

Institute/Department	UNIVERSITY INSTITUTE OF ENGINEERING (UIE)	Program	Bachelor of Engineering (Artificial Intelligence and Data Science) (AI201)
Master Subject Coordinator Name:	Siddharth Kumar	Master Subject Coordinator E-Code:	E12853
Course Name	Advanced Machine Learning and Mathematical Modelling	Course Code	23CSH-379

Lecture	Tutorial	Practical	Self Study	Skilling	TC	TGT	TGP	Studio	Credit	Subject Type
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Course Type	Course Category	Mode of Assessment	Mode of Delivery
Major Elective	Graded (GR)	Hybrid	Hybrid (HYB)

Mission of the Department	<p>M1: To provide relevant, rigorous and contemporary curriculum and aligned assessment system to ensure effective learning outcomes for engineering technologies.</p> <p>M2: To provide platform for industry engagement aimed at providing hands-on training on advanced technological and business skills to our students.</p> <p>M3: To provide opportunities for collaborative, interdisciplinary and cutting-edge research aimed at developing solutions to real life problems.</p> <p>M4: To imbibe quest for innovation, continuous learning and zeal to pursue excellence through hard work and problem-solving approach.</p> <p>M5: To foster skills of leadership, management, communication, team spirit and strong professional ethics in all academic and societal endeavours of our students.</p>
Vision of the Department	To be recognized as a centre of excellence for Computer Science & Engineering education and research, through effective teaching practices, hands-on training on cutting edge computing technologies and excellence in innovation, for creating globally aware competent professionals with strong work ethics whom would be proficient in implementing modern technology solutions and shall have entrepreneurial zeal to solve problems of organizations and society at large.

## Program Educational Objectives(PEOs)

PEO1	To be able to explore areas of research, technology application & innovation and make a positive impact in different types of institutional settings such as corporate entities, government bodies, NGOs, inter-government organizations, & start-ups.
PEO2	To be able to design, and implement technology and computing solutions to organizational problems, effectively deploy knowledge of engineering principles, demonstrate critical thinking skills & make the intellectual connections between quantitative and qualitative tools, theories, and context to solve the organizational problems
PEO3	To be able to work with, lead & engage big and small teams comprising diverse people in terms of gender, nationality, region, language, culture & beliefs. To understand stated and unstated differences of views, beliefs & customs in diverse & interdisciplinary team settings
PEO4	To be able to continuously learn and update one's knowledge, engage in lifelong learning habits and acquire latest knowledge to perform in current work settings
PEO5	To continuously strive for justice, ethics, equality, honesty, and integrity both in personal and professional pursuits. Able to understand and conduct in a way that is responsible and respectful.

## Program Specific OutComes(PSOs)

PSO1	PSO1: Graduates will be able to analyze, design, and develop intelligent systems and applications by applying core concepts of Artificial Intelligence and Machine Learning across diverse domains.
PSO2	PSO2: Graduates will demonstrate proficiency in utilizing advanced AI/ML tools, frameworks, and technologies to innovate, implement, and manage projects in the rapidly evolving field of Artificial Intelligence and its allied application areas.
PSO3	PSO3: Graduates will apply AI, Machine Learning, and Data Analytics techniques to address real-world challenges, delivering effective and ethical solutions for industry, research, and societal needs.

## Program OutComes(POs)

PO1	Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
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PO2	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety and the cultural, societal, and environmental considerations.
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
PO5	Create, select, and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitationsPO4 Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
PO7	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context to technological change.
PO13	Demonstrate the capability to apply analytic thought to a body of knowledge, including the analysis and evaluation of policies, and practices. Identify relevant assumptions or implications, logical flaws and loopholes in the presented arguments
PO14	Demonstrate to create, perform, or think in different and diverse ways about the given scenario. Innovate and perform tasks in a better manner, view a problem or a situation from multiple perspectives, think 'out of the box' and generate solutions to complex problems in unfamiliar contexts
PO15	Demonstrate the ability to identify with or understand the perspective, experiences, or points of view of another individual or group, and to identify and understand other people's emotions
PO16	Demonstrate the ability to participate in community-engaged services/ activities for promoting the well-being of society
PO17	Demonstrate the acquisition of knowledge of the values and beliefs of multiple cultures, capability to effectively engage in a multicultural group/society and interact respectfully with diverse groups and gender sensitivity and adopting a gender-neutral approach, as also empathy for the less advantaged and the differently-abled including those with learning disabilities.

