



GU/Acad –PG/BoS -NEP Engg. /2024-25/503

Date: 18.10.2025

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP Engg. /2024-25/782 dated 27.01.2025

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

The Dean, Faculty of Engineering and Principals of affiliated Colleges offering the **Master of Engineering in Computer Science and Engineering (Artificial Intelligence and Machine Learning)** 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 IN COMPUTER SCIENCE AND ENGINEERING (ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)
RC 2024-25

TWO YEAR PROGRAMME STRUCTURE						
Semester I						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-500	Modern Algorithms and Data Structures	3	0	0	3
2	CAM-501	Modern Algorithms and Data Structures Lab	0	0	1	1
3	CAM-502	Mathematical Foundations for Computer Science	4	0	0	4
4	CAM-503	Artificial Intelligence	3	0	0	3
5	CAM-504	Artificial Intelligence Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
6	CAM-531	Image and Video Processing	4	0	0	4
OR						
7	CAM-532	Bio-inspired Computing	4	0	0	4
Research Specific Elective (RSE) Courses						
8	REC-561	Engineering Research & Publications	3	1	0	4
OR						
9	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
TOTAL			17	1	2	20
Semester II						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-505	Machine Learning	3	0	0	3
2	CAM-506	Machine Learning Lab	0	0	1	1
3	CAM-507	Speech and Natural Language Processing	3	0	0	3
4	CAM-508	Speech and Natural Language Processing Lab	0	0	1	1
5	CAM-509	Data and Visual Analytics	3	0	0	3
6	CAM-510	Data and Visual Analytics Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
7	CAM-533	Cloud Computing	3	0	0	3
8	CAM-534	Cloud Computing Lab	0	0	1	1
OR						
9	CAM-535	Pattern Recognition	3	0	0	3
10	CAM-536	Pattern Recognition Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
11	REC-563	Statistics and Data Analysis for Engineering Research	2	0	0	2
12	REC-564	Statistics and Data Analysis Lab	0	0	2	2
OR						
13	REC-565	Statistical Techniques for Engineering Research	2	0	0	2
14	REC-566	Probability and Statistical Analysis lab	0	0	2	2
TOTAL			14	0	6	20

Semester III						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-600	Deep Learning	3	0	0	3
2	CAM-601	Deep Learning Lab	0	0	1	1
3	CAM-602	Optimization Techniques in Machine Learning	3	0	0	3
4	CAM-603	Optimization Techniques in Machine Learning Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	CAM-631	Brain Computer Interface	3	0	0	3
6	CAM-632	Brain Computer Interface Lab	0	0	1	1
OR						
7	CAM-633	Recommender Systems	3	0	0	3
8	CAM-634	Recommender Systems Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
9	CAM-661	Digital Forensics	2	0	0	2
10	CAM-662	Digital Forensics Lab	0	0	2	2
OR						
11	CAM-663	Social Network Analysis	2	0	0	2
12	CAM-664	Social Network Analysis Lab	0	0	2	2
General Elective Course (GEC)						
13	GEC-681	Sustainability - Principles & Practices	3	0	0	3
14	GEC-682	Sustainability - Principles & Practices Lab	0	0	1	1
OR						
15	GEC-683	Project Management	3	0	0	3
16	GEC-684	Project Management Lab	0	0	1	1
TOTAL			14	0	6	20
Semester IV						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
General Elective Course (GEC)						
1	GEC-685	Financial Management	4	0	0	4
OR						
2	GEC-686	Entrepreneurship	4	0	0	4
Program Specific Dissertation/Internship						
3	CAM-698	Dissertation	0	0	0	16
OR						
4	CAM-699	Internship	0	0	0	16
TOTAL			4	0	0	20

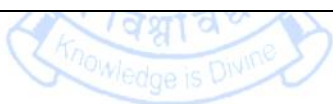
THREE YEAR PROGRAMME STRUCTURE						
Semester I						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-502	Mathematical Foundations for Computer Science	4	0	0	4
Programme Specific Elective (PSE) Courses						
2	CAM-531	Image and Video Processing	4	0	0	4
OR						
3	CAM-532	Bio-inspired Computing	4	0	0	4
Research Specific Elective (RSE) Courses						
4	REC-561	Engineering Research & Publications	3	1	0	4
OR						
5	REC-562	Literature Review & Technical Writing for Engineers	3	1	0	4
TOTAL			11	1	0	12
Semester II						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-505	Machine Learning	3	0	0	3
2	CAM-506	Machine Learning Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
3	CAM-533	Cloud Computing	3	0	0	3
4	CAM-534	Cloud Computing Lab	0	0	1	1
OR						
5	CAM-535	Pattern Recognition	3	0	0	3
6	CAM-536	Pattern Recognition Lab	0	0	1	1
Research Specific Elective (RSE) Courses						
7	REC-563	Statistics and Data Analysis for Engineering Research	2	0	0	2
8	REC-564	Statistics and Data Analysis Lab	0	0	2	2
OR						
9	REC-565	Statistical Techniques for Engineering Research	2	0	0	2
10	REC-566	Probability & Statistical Analysis lab	0	0	2	2
TOTAL			8	0	4	12



Semester III						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-500	Modern Algorithms and Data Structures	3	0	0	3
2	CAM-501	Modern Algorithms and Data Structures Lab	0	0	1	1
3	CAM-503	Artificial Intelligence	3	0	0	3
4	CAM-504	Artificial Intelligence Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	CAM-631	Brain Computer Interface	3	0	0	3
6	CAM-632	Brain Computer Interface Lab	0	0	1	1
OR						
7	CAM-633	Recommender Systems	3	0	0	3
8	CAM-634	Recommender Systems Lab	0	0	1	1
TOTAL			9	0	3	12
Semester IV						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-507	Speech and Natural Language Processing	3	0	0	3
2	CAM-508	Speech and Natural Language Processing Lab	0	0	1	1
3	CAM-509	Data and Visual Analytics	3	0	0	3
4	CAM-510	Data and Visual Analytics Lab	0	0	1	1
Generic Elective (GE) Course						
5	GEC-681	Sustainability - Principles & Practices	3	0	0	3
6	GEC-682	Sustainability - Principles & Practices Lab	0	0	1	1
OR						
7	GEC-683	Project Management	3	0	0	3
8	GEC-684	Project Management Lab	0	0	1	1
TOTAL			9	0	3	12



Semester V						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
Programme Specific Core (PSC) Courses						
1	CAM-600	Deep Learning	3	0	0	3
2	CAM-601	Deep Learning Lab	0	0	1	1
3	CAM-602	Optimization Techniques in Machine Learning	3	0	0	3
4	CAM-603	Optimization Techniques in Machine Learning Lab	0	0	1	1
Programme Specific Elective (PSE) Courses						
5	CAM-661	Digital Forensics	2	0	0	2
6	CAM-662	Digital Forensics Lab	0	0	2	2
OR						
7	CAM-663	Social Network Analysis	2	0	0	2
8	CAM-664	Social Network Analysis Lab	0	0	2	2
TOTAL			8	0	4	12
Semester VI						
Sr. No.	Course Code	Title of the Course	L	T	P	Credits
General Elective Course (GEC)						
1	GEC-685	Financial Management	4	0	0	4
OR						
2	GEC-686	Entrepreneurship	4	0	0	4
Program Specific Dissertation/Internship						
3	CAM-698	Dissertation	0	0	0	16
OR						
4	CAM-699	Internship	0	0	0	16
TOTAL			4	0	0	20



SEMESTER I

Programme Specific Core (PSC) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-500

Title of the course : Modern Algorithms and Data Structures

Number of credits : 3(3L)

Effective from AY : 2024-25

Pre-requisites for the Course:	Basics of Data Structures	
Course Objectives:	<ol style="list-style-type: none"> 1. The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem. 2. To familiarize students with advanced paradigms and data structure used to solve algorithmic problems. 3. Student should be able to come up with analysis of efficiency and proofs of correctness. 	
Contents:	TOPICS	No of Hours
UNIT 1	Algorithm Analysis: Mathematical Background, Running time computation. Abstract Data Types (ADTs): The List ADT, The Stack ADT, The Queue ADT, The Search Tree ADT-Binary Search Trees. Trees: Binary Trees, AVL Trees, Splay Trees, B-trees, Tree Traversals	12
UNIT 2	Hashing: Hash Function, Separate Chaining, Hash Tables without Linked Lists, Rehashing, Extendible Hashing. Priority Queues (Heaps): Binary Heap, Application of Priority Queues, d-heap, Leftist Heaps, Skew Heaps, Binomial Queues.	11
UNIT 3	Sorting: A General Lower Bound for Sorting, Bucket Sort, External Sorting Graph Algorithms: Definition, Topological Sort, Shortest-Path Algorithms, Network Flow Problems, Minimum Spanning Tree, Applications of Depth-First Search Algorithm Design Techniques: Greedy Algorithms, Divide and Conquer, Dynamic Programming, Randomized Algorithms, Backtracking Algorithms	11
UNIT 4	Amortized Analysis: Binomial Queues, Skew Heaps, Fibonacci Heaps Advanced Data Structures: Top-Down Splay Trees, Red-Black Trees, Deterministic Skip Lists, AA-Trees, Treaps, k-d Trees, Pairing Heaps.	11
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/	Text Books:	

<p>Readings:</p>	<ol style="list-style-type: none"> 1. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C++", 3rd edition, Pearson Education, 2009 2. T. H Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, "Introduction to Algorithms ", Prentice Hall of India, 2001. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Aaron M. Tenenbaum, Yedidiah Langsam, Moshe J. Augenstein, "Data Structures Using C", Eastern Economy Edition, 2008 2. Michael Garey and David Johnson, Computers and Intractability, A guide to the theory of NP- Completeness, W.H. Freeman and Company, New York, 1999 3. G. Brassard and Bratley, Fundamentals of Algorithmic, Prentice. Hall 1996. 4. Sara Baase, Allen Van Gelder, "Computer Algorithms: Introduction to design and Analysis ", Addison Wesley, 2000.
<p>Course Outcomes:</p>	<p>CO 1. Demonstrate the use of advanced data structures like trees, and heaps.</p> <p>CO 2. Demonstrate how the different algorithm design approaches are used to solve various classes of engineering problems</p> <p>CO 3. Apply the knowledge of data structures to a given problem.</p> <p>CO 4. Illustrate searching, sorting and hashing techniques by identifying suitable data structures and algorithms.</p>

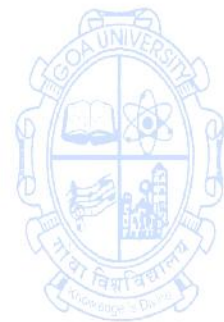
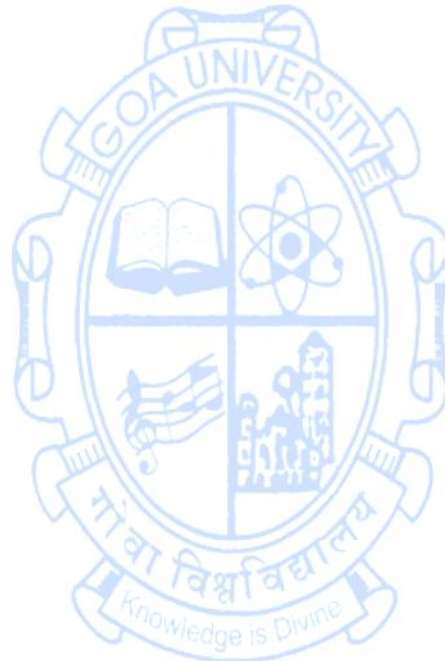
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-501
Title of the course : Modern Algorithms and Data Structures Lab
Number of credits : 1
Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of programming in any higher-level languages.	
Course Objectives:	This course will enable students to: 1. To apply appropriate data structures, and the ADT/libraries to design algorithms for an application. 2. To familiarize advanced paradigms and data structure used to solve algorithmic problems. 3. To analysis the efficiency of an algorithm and to provide proofs of correctness.	
Contents:		No of Hours
	Minimum 8 experiments to be done.	30
List of Experiments:	1. Implementation of Binary trees. 2. Implementation of AVL Trees 3. Implementation of Splay trees. 4. Implementation of B trees. 5. Implementation of hash functions and associated algorithms 6. Implementation of operations on binary heaps 7. Implementation of operations on Leftist heaps 8. Implementation of operations on binomial queues 9. Implementation of Dijkstra’s algorithm 10. Implementation of a problem using dynamic programming. 11. Implementation of a problem using backtracking 12. Implementation of operations on Fibonacci heaps 13. Implementation of Red-Black trees.	
Pedagogy:	Constructivist, collaborative, integrative and inquiry-based approach.	
References/ Readings:	Text Books: 1. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C++”, 3rd edition, Pearson Education, 2009 2. T. H Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, "Introduction to Algorithms ", Prentice Hall of India, 2001. Reference Books: 1. Aaron M. Tenenbaum, Yedidyah Langsam, Moshe J. Augenstein, “Data Structures Using C”, Eastern Economy Edition, 2008 2. Michael Garey and David Johnson, Computers and Intractability, A guide to the theory of NP- Completeness, W.H. Freeman and Company, New York, 1999 3. G. Brassard and Bratley, Fundamentals of Algorithmic, Prentice. Hall 1996. 4. Sara Baase, Allen Van Gelder, "Computer Algorithms: Introduction to design and Analysis ", Addison Wesley, 2000.	

Course Outcomes:	CO1: Demonstrate the use of modern data structures in problem solving. CO2: Apply different algorithm design approaches to solve various classes of engineering problems CO3: Analyse the space and time requirements to solve the given problem. CO4: Illustrate the working of an algorithms and to prove its correctness.
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-502
Title of the course : Mathematical Foundations for Computer Science
Number of credits : 4(4L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Basics of probability and matrices	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. To understand the mathematical fundamentals that is prerequisites for a variety of courses like Data mining, Network protocols, Analysis of Web traffic, 2. Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning. 3. The foundational concepts of Mathematics for Machine Learning like Linear Algebra, Vector Calculus, Probability and Distributions, Analytical geometry, Matrix decompositions and Optimization 	
Contents:	TOPICS	No of Hours
UNIT 1	<p>Introduction, Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings.</p> <p>Analytic Geometry: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Gram-Schmidt orthogonalization process, QR decomposition.</p>	15
UNIT 2	<p>Analytic Geometry: Orthogonal Projections, Rotations.</p> <p>Matrix Decompositions: Determinant and Trace, Least Squares solution, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, LU decomposition, Matrix Approximation, Eckart-Young Theorem.</p>	15
UNIT 3	<p>Vector Calculus: Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradient Descent algorithm, optimization using gradient descent, 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, Constrained optimization and Lagranges multiplier method.</p>	15
UNIT 4	<p>Probability and Distributions: Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform, Applications of univariate and multivariate central limit theorem.</p>	15

	Bernoulli and Poisson processes, Markov chains, limit theorems
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, “Mathematics for Machine Learning”, Cambridge University Press, 2020 <p>Reference Books</p> <ol style="list-style-type: none"> 1. Dimitri P. Bertsekas and John N. Tsitsiklis, “Introduction to Probability” 2nd edition, Athena Scientific. 2008 2. David C Lay, “Linear Algebra and Its Applications”, 3rd edition, Pearson Education India, 2010 3. Jay Dawani, “Hands-On Mathematics for Deep Learning: Build a solid mathematical foundation for training efficient deep neural networks”, Packt Publishing Limited, 2020 4. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, The MIT Press, 2016
Course Outcomes:	<p>After going through this course, the students will be able to:</p> <p>CO 1. Understand the need and importance of various foundational mathematical concepts for Machine Learning.</p> <p>CO 2. Apply the important concepts in Linear Algebra, Analytic Geometry, Matrix Decompositions, Vector Calculus and Probability & Distributions required for different applications in Machine Learning.</p> <p>CO 3. Compare and contrast various mathematical techniques.</p> <p>CO 4. Analyze the need and usage of the basic optimization techniques used in Machine Learning.</p>

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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-503

Title of the course : Artificial Intelligence

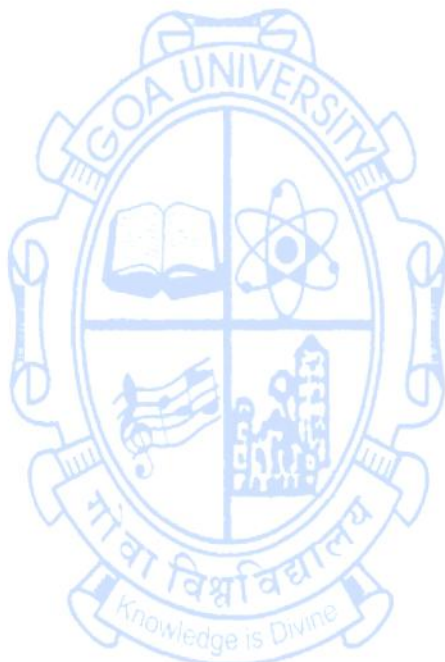
Number of credits : 3(3L)

Effective from AY : 2024-25

Pre- requisites for the Course:	Basic Data Structures	
Course Objectives:	This course will enable students to: 1. To establish theoretical knowledge and understanding in the field of Artificial Intelligence and identify its possible applications. 2. To learn various important search strategies in AI. 3. To learn the methods of solving problems using Artificial Intelligence	
Contents:	TOPICS	No of Hours
UNIT 1	Introduction to Artificial Intelligence Searching techniques: State Space Search- Depth First Search, Breadth first Search, Depth First Iterative Deepening. Heuristic Search- Best First Search, Hill Climbing, Beam Search, Tabu Search. Randomized Search- Simulated annealing, Genetic Algorithms, Ant colony optimization.	12
UNIT 2	Finding Optimal Paths: Branch and Bound, A*, IDA*, Divide and Conquer approaches, Divide and Conquer Beam Stack Search. Problem Decomposition: Goal Trees, AO*, Rule Based Systems, Rule Based Expert Systems Game Playing: Minimax Algorithm, Alpha Beta Algorithm	12
UNIT 3	Constraint Satisfaction: Constraint Propagation, Algorithm Backtracking Knowledge Based Reasoning: Agents, Facets of Knowledge. Logic and Inferences: Propositional Logic, Resolution method in Propositional Logic, First Order Logic, Resolution Refutation in FOL, Forward and Backward Chaining	11
UNIT 4	Planning: Domains, Forward and Backward State Space planning, Goal Stack Planning, Plan Space Planning, Planning graph. Knowledge Representation: Frames, Semantic nets, Description Logics. Reasoning under uncertainty: Model Based Diagnosis	10
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning,	
References/ Readings:	Text Books 1. Deepak Khemani, A First Course in Artificial Intelligence, ISBN: 978-1-25-902998-1, McGraw Hill Education (India) 2013. Reference Books 1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Third edition, ISBN :10: 0136042597, Pearson, 2003 2. Elaine Rich, Kevin Knight and Nair, Artificial Intelligence, ISBN-978-0-	

	07-008770-5, TMH, 2000
Course Outcomes:	<p>After going through this course, the students will be able to:</p> <p>CO 1. Understand the foundation of AI and apply various search algorithms to identify optimal solutions in state spaces.</p> <p>CO 2. Compare strengths and weaknesses of different Artificial Intelligence techniques</p> <p>CO 3. Apply AI algorithms for solving practical problems</p> <p>CO 4. Analyze the suitability of knowledge models and search algorithms to solve any AI application.</p>

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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-504
Title of the course : Artificial Intelligence Lab
Number of credits : 1
Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of programming in any higher-level languages.	
Course Objectives:	This course will enable students: 1. To implement algorithms of typical AI problems to enhance the theoretical knowledge and understanding in the field of Artificial Intelligence. 2. To identify the suitability of techniques to develop A.I. applications. 3. To learn the methods of solving AI problems using knowledge bases.	
Contents:		No of Hours
	Students must undertake minimum of 8 programming exercises.	30
List of Experiments:	<ol style="list-style-type: none"> 1. Program to solve any problem using Depth First search. 2. Program to solve any problem using Best First search. 3. Program to solve any problem using Best First search 4. Program to implement Beam Search 5. Program to implement Hill climbing problem 6. Program to implement Alpha Beta search 7. Program to solve any problem using A* algorithm 8. Program to solve any problem using Min-max algorithm 9. Program to solve Traveling salesman problem 10. Program to solve Monkey banana problem 11. Program to solve Missionaries and Cannibals problem 	
Pedagogy:	Constructivist, collaborative, integrative and inquiry-based approach, Innovation-conducive pedagogy, digital pedagogical competency.	
References/ Readings:	Text Books 1. Deepak Khemani, A First Course in Artificial Intelligence, ISBN: 978-1-25-902998-1, McGraw Hill Education (India) 2013. Reference Books 1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Third edition, ISBN :10: 0136042597, Pearson, 2003 2. Elaine Rich, Kevin Knight and Nair, Artificial Intelligence, ISBN-978-0-07-008770-5, TMH, 2000 3. Ela Kumar, I.K. Artificial Intelligence, International Publishing House Pvt. Ltd. 2008.	
Course Outcomes:	CO 1. Develop solutions for various Artificial Intelligence problems. CO 2. Discriminate the suitability of different search techniques. CO 3. Apply AI problem solving techniques to solve real world problems. CO 4. Demonstrate the working of Artificial Intelligence algorithms to solve problems	

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Programme Specific Elective (PSE) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-531

Title of the course : Image and Video Processing

Number of credits : 4(4L)

Effective from AY : 2024-25

Pre- requisites for the Course:	Basics of Computer Graphics	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Introduce the fundamental concepts of digital image processing and video analysis. 2. Understand the image processing techniques in the spatial domain. 3. Give the usage of image restoration, compression and segmentation techniques. 4. Study the basic concepts of video processing. 	
Contents:	TOPICS	No of Hours
UNIT 1	<p>Introduction to Image Processing: Digital Image Representation, Sampling and quantization of an Image, Basic relationship between pixels</p> <p>Digital Image Transforms: 2-D Discrete Fourier Transform, Properties of Fourier Transform, Discrete cosine Transform, Hadamard Transform, Haar Transform.</p> <p>Image enhancement in Spatial Domain: Intensity transformations, Histogram processing, Fundamentals of Spatial filtering, Smoothing spatial filters, Sharpening Spatial filters.</p>	15
UNIT 2	<p>Image Restoration: Introduction to Image restoration, Degradation model, Noise Models, Restoration in the presence of Noise only-Spatial Filtering, Inverse Filtering, Least Mean Square Filters, Constrained Least Squares Restoration.</p> <p>Color Image Processing: Color Fundamentals, Color Models, Pseudo color image processing, Basics of Full Color image processing.</p>	15
UNIT 3	<p>Image Compression: Fundamentals - coding Redundancy, spatial and temporal redundancy, Irrelevant information, Compression models: Lossy & Lossless, Huffmann coding, Arithmetic coding, run length coding, transform coding, predictive coding, JPEG standards.</p> <p>Image segmentation: Point, line and edge detection, Thresholding, Basic Global Thresholding using Otsu's method, region based segmentation, region growing by region splitting and merging.</p>	15
UNIT 4	<p>Steps in Video Processing: Analog video, Digital video, Time varying image formation model, Geometric image formation, Sampling of video signal.</p> <p>2-D Motion Estimation: Optical flow, Pixel based motion</p>	15

	<p>estimation, Region based Motion estimation, Multi resolution motion estimation, Application of motion estimation in video coding.</p> <p>Video compression: Video compression standards - H.261, MPEG-1, MPEG-2.</p>	
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	<p>TEXT BOOKS:</p> <ol style="list-style-type: none"> 1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Third Edition, Addison Wesley, 2008. 2. A Murat Tekalp, Digital Video Processing, PEARSON, 2010 <p>REFERENCE BOOKS:</p> <ol style="list-style-type: none"> 1. Rafael C. Gonzalez, Richard E Woods and Steven L. Eddins, Digital Image Processing using MAT LAB, Pearson Edu., 2004 2. Yao Wang, Joem Ostermann and Ya–quin Zhang. Video Processing and Communication 1st Ed., PH Int, 2006 3. Anil K. Jain, Fundamentals of Digital Image Processing, First Edition, Pearson Education, 2015 4. Milan Sonka, Vaclan Hlavac, Image Processing Analysis and Machine Vision, 3rd edition, CENGAGE, 2008 5. S.Jayaraman, S.Esakkirajan, T.Veera Kumar, Digital Image Processing, 2nd edition TMH, 2020 	
Course Outcomes:	<p>At the end of the course, the students will be able to:</p> <p>CO 1. Identify the fundamental concepts of digital image processing system.</p> <p>CO 2. Evaluate the techniques for image enhancement, image restoration and image segmentation.</p> <p>CO 3. Categorize various image compression techniques.</p> <p>CO 4. Utilize the fundamental methods of video processing for a specific video.</p>	

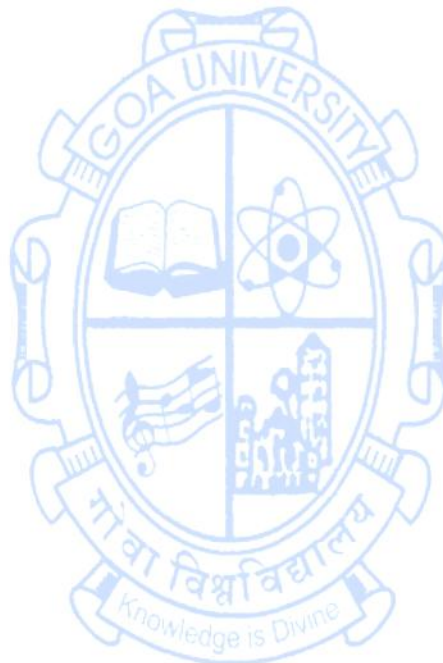
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-532
Title of the course : Bio Inspired Computing
Number of credits : 4(4L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Fundamentals of Artificial Intelligence and Algorithms	
Course Objectives:	<ol style="list-style-type: none"> 1. To understand the fundamentals of nature inspired techniques which influence computing. 2. To study the Swarm Intelligence and Immuno computing techniques. 3. To familiarize the DNA Computing and Genetic Computing techniques. 	
Contents:	TOPICS	No of Hours
UNIT 1	Introduction: From Nature-to-Nature Computing, Philosophy, Three Branches: A Brief Overview, Individuals, Entities and agents - Parallelism and Distributivity Interactivity, Adaptation-Feedback-Self-Organization-Complexity, Emergence and Reductionism, Bottom-up Vs Top-Down- Determination, Chaos and Fractals.	15
UNIT 2	Biological Databases and Data Search Methods: Importance of databases, biological databases, primary sequence databases, composite sequence databases, secondary databases. Computing Inspired by Nature: Evolutionary Computing, Hill Climbing and Simulated Annealing, Darwin's Dangerous Idea, Genetics Principles, Standard Evolutionary Algorithm -Genetic Algorithms, Reproduction-Crossover, Mutation, Evolutionary Programming, Genetic Programming	15
UNIT 3	Swarm Intelligence: Ant Colonies, Ant Foraging Behaviour, Ant Colony Optimization, SACO and scope of ACO algorithms, Ant Colony Algorithm (ACA), Swarm Robotics, Foraging for food, Social Adaptation of Knowledge, Particle Swarm Optimization (PSO)	15
UNIT 4	Computing With New Natural Materials: DNA Computing: Motivation, DNA Molecule, Adleman's experiment, Test tube programming language, Universal DNA Computers, PAM Model, Splicing Systems, Lipton's Solution to SAT Problem, Scope of DNA Computing, From Classical to DNA Computing	15
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	<p>Text Books:</p> <ol style="list-style-type: none"> 1. Leandro Nunes de Castro, " Fundamentals of Natural Computing, Basic Concepts, Algorithms and Applications", Chapman & Hall/ CRC, Taylor and Francis Group, 2007 2. T K Attwood, D J Parry-Smith, "Introduction to Bioinformatics", Pearson Education, 2005 <p>Reference Books:</p>	

	<ol style="list-style-type: none"> 1. Floreano D. and Mattiussi C., "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", MIT Press, Cambridge, MA, 2008. 2. Albert Y.Zomaya, "Handbook of Nature-Inspired and Innovative Computing", Springer, 2006. 3. Marco Dorigo, Thomas Stutzle," Ant Colony Optimization", PHI,2005
Course Outcomes:	<p>CO 1. Apply nature inspired algorithms to real world problems.</p> <p>CO 2. Analyze nature inspired algorithms</p> <p>CO 3. Compare various natural systems functions (operations)</p> <p>CO 4. Choose appropriate algorithms for specific applications.</p>

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Research Specific Elective (RSE) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : REC-561

Title of the course : Engineering Research & Publication

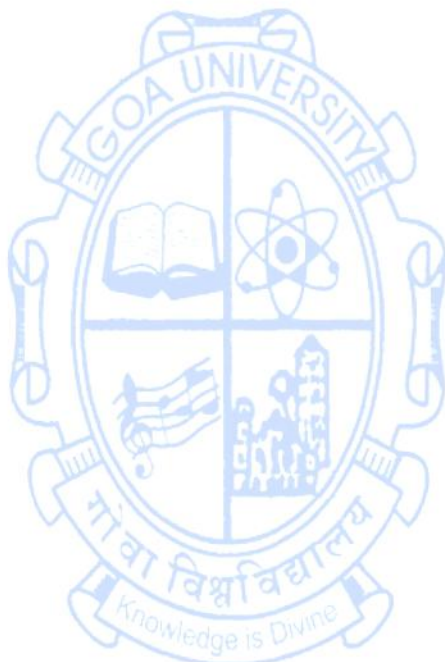
Number of credits : 4(3L+1T)

Effective from AY : 2024-25

Pre-requisites for the Course:	Knowledge of research requirements in real life	
Course Objectives:	<p>The course will enable the students to</p> <ol style="list-style-type: none"> 1. Understand the importance of literature review, defining the research objectives. 2. Explain qualitative and quantitative methods of data analyses and its importance. 3. Classify research publications, select appropriate journals based on research areas. 4. Practice ethics in publication and academic integrity 	
Content:		No of Hours
Unit -1	Overview of scientific research in engineering , foundational and fundamental concepts like types of research and considerations for research in specific domains, motivation to do research, critical thinking, assumptions and hypotheses, basic and applied research, importance of formulation of broad research objectives	11 + 4T
Unit -2	Purpose and Methodology of Literature Search and Review of the scientific and engineering publications. Sources such as scholarly databases, public domain, open access, current literature, review articles, critical review and gap analysis, defining research objectives	11 + 4T
Unit -3	Quantitative and qualitative Data – importance of data in research, types of data, data collection techniques, Quantitative methods for analysis of data – statistical tools, mathematical modeling, simulation, experimental data, optimization methods; Qualitative data collection, preparing questioners, rating scale, conducting survey, validation of models.	12 + 4T
Unit- 4	Preparation of Publications- Elements of research publications, types of publications, writing for journal publications, basic requirements for publication, selection of journals, journal quality indicators, peer review, reply to comments and responses, publication ethics, references, citations, authorship, plagiarism, academic integrity	11 + 3T
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning , Constructive learning and Collaborative learning	
References/ Readings:	1. Herman Tang, 'Engineering Research-Design, Methods and Publications', John Wiley and Sons, 2021, ISBN:9781119624486.	

	<ol style="list-style-type: none"> 2. Michael Jay Katz, 'From Research to Manuscript', Springer Publication, 2009, ISBN:9781402094668. 3. Rob Dekkers, Lindsey Casey, Peter Langhorne, 'Making Literature Review Work', Springer Publications, 2022, ISBN:9783030900243 4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.
Course Outcomes:	<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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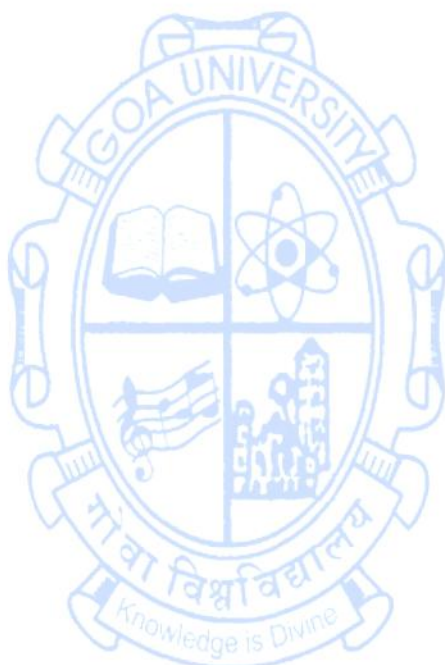


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : REC-562
Title of the course : Literature Review & Technical Writing for Engineers
Number of credits : 4(3L + 1T)
Effective from AY : 2024-25

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

	4. Meikang Qiu, Han Qiu, Yi Zeng, 'Research & Technical Writing for Science and Engineering', Taylor & Francis Publications, 2022, ISBN:9781003139058.
Course Outcomes:	<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 : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-505
Title of the course : Machine Learning
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Artificial Intelligence.	
Course Objectives:	The course will enable the students: <ol style="list-style-type: none"> 1. To gain knowledge on supervised and unsupervised Learning techniques. 2. To be able to formulate machine learning problems corresponding to different applications 3. To understand a range of machine learning algorithms along with their strengths and weaknesses 	
Content:		No. of hours
Unit - 1	Introduction: Learning problems, Designing a learning system, Issues in machine learning. Concept Learning. Types of machine learning: supervised, unsupervised, reinforcement. Testing ML algorithms: Overfitting, Training, Testing and Validation sets, Confusion matrix, Accuracy metrics, ROC Curve, Unbalanced datasets. Bias-Variance tradeoff Supervised learning: Linear Regression, Logistic Regression, Generalized Linear Models. Instance based learning - k-Nearest Neighbour Learning	11
Unit - 2	Tree based learning - Decision Tree Representation, Decision Tree Learning Algorithms – ID3, CART, hypothesis space search, Inductive bias and issues in decision tree learning Bayesian Learning: Bayes Theorem, Maximum Likelihood and Least squared error hypothesis, Minimum Description Length principle, Bayes Optimal classifier, Gibbs Algorithm, Naive Bayes classifier, Bayesian belief network	11
Unit - 3	Unsupervised Learning: Introduction to clustering, similarity / dissimilarity measures, clustering criteria, Types of Clustering: Hierarchical- Agglomerative Clustering and Divisive clustering, Partitional Clustering - K-means clustering, Density based clustering- DBSCAN, Cluster validation, Self organizing maps Evaluating Machine Learning algorithms and Model Selection	12

	Ensemble Learning-Boosting, Bagging, Random Forest	
Unit – 4	Artificial Neural Networks–Perceptron’s, Gradient descent and the Delta Rule, Multilayer Networks, Backpropagation Algorithm Convergence, Generalization. Reinforcement Learning-The learning process, Markov Decision Process	11
Pedagogy:	Inquiry Based Learning, Reflective, Integrative Learning	
References/ Readings:	Text Books: 1. Tom Mitchell, Machine Learning, McGraw Hill Inc, 1997 2. Stephen Marsland, Machine Learning, An Algorithmic Perspective, Second Edition Reference Books: 1. Introduction to Machine Learning Edition 2, by Ethem Alpaydin 2. Christopher Bishop, Pattern recognition and machine learning , Springer Verlag 3. Pang-Ning Tan, Michael Steinbach and Vipin Kumar “Introduction to Data Mining”, Pearson Education, 2007.	
Course Outcomes:	CO 1. Apply the suitable learning methods for real-world problems CO 2. Analyze various machine learning methods for real-world problems CO 3. Evaluate the performance of machine learning algorithms CO 4. Identify and integrate more than one technique to enhance the performance of learning	

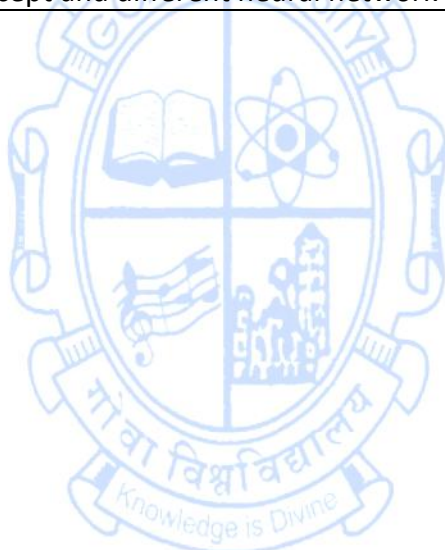
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-506
Title of the course : Machine Learning Lab
Number of Credits : 1(1P)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of python programming.	
Course Objectives:	<p>The course will enable the students to:</p> <ol style="list-style-type: none"> 1. Understand the concepts of Machine learning and learn about Python libraries. 2. Demonstrate the knowledge of various supervised learning algorithms. 3. Implement Python programs for data clustering, transformation and dimensionality reduction techniques. 4. Illustrate knowledge of logic functions, linear and non-linear separability concept and different training rules. 	
Content:	List of Programs /Experiments	No. of hours
	<ol style="list-style-type: none"> 1. Data Collection and various preprocessing operations 2. Overview of Python machine learning libraries. 3. Implementation of Linear regression 4. Implementation of ID3 algorithm to construct a decision tree. 5. Implementation of Decision tree classifier C4.5. 6. Implementation of Random Forest algorithm. 7. Implementation of KNN classifier. 8. Implementation of Naive Bayes Classifier. 9. Implementation of Hierarchical clustering algorithm (agglomerative) 10. Implementation of Hierarchical clustering algorithm. (Partition based) 11. Implementation of clustering using SOM. 12. Implementation of K-Means clustering. 13. Implementation of Neural network-based Logic functions 14. Implementation of Neural network perceptron learning rule. 15. Implementation of Hebbian learning rule. <p>Minimum 10 experiments to be performed from above list.</p>	30
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 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. 	

	<p>4. Tom M Mitchell, Machine Learning, Indian edition, McGraw Hill Publication, 1997.</p> <p>Reference Books</p> <ol style="list-style-type: none"> 1. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Prentice Hall of India, 4th Edition, 2020. 2. J. Zurada, "Introduction to Artificial neural network", Jaico Publications. 3. Satish Kumar, "Neural Networks A Classroom Approach", VISIONIAS Publication, 2nd Edition, 2020
<p>Course Outcomes:</p>	<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 : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-507
Title of the course : Speech and Natural Language Processing
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	This course will enable students to: <ol style="list-style-type: none"> 1. Learn the fundamental theories and principles of speech and natural language processing. 2. Gain proficiency in automatic speech recognition (ASR) and text-to-speech (TTS) synthesis methods. 3. Master key NLP techniques such as tokenization, parsing, and named entity recognition. 4. Develop skills to conduct research and analyze current advancements in speech and NLP. 	
Contents:	TOPICS	No of Hours
UNIT 1	Introduction: Knowledge in Speech and Language Processing, Ambiguity, Models and Algorithms, Language, Thought, and Understanding. Regular Expressions, Words and Transducer. N-Grams Language Modeling: Language Models, Training and Test Sets, Smoothing Techniques: Laplace smoothing, Discounting, Interpolation and Backoff, Kneser Ney Smoothing.	11
UNIT 2	Part of Speech Tagging: English word classes, Tagsets for English, Part of speech tagging, HMM POS tagging, Transformation based POS tagging, Practical Issues, Maximum entropy markov model. Formal Grammars for English Syntax Parsing: Context Free Grammars, CKY Parsing, the Earley Algorithm, Probabilistic CFG, Probabilistic CKY Parsing. Dependency Parsing	11
UNIT 3	Lexical Semantics: Word Senses, Relations between senses, WordNet, Event Participants. Word-Sense Disambiguation: Supervised Word Sense Disambiguation, WSD Evaluation, Baselines, and Ceilings, WSD: Dictionary and Thesaurus Methods, Minimally Supervised WSD: Bootstrapping Information Extraction: Named Entity Recognition, Relation detection and classification, Temporal and Event Processing, Template Filling.	12
UNIT 4	Phonetics: Speech Sounds and Phonetic Transcription, Articulatory Phonetics, Phonological Categories and Pronunciation Variation, Acoustic Phonetics and Signals Speech Synthesis: Text Normalization, Phonetic Analysis, Prosodic Analysis.	11

	Automatic Speech Recognition Architecture Dialogue and Conversational Agents Question Answering and Summarization	
References/ Readings:	Text Books: 1. Dan Jurafsky and James Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Prentice Hall, Second Edition, 2009. 2. Chris Manning and Hinrich Schütze. Foundations of Statistical Natural Language Processing. MIT Press, Cambridge, MA: May 1999. Reference books: 1. J. Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019. 2. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana. 2020. Practical Natural Language Processing. O'Reilly. 3. Hobson Lane, Cole Howard, Hannes Hapke. 2019. Natural Language Processing in Action. Live Book.	
Course Outcomes:	CO 1. Identify the fundamental concepts and terminology in speech and natural language processing and explain the processes involved in speech and natural language processing. CO 2. Apply theoretical models to analyze and interpret linguistic data. CO 3. Implement basic NLP algorithms and models to solve practical language processing problems. CO 4. Design and develop an original NLP application or conduct a research project that addresses a specific problem in the field.	

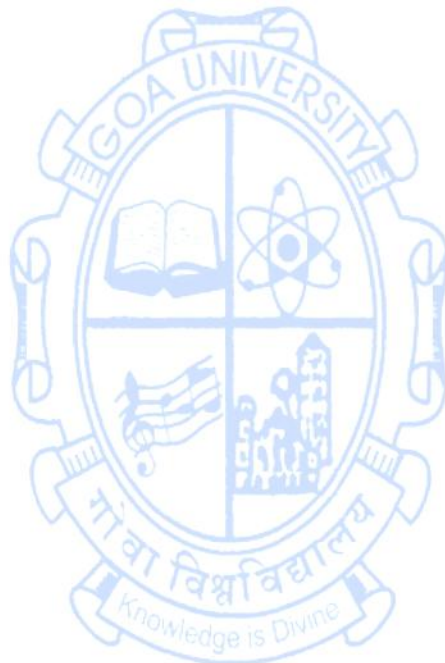
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : CAM-508
Title of the course : Speech and Natural Language Processing Lab
Number of Credits : 1(1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	This course will enable students to: <ol style="list-style-type: none"> 1. Understand the key concepts of NLP. 2. Implement various concepts like POS tagging, parsing in NLP. 3. Understand and implement concepts in speech processing 4. Implement various applications of NLP and speech processing. 	
Contents:		No of Hours
List of Experiments:	Students must undertake minimum of 8 programming exercises <ol style="list-style-type: none"> 1. Perform a case study on the NLTK, Spacy and Flair toolkits for NLP in Python. Compare the distinct features of each. 2. Develop a program to implement: Search using Regular Expressions, word Tokenizer, Sentence and Paragraph Tokenizers. 3. Develop a program to generate Unigrams, Bi-grams, and Tri-grams from a given corpus. Further extend the program to compute the respective probabilities. 4. Develop a program to perform stopword elimination, stemming and lemmatization of the given corpus. 5. Develop a program to implement POS tagging in a given corpus. 6. Develop a program to implement CYK Parsing. 7. Develop a semantic analyser using at least two machine learning techniques. Compare the accuracy of the two techniques. 8. Develop a program to perform Named Entity Recognition. 9. Develop a basic speech to text converter for speech recorded in English. 10. Develop a Python code for Fake News detection using NLP. 	30
References/ Readings:	Text Books: <ol style="list-style-type: none"> 1. Dan Jurafsky and James Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Prentice Hall, Second Edition, 2009. 2. Chris Manning and Hinrich Schütze. Foundations of Statistical Natural Language Processing. MIT Press, Cambridge, MA: May 1999. Reference books: <ol style="list-style-type: none"> 1. J. Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019. 	

	<ol style="list-style-type: none"> 2. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana. 2020. Practical Natural Language Processing. O'Reilly. 3. Hobson Lane, Cole Howard, Hannes Hapke. 2019. Natural Language Processing in Action. Live Book.
Course Outcomes:	<p>CO 1. Analyze speech features and NLP tasks, identifying key components and relationships.</p> <p>CO 2. Implement NLP algorithms accurately and effectively.</p> <p>CO 3. Develop advanced speech processing solutions, such as speech-to-text or sentiment analysis.</p> <p>CO 4. Create innovative speech and NLP solutions using modern tools and methods.</p>

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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-509
Title of the course : Data and Visual Analytics
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Introduce the concepts of Data and Visual Analytics. 2. Teach fundamental techniques of data visualization using R programming. 3. Understand and learn about the tools required to manage and analyze Big Data with Hadoop, MapReduce, Yarn and the Hadoop ecosystem. 4. Enable students to have skills that will help them to solve complex real-world problems for decision support 	
Contents:	TOPICS	No of Hours
UNIT 1	<p>Basic Data Analytics: Need of Data analytic lifecycle, Key roles for successful analytic projects.</p> <p>Phases of Data analytic lifecycle: Discovery, Data Preparation, Model Planning, Model Building, Communicating Results, Operationalization.</p> <p>Data Visualization: Data for Graphics, Design principles, Value for visualization, Introduction to D3.js, Environmental setup, Data loading in D3, Bar chart with D3, Line Chart, Area Chart, Histogram.</p>	11
UNIT 2	<p>Introduction to R: Data types in R, Basic operations, Basic statistics, Generic functions, Data wrangling in R.</p> <p>Data Analytics with R: Supervised learning, Unsupervised learning, Collaborative Filtering.</p> <p>Data Visualization using R: ggplot2, Bar Charts, Histograms, Pie Charts, Scatter plots, Line Plots and Regression, Box Plots, Creating Map.</p>	11
UNIT 3	<p>Hadoop: Hadoop Overview, Architecture, Features of Hadoop, Key advantages of Hadoop, RDBMS V/s Hadoop, Distributed Computing challenge.</p> <p>HDFS: Design of HDFS, Command line interface, Hadoop File systems Interface, Anatomy of HDFS File read, Anatomy of HDFS File write, Limitations.</p> <p>YARN: Overview of YARN, Process flow, Managing Resources and Applications with Hadoop YARN, Interacting with Hadoop Ecosystem.</p>	11
UNIT 4	<p>Map-Reduce Programming: Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression. Word Count Example.</p> <p>Hadoop Ecosystem: Introduction to Pig, Execution Modes of Pig,</p>	12

	Comparison of Pig with Databases, Grunt, Pig Latin, Hive architecture, Running Hive, Configuring Hive, Hive Services, Hive data type, File format, Hive Query Language, RCFile implementation	
References/ Readings:	<p>Text Books:</p> <ol style="list-style-type: none"> 1. “Data Science & Big Data Analytics”, David Dietrich, Barry Hiller, EMC education services, Wiley publications, 2012. 2. Mark gardner, “Beginning R: The Statistical Programming Language”, Wrox Press (WILEY), 2012. 3. Tom White, “Hadoop: The Definitive Guide”, First Edition, O’REILLY Publication <p>Reference books:</p> <ol style="list-style-type: none"> 1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education services Wiley Publication 2. Practical Statistics for Data Scientists 50+ Essential Concepts Using R and Python, O’Reilly Publications 2nd Edition 	
Course Outcomes:	<p>CO 1. Demonstrate the Data Analytics Lifecycle to address big data analytics projects.</p> <p>CO 2. Illustrate the appropriate data visualizations to clearly communicate analytic insights through R Language.</p> <p>CO 3. Apply appropriate analytical techniques and tools.</p> <p>CO 4. Analyze big data and create statistical models using Hadoop and its ecosystem.</p>	

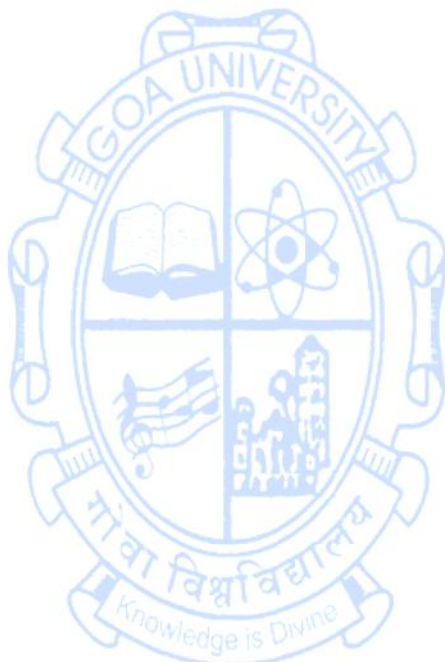
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : CAM-510
Title of the course : Data and Visual Analytics Lab
Number of Credits : 1(1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Introduce the concepts of Data and Visual Analytics. 2. Teach fundamental techniques of data visualization using R programming. 3. Understand and learn about the tools required to manage and analyze Big Data with Hadoop, MapReduce, Yarn and the Hadoop ecosystem. 4. Enable students to have skills that will help them to solve complex real-world problems for decision support 	
Contents:		No of Hours
List of Experiments:	<p>Students must undertake minimum of 8 programming exercises</p> <ol style="list-style-type: none"> 1. Create a simple bar chart to display categorical data using D3. 2. Plot a line chart to represent time series data using D3. 3. Create a histogram to show the distribution of numerical data using D3. 4. Implementation of Calculator application using R. 5. Implementation of Visualization in R. 6. Implementation and use of data frames and performing data Manipulation with dplyr package. 7. Installation, configuration and running of Hadoop and HDFS. 8. Implementation of Word Count Program using Map-Reduce. 9. Implementation of application that stores big data in Pig using R 10. Implement basic querying capabilities using Hive. 	30
References/ Readings:	<p>Text Books:</p> <ol style="list-style-type: none"> 1. "Data Science & Big Data Analytics", David Dietrich, Barry Hiller, EMC education services, Wiley publications, 2012. 2. Mark gardner, "Beginning R: The Statistical Programming Language", Wrox Press (WILEY), 2012. 3. Tom White, "Hadoop: The Definitive Guide", First Edition, O'REILLY Publication <p>Reference books:</p> <ol style="list-style-type: none"> 1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education services Wiley Publication 2. Practical Statistics for Data Scientists 50+ Essential Concepts Using R and Python, O'Reilly Publications 2nd Edition 	

Course Outcomes:	CO 1. Demonstrate data visualization using D3 CO 2. Illustrate the appropriate data visualizations to clearly communicate analytic insights through R Language. CO 3. Apply appropriate analytical techniques and tools. CO 4. Analyze big data and create statistical models using Hadoop and its ecosystem.
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Programme Specific Elective (PSE) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-533

Title of the course : Cloud Computing

Number of Credits : 3(3L)

Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. To introduce the fundamentals and essentials of Cloud Computing to the students. 2. To provide a foundation of Cloud Computing to the students so that they can use and adopt Cloud Computing services and tools. 3. To motivate the students to explore some important cloud computing driven commercial systems and applications in the industry. 4. To provide sufficient foundations to the students to enable further study and research. 	
Contents:	TOPICS	No of Hours
UNIT 1	<p>Introduction to cloud computing, Enabling Technologies (SOA and Virtualization), cloud computing Characteristics, SLA-management, cloud computing deployment and service delivery models.</p> <p>Cloud Infrastructure : Historical Perspective of Data Centers, Datacenter Components and design considerations, Resource management in cloud (Provisioning, allocation and mapping),Cloud Application Design & Development with service delivery models (IaaS,PaaS,SaaS), Open source and commercial support for cloud and Industry case studies of cloud platforms (Microsoft, Apache, Amazon, IBM,Eucalyptus, Google, SAP, salesforce and other cloud platforms etc).</p>	11
UNIT 2	<p>Cloud Storage: Introduction to Storage Systems, Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB etc), Cloud Object Storage (Amazon , OpenStack Swift, Ceph FS).</p> <p>Hypervisors and Virtualization techniques with approaches and different types, case studies on VMware/Xen/KVM, Cloud-based/big data/real time analytics, security issues in Cloud computing environments.</p>	11
UNIT 3	<p>Mobile cloud computing (MCC)- MbaaS and architecture, key features and requirements of MCC, advantages ,disadvantages and challenges of MCC, applications of MCC.</p> <p>Fog Computing (FC): architecture, benefits and limitations, difference between fog and cloud computing, use-cases of FC, resource management and challenges of FC, case study on cloud-fog-edge computing and Geospatial cloud.</p> <p>Introduction to green and sensor cloud frameworks with advantages, disadvantages and challenges.</p>	11

<p>UNIT 4</p>	<p>Introduction to Docker, Docker features, Docker components and architecture. Container concept, VMs and Containers, Working of Dockers. Software Defined Networks (SDN)- need, architecture, key ideas, opportunities and challenges of SDN Introduction to Dew, Serverless Computing and FaaS Model, sustainable cloud computing, Case Studies and Recent trends, advancements and challenges in Next generation cloud computing.</p>	<p>12</p>
<p>References/ Readings:</p>	<p>Text Books:</p> <ol style="list-style-type: none"> 1. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley,2011 2. Cloud Computing (concepts and technologies) Sunil Kumar Malvi and Gopal Kumar Shyam, CRC Press, First edition. 3. Cloud Computing by Sandeep Bhowmik Cambridge University press, First edition <p>Reference books:</p> <ol style="list-style-type: none"> 1. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010 2. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India,2010 3. Essentials of Cloud Computing K Chandrasekaran, CRC Press, First Edition. 4. Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press, 2010 	
<p>Course Outcomes:</p>	<p>CO 1. Compare the advantages and disadvantages of various cloud computing platforms. CO 2. Analyze the performance, scalability, and availability of the underlying cloud technologies and software. CO 3. Solve a real-world problem using cloud computing through group collaboration. CO 4. Summarize the different cloud service providers and recent advancements in cloud computing.</p>	

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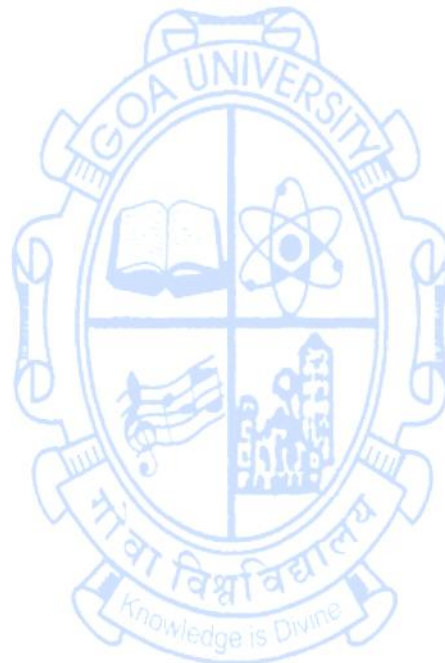
Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : CAM-534
Title of the course : Cloud Computing Lab
Number of Credits : 1(1P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Analyze the components of cloud computing showing how business agility in an organization can be created. 2. Evaluate the deployment of different services from cloud architecture. 3. Critique the consistency of services deployed from a cloud architecture. 4. Compare and contrast the benefits delivered by various cloud models based on application requirements, economic constraints and business requirements. 	
Contents:		No of Hours
List of Experiments:	<p>Students must undertake minimum of 8 programming exercises</p> <ol style="list-style-type: none"> 1. Study and deployment of service delivery models (IaaS). 2. Study and deployment of service delivery models (PaaS). 3. Study and deployment of service delivery models (SaaS). 4. Study of various virtualization techniques in cloud. 5. Study on various cloud storage architectures. 6. Study and deployment various cloud deployment models 7. Resource management with Mobile cloud computing . 8. Resource Management with Fog and Edge Computing. 9. Study and deployment of Docker architectures. 10. Study and deployment of Software defined networking 11. Study on Hadoop and Map reduce architecture. . 12. Case study on developing secure applications on cloud. 13. Study and analysis of dew/serverless/FaaS computing 	30
References/ Readings:	<p>Text Books:</p> <ol style="list-style-type: none"> 1. Gautam Shroff; Enterprise Cloud Computing Technology Architecture Applications; Cambridge University Press; 1st edition; 2010. 2. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010 <p>Reference books:</p> <ol style="list-style-type: none"> 1. Mastering Cloud Computing; Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, McGraw Hill, 1/e/2013 2. *Students are advised to refer to the resources available in Internet for more information. 	

**Course
Outcomes:**

- CO 1. Explain the principles of Cloud Computing.
- CO 2. Describe the architecture of Cloud Computing Resources.
- CO 3. Demonstrate the applications of Cloud Computing for Business.
- CO 4. Apply the skills and knowledge to incorporate agility in an organization

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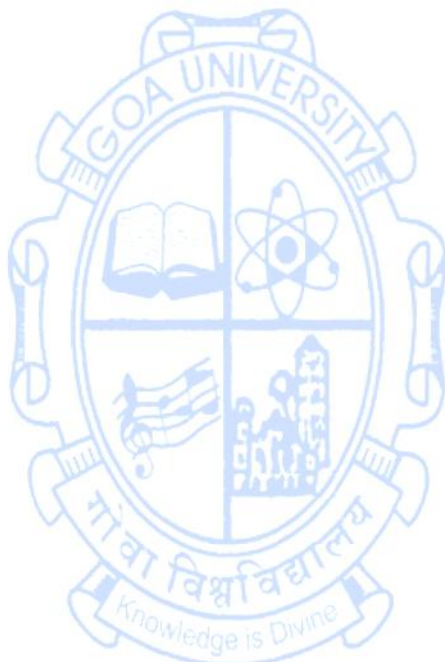
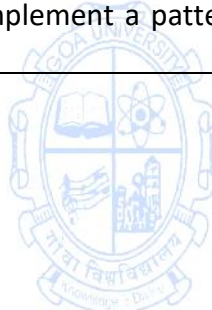


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-535
Title of the course : Pattern Recognition
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Vector spaces and Linear Algebra, Algorithms, Probability theory.	
Course Objectives:	This course will enable students to: 1. Introduce the concepts of pattern recognition. 2. Understand the fundamentals of neural network models. 3. Describe feature selection and feature generation algorithms. 4. Study applications of pattern recognition.	
Contents:	TOPICS	No of Hours
UNIT 1	Introduction: Importance of Pattern Recognition, Simple pattern recognition model, Applications, Fundamental problems in pattern recognition system design, Feature Vectors and Classifiers, Supervised and Unsupervised learning. Parameter Estimation Methods: Gaussian mixture models, Expectation-Maximization method for parameter estimation, Maximum entropy estimation.	11
UNIT 2	Non-parametric techniques: Parzen-window method, K-Nearest Neighbour method. Linear Discriminant Functions: Gradient descent procedures, Support Vector Machines, Multi-Class Classification, Nonlinearity and Kernel Methods	11
UNIT 3	Sequential Pattern Recognition: Hidden Markov Models (HMMs), Discrete HMMs, Continuous HMMs. Feature Selection: Pre-processing, Feature selection based on statistical hypothesis testing, Class separability measures, Feature subset selection.	11
UNIT 4	Feature Generation: Dimensionality Reduction, Singular Value Decomposition, Linear Discriminant Analysis (LDA), Principal, PCA, Kernel PCA, Factor Analysis. Applications of Pattern Recognition: Bio-metric, OCR, Facial recognition, Finger prints.	12
References/ Readings:	Text Books: 1. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001 2. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009 3. C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006 Reference books: 1. Gose. Johnsonbaugh, Jost. Pattern recognition and Image Analysis, PHI. 1996 2. Tou. Rafael. Gonzalez. Pattern Recognition Principle, Pearson	

	Education. 1975
Course Outcomes:	<p>At the end of the course, the students will be able to:</p> <p>CO 1. Outline basic concepts of pattern recognition.</p> <p>CO 2. Apply feature selection and generation algorithms in pattern recognition.</p> <p>CO 3. Compare different pattern recognition techniques.</p> <p>CO 4. Design and implement a pattern recognition model for a real- time application.</p>

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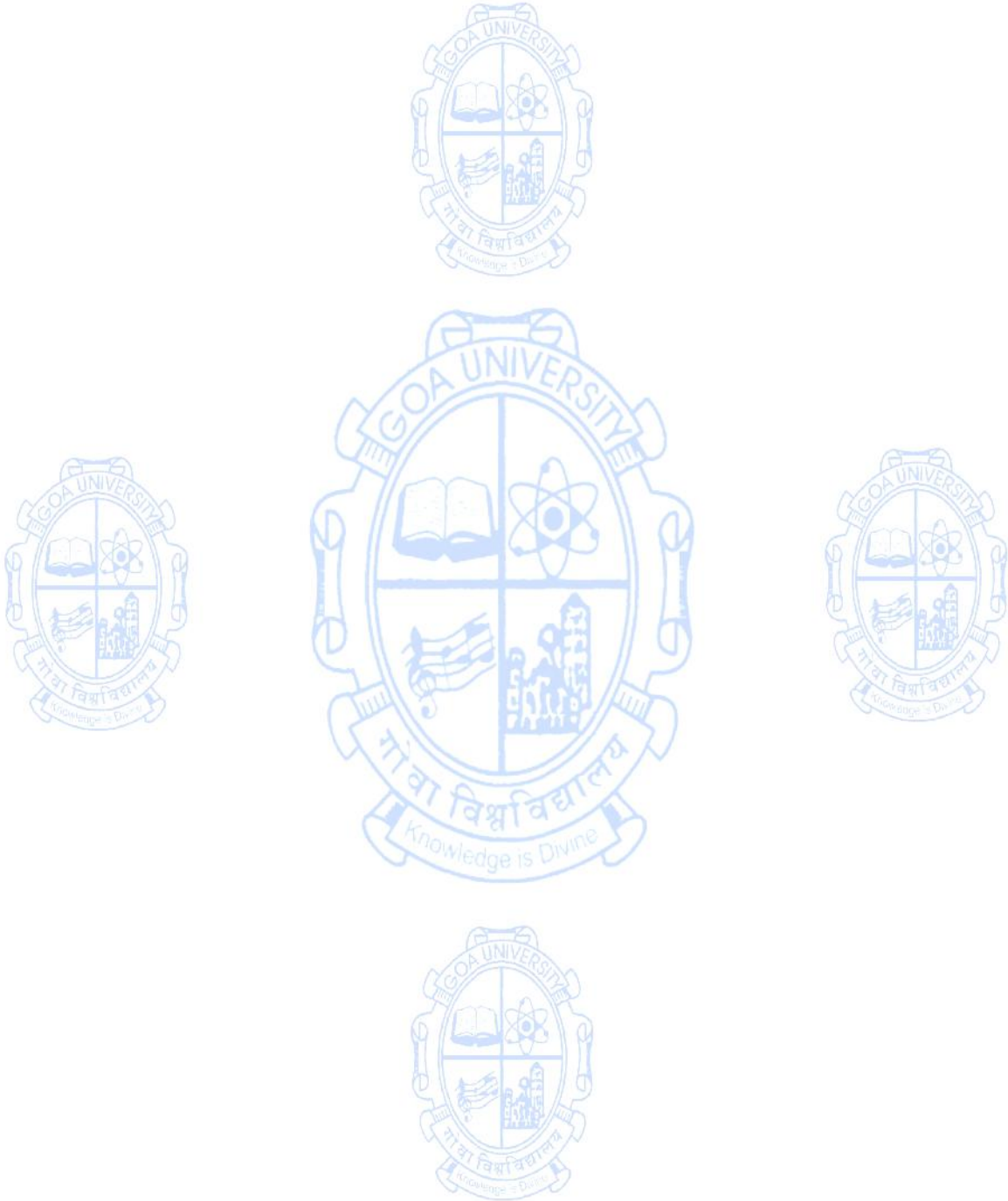


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : CAM-536
Title of the course : Pattern Recognition Lab
Number of Credits : 1(1P)
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of python programming.	
Course Objectives:	The course will enable the students to: 1. Understand the concepts of Pattern Recognition and learn about Python libraries. 2. Demonstrate the knowledge of linear discriminant functions 3. Implement Python programs for Non-parametric techniques. 4. Illustrate knowledge of Feature selection and feature generation techniques.	
Contents:		No of Hours
List of Experiments:	Students must undertake minimum of 8 programming exercises 1. Study experiment on pattern Recognition. 2. Loading the data set and calculate basic statistics such as Mean, Mode and standard deviation. 3. Implementation of KNN classifier. 4. Implementation of Gradient Descent algorithm. 5. Implementation of SVM classifier. 6. Implement Bayesian classification for different decision surfaces. 7. Implement feature selection techniques. 8. Implement feature reduction techniques. 9. Implement linear discriminant functions. 10. Implementing Hidden Markov Models for speech analysis	30
References/ Readings:	Text Books: 1. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001 2. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009 3. C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006 Reference books: 1. Gose. Johnsonbaugh, Jost. Pattern recognition and Image Analysis, PHI. 1996 2. Tou. Rafael. Gonzalez. Pattern Recognition Principle, Pearson Education. 1975	
Course Outcomes:	After taking this course, student will be able to: CO 1. Outline basic concepts of pattern recognition. CO 2. Apply feature selection and generation algorithms in pattern recognition. CO 3. Compare different pattern recognition techniques.	

	CO 4. Design and implement a pattern recognition model for a real- time application.
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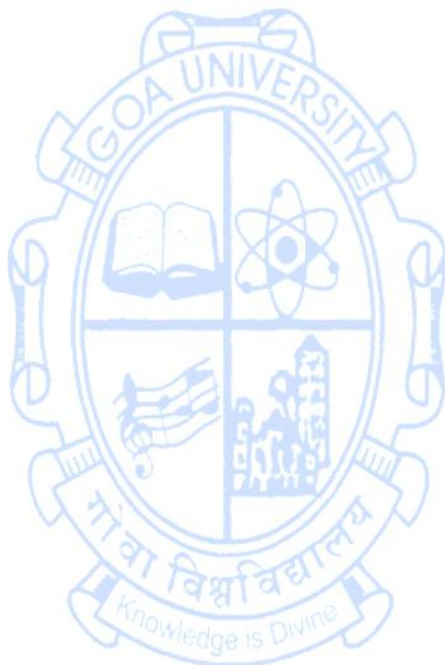
Research Specific Elective (RSE) Courses

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

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

	<ol style="list-style-type: none"> 3. D. C. Montgomery, C. G. Runger, 'Applied Statistics and Probability for Engineers', 6th Edition, Wiley India, 2016, ISBN 0-471-20454-4 4. R. E. Walpole, R. H. Myers, S. L. Myers, K. E. Ye; Probability and Statistics for Engineers and Scientists ,9th Edition, Pearson Education India, 2013, ISBN 978-0-321-62911-1 5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5th Edition, John Wiley & Sons, 2022.
Course Outcomes:	<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 & 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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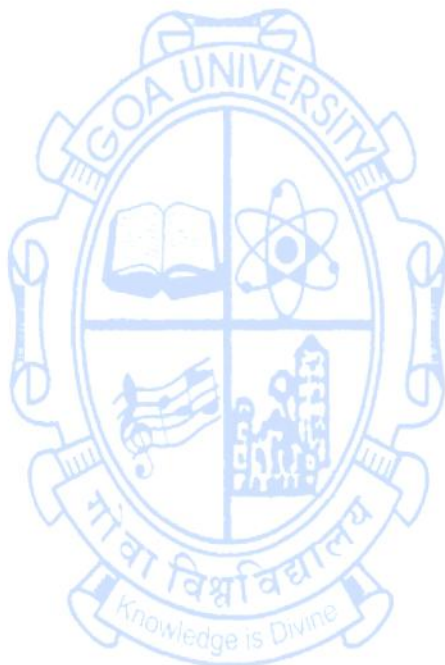


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : REC-564
Title of the Course : Statistics and Data Analysis Lab
Number of Credits : 2
Effective from AY : 2024-25

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

	5. J. Schmuller, Statistical Analysis with Excel for Dummies, 5 th Edition, John Wiley & Sons, 2022.
Course Outcomes:	<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 & distribution methods</p> <p>CO 4. Co-relate different Hypotheses</p>

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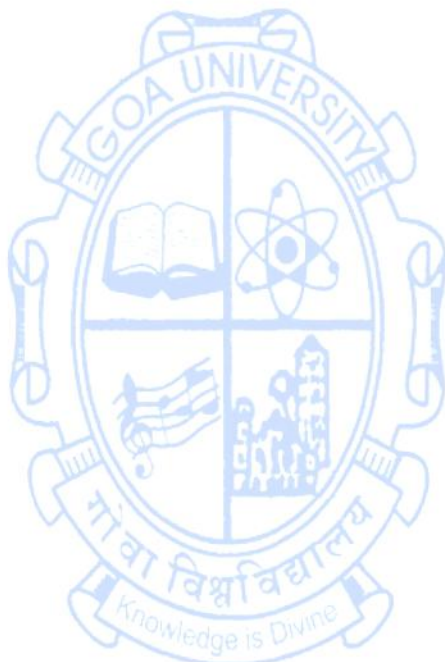


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : REC-565
Title of the Course : Statistical Techniques for Engineering Research
Number of Credits : 2
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Statistics and Probability	
Course Objectives:	<p>The course will enable the students to</p> <ol style="list-style-type: none"> 1. Understand the importance of statistical methods for research 2. Select the appropriate factorial design method for a given set of experimental plan. 3. Apply basic probability theorems and draw relevant inferences. 4. Analyze suitable probability model for given set of data 	
Content:		No of Hours
Unit-1	Overview on Statistical methods , collection of data, one dimensional and two-dimensional statistical analysis, computation of central tendency and dispersion for grouped and ungrouped data, correlation preliminary, understanding variability in data.	6
Unit-2	Design of Experiments , Preparation of experimental plan, full factorial design, fractional factorial design, identification of parameters and levels, randomization, replication, blocking, interaction; numerical; Optimization methods for two parameters.	9
Unit-3	Probability Preliminary: Introduction to Probability, definition, Sample Space, Events, Conditional Probability, Theorem on total probability, Bayes' theorem. Random Variable: Introduction, Discrete and Continuous distribution, Characteristics- Mean, Variance and distribution function.	8
Unit-4	Probability and Sampling Distribution: Bernoulli, Binomial, Exponential, Normal, distribution. Mean, variance and distribution function, important properties, approximations and applications. Statistic and Sampling Distribution: Population and Sample. Statistic, Sampling distributions- Normal, t-distribution, Chi-square and F- distributions.	7
Pedagogy:	Inquiry based learning, Integrative, Reflective Learning, Constructive learning and Collaborative learning	
References/ Readings:	<ol style="list-style-type: none"> 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, 	

	<p>2010, ISBN: 9788126523504</p> <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, 5th Edition, John Wiley & Sons, 2022.</p>
Course Outcomes:	<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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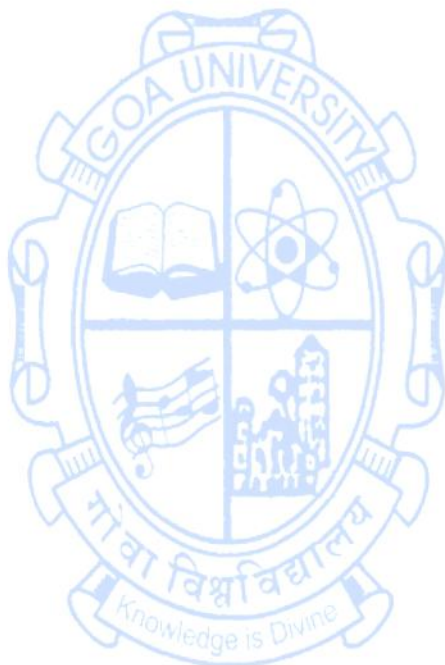


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : REC-566
Title of the Course : Probability & Statistical Analysis lab
Number of Credits : 2
Effective from AY : 2024-25

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

	6. J. Schmuller, Statistical Analysis with Excel for Dummies, 5 th Edition, John Wiley & Sons, 2022.
Course Outcomes:	<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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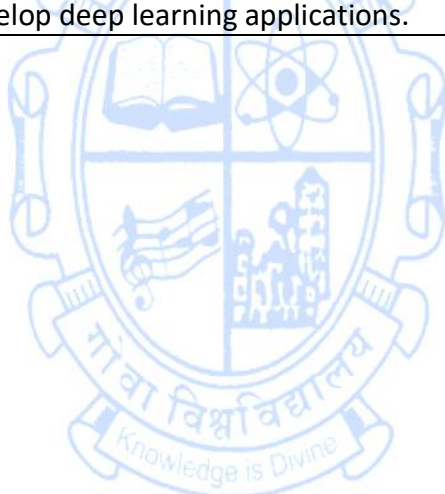
SEMESTER III

Programme Specific Core (PSC) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-600
Title of the course : Deep Learning
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of Linear Algebra, Machine Learning	
Course Objectives:	This course will enable students to: <ol style="list-style-type: none"> 1. Discuss the concepts of Attention and Transformers. 2. Describe the core concepts of deep learning models like CNNs and RNNs. 3. Summarize the idea of Deep Generative Models. 4. Analyze current advancements in deep learning.. 	
Contents:	Topics	No of Hours
UNIT 1	Convolutional Neural Networks (CNNs): Building blocks of CNN, Convolutions, pooling, padding, Transfer Learning Architectures: LeNet, AlexNet, VGG, ResNet Recurrent Neural Networks (RNNs): RNNs, Vanishing & Exploding Gradient Problems, Gated Recurrent Unit Networks, Long Short Term Memory Applications: language modelling, sequence prediction	11
UNIT 2	Attention and Transformers Overview of Attention, Attention mechanism (visual/interactive explanation), Transformer architecture, BERT, GPT, and modern NLP models Graph Neural Networks Graph overview, Graph convolutions and message passing, Real-world use cases: Social networks, molecular biology, recommender systems	11
UNIT 3	Deep Generative Models: Deep Belief networks, Boltzmann Machines, Deep Boltzmann Machine, Generative Adversarial Networks Autoencoder: Denoising, Convolutional, Variational, Recurrent, Sparse Applications: Image generation with GANs, Time series forecasting, Medical image analysis	12
UNIT 4	Representation Learning Greedy Layer-Wise Unsupervised Pretraining, Transfer Learning and Domain Adaptation, Semi-Supervised Disentangling of Causal Factors, Distributed Representation, Exponential Gains from	11

	Depth, Providing Clues to Discover Underlying Causes	
Pedagogy	Interactive Teaching, Critical Thinking, Problem Solving	
References/ Readings:	<p>Text Books:</p> <ol style="list-style-type: none"> 1. Ian Goodfellow, Yoshua Benjio, Aaron Courville, “Deep Learning”, The MIT Press, 5thed, 2016, ISBN: 9789355961525 2. Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola, “Dive into deep learning”, Cambridge Univ Press, 1st ed, 2023, ISBN:9781009389433 <p>Reference Books:</p> <ol style="list-style-type: none"> 1. Jeff Heaton, “Artificial Intelligence for Humans, Vol 3: Neural Networks and Deep Learning”, Heaton Research, Inc., 1st edition, 2015, ISBN: 1505714346 2. Deng, L., & Yu, D., “Deep Learning: Methods and Applications (Foundations and Trends in Signal Processing)”, Publishers Inc., vol 7, 2013, ISBN: 978-1-60198-815-7. 	
Course Outcomes:	<p>At the end of the course, the students will be able to</p> <p>CO 1. Understand deep neural networks and convolutional neural networks (CNNs).</p> <p>CO 2. Apply deep learning for various applications</p> <p>CO 3. Analyze and compare various deep learning models.</p> <p>CO 4. Develop deep learning applications.</p>	



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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-601
Title of the course : Deep Learning lab
Number of Credits :1(2P)
Effective from AY : 2024-25

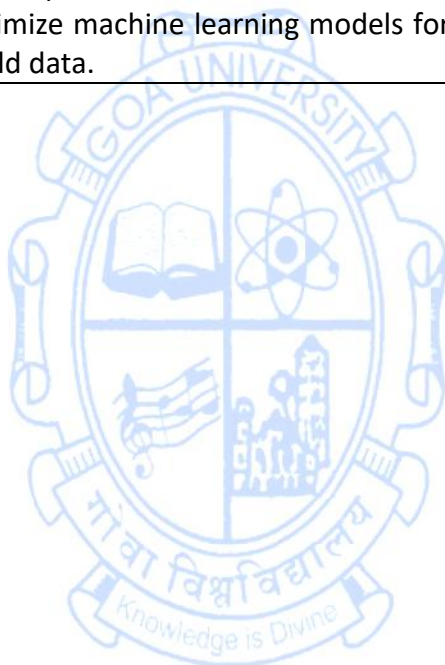
Pre-requisites for the Course:	Knowledge of Linear Algebra, Machine Learning and python programming language	
Course Objectives:	The course will enable the students to: 1. Discuss the concepts of Attention and Transformers. 2. Describe the core concepts of deep learning models like CNNs and RNNs. 3. Summarize the idea of Deep Generative Models. 4. Analyze current advancements in deep learning.	
Content:	List of Programs /Experiments	No. of hours
	1. Study of different libraries for DNN. 2. Implement a Convolutional Neural Network in deep learning. 3. Implement Recurrent Neural Networks. 4. Develop an application to implement GAN. 5. Implement a basic graph neural network for node classification using standard graph dataset. 6. Implement a recommender system using CNN. 7. Develop an application in CNN that uses Transfer Learning approach. 8. Develop an application to analyse various DNN architectures studied. 9. Implement Long Short Term Memory Network. 10. Visualize and interpret Attention Mechanism.	30
Pedagogy:	Constructive, Collaborative and Inquiry Based Learning	
References/ Readings:	Text Books: 1. Ian Goodfellow, Yoshua Benjio, Aaron Courville, “Deep Learning”, The MIT Press, 5 th ed, 2016, ISBN: 9789355961525 2. Aston Zhang, Zack C. Lipton, Mu Li, Alex J. Smola, “Dive into deep learning”, Cambridge Univ Press, 1 st ed, 2023, ISBN:9781009389433 Reference Books: 1. Jeff Heaton, “Artificial Intelligence for Humans, Vol 3: Neural Networks and Deep Learning”, Heaton Research, Inc., 1st edition, 2015, ISBN: 1505714346 2. Deng, L., & Yu, D., “Deep Learning: Methods and Applications (Foundations and Trends in Signal Processing)”, Publishers Inc., vol 7, 2013, ISBN: 978-1-60198-815-7.	
Course Outcomes:	After taking this course, student will be able to: CO 1. Apply deep learning for various applications CO 2. Compare various deep learning models. CO 3. Analyze the performance of various deep learning models CO 4. Develop deep learning applications.	

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-602
Title of the course : Optimization Techniques in Machine Learning
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Linear Algebra, Calculus, Python Programming	
Course Objectives:	This course will enable students to: 4. Understand Core Optimization Concepts in ML 5. Discuss and implement advanced optimization strategies 6. Analyze constrained optimization problems	
Contents:	Topics	No of Hours
UNIT 1	Introduction to Optimization in ML Types of optimization problems: Linear vs Non-linear, Constrained vs. Unconstrained Convex Optimization Convex sets and convex functions, Properties of convex optimization problems.Gradient Descent, Sub gradient methods	11
UNIT 2	Gradient-Based Optimization Stochastic Gradient Descent, Mini batch Gradient Descent, AdaDelta, Momentum-based methods: Momentum, Nesterov Accelerated Gradient (NAG) Adaptive methods: AdaGrad, RMSprop, Adam, AdamW Learning rate schedules and their impact on optimization Convergence analysis and stopping criteria	11
UNIT 3	Second-Order Optimization Techniques Newton’s Method,Quasi-Newton methods: BFGS, L-BFGS Constrained Optimization Lagrange multipliers and the KKT conditions Projected Gradient Descent	11
UNIT 4	Optimization in Deep Learning Challenges in deep learning optimization: Non-convexity, saddle points, vanishing gradients Techniques for improving deep learning optimization: Weight initialization, Regularization(L1/ L2, dropout, dropConnect, early stopping, batch normalization) Non-Convex Optimization	12
Pedagogy	Interactive Teaching, Critical Thinking, Problem Solving	
References/ Readings:	Text Books 1. Stephen Boyd and Lieven Vandenberghe, "Convex Optimization", Cambridge University Press,1st Edition,2004, ISBN:978-0-521-83378-3	

	<p>2. Edwin K. P. Chong & Stanislaw H. Zak, "Introduction To Optimization", Wiley India, 4th Edition, 2017, ISBN:9788126567898</p> <p>Reference Books</p> <p>1. Amir Beck, " Introduction to Nonlinear Optimization", Society for Industrial and Applied Mathematics, 1st Edition, 2014, ISBN: 1611973643</p> <p>2. Sébastien Bubeck, "Convex Optimization: Algorithms and Complexity", Now Publishers, 1st Edition, 2015, ISBN:9781601988607</p>
<p>Course Outcomes:</p>	<p>After taking this course, the students will be able to:</p> <p>CO 1. Understand and apply various optimization algorithms to machine learning problems.</p> <p>CO 2. Analyze the convergence properties and computational complexity of optimization algorithms.</p> <p>CO 3. Implement optimization techniques for both convex and non-convex problems.</p> <p>CO 4. Optimize machine learning models for better performance on real-world data.</p>

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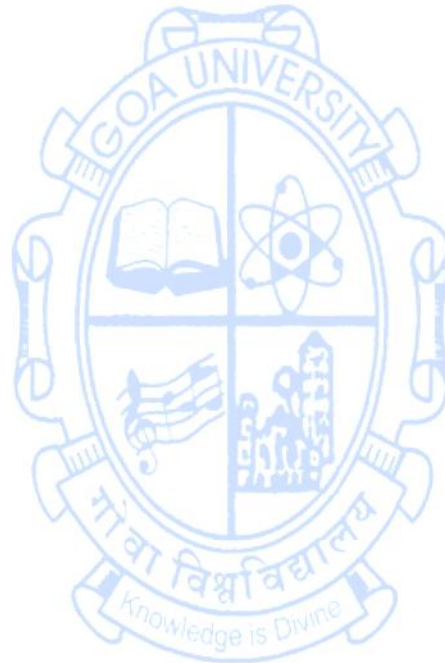


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-603
Title of the course : Optimization Techniques in Machine Learning Lab
Number of Credits :1(2P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 4. Summarize and implement core optimization algorithms used in training machine learning models. 5. Analyze the impact of gradient-based and adaptive optimization methods on model convergence. 6. Apply regularization and constraint-based techniques for improving generalization and model robustness. 	
Contents:	List of Programs/ Experiments	No of Hours
	<ol style="list-style-type: none"> 1. Implement Gradient Descent 2. Develop an application which uses adaptive Optimizers and compare their performance. 3. Implement Regularization Techniques with SGD 4. Implement different Weight Initialization Methods and analyze the performance. 5. Train a model with and without Batch Normalization to assess its impact on the convergence speed and model accuracy 6. Implement Mini batch Gradient Descent 7. Implement Stochastic Gradient Descent on Linear Regression 8. Implement Momentum based optimization 9. Implement Nesterov Accelerated Gradient 10. Apply AdaGrad to a classification task and observe its performance. 	30
Pedagogy	Inquiry Based Learning, Experiential Learning, Problem Solving.	
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. Stephen Boyd and Lieven Vandenberghe, "Convex Optimization", Cambridge University Press, 1st Edition, 2004, ISBN:9780521833783 2. Edwin K. P. Chong & Stanislaw H. Zak, "Introduction To Optimization", Wiley India, 4th Edition, 2017, ISBN:9788126567898 <p>Reference Books</p> <ol style="list-style-type: none"> 1. Amir Beck, "Introduction to Nonlinear Optimization", Society for Industrial and Applied Mathematics, 1st Edition, 2014, ISBN: 1611973643 2. Sébastien Bubeck, "Convex Optimization: Algorithms and Complexity", Now Publishers, 1st Edition, 2015, ISBN:9781601988607 	
Course Outcomes:	<p>After taking this course, the students will be able to:</p> <p>CO 1. Understand various optimization methods in practical ML</p>	

	scenarios CO 2. Apply constrained optimization methods CO 3. Analyze different optimization methods CO 4. Implement various optimization algorithms
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Programme Specific Elective (PSE) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-631

Title of the course : Brain Computer Interface

Number of Credits : 3(3L)

Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of signal processing	
Course Objectives:	This course will enable students to: 1. Describe the fundamentals of BCI systems, their components and applications 2. Identify various signal processing techniques used in BCI 3. Summarize feature extraction and classification techniques for BCI 4. Develop practical BCI applications	
Contents:	Topics	No of Hours
UNIT 1	Introduction to BCI Definition and history of BCI, Overview of BCI applications, Ethical and social implications of BCI, Neurophysiology and Signal Acquisition Neurophysiology Basics Structure and function of the brain, Neural activity and brain waves, Brain signal generation and propagation	11
UNIT 2	Brain Signal Acquisition EEG, MEG, fNIRS, and other brain signal acquisition methods, hardware and software for signal acquisition, preprocessing and artifact removal techniques. Signal Processing Techniques PCA and ICA, Time-domain analysis, Frequency-domain analysis, Time-frequency analysis, amplification, sampling, anti aliasing , Fourier analysis,	11
UNIT 3	Feature Extraction Common Spatial Patterns (CSP), Wavelet Transform, Statistical measures, CNN-based feature extraction Machine Learning for BCI Classification Techniques - Linear classifiers (LDA, SVM), Non-linear classifiers (k-NN, Decision Trees), Deep learning for BCI (CNN, RNN, Transformers) Optimization and Feature Selection - Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Genetic Algorithms	11
UNIT 4	Applications and Case Studies <ul style="list-style-type: none"> • BCI in Medicine and Rehabilitation • BCI in Human-Computer Interaction • BCI in Biometric Identification 	12

	<p>Practical BCI Development BCI System Design - Designing a BCI system: from signal acquisition to application, Software and tools for BCI development</p>	
Pedagogy	Critical Thinking, Reflective Learning, Enquiry Based Learning.	
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. Rajesh P. N. Rao, "Brain-Computer Interfacing: An Introduction", Cambridge University Press. 2013, ISBN 9780521769419 2. Mousa Mohammad Nia, "Brain Computer Interface with ICA and Evolutionary Algorithms", Lambert Academic Publishing, 2018, ISBN:9786202052627 <p>Reference Books</p> <ol style="list-style-type: none"> 1. Xin-SheYang, "Nature-Inspired Optimization Algorithms", publisher: Elsevier, 1st edition, 2014, ISBN:9780124167452 2. M.G. Sumithra, Mariofanna Milanova Balamurugan Balusamy, Chandran Venkatesan, "Brain-Computer Interface Using deep learning applications", Wiley-Scrivener, 2023, ISBN: 9781119857655 	
Course Outcomes:	<p>After taking this course, the students will be able to:</p> <p>CO 1. Understand the fundamental principles and history of Brain-Computer Interface (BCI) systems, including key applications and ethical considerations.</p> <p>CO 2. Demonstrate knowledge of various brain signal acquisition techniques and apply pre-processing methods to clean and prepare the data for analysis.</p> <p>CO 3. Utilize different signal processing methods (time-domain, frequency-domain, and time-frequency analysis) to extract meaningful information from brain signals.</p> <p>CO 4. Implement feature extraction techniques, selection, optimization and classification</p>	

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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-632
Title of the course : Brain Computer Interface Lab
Number of Credits :1(2P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	This course will enable students to: 1. Describe and Analyze EEG-Based Research and Applications 2. Discuss EEG Signal Visualization Techniques 3. Apply EEG Preprocessing and Feature Extraction Techniques 4. Classify EEG Signals Using Machine Learning and Deep Learning Models	
Contents:	List of Programs/ Experiments	No of Hours
	1. Case study of different types of EEG-based research, BCI paradigms used in neuroscience, BCI applications, and repositories of EEG datasets. 2. To visualize EEG signals through time-series plots, spatial electrode layout maps (2D and 3D), topographic scalp maps of brain activity in specific frequency bands, and power spectral density (PSD) analysis to explore frequency components of EEG data. 3. To apply and evaluate essential EEG preprocessing techniques for improving signal quality by removing noise, artifacts, and irrelevant frequency components, enabling more accurate analysis of brain activity. 4. To classify time domain EEG signals using machine learning techniques for pattern recognition and decision-making applications. 5. To extract various statistical features from time and frequency domain EEG signals. 6. To improve generalization and training performance of models, especially when data is limited by noise addition, time-shifting, window slicing, GANs). 7. To convert EEG signals from the time domain to the frequency domain using the Fast Fourier Transform (FFT) and extract different frequency components (e.g., delta, theta, alpha, beta, gamma) and spectral features. 8. To convert EEG signal to time-frequency domain and classify them using deep learning. 9. To convert EEG signals to the time-frequency domain using techniques like the Wavelet Transformer Short-Time Fourier Transform (STFT). 10. To extract features from EEG signals using convolution neural network and use these features for classification using machine learning models.	30

Pedagogy	Instructional, Collaborative Learning, Constructive
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. Rajesh P. N. Rao, “Brain-Computer Interfacing: An Introduction”, Cambridge University Press. 2013, ISBN 9780521769419 2. Mousa Mohammad Nia, “Brain Computer Interface with ICA and Evolutionary Algorithms”, Lambert Academic Publishing, 2018, ISBN:9786202052627 <p>Reference Books</p> <ol style="list-style-type: none"> 1. Xin-SheYang, “Nature-Inspired Optimization Algorithms”, publisher: Elsevier, 1st edition, 2014, ISBN: 9780124167452 2. M.G. Sumithra, Mariofanna Milanova Balamurugan Balusamy, Chandran Venkatesan, “Brain-Computer Interface Using deep learning applications”, Wiley-Scrivener, 2023, ISBN: 9781119857655
Course Outcomes:	<p>After taking this course, the students will be able to:</p> <p>CO 1. Apply EEG pre-processing techniques, including artifact removal, filtering, and feature extraction from both time-domain and frequency-domain EEG signals to prepare data for classification.</p> <p>CO 2. Analyze EEG signals using various visualization techniques to explore brain activity and frequency components.</p> <p>CO 3. Classify EEG signals using machine learning and deep learning models for pattern recognition and decision-making applications.</p> <p>CO 4. Extract meaningful features by converting EEG signals to the frequency and time-frequency domains.</p>

