual, AI in Query Editor.</p> <p><b>Power BI Service:</b> Understanding the Power BI Service, Foundational elements of Power BI service, Publishing reports from the Power BI Desktop</p>	<p><b>8</b></p>
<p><b>Pedagogy:</b></p>	<p>Inquiry Based Learning, Reflective, Integrative Learning</p>	
<p><b>References/ Readings:</b></p>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Sam Gounder and Praveen Kumar Rayani, "Applications of Big Data in large- and small-scale systems", IGI Global publications, 2024,ISSN: 2327.</li> <li>2. Chandraish Sinha , "Mastering Power BI", 2<sup>nd</sup> Edition, bpb publications, 2024, ISBN: 978-9355517166.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Krish Krishnan, "Building Big Data Application", 1<sup>st</sup> Edition, Academic Press Inc, 2015, ISBN: 978-0128157466.</li> <li>2. P.Kaliraj and T. Devi, "Big Data Applications in Industry 4.0", 1<sup>st</sup> Edition, CRC Press, 2020, ISBN: 978-1-032-00811-0.</li> </ol>	
<p><b>Course Outcomes:</b></p>	<p>After taking this course, student will be able to:</p> <p>CO1. Understand Big Data technologies and their role in solving domain-specific problems in healthcare, cloud computing, and smart farming.</p> <p>CO2. Demonstrate machine learning and data analytics techniques to practical IoT-based systems such as intelligent traffic control and healthcare diagnostics.</p> <p>CO3. Design and implement business intelligence solutions using Power BI, including data modeling, transformation, and DAX-based analytics.</p> <p>CO4. Develop interactive dashboards and AI-driven visual reports using Power BI and deploy them through the Power BI service platform</p>	

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : REC-664  
**Title of the Course** : Research Directions in Data Science Lab  
**Number of Credits** : 2 (4P)  
**Effective from AY** : 2025-26

<b>Pre-requisites for the Course:</b>	Basics of data science.	
<b>Course Objectives:</b>	<p>The course will enable the students to:</p> <ol style="list-style-type: none"> <li>1. Explain concepts of import, clean, and transform diverse datasets using Power Query and Power BI's data preparation tools.</li> <li>2. Equip students with skills to create interactive, multi-page reports and dashboards, incorporating drill-down, slicers, and filters for enhanced data exploration.</li> <li>3. Explore the integration of artificial intelligence and cloud-based Power BI services in building scalable and intelligent business intelligence solutions.</li> <li>4. Develop the ability to design relational data models, apply DAX functions for advanced analytics, and perform time-based computations.</li> </ol>	
<b>Content:</b>	<b>List of Programs /Experiments</b>	<b>No. of hours</b>
	<ol style="list-style-type: none"> <li>1. To explore the Power BI Desktop interface and its core functionalities</li> <li>2. To implement data cleaning and transformation operations using Power Query Editor</li> <li>3. To build a star/snowflake schema and establish relationships among tables to create a data model.</li> <li>4. To explore advanced DAX functions for time-based analysis such as YTD, MTD, and logical filters.</li> <li>5. To design visually rich reports with multiple pages, implementing slicers, filters, and custom themes.</li> <li>6. To enable drill-through and drill-down functionalities for hierarchical data navigation.</li> <li>7. To publish reports to Power BI Service, create dashboards, and share them with collaborators.</li> <li>8. Integrate AI features like Key Influencers, Decomposition Trees, and Smart Narratives in reports.</li> <li>9. To evaluate natural language querying capabilities using the Q&amp;A visual</li> <li>10. To develop and share dashboards with collaborative features in Power BI Service</li> <li>11. To develop an interactive dashboard for patient health monitoring and disease prediction analytics</li> <li>12. To implement a Power BI dashboard for monitoring smart farming metrics using IoT data</li> </ol>	<b>60</b>