Text Books					
Sr No	Title of the Book	Author Name	Volume/Edition	Publish Hours	Years
1	Regression analysis with Python	Massaron, L., & Boschetti, A.	1st Edition	Packt Publishing Ltd.	2016
2	Classification, clustering, and data analysis: recent advances and applications	Jajuga, K., Sokolowski, A., & Bock, H. H. (Eds.).	1st Edition	Springer Science & Business Media	2012
3	Deep learning: Foundations and concepts	Bishop, C. M., & Bishop, H.	1st Edition	Springer Nature	2023

Reference Books					
Sr No	Title of the Book	Author Name	Volume/Edition	Publish Hours	Years
1	Statistical regression and classification: from linear models to machine learning	Matloff, N.	1st Edition	Chapman and Hall/CRC	2017
2	Classification, clustering, and data analysis: recent advances and applications.	K. Jajuga, A. Sokolowski, & H. H. Bock(Eds.)	1st Edition	Springer Science & Business Media	2012
3	An introduction to deep learning	Vishnoi, V. K., Chauhan, N. R., & Kumar, K.	2nd Edition	Xoffencer publication	2024



Course OutCome	
SrNo	OutCome
CO1	Recall the foundational concepts, terminology, and mathematical principles underlying regression, classification and clustering approaches.
CO2	Illustrate the working mechanisms, characteristics, and theoretical concept of regression, clustering and classification techniques in machine learning.
CO3	Apply appropriate regression, clustering and classification algorithms to solve real-world machine learning tasks while addressing performance constraints.
CO4	Analyze and evaluate machine learning models using performance parameters to identify the best-suited techniques for specific applications regression, clustering and classification algorithms.
CO5	Design and implement optimized machine learning solutions by integrating regression, clustering and classification models to solve complex predictive and decision-making problems.

Lecture Plan Preview-Theory							
Unit No	LectureNo	ChapterName	Topic	Text/ Reference Books	Pedagogical Tool**	Mapped with CO Number(s)	BT Level
1	1	Regression	Linear Regression	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT2,BT3
1	2	Regression	Polynomial Regression	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT2,BT3
1	3	Regression	Maxima and Minima of Function of One Variable	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
1	4	Regression	Rank, Eigen Values and Eigen Vectors	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT3
1	5	Regression	Positive & Negative Definite/Semi-Definite Matrices	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT3
1	6	Error Estimation	Maxima and Minima of Function of Several Variables	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT2
1	7	Error Estimation	Convexity of Errors Function	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT2
1	8	Error Estimation	Building Simple Linear Regression Model by Solving Normal Equations	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT2
1	9	Error Estimation	Gradient Descent	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT4
1	10	Error Estimation	Stochastic Gradient Descent Algorithms	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT4
1	11	Error Estimation	Mini-Batch Gradient Descent Algorithms	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT4
1	12	Probability Theory	Discrete Probability Distributions	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT1
1	13	Probability Theory	Continuous Probability Distributions	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT1
1	14	Probability Theory	Normal Distribution and T Distributions	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO1	BT1



1	15	Probability Theory	RSE and R2	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2
2	16	Classification	K-Nearest Neighbor Classifier	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
2	17	Classification	Maximum Margin Classification	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
2	18	Classification	Classification Errors	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT2,BT3
2	19	Classification	Regularization	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT2,BT3
2	20	Classification	Support Vector Machine (SVM) and Kernels	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
2	21	Classification	Kernel Optimization	,T-Regression analysis with Pytho,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT2,BT3
2	22	Ensemble Learning	Combining Classifiers	,T-Regression analysis with Pytho,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
2	23	Ensemble Learning	Boosting, Boosting Margin, and Complexity	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
2	24	Ensemble Learning	Naive Bayes	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO2	BT2,BT3
2	25	Ensemble Learning	Laplace Smoothing	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT2,BT3
2	26	Clustering	Spectral Clustering	,T-Classification, clustering, an,R-Classification, clustering, an	PPT,Simulati on,Video Lecture	CO2	BT3
2	27	Clustering	Markov Models	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT3
2	28	Clustering	Hidden Markov Models (HMMs)	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT4
2	29	Clustering	Bayesian Networks	,T-Classification, clustering, an,R-Classification, clustering, an,R-Statistical regression and cla	PPT,Simulati on,Video Lecture	CO3	BT4
2	30	Clustering	Learning Bayesian Networks	,T-Classification, clustering, an,R-Classification, clustering, an	PPT,Simulati on,Video Lecture	CO3	BT4
3	31	Artificial Neural Network	Artificial Neural Network: Introduction and Background	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO1	BT1,BT2
3	32	Artificial Neural Network	Discrimination Power of Single Neuron	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO2	BT1,BT2
3	33	Artificial Neural Network	Training a Single Perceptron (Delta Rule)	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT3,BT4
3	34	Artificial Neural Network	Multilayer Neural Networks	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT1,BT2
3	35	Artificial Neural Network	Activation Functions	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO5	BT4,BT5





3	36	Artificial Neural Network	Loss Functions	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO4	BT4,BT5
3	37	Artificial Neural Network	Backpropagation	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT1,BT2
3	38	Deep Learning	Deep Learning: Introduction to End-to-End Learning	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO1	BