Engineering Branch: Computer Engineering

Minor/ Honours (Specialization) Subject: Artificial Intelligence and Machine Learning

SCHEME OF INSTRUCTION AND EXAMINATION

Course Code	**SEMESTER**	**Nomenclature of the Course**	**Scheme of Instruction Hrs/Week**			**Scheme of Examination**						
							Marks					
			L	**T**	**P**	Duration (Hrs)	TH	IA	TW*	O	Total	Credits
CEAM-01	IV	Mathematical Foundations for Artificial Intelligence & Machine Learning	3	0	2	3	100	25	0	25	150	4
CEAM-02	V	Introduction to Artificial Intelligence & Machine Learning	3	0	2	3	100	25	0	25	150	4
CEAM-03	VI	Data Science and Analytics	3	0	2	3	100	25	0	25	150	4
CEAM-04	VII	Neural Networks and Deep Learning	3	0	2	3	100	25	0	25	150	4
CEAM-05	VIII	* Elective - Honours/Minor CEAM-051 Applications of Artificial Intelligence	4	0	0	3	100	25	25	0	150	4
					8	**--**	**500**	**125**	**25**	**100**	**750**	**20**

***** More Course titles for Elective-Honours/Minor can be included based on Industry requirements.

LEGEND

Abbreviation	**Description**
L	Lecture
T	Tutorial
P	Practical
O	Oral
TH	Theory
TW	Term Work
IA	Internal Assessment

MATHEMATICAL FOUNDATIONS FOR ARTIFICIAL INTELLIGENCE & MACHINE LEARNING					
Semester	**IV**	**Course Code**	**CEAM-01**	**Credits**	**4**
Scheme of Instruction Hours/ Week	**L**	**T**	**P**	**TOTAL**	
	3	**0**	**2**	**42Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks	**TH**	**IA**	**TW**	**P**	**O**
	100	**25**	**0**	**0**	**25**

Prerequisite:

- The students should have knowledge on basics of Python programming.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	The foundational concepts of Mathematics for Machine Learning like Linear Algebra, Vector Calculus, Probability and Distributions, Analytical geometry, Matrix decompositions and Optimization.
2	The understanding and use of various python constructs required for implementation of the mathematics for machine learning.

Course Outcomes:

At the end of course, students will be able to:

CO1	Understand the need and importance of various foundational mathematical concepts for Machine Learning.
CO2	Apply the important concepts in Linear Algebra, Analytic Geometry, Matrix Decompositions, Vector Calculus andProbability & Distributions required for different applications in Machine Learning.
CO3	Analyze the need and usage of the basic optimization techniques used in Machine Learning.
CO4	Utilize the various python constructs required for implementing the mathematics for machine learning programmatically.

UNIT -1	
Introduction, Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings. **Analytic Geometry:** Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions.	12 Hrs
UNIT -2	

Analytic Geometry: Orthogonal Projections, Rotations. **Matrix Decompositions**: Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation, Matrix Phylogeny.	10 Hrs
UNIT -3	
Vector Calculus: Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series.	10 Hrs
UNIT -4	
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 **Continuous Optimization:** Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Convex Optimization.	10Hrs

TEXTBOOKS	
1	Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", 2020, Cambridge University Press
2	Ian Goodfellow, YoshuaBengio and Aaron Courville, "Deep Learning", 2016, The Mit Press

REFERENCES	
1	Dimitri P. Bertsekas and John N. Tsitsiklis, "Introduction to Probability" 2nd edition (1 June 2008), Athena Scientific
2	David C Lay, "Linear Algebra and Its Applications", 3rd edition, Pearson Education India
3	Jay Dawani, "Hands-On Mathematics for Deep Learning: Build a solid mathematical foundation for training efficient deep neural networks",(June 2020), Packt Publishing Limited

List of Experiments

(Minimum 08 Experiments to be performed from the following list in Python)

Sr. No.	Experiment
1	Program to solve linear equations in one variable.
2	Program to solve linear equations in multiple variables.
3	Program to implement basic operations on Matrices and vectors.
4	Program to find matrix Determinant, Trace, Eigenvalues, Eigenvectors, Singular value decompositions.

5	Program to implement Cholesky Decomposition.
6	Program to implement Taylor series.
7	Program to implement and visualize higher order derivatives.
8	Program to implement conditional probability distribution.
9	Program to implement marginal probability distribution.
10	Program to plot Gaussian distribution.
11	Program to implement gradient descent algorithm.
12	Program to implement convex optimization.

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INTRODUCTION TO ARTIFICIAL INTELLIGENCE & MACHINE LEARNING						
Semester	**V**	**Course Code**		**CEAM-02**	**Credits**	**4**
Scheme of Instruction Hours/ Week		**L**	**T**	**P**	**TOTAL**	
		3	**0**	**2**	**42Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**0**	**0**	**25**

Prerequisites:

- Students are expected to be familiar with basics of mathematics.
- Ability to program in Python.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	The course is designed to present an overview of the principles and practices of AI to address real-world problems and to develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI.
2	To introduces the concept of learning from data and develop a strong foundation for understanding important Machine Learning algorithms and their applications.

Course Outcomes:

At the end of course, students will be able to:

CO1	Understand problem solving through search techniques and classify various types of learning.
CO2	Discuss various knowledge representation methods for AI problems.
CO3	Illustrate and apply learning techniques for real-time problems.
CO4	Formulate solutions to various machine learning tasks.

UNIT -1	
Introduction to Artificial Intelligence: Overview, Turing test, Applications. **Problem Solving by Search:** Importance of search in AI, Defining the Problem, State space search, Problem Solving Approach to Typical AI problems, Problem characteristics, production system characteristics, BFS and DFS. **Predicate Logic:** Representing Knowledge as Rules, Representing simple facts in logic, Computable functions and predicates, Unification and resolution.	12 Hrs
UNIT -2	
Knowledge Representation: Representation and Mapping, Approaches to knowledge Representation. **Weak slot and filter structure:** Semantic nets, partitioned semantic nets, Frames.	10 Hrs

Strong Slot and Filter Structures: Conceptual dependency, Scripts. **Game Playing:** Overview, MiniMax Search Procedure, Adding alpha-beta cut offs, Additional refinements.	
UNIT -3	
Machine Learning: Introduction, Designing a learning System, Issues in machine learning. **Concept Learning**: Introduction, General to specific ordering of hypothesis, Finding a maximally specific hypothesis, Version Spaces, candidate elimination algorithms. **Decision tree Learning**: Introduction, Appropriate problems for decision tree learning, Basic Decision Tree Learning Algorithm, Issues in decision tree learning. **Bayesian Learning**: Introduction, Bayes theorem, Naive Bayes Classifier, K-Nearest neighbor classifier.	10 Hrs
UNIT -4	
Clustering: Introduction, k-Means Clustering, Expectation-Maximization Algorithm, Hierarchical Clustering. **Linear Discrimination**: Introduction, Generalizing the Linear Model, Geometry of the Linear Discriminant, Gradient Descent, Logistic Discrimination. **Reinforcement Learning**: Introduction, Elements of Reinforcement Learning, Model-Based Learning, Temporal Difference Learning.	10Hrs

TEXTBOOKS	
1	Elaine Rich and Kevin Knight, Artificial Intelligence, 2nd edition, McGraw Hill.
2	Tom M Mitchell, Machine Learning, Indian edition, McGraw Hill.
3	Ethem Alpaydin, Introduction to Machine Learning, 2ndEdition,The MIT Press.
REFERENCES	
1	Struart Russell and Peter Norvig, Artificial Intelligence, a Modern Approach, 3rd edition, Prentice Hall.
2	Shaishalev-Shwartz and Shai Ben-David, Understanding Machine Learning (FromTheory to Algorithms), First Edition, Cambridge University Press.

List of Experiments

(Minimum 08 Experiments to be performed from the following list in Python)

Sr. No.	Experiment
1	Implementation of Breadth first search using list or queue.
2	Implementation of depth first search using list or stack.

3	Implementation of 2-gallon and 3-gallon water jug problem based on production rules.
4	Implementation of Tower of Hanoi puzzle using recursion.
5	Implementation of 8-puzzle Problem.
6	Implementation of game tree using min-max algorithm.
7	Implementation of decision tree for a given dataset.
8	Implementation of Naive Bayes Classifier.
9	Implementation of K-nearest neighborhood classifier for the given dataset.
10	Implementation of K-means clustering algorithm.
11	Implementation of Hierarchical clustering algorithm.
12	Implementation of a problem using reinforcement learning.

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DATA SCIENCE & ANALYTICS						
Semester	VI	Course Code		CEAM-03	Credits	4
Scheme of Instruction Hours/Week		L	T	P	TOTAL	
		3	0	2	42Hrs/Sem	
Scheme of Examination TOTAL = 150 marks		TH	IA	TW	P	O
		100	25	0	0	25

Prerequisites:

- Basic knowledge of programming and mathematics involved in data analytics.
- Ability to program using Java and R programming language.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	Introduction to basics of data science and data analytics.
2	Provide a sound understanding of the foundations including fundamental concepts like data collection, segregation, and application of various analytics techniques as well as visualization as per end users requirements.

Course Outcomes:

At the end of course, student will be able to:

CO1	Relate practical use of Data Science concept for solving real life problems along with visualization of end results in required form
CO2	Use various techniques on handling stream data& clustering of data for analytics
CO3	Implement Hadoop framework for providing solutions on decision making process in various domains like e-commerce using data analytics
CO4	Performing data analytic using R programming till visualization.

UNIT -1	
Introduction to Data Science: About data science, Terminologies related to data science, Methods of data repository, Personnel involved in data science, Types of Data, Data science process, Popular Data science toolkits. **Recent Trends in Data Science:** Recent trends in data collection and analysis technique	**11Hrs**

Data Visualization: importance, conventional data visualization technique, Retinal variables, Mapping variables to encodings, Various Big Data Visualization tools, Visualization of Big Data, Pre-attentive attributes, Challenges in Big Data Visualization & Potential solutions.	
UNIT -2	
Mining Data Streams: Stream Data Model and Architecture, Sampling data in a stream, Filtering streams, Counting Distinct Elements in a Stream, **Estimating Moments,** Counting Oneness in a Window, Decaying windows. **Frequent itemset Mining**: Market Baskets model and the A-Priori Algorithm, FP growth Algorithm, Handling Larger Datasets in Main Memory, Limited pass algorithm, computing frequent itemset in a stream. **Clustering**: Introduction to clustering techniques, K-Means, Agglomerative Hierarchical clustering, BFR Algorithm, CURE Algorithm.	**10Hrs**
UNIT -3	
Big Data technology Landscape: **NoSQL,:** Types of NoSQL, Advantages of NoSQL, SQL v/s NoSQL, NewSQL. **Hadoop:** Features of Hadoop, Key advantages of Hadoop, Overview of Hadoop Ecosystem, Hadoop verses SQL. **Big Data Analytics:** RDBMS V/s Hadoop, Distributed Computing challenges, Hadoop Overview, The design of HDFS, HDFS Concept, Name node, Data node, command line interface, Basic File system operations, Hadoop File systems, Anatomy of HDFS File read, Anatomy of HDFS File write, Coherency model, Parallel copying with distcp. Hadoop archives, Limitations. YARN, Managing Resources and Applications with Hadoop YARN, Interacting with Hadoop Eco-system. **Map-Reduce Programming:** Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression. Word Count Example. **HIVE:** Hive architecture, Running Hive, Configuring Hive, Hive Services, Hive data type, File format, Hive Query Language, RCFile implementation, SerDe, UDF.	**10 Hrs**

UNIT -4	
Data Analysis using R Programming: Introduction to applied statistical techniques, Types of statistical data, Types of Big Data analytics, Collecting data for sampling and distribution, Probability, Frequency distribution, Population and parameters, Central tendency or Central Value, Measure of central tendency, Different types of statistical means, **Problems of Estimation:** Population or Sample, Normal distribution curve. **Working with R:** Variables, Vectors and assignments, SQL, Box-Plots, Histograms, Multivariate Graphical Methods, Quartile, Variance, Co-Variance, Co-relation coefficient, Skewness, kurtosis, Probability distribution, Binomial distribution & Normal distribution	**11 Hrs**

TEXTBOOKS

1	V. K. Jain, "Data Science and Analytics", Edition 1, Khanna Book Publishing Co. (P) Lts
2	Seema Acharya, Subhashini Chellappan, "Big Data Analytics", Second Edition 2019, WILEY Publication
3	Tom White, "Hadoop: The Definitive Guide", First Edition, O'REILLY Publication
4	Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, "Mining of Massive Datasets", 3rd edition, Cambridge University Press.

REFERENCES

1	Bill Granks, John Wiley & sons, "Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams With Advanced Analytics", 2007, WILEY Publication

(Minimum 08 Experiments to be performed from the following list)

Sr. No	EXPERIMENT
1	Installation, configuration and running of Hadoop and HDFS
2	Implementation of Word Count Program using Map-Reduce
3	Implementation of Calculator application using R

4	Implementation of Descriptive statistics in R
5	Implementation of Reading and writing different types of datasets
6	Implementation of Visualization in R
7	Implementation and use of data frames in R
8	Performing data Manipulation with dplyr package
9	Performing data Manipulation with data.table package
10	Implementation of MR program that processes a weather dataset
11	Implementation of application that stores big data in Hbase/MongoDB/Pig using R

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NEURAL NETWORKS & DEEP LEARNING						
Semester	VII	Course Code		CEAM-04	Credits	4
Scheme of Instruction Hours/ Week		L	T	P	TOTAL	
		3	0	2	42Hrs/Sem	
Scheme of Examination TOTAL = 150 marks		TH	IA	TW	P	O
		100	25	0	0	25

Prerequisites:

- Students should possess knowledge of basic linear algebra
- Knowledge of programming languages is a must.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	Understanding of concepts of neural network, design of logic functions and implementation of various learning rules using neural network.
2	Knowledge about multilayer neural network, unsupervised learning algorithms and associative memories.
3	An understanding of Deep Neural Networks such as Auto encoders, recurrent neural networks and convolutional neural networks.
4	Knowledge about Deep Neural Networks such as Recurrent and Recursive neural networks.

Course Outcomes:

At the end of course, student will be able to:

CO1	Describe concepts of neural network, design neural network to implement logic functions and solve problems related to various learning rules.
CO2	Explain working of multilayer neural network, its design considerations, implement clustering algorithms and associative memory networks for various applications.
CO3	Implement Deep Neural Network algorithms such as Auto encoders and Convolutional neural networks.
CO4	Design and implement Deep Neural Networks such as Recurrent and Recursive neural networks.

UNIT 1	
Introduction: Introduction to neural networks, structure of biological neuron, Mc-Culloch Pitts neuron model, Logic network realization by using Mc-Culloch Pitts neuron model, Neuron modelling for artificial neuron systems, Neural learning. **Single layer network:** Concept of linear seperability and non-linear separability. Training rules- Hebbian learning rule, perceptron learning rule, Delta learning rule, Widrow-Hoff learning rule and related problems. **Multilayer network :** Error back propagation algorithm or generalized delta rule.	**12Hrs**
UNIT 2	
Multilayer network Setting of parameter values and design considerations (Initialization of weights, Frequency of weight updates, Choice of learning rate, Momentum, Generalizability, Network size, Sample size, Non-numeric inputs), performance evaluation. **Unsupervised learning**: Clustering, simple competitive learning algorithm, LVQ algorithm, , SOM, Adaptive Resonance Theory. **Associative memories:** Hopfield networks, Brain-state-in-a-box network, and problems.	**10 Hrs**
UNIT 3	
Deep Neural Networks: Introduction & Necessity of deep neural networks (DNN), Auto encoder and its types. **Convolutional Networks:** The Convolution Operation - Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features - LeNet, AlexNet.	**10 Hrs**
UNIT 4	
Recurrent Neural Networks: Recurrent Neural Networks: Bidirectional RNNs - Deep Recurrent Networks **Recursive Neural Networks:** The Long Short-Term Memory and Other Gated RNNs. **Deep Generative Models:** Deep Belief networks, Boltzmann Machines, Deep Boltzmann Machine, Generative Adversial Networks.	**10 Hrs**

TEXTBOOKS	
1	Kishan Mehrotra, Chilukuri Mohan, Sanjay Ranka, Elements of artificial neural network, Edition-Second, Penram Publications.
2	J. Zurada; Introduction to Artificial neural network, Edition-Second, Jaico Publications
3	Ian Goodfellow, Yoshua Bengio, Aaron Courville; Deep Learning, Edition-Second, MIT Press
REFERENCES	
1	Satish Kumar, Neural networks: a classroom approach, Edition-Second,Tata McGraw-Hill
2	B. Yegnanarayana, Artificial Neural Netwoeks, Edition-Second, Prentice Hall
3	S. Haykin, Neural Network and Learning Machines,Edition-Second, Prentice Hall

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(Minimum 08 Experiments to be performed from the following list)

Sr. No	Experiment
1	Study of different libraries for ANN and DNN
2	Design of logic gates using neural network
3	Implementation of Perceptron learning rule
4	Implementation of Delta learning rule
5	Implementation of classifier using EBPA
6	Implementation of clustering using SCL
7	Design of associative memory using Hopfield network
8	Implementation of Autoencoders-1
9	Implementation of Autoencoders-2
10	Implementation of Convolutional Neural Networks
11	Implementation of Recurrent Neural Networks
12	Implementation of Recursive Neural Network

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CEAM-05 ELECTIVE - HONOURS/MINOR *						
APPLICATIONS OF ARTIFICAL INTELLIGENCE						
Semester	**VIII**	**Course Code**		**CEAM-051**	**Credits**	**4**
Scheme of Instruction Hours/ Week		**L**	**T**	**P**	**TOTAL**	
		4	**0**	**0**	**56Hrs/Sem**	
Scheme of Examination TOTAL = 150 marks		**TH**	**IA**	**TW**	**P**	**O**
		100	**25**	**# 25**	**0**	**0**

***** More Course titles for Elective-Honours/Minor can be included based on Industry requirements.

Term Work (**TW**) marks are to be awarded through continuous evaluation. One or more evaluation technique/techniques such as assignments, case studies, Seminars can be included to award term work marks.