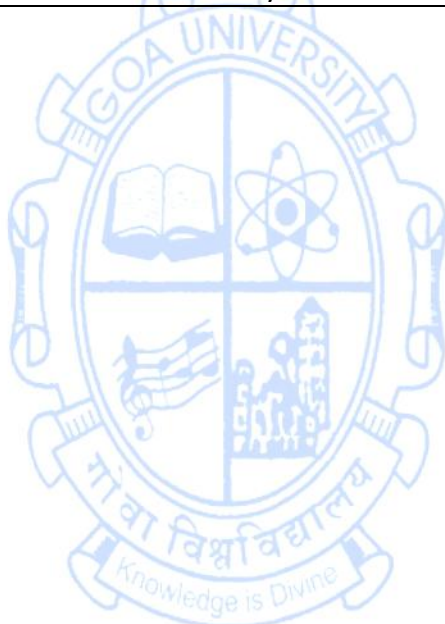
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-633
Title of the course : Recommender Systems
Number of Credits : 3(3L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of machine learning	
Course Objectives:	This course will enable students to: 1. Describe basic techniques and problems in the field of recommender systems 2. Apply algorithms and techniques to develop Recommender Systems 3. Evaluate Types of recommender systems: non-personalized, content based, collaborative filtering 4. Develop recommender systems	
Contents:	Topics	No of Hours
UNIT 1	Introduction to Recommender systems: Goals of recommender systems, basic models of recommender systems, domain specific challenges in recommender systems, applications Collaborative Recommendation: User-based nearest neighbor recommendation, Item-based nearest neighbor recommendation, model-based and pre-processing-based approaches.	10
UNIT 2	Content-based recommendation: Content representation and content similarity, Similarity-based retrieval, Other text classification methods Knowledge-based recommendation: Introduction, Knowledge representation and reasoning, interacting with constraint-based recommenders, Interacting with case-based recommenders.	12
UNIT 3	Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies	11
UNIT 4	Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs: Accuracy, Coverage, confidence, novelty, diversity, scalability, serendipity, Evaluation on historical data sets. Attacks on collaborative recommender systems: Attack dimensions, Attack types, Countermeasures, Privacy aspects – distributed collaborative filtering.	12
Pedagogy	Interactive Teaching, Critical Thinking, Reflective Learning	

References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. Jannach D., Zanker M. and FelFering A., “Recommender Systems: An Introduction”, Cambridge University Press, 1st ed, 2011, ISBN: 9780521493369. 2. Charu C. Aggarwal, “RecommenderSystems:TheTextbook”, Springer, 1st Edition, 2016, ISBN: 9783319296579. <p>Reference Books</p> <ol style="list-style-type: none"> 1. F. Ricci, L. Rokach, B. Shapira, P. B. Kantor, “Recommender Systems Handbook”, Springer, 1st ed., 2011, ISBN: 9780387858203. 2. Erwin Kreyzig, “Advanced Engineering Mathematics”, Wiley publishers, 10th Edition, 2011, ISBN: 9788126554232.
Course Outcomes:	<p>After taking this course, the students will be able to:</p> <p>CO 1. Familiarize with recommender systems and their applications</p> <p>CO 2. Analyze the different approaches towards recommendation</p> <p>CO 3. Evaluate the effectiveness of recommender system</p> <p>CO 4. Create a recommender system</p>

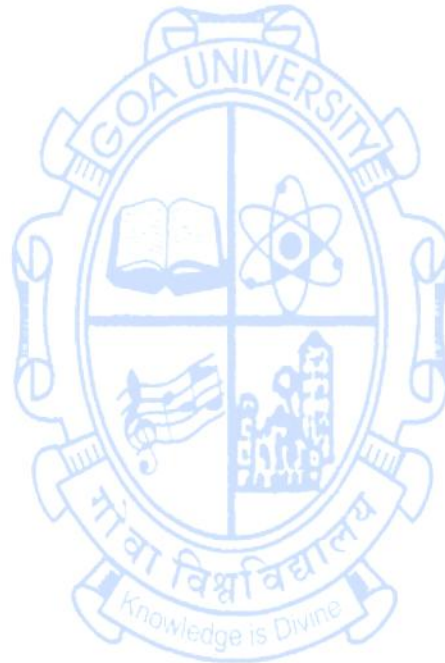
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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-634
Title of the course : Recommender Systems Lab
Number of Credits : 1(2P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	This course will enable students to: <ol style="list-style-type: none"> 1. Discuss basic techniques and problems in the field of recommender systems 2. Apply algorithms and techniques to develop Recommender Systems 3. Evaluate Types of recommender systems: non-personalized, content based, collaborative filtering 4. Develop recommender systems 	
Contents:	List of Programs/ Experiments	No of Hours
	<ol style="list-style-type: none"> 1. Study of different python libraries required for recommender systems 2. Implement User-Item Interaction Matrix Creation 3. Implement User-Based Collaborative Filtering 4. Perform a case study on recommender systems 5. Create attacks for recommender systems 6. Implement Item-Based Collaborative Filtering 7. Implement content-based filtering 8. Implement Model-Based Collaborative Filtering (use ML models like KNN, XGBoost) 9. Evaluate using different metrics to understand the performance of the recommender systems 10. Use deep learning models to implement Collaborative Filtering 	30
Pedagogy	Constructive, Inquiry Based Learning, Experiential Learning	
References/ Readings:	Text Books <ol style="list-style-type: none"> 1. Jannach D., Zanker M. and FelFering A., "Recommender Systems: An Introduction", Cambridge University Press, 1st edition, 2011, ISBN: 9780521493369. 2. Charu C. Aggarwal, "RecommenderSystems:TheTextbook", Springer, 1st Edition, 2016, ISBN: 9783319296579. Reference Books <ol style="list-style-type: none"> 1. F. Ricci, L. Rokach, B. Shapira, P. B. Kantor, "Recommender Systems Handbook", Springer, 1st ed., 2011, ISBN: 9780387858203. 2. Erwin Kreyzig, "Advanced Engineering Mathematics", Wiley publishers, 10th Edition, 2011, ISBN: 9788126554232. 	
Course Outcomes:	After taking this course, the students will be able to: CO 1. Familiarize with recommender systems and their applications CO 2. Analyze the different approaches towards recommendation CO 3. Evaluate the effectiveness of recommender system	

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Research Specific Elective (RSE) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-661

Title of the course : Digital Forensics

Number of Credits : 2(2L)

Effective from AY : 2024-25

Pre- requisites for the Course:	Knowledge of networks	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Understand the basic digital forensics and techniques for conducting the forensic examination on different digital devices. 2. Examine digital evidences such as the data acquisition, identification analysis. 3. Collect, Preserve and seize various digital evidences. 4. Validate and test evidences using various methods. 	
Contents:	Topics	No of Hours
UNIT 1	<p>Computer Forensics Fundamentals: What is Computer Forensics? Use of Computer Forensics in Law Enforcement, Computer Forensics Assistance to Human Resources/Employment Proceedings, Computer Forensics Services, Benefits of professional Forensics Methodology, Steps taken by Computer Forensics Specialists.</p> <p>Types of Computer Forensics Technology: - Types of Business Computer Forensic Technology.Types of Military Computer Forensic Technology, Types of Law Enforcement- Computer Forensic Technology, Types of Business Computer Forensic Technology.</p> <p>Computer Forensics Evidence and capture: Data Recovery Defined-Data Back-up and Recovery-The Role of Back -up in Data Recovery-The Data -Recovery Solution.</p>	8
UNIT 2	<p>Evidence Collection and Data Seizure: Why Collect Evidence? Collection Options-Obstacles-Types of Evidence-The Rules of Evidence-Volatile Evidence-General Procedure-Collection and Archiving-Methods of Collections-Art facts -Collection Steps - Controlling Contamination: The chain of custody.</p> <p>Duplication and Preservation of Digital Evidence: Preserving the Digital Crime Scene-Computer Evidence processing steps-Legal Aspects of collecting and Preserving Computer forensic Evidence.</p> <p>Computer image Verification and Authentication: Special needs of Evidential Authentication - Practical Consideration-Practical Implementation.</p>	7

UNIT 3	<p>Computer forensic analysis and validation: Determining what data to collect and analyze, validating forensic data, addressing data-hiding techniques, performing remote acquisitions</p> <p>Network Forensics: Network forensic overview, performing live acquisitions, developing standard procedures for network forensics, using network tools, examining the honeynet project.</p> <p>Processing crime at incident scenes: Identifying digital evidence, collecting evidence in private-sector incident scenes, processing law enforcement crime scenes, preparing for a search, securing a computer incident or crime scene, seizing digital evidence at the scene, storing digital evidence, obtaining a digital hash, reviewing a case.</p>	7
UNIT 4	<p>Current Computer Forensic Tools: evaluating computer forensic tool needs, computer forensic software tools, computer forensic hardware tools, validating and testing forensic software.</p> <p>E-mail investigations: Exploring the role of email in investigations, exploring the role of client and server in email, investigating email crimes and violations, understanding email servers, using specialized email forensic tools.</p> <p>Cell phone and mobile device forensics: Understanding mobile device forensic, understanding acquisition procedures for cell phones and mobile devices.</p>	8
Pedagogy	Interactive Teaching, Critical Thinking, Enquiry Based Learning	
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. John R Vacca, "Computer Forensics, Computer Crime Investigation", 2nd Ed, Charles River Media, 2005, ISBN: 1-58450-389. 2. Nelson, Phillips Enfinger, Stuart, "Guide to Computer Forensics and Investigations", 2nd ed., Thomson Course Technology, 2006, ISBN: 0-619-21706-5. <p>Reference Books</p> <ol style="list-style-type: none"> 1. Warren G. Kruse II and Jay G. Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley, 2002, ISBN: 978-0201707199 	
Course Outcomes:	<p>After taking this course, the students will be able to:</p> <p>CO 1. Describe the role of investigator and lab requirements in Digital Forensics.</p> <p>CO 2. Collect, preserve and seize various digital evidences.</p> <p>CO 3. Apply data Acquisition methods, tools and storage formats of digital evidence.</p> <p>CO 4. Analyze various validating and testing of evidences using different methods</p>	

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Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)

Course code : CAM-662

Title of the course : Digital Forensics Lab

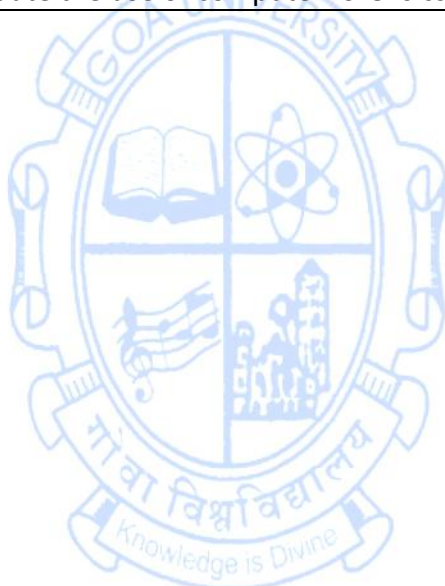
Number of Credits : 2(2P)

Effective from AY : 2024-25

Pre requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Understand file system basics and where hidden files may lie on the disk, as well as how to extract the data and preserve it for analysis. 2. Explore network analysis, Registry analysis and analyze attacks using different forensics tools. 3. Evaluate some of the tools of e-discovery. 	
Contents:	List of Programs/ Experiments	No of Hours
	<ol style="list-style-type: none"> 1. Install and configure tools like Autopsy, FTKImager, Sleuth Kit, and CAINE Linux. 2. Evaluate commercial (e.g., EnCase, X-Ways) vs.open-source tools (e.g., Autopsy, FTK Imager). 3. Duplicate digital evidence without altering the original data using tools like dd, FTK Imager, Guymager. 4. Perform email analysis using the tools like Exchange EDB viewer, MBOX viewer and View user mailboxes and public folders, Filter the mailbox data based on various criteria, Search for particular items in user mailboxes and public folders 5. Use tools like PhotoRec, Foremost, or Autopsy to recover deleted files. 6. Perform File type detection using Autopsy tool 7. Perform Browser history analysis and get the downloaded content, history, saved logins, searches, websites visited etc using Foxton Forensics tool, Dumpzilla. 8. Perform static and dynamic analysis of a suspicious file using tools like VirusTotal, PEStudio, or Cuckoo Sandbox. 9. Detect and analyze hidden data in images or audio using tools like Steghide, zsteg, or OpenStego. 10. Perform mobile analysis in the form of retrieving call logs, SMS log, all contacts list using the forensics tool like SAFT . 11. Perform Registry analysis and get boot time logging using process monitor tool 12. Perform Disk imaging and cloning the using the X-way Forensics tools 13. Perform Data Analysis i.e History about open file and folder, and view folder actions using Lastview activity tool 14. Perform Network analysis using the Network Miner tool. 15. Capture and analyze network traffic using Wireshark or 	60

	tcpdump.	
Pedagogy	Collaborative Learning, Constructive, Inquiry Based Learning	
References/ Readings:	Textbooks: 1. E. P. Dorothy, "Real Digital Forensics for Handheld Devices", CRC Press Inc; 1st edition (2012), ISBN: 978-1439898772 2. J. Sammons, "The Basics of Digital Forensics: The Primer for Getting Started in Digital Forensics", Syngress Publishing, 2012, ISBN:978-1-59749-661-2	
Course Outcomes:	After taking this course, the students will be able to: CO 1. Understand the importance of a systematic procedure for investigation of data found on digital storage media. CO 2. Analyze the file system storage mechanisms and retrieve files in hidden format. CO 3. Analyze methods to find data that may be clear or hidden on a computer disk, find out the open ports for the attackers through network analysis, Registry analysis. CO 4. Evaluate the use of computer forensics tools used in data analysis.	