	<p>13. To analyze key financial performance indicators and risk metrics using Power BI</p> <p>14. To create a multi-source IoT analytics report integrating health and environmental sensors</p> <p>15. To build a complete business intelligence solution starting from data import to final dashboard publishing using a real-world dataset (e.g., sales, healthcare, or IoT data).</p>	
<b>Pedagogy:</b>	Constructive, Collaborative and Inquiry Based Learning	
<b>References/ Readings:</b>	<p><b>Text Books</b></p> <ol style="list-style-type: none"> <li>1. Chandraish Sinha , “Mastering Power BI”, 2<sup>nd</sup> Edition, bpb publications, 2024, ISBN: 978-9355517166.</li> <li>2. Brett Powell,” Mastering Microsoft Power BI: Expert techniques for effective data analytics and business intelligence”, 1<sup>st</sup> Edition, Packt Publishing, 2021, ISBN: 978-1788297233.</li> </ol> <p><b>Reference Books</b></p> <ol style="list-style-type: none"> <li>1. Krish Krishnan, “Building Big Data Application”, 1<sup>st</sup> Edition, Academic Press Inc, 2015, ISBN: 978-0128157466.</li> <li>2. P.Kaliraj and T. Devi, “Big Data Applications in Industry 4.0”, 1st Edition, CRC Press, 2020, ISBN: 978-1-032-00811-0.</li> </ol>	
<b>Course Outcomes:</b>	<p>After taking this course, student will be able to:</p> <ol style="list-style-type: none"> <li>CO1. Explain end-to-end business intelligence solutions in Power BI Service for real-world scenarios including healthcare, IoT, and financial analytics.</li> <li>CO2. Demonstrate proficiency in using Power BI Desktop for data import, cleaning, and transformation from multiple sources using Power Query Editor.</li> <li>CO3. Implement effective data models using star/snowflake schemas and apply DAX functions for custom analytics, including KPIs and time-based measures.</li> <li>CO4. Develop interactive and visually appealing reports and dashboards incorporating advanced features such as drill-through, slicers, smart narratives, and AI visuals.</li> </ol>	

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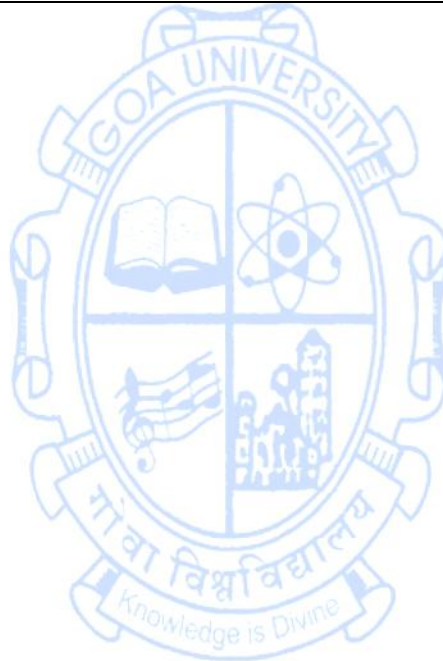
## Generic Elective (GE) Courses

**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : GEC-681  
**Title of the Course** : Sustainability - Principles & Practices  
**Number of Credits** : 03  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Undergraduate level knowledge of any branch of engineering	
<b>Course Objectives:</b>	The course aims to provide the student with an: <ol style="list-style-type: none"> <li>1. Understanding of importance of Sustainability Practices</li> <li>2. Explanation of Assessment, Planning and Implementation of Sustainability Principles</li> <li>3. Description of the steps involved in implementing sustainable solutions</li> <li>4. Apply the knowledge of sustainability practices to real life situations.</li> </ol>	
<b>Content:</b>		<b>No. of Hours</b>
<b>Unit-1</b>	<b>Overview on Global Sustainability Goals (SDGs):</b> Industry-Innovation-Infrastructure, Health & Well Being, Clean Water & Sanitation, Education, Responsible Consumption and production, Climate Action, Quality Education, Economic growth, sustainable community living,	<b>10</b>
<b>Unit-2</b>	<b>Sustainability:</b> Requirements for Sustainability, Approaches towards Sustainable Engineering, Sustainability Challenges, Environmental Challenges; <b>Reasons for Un-sustainability</b> – Economics and Environment, Corporate View of Sustainability, Social Attitude, Approach, Cultural Narratives, Political Aspects, Ethics and Morals. Steps in life cycle impact assessment	<b>13</b>
<b>Unit-3</b>	<b>Sustainability Assessment:</b> Steps in assessing life cycle, data availability, process network analysis, Input-Output Analysis, Hybrid Models; Carbon footprint, Water footprint, Energy analysis of technologies, processes and its economics; Concept of Exergy and Energy Analysis; Ecosystem Services in Sustainability Assessment; Case Studies	<b>10</b>
<b>Unit-4</b>	<b>Solutions for Sustainability:</b> Designing sustainable processes and products; Techno-Economic Analysis; Energy Ecosystem and its dynamic characteristics; Circular Economy; Nature based solutions, Green infrastructure, Techno-ecological synergy; Economic Policies, Societal Developments; Case Studies.	<b>12</b>
<b>Pedagogy</b>	Interactive learning, reflective thinking, critical analysis, and problem-	

	solving.
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403</li> <li>2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457</li> <li>3. Margaret Robertson, 'Sustainability – Principles &amp; Practices', Routledge Publishers, 2017, ISBN: 97811138650244</li> </ol>
<b>Course Outcomes:</b>	<p>After going through this course, student will be able to:</p> <p>CO 1. Understand the importance of sustainability practices</p> <p>CO 2. Assess, Plan and Suggest basic sustainability practices</p> <p>CO 3. Explain the steps involved in implementing sustainable solutions</p> <p>CO 4. Prepare a plan for sustainability practices to real life situations.</p>

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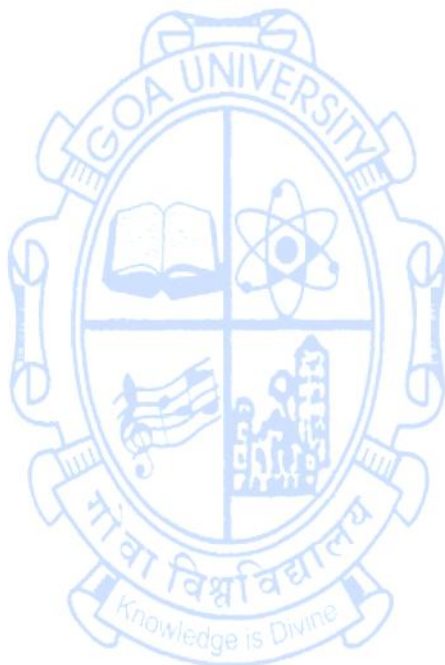


**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : GEC-682  
**Title of the Course** : Sustainability - Principles & Practices Lab  
**Number of Credits** : 01  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Undergraduate level knowledge of any branch of engineering	
<b>Course Objectives:</b>	The course aims to provide the student with an: <ol style="list-style-type: none"> <li>1. Understanding of importance of Sustainability Development Goals (SDG)</li> <li>2. Explanation on Assessment, Planning and Implementation of SDG</li> <li>3. Description of the steps involved in order to achieve the SDG.</li> <li>4. Apply the knowledge of sustainability practices to real life situations.</li> </ol>	
<b>Content:</b>		<b>No. of Hours</b>
	The United Nations has promulgated Sustainable Development Goals (SDGs). Every student has to prepare a detail report and presentation, based relevant literature, field visits and data collection, interaction with experts, on ANY TWO topics of SDG as applied to the local region or State of Goa. <ol style="list-style-type: none"> <li>(1) No Poverty</li> <li>(2) Zero Hunger</li> <li>(3) Good Health &amp; Well Being</li> <li>(4) Quality Education</li> <li>(5) Gender Equality</li> <li>(6) Clean Water &amp; Sanitation</li> <li>(7) Affordable &amp; Clean Energy</li> <li>(8) Decent Work and Economic Growth</li> <li>(9) Industry, Innovation and Infrastructure</li> <li>(10) Reduce Inequalities</li> <li>(11) Sustainable Cities &amp; Communities</li> <li>(12) Responsible Consumption and Production</li> <li>(13) Climate Action</li> <li>(14) Life Below Water</li> <li>(15) Life on Land</li> <li>(16) Peace, Justice &amp; Strong Institutions</li> </ol>	<b>30</b>
<b>Pedagogy</b>	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving	
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403</li> <li>2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457</li> </ol>	

	3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244
<b>Course Outcomes:</b>	<p>After going through this course, student will be able to:</p> <p>CO 1. Understand the importance of sustainability Development Goals (SDGs)</p> <p>CO 2. Assess, Plan and Suggest basic sustainability practices</p> <p>CO 3. Explain the steps involved in order to achieve the SDG</p> <p>CO 4. Prepare a plan for sustainability practices to real life situations.</p>

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : GEC-683  
**Title of the Course** : Project Management  
**Number of Credits** : 03  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Undergraduate level knowledge of any branch of engineering	
<b>Course Objectives:</b>	The course aims to provide the student with an: <ol style="list-style-type: none"> <li>1. Understanding of the various features of project management</li> <li>2. Explanation of the relevance of human resource planning and management</li> <li>3. Describes the importance of procurement planning, cost estimation, and quality management.</li> <li>4. Detailed explanation on time and risk management.</li> </ol>	
<b>Content:</b>		<b>No. of Hours</b>
<b>Unit-1</b>	<b>Overview on Project Management:</b> Need for Project Management, Project Life Cycle and its Phases, Scope of the project, requirements and scope, Organizational Influences, Project Management Plan, Integrated Change Control Plan, Agile Project Management and Lean Project Management, Project selection and portfolio management. <b>Economics &amp; Cost Management:</b> Time Value of Money, Cost-Benefit Ratio, Cost estimation, methods of preparing estimates, budgeting, Cost monitoring and Control, cost on completion.	<b>10</b>
<b>Unit-2</b>	<b>Human Resource Management,</b> Planning Human Recourses, Acquiring human resources, developing and strategizing deployment of resources, leadership qualities, team management – motivation, monitoring and control, conflict management and interpersonal relationship management. Importance of Communication and communication management – tools and techniques; basic human fundamentals, ethics and professional conduct,	<b>12</b>
<b>Unit-3</b>	<b>Procurement Management-</b> Planning, Implementation – Monitoring and control of goods and services; Stakeholders Management, Contracts drafting, preparation, approval, implementation and closure. <b>Quality Management:</b> Introduction, quality planning tools and techniques, quality monitoring and control, tools and techniques,	<b>13</b>
<b>Unit-4</b>	<b>Time Management:</b> Purpose of Time Management, Time Planning, different methods of activity planning, milestones,	<b>10</b>

	<p>resource assignment and time lines. Time monitoring and control - different types of charts; Path Planning – forward, backward, critical, lag and lead time lines.</p> <p><b>Risk Management</b> – Risk Identification, Risk Qualitative Analysis, Risk Quantitative Analysis, Risk Response, Monitoring and Control</p>	
<b>Pedagogy</b>	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. J. Michael Bennet, Danny S.K. Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928.</li> <li>2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6<sup>th</sup> Edn, Taylor &amp; Francis Publications, 2021, ISBN: 978-0-367-277730-7</li> <li>3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769.</li> <li>4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.</li> </ol>	
<b>Course Outcomes:</b>	<p>After going through this course, student will be able to:</p> <p>CO 1. Explain the importance of Project Management</p> <p>CO 2. Describe the various components of Project Management</p> <p>CO 3. Analyze the importance of cost, human resource, procurement, quality, time and risk management</p> <p>CO 4. Apply project management knowledge in their professional life.</p>	

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : GEC-684  
**Title of the Course** : Project Management Lab  
**Number of Credits** : 01  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Undergraduate level knowledge of any branch of engineering	
<b>Course Objectives:</b>	The course aims to provide the student with an: <ol style="list-style-type: none"> <li>1. Understanding of the various features of project management</li> <li>2. Explanation of the relevance of applying project management knowledge to any one domain</li> <li>3. Describes the advantages of applying project management tools &amp; techniques to address specific problems</li> <li>4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management</li> </ol>	
<b>Content:</b>		<b>No. of Hours</b>
	 <p>Project Management is applicable to all types of Human Activities. Every Student has to choose ANY TWO topics, prepare a detail report and presentation, based relevant literature, field visits and data collection, interaction with experts in the local region or State of Goa.</p> <p>The student shall apply project management knowledge to any ONE topics given below, the list is only indicative, students can choose topics from related / allied areas:</p> <ol style="list-style-type: none"> <li>(1) Large construction site (on-going projects) – residential, commercial, highways, ports, airports</li> <li>(2) Large Manufacturing Industry in any of the Industrial Areas in Goa, scaling up production, sales / marketing.</li> <li>(3) Waste Management; Water Management;</li> <li>(4) Application of Project Management to Law Enforcement</li> <li>(5) Project Management in Education – infrastructure, skill training</li> <li>(6) Project Management as applied to consumer goods / supplies</li> <li>(7) Manpower Management in the context of AI in software industry</li> <li>(8) Project Management – Global markets for local products using Digital Marketing platforms</li> <li>(9) Project management for Logistics and Transportation</li> <li>(10) Project management for Hospital &amp; Health Management</li> </ol>	<b>30</b>
<b>Pedagogy</b>	Instructional learning, Inquiry based learning, Constructive learning,	

	Collaborative learning and problem solving
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928.</li> <li>2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6<sup>th</sup> Edn, Taylor &amp; Francis Publications, 2021, ISBN: 978-0-367-277730-7</li> <li>3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769.</li> <li>4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.</li> </ol>
<b>Course Outcomes:</b>	<p>After going through this course, student will be able to:</p> <p>CO 1. Understanding of the various features of project management</p> <p>CO 2. Explanation of the relevance of applying project management knowledge to any one domain</p> <p>CO 3. Describes the advantages of applying project management tools &amp; techniques to address specific problems</p> <p>CO 4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management</p>

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## SEMESTER IV

### Generic Elective (GE) Courses

**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : GEC-685  
**Title of the Course** : Financial Management  
**Number of Credits** : 04  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic knowledge of Finance, Economics	
<b>Course Objectives:</b>	The course aims to provide the student with an: <ol style="list-style-type: none"> <li>1. Understanding of Financial Systems and Its Management</li> <li>2. Explanation of Financial Planning, Fund Flow and Cost Analysis</li> <li>3. Analysis of Capital &amp; Working Capital Management, Valuation, Long Term Financing</li> <li>4. Description of product cost analysis, break even analysis and investment management.</li> </ol>	
<b>Content:</b>		<b>No. of Hours</b>
<b>Unit-1</b>	<b>Financial Management: An Overview</b> – Types of Business organizations, Fundamental principle of finance. <b>The Financial System-</b> Functions, Financial Assets and Markets, <b>Financial Statements, Taxes, and Cash Flow-</b> Balance Sheet, Profit and loss Account, Profits Vs Cash Flow, Taxes; Financial decision making.	<b>15</b>
<b>Unit-2</b>	<b>Financial Statement Analysis-</b> Financial Ratios- Liquidity Ratios, Leverage & Profitability Ratios; <b>Fund Flow Analysis</b> - Fund Flow Statement; <b>Breakeven Analysis and Leverages-</b> Cost Volume Profit Analysis; <b>Financial Planning &amp; Forecasting-</b> Financial Planning, Sales Forecast; <b>Cost Analysis-</b> Determination of product cost, overhead cost, volume and profits, planning and control on costs and decision making using costs.	<b>16</b>
<b>Unit-3</b>	<b>Fundamental Valuation Concepts</b> -The Time Value of Money, Risk and Return. <b>Capital Budgeting</b> -Techniques of Capital Budgeting – Capital Budgeting Process, project classification; cash flows, risk analysis, cost of capital; <b>Investment Criteria-</b> Net Present value, Benefit Cost Ratio, Internal Rate of return, Payback Period, Accounting rate of Return.	<b>15</b>

<b>Unit-4</b>	<b>Working Capital Management</b> -Working Capital Policy, Cash and Liquidity Management, Credit Management, Inventory Management, Working Capital Financing; <b>Corporate Valuation:</b> Debt analysis and management, Leasing, Hire Purchase, Valuation, Mergers, acquisitions and Restructuring; <b>Long Term Financing:</b> Sources of Long Term Finance, Raising Long Term Finance.	<b>14</b>
<b>Pedagogy</b>	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Prasanna Chandra “Financial Management: Theory and Practice” 11th Edition, McGraw Hill Education Publishers, 2023, ISBN: 978-9355-322-203</li> <li>2. Pandey I.M., Finance- A Management Guide for Managing Company Funds and Profits, Prentice Hall India Publications, 1995, ISBN:978-8120-309-180</li> <li>3. Van Horne, J.C, “Fundamentals of Financial Management”, 13th Edition, Pearson Publications, 2015, ISBN:978-933-255-8670.</li> <li>4. Khan, M.Y. and Jain, P.K., “Financial Management”, 8th Edition, McGraw-Hill Education Publishers, 2018, ISBN:978-9353-1622-184</li> </ol>	
<b>Course Outcomes:</b>	<p>After going through this course, student will be able to:</p> <p>CO 1. Understand the Financial Systems and Its Management</p> <p>CO 2. Explain Financial Planning, Fund Flow and Cost Analysis</p> <p>CO 3. Analyze Capital &amp; Working Capital Management, Valuation, Long Term Financing</p> <p>CO 4. Describe product cost analysis, break even analysis and investment management.</p>	