Prerequisite:

- Linear algebra, Linear calculus, Probability, Statistics, Data Structures, Image Processing, Artificial Intelligence and Neural Networks.

Course Objectives:

The subject aims to introduce and equip students with knowledge on:

1	The course introduces the fundamental concepts and techniques of natural language processing (NLP).
2	The course aims to provide students with knowledge about applications of AI in recognition, feature tracking and motion estimation.

Course Outcomes:

At the end of course, students will be able to:

CO1	Justify the need of Natural Language Processing & various approaches to text pre-processing.
CO2	Identify the approaches to syntax and semantics in NLP.
CO3	Understand the recognition, feature tracking and motion estimation.
CO4	Compare various motion estimation techniques.

UNIT -1	
Introduction to Natural Language Understanding The Study of Language, Applications of Natural Language understanding, Evaluating Language Understanding Systems, The Different Levels of Language Analysis, Representations and Understanding, The Organization of Natural Language Understanding Systems. **Linguistic Background & Grammars and Parsing** An Outline of English Syntax Words- The Elements of Simple Noun Phrases, Verb Phrases and Simple Sentences, Noun Phrases Revisited, Adjective Phrases, Adverbial Phrases, Grammars and Sentence Structure, What Makes a Good Grammar, A Top-Down Parser, A Bottom-Up Chart Parser, Top-Down Chart Parsing, Finite State Models and Morphological Processing, Grammars and Logic Programming. **Features and Augmented Grammars** Feature Systems and Augmented Grammars, Some Basic Feature Systems for English, Morphological Analysis and the Lexicon, A Simple Grammar Using Features, Parsing with Features, Augmented Transition Networks, Definite Clause Grammars, Generalized Feature Systems and Unification Grammars.	**14 Hrs**
UNIT -2	
Semantic Interpretation and Ambiguity Resolution Semantics and Logical Form, Word Senses and Ambiguity, The Basic Logical Form Language, Encoding Ambiguity in Logical Form, Verbs and States in Logical Form. **Linking Syntax and Semantics** Semantic Interpretation and Compositionality, A Simple Grammar and Lexicon with Semantic Interpretation, Prepositional Phrases and Verb Phrases, Lexicalized Semantic Interpretation and Semantic roles, Handling Simple Questions, Semantic Interpretation Using Feature Unification. **News Headline Summarization** Approach, Environment setup, Understanding the data, Text Preprocessing, Model building, T5 Pretrained Model, Evaluation Metrics for Summarization. **Text Generation: Next Word Prediction** Problem statement, Approach: Understanding Language Modelling, Implementation: Model 1, Model 2, Model 3, GPT-2 (Advanced Pretrained Model)	**14 Hrs**
UNIT -3	

Recognition Instance Recognition, Image Classification, Object Detection, Semantic Segmentation, Video Understanding. **Feature Detection and Matching** Points and Patches: Feature Tracking, Application, Edges and Contours, Contour Tracking, Lines and Vanishing points.	**14 Hrs**
UNIT-4	
Motion Estimation Translational Alignment, Parametric Motion, Optical Flow, Layered Motion. **Structure from Motion and SLAM** Geometric Intrinsic Calibration, Pose Estimation, Two-Frame Structure from Motion, Multi-Frame Structure from Motion.	**14 Hrs**

TEXTBOOKS

1	James Allen, Natural Language Understanding, 2nd Edition, Pearson.
2	Akshay Kulkarni, Adarsha Shivananda, Anoosh Kulkarni, Natural Language Processing Projects Build Next-Generation NLP Applications Using AI Techniques 1st ed. Edition,, Apress.
3	Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, Springer.

REFERENCES

1	Steven Bird, Ewan Klein, Edward Lopper, Natural Language Processing with Python,1st Edition,O'reilly.
2	Daniel Jurafsky and James H. Martin,Speech and Language Processing, 2nd Edition, Pearson Education.
3	Robert B. Fisher et al, Dictionary of Computer Vision and Image Processing, 2nd Edition, John Wiley and Sons Ltd.
4	Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press.