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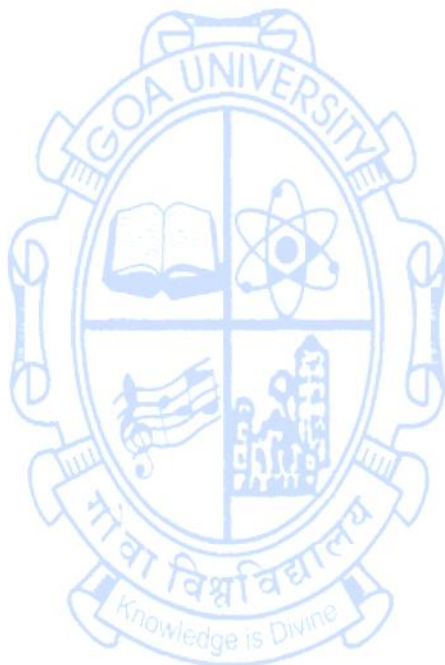


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-663
Title of the course : Social Network Analysis
Number of Credits : 2(2L)
Effective from AY : 2024-25

Pre- requisites for the Course:	Machine Learning	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Understand the fundamentals and essentials of social networks. 2. Develop a foundation of social networks to the students so that they can use and adopt basic tools for analysis of social networks. 3. Explore some important social networking concepts with analysis of the social networks and recent trends in the industry. 4. Study and research in the area of analysis of next generation social networks 	
Contents:	Topics	No of Hours
UNIT 1	Introduction to social networks, Handling Real-world Network Datasets, Network Measures Network Growth Models. Link Analysis, signed networks, strong and weak ties, Homophily, +Ve / -Ve Relationships, Page Rank and algorithms for Link Analysis.	8
UNIT 2	Community structure in networks, communities' types, community detection methods, Applications and evaluation of community detection networks. Link Prediction, methods and models for link prediction, latest trends and applications.	7
UNIT 3	Cascade behaviour and network effects, cascade models, prediction, Epidemics Power Laws and Rich-Get-Richer Phenomena. Anomaly detection in static and dynamic networks and challenges.	7
UNIT 4	Graph Representation Learning. Machine learning pipelines, Benefits, criterion and representation learning methods. Applications and case studies of Online social networks.	8
Pedagogy	Reflective Learning, Problem Solving, Enquiry Based Learning	
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. David Easley and Jon Kleinberg, "Networks, Crowds and Markets: Reasoning About a Highly Connected World", Cambridge University Press, 2010, ISBN: 9780521195331. 2. Matthew O. Jackson, "Social and Economic Networks", Princeton University Press, 2010, ISBN: 978-0691148205. 3. Tanmoy Chakraborty, " Social Network Analysis", Wiley, 2021, ISBN: 978-9354247835. <p>Reference Books</p> <ol style="list-style-type: none"> 1. Albert-László Barabási, Márton Pósfai, "Network Science", Cambridge 	

	<p>University Press, 2016, ISBN: 978-1107076266.</p> <p>2. Stanley Wasserman, Katherine Faus, "Social Network Analysis: Methods and Applications", Cambridge University Press, 1994, ISBN: 978-0521387071</p>
Course Outcomes:	<p>After taking this course, the students will be able to:</p> <p>CO 1. Understand the fundamentals and essentials of social networks.</p> <p>CO 2. Apply basic tools for analysis of social networks</p> <p>CO 3. Analyse various social networks</p> <p>CO 4. Evaluate the performance of social networks</p>

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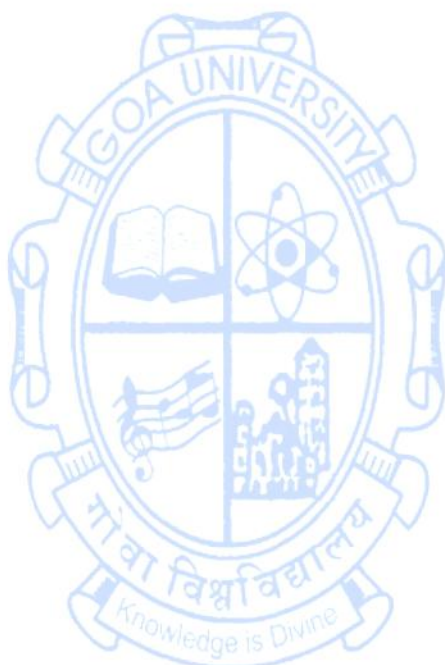


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course code : CAM-664
Title of the course : Social Network Analysis Lab
Number of Credits : 2(2P)
Effective from AY : 2024-25

Pre- requisites for the Course:	Nil	
Course Objectives:	<p>This course will enable students to:</p> <ol style="list-style-type: none"> 1. Understand the fundamentals and essentials of social networks. 2. Develop a foundation of social networks to the students so that they can use and adopt basic tools for analysis of social networks. 3. Explore some important social networking concepts with analysis of the social networks and recent trends in the industry. 4. Study and research in the area of analysis of next generation social networks. 	
Contents:	List of Programs/ Experiments	No of Hours
	<ol style="list-style-type: none"> 1. Introduction to Networkx package in python 2. Various tools for analysing social networks using R 3. Implementation of various measures for representing social networks 4. Implementation of various network growth models 5. Modelling and aggregating social network data using python and R 6. Modelling and aggregating social network data using python and R 7. Visualizing online social networks using tools/libraries 8. Random walks and their applications. 9. Implementation of ontological representation of social individuals and relationships. 10. Implementation of Page Rank Algorithms (Link Analysis). 11. Detecting communities in social networks 12. Demonstration of cascading behaviour in social networks 13. GraphML on social networks 14. Implementation of Rich get Richer Phenomena 15. Anomaly Detection in social networks 	60
Pedagogy	Inquiry Based Learning, Experiential Learning, Problem Solving.	
References/ Readings:	<p>Text Books</p> <ol style="list-style-type: none"> 1. David Easley and Jon Kleinberg, "Networks, Crowds and Markets: Reasoning About a Highly Connected World", Cambridge University Press, 2010, ISBN: 9780521195331 . 2. Matthew O. Jackson, "Social and Economic Networks", Princeton University Press, 2010, ISBN: 978-0691148205. 3. Tanmoy Chakraborty, " Social Network Analysis", Wiley, 2021, ISBN:978-9354247835. 	

	<p>Reference Books</p> <ol style="list-style-type: none"> 1. Albert-László Barabási, Márton Pósfai, “Network Science”, Cambridge University Press, 2016, ISBN: 978-1107076266. 2. Stanley Wasserman, Katherine Faus, “Social Network Analysis: Methods and Applications”, Cambridge University Press, 1994, ISBN: 978-0521387071
<p>Course Outcomes:</p>	<p>After taking this course, the students will be able to:</p> <p>CO 1. Explain the fundamentals and essentials of social networks.</p> <p>CO 2. Implement basic tools for analysis of social networks</p> <p>CO 3. Analyse various social networks</p> <p>CO 4. Evaluate the performance of social networks</p>

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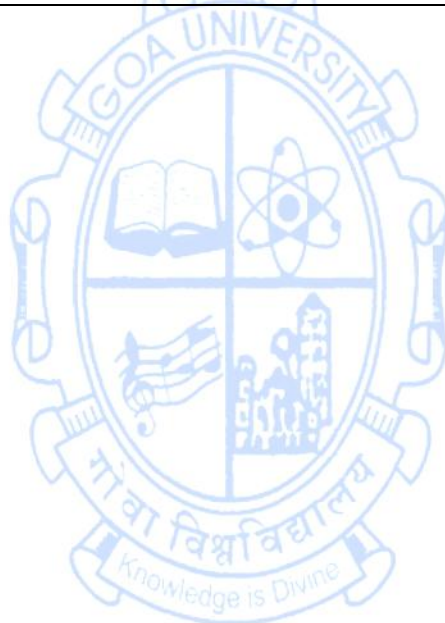
Generic Elective (GE) Courses

Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : GEC-681
Title of the Course : Sustainability - Principles & Practices
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: <ol style="list-style-type: none"> 1. Understanding of importance of Sustainability Practices 2. Explanation of Assessment, Planning and Implementation of Sustainability Principles 3. Description of the steps involved in implementing sustainable solutions 4. Apply the knowledge of sustainability practices to real life situations. 	
Content:		No. of Hours
Unit-1	Overview on Global Sustainability Goals (SDGs): Industry-Innovation-Infrastructure, Health & Well Being, Clean Water & Sanitation, Education, Responsible Consumption and production, Climate Action, Quality Education, Economic growth, sustainable community living,	10
Unit-2	Sustainability: Requirements for Sustainability, Approaches towards Sustainable Engineering, Sustainability Challenges, Environmental Challenges; Reasons for Un-sustainability – Economics and Environment, Corporate View of Sustainability, Social Attitude, Approach, Cultural Narratives, Political Aspects, Ethics and Morals. Steps in life cycle impact assessment	13
Unit-3	Sustainability Assessment: 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	10
Unit-4	Solutions for Sustainability: 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.	12

Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.
References/ Readings:	<ol style="list-style-type: none"> 1. Raj Gaurang Tiwari, 'Sustainability Principles and Applications in Engineering Practices', Nova Science Publishers, 2024, ISBN:9798891136403 2. Bhavik R Bakshi, 'Sustainable Engineering', Cambridge University Press, 2019, ISBN:9781108420457 3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244
Course Outcomes:	<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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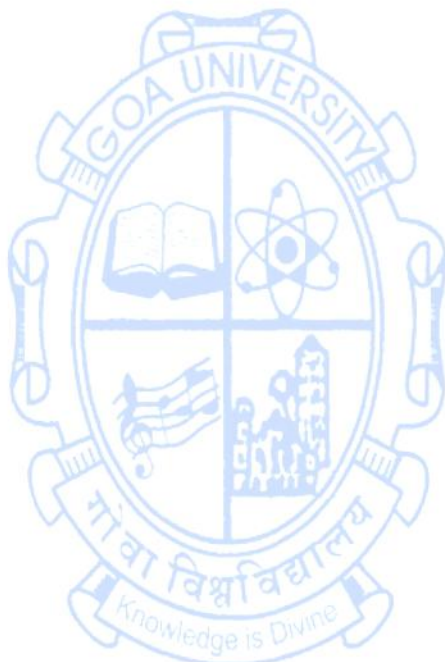


Name of the Programme : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : GEC-682
Title of the Course : Sustainability - Principles & Practices Lab
Number of Credits : 01
Effective from AY : 2024-25

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

	<p>Press, 2019, ISBN:9781108420457</p> <p>3. Margaret Robertson, 'Sustainability – Principles & Practices', Routledge Publishers, 2017, ISBN: 97811138650244</p>
<p>Course Outcomes:</p>	<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 : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : GEC-683
Title of the Course : Project Management
Number of Credits : 03
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	The course aims to provide the student with an: <ol style="list-style-type: none"> 1. Understanding of the various features of project management 2. Explanation of the relevance of human resource planning and management 3. Describes the importance of procurement planning, cost estimation, and quality management. 4. Detailed explanation on time and risk management. 	
Content:		No. of Hours
Unit-1	Overview on Project Management: 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. Economics & Cost Management: Time Value of Money, Cost-Benefit Ratio, Cost estimation, methods of preparing estimates, budgeting, Cost monitoring and Control, cost on completion.	10
Unit-2	Human Resource Management, 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,	12
Unit-3	Procurement Management- Planning, Implementation – Monitoring and control of goods and services; Stakeholders Management, Contracts drafting, preparation, approval, implementation and closure. Quality Management: Introduction, quality planning tools and techniques, quality monitoring and control, tools and techniques,	13
Unit-4	Time Management: Purpose of Time Management, Time	10

	<p>Planning, different methods of activity planning, milestones, 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>Risk Management – Risk Identification, Risk Qualitative Analysis, Risk Quantitative Analysis, Risk Response, Monitoring and Control</p>	
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	<ol style="list-style-type: none"> 1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928. 2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6th Edn, Taylor & Francis Publications, 2021, ISBN: 978-0-367-277730-7 3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769. 4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288. 	
Course Outcomes:	<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 : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : GEC-684
Title of the Course : Project Management Lab
Number of Credits : 01
Effective from AY : 2024-25

Pre-requisites for the Course:	Undergraduate level knowledge of any branch of engineering	
Course Objectives:	<p>The course aims to provide the student with an:</p> <ol style="list-style-type: none"> 1. Understanding of the various features of project management 2. Explanation of the relevance of applying project management knowledge to any one domain 3. Describes the advantages of applying project management tools & techniques to address specific problems 4. Ability to prepare reports and presentation on specific areas by applying knowledge of Project Management 	
Content:		No. of Hours
	<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"> (1) Large construction site (on-going projects) – residential, commercial, highways, ports, airports (2) Large Manufacturing Industry in any of the Industrial Areas in Goa, scaling up production, sales / marketing. (3) Waste Management; Water Management; (4) Application of Project Management to Law Enforcement (5) Project Management in Education – infrastructure, skill training (6) Project Management as applied to consumer goods / supplies (7) Manpower Management in the context of AI in software industry (8) Project Management – Global markets for local products using Digital Marketing platforms (9) Project management for Logistics and Transportation (10) Project management for Hospital & Health Management 	30

Pedagogy	Instructional learning, Inquiry based learning, Constructive learning, Collaborative learning and problem solving
References/ Readings:	<ol style="list-style-type: none"> 1. J.Michael Bennet, Danny S.K.Ho, 'Project Management for Engineers', World Scientific Publishing, 2014, ISBN: 13-978-981444-7928. 2. J. M. Nicholas, Herman Steyn, 'Project Management for Engineering, Business and Technology, 6th Edn, Taylor & Francis Publications, 2021, ISBN: 978-0-367-277730-7 3. Neil G Siegel, Engineering Project Management, Wiley Publications, 2019, ISBN: 9781119525769. 4. Khanna.R.B., Project Management, PHI Publishing, 2011, ISBN: 978-81-203-4288.
Course Outcomes:	<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 & 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 : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : GEC-685
Title of the Course : Financial Management
Number of Credits : 04
Effective from AY : 2024-25

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

Unit-4	Working Capital Management -Working Capital Policy, Cash and Liquidity Management, Credit Management, Inventory Management, Working Capital Financing; Corporate Valuation: Debt analysis and management, Leasing, Hire Purchase, Valuation, Mergers, acquisitions and Restructuring; Long Term Financing: Sources of Long Term Finance, Raising Long Term Finance.	14
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	<ol style="list-style-type: none"> 1. Prasanna Chandra “Financial Management: Theory and Practice” 11th Edition, McGraw Hill Education Publishers, 2023, ISBN: 978-9355-322-203 2. Pandey I.M., Finance- A Management Guide for Managing Company Funds and Profits, Prentice Hall India Publications, 1995, ISBN:978-8120-309-180 3. Van Horne, J.C, “Fundamentals of Financial Management”, 13th Edition, Pearson Publications, 2015, ISBN:978-933-255-8670. 4. Khan, M.Y. and Jain, P.K., “Financial Management”, 8th Edition, McGraw-Hill Education Publishers, 2018, ISBN:978-9353-1622-184 	
Course Outcomes:	<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 & 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 : Masters in Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Course Code : GEC-686
Title of the Course : Entrepreneurship
Number of Credits : 04
Effective from AY : 2024-25

Pre-requisites for the Course:	Basic knowledge of Creative Thinking, Innovation, Finance, Economics	
Course Objectives:	<p>The course aims to provide the student with an:</p> <ol style="list-style-type: none"> 1. Understanding of entrepreneurial skill sets and different types of entrepreneurship. 2. Explanation of Differences between New Enterprise, Social Enterprise and Family Business 3. Describes the process of preparing business plan, operational plans to start an enterprise 4. Apply the knowledge of market analysis, product planning, customer requirements, costing and finance 	
Content:		No. of Hours
Unit-1	Entrepreneurial Characteristics: 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	18
Unit-2	Creation of New Enterprise: 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	14
Unit-3	Social Entrepreneurship: 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	14

Unit-4	Family Business Management : 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;	14
Pedagogy	Interactive learning, reflective thinking, critical analysis, and problem-solving.	
References/ Readings:	<ol style="list-style-type: none"> 1. Nagasubba Rayudu, 'A Textbook on Entrepreneurship & Incubation', Mahi Publications, 2023, ISBN: 978811949282 2. Balasubramanya. M.H., 'Entrepreneurial Ecosystems for Tech Startup in India', Verlag Max Publications, 2021, 9783110679298. 3. Kenji Uchino, 'Entrepreneurship for Engineers', CRC Press, 2010, ISBN: 978143980063 4. Ryszard Praszkiel, Andrzej Nowak, 'Social Entrepreneurship', Theory and Practice, Cambridge University Press, 2011, ISBN 9781139504331 5. Peter Leach, Tatwamasi Dixit, 'Indian Family Business Mantras', Rupa Publications, 2016, ISBN: 9788129136945 6. Bill Bolton, John Thompson, 'Entrepreneurs – Talent, Temperament, Opportunity', Elsevier Publications, 2004, ISBN:0750661283 7. John Bessant, Joe Tidd, 'Entrepreneurship', John Wiley Publications, 2015, ISBN: 9781118993095 	
Course Outcomes:	<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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