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**Name of the Programme** : Master Of Engineering (Artificial Intelligence and Data Science)  
**Course Code** : GEC-686  
**Title of the Course** : Entrepreneurship  
**Number of Credits** : 04  
**Effective from AY** : 2024-25

<b>Pre-requisites for the Course:</b>	Basic knowledge of Creative Thinking, Innovation, Finance, Economics	
<b>Course Objectives:</b>	The course aims to provide the student with an: <ol style="list-style-type: none"> <li>1. Understanding of entrepreneurial skill sets and different types of entrepreneurship.</li> <li>2. Explanation of Differences between New Enterprise, Social Enterprise and Family Business</li> <li>3. Describes the process of preparing business plan, operational plans to start an enterprise</li> <li>4. Apply the knowledge of market analysis, product planning, customer requirements, costing and finance</li> </ol>	
<b>Content:</b>		<b>No. of Hours</b>
<b>Unit-1</b>	<b>Entrepreneurial Characteristics:</b> Overview on Entrepreneurship, Broad classification of entrepreneurs; Leadership, Goal Setting, Time and resource Planning, Communication, Networking, Knowledge & Skill Upgradation; Awareness of Social and Industrial Eco-system; Awareness of Government Policies and Schemes; Digital marketing and business promotion; Local and global market; Basic understanding of Legal and regulatory system, Intellectual Property Rights; Financial Literary; Decision making and risk taking abilities	<b>18</b>
<b>Unit-2</b>	<b>Creation of New Enterprise:</b> Creativity, Innovation, technology, wealth creation, social impact, Team building, Business Plan, project formulation and feasibility analysis; business simulation; designing and configuring business models and customers, Enterprise management tools and techniques; Launching and managing enterprises; Sales & Marketing Strategies; Human Resources; Incubation, Costing and Financial Plans, Case Studies	<b>14</b>
<b>Unit-3</b>	<b>Social Entrepreneurship:</b> Overview, project formulation and feasibility analysis; understanding customer needs, positioning the firm for social change and strategic advantage; social business model; participatory development; stakeholders; social impact assessment; networking; regional economic models; banking and loans; Women Entrepreneurship; Case Studies	<b>14</b>

<b>Unit-4</b>	<b>Family Business Management</b> : Small and Medium Business Enterprises; Growth plan formulation; Vision, Values and Strategies, Turn around strategies, cost management, finance and liquidity, family to corporate culture; Case Studies;	<b>14</b>
<b>Pedagogy</b>	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Nagasubba Rayudu, 'A Textbook on Entrepreneurship &amp; Incubation', Mahi Publications, 2023, ISBN: 978811949282</li> <li>2. Balasubramanya. M.H., 'Entrepreneurial Ecosystems for Tech Startup in India', Verlag Max Publications, 2021, 9783110679298.</li> <li>3. Kenji Uchino, 'Entrepreneurship for Engineers', CRC Press, 2010, ISBN: 978143980063</li> <li>4. Ryszard Praszquier, Andrzej Nowak, 'Social Entrepreneurship', Theory and Practice, Cambridge University Press, 2011, ISBN 9781139504331</li> <li>5. Peter Leach, Tatwamasi Dixit, 'Indian Family Business Mantras', Rupa Publications, 2016, ISBN: 9788129136945</li> <li>6. Bill Bolton, John Thompson, 'Entrepreneurs – Talent, Temperament, Opportunity', Elsevier Publications, 2004, ISBN:0750661283</li> <li>7. John Bessant, Joe Tidd, 'Entrepreneurship', John Wiley Publications, 2015, ISBN: 9781118993095</li> </ol>	
<b>Course Outcomes:</b>	<p>After going through this course, student will be able to:</p> <p>CO 1. Understand entrepreneurial skill sets and different types of entrepreneurship.</p> <p>CO 2. Classify New Enterprise, Social Enterprise and Family Business</p> <p>CO 3. Explain process of preparing business plan, operational plans to start an enterprise</p> <p>CO 4. Apply the knowledge of market analysis, product planning, customer requirements, costing and finance</p>	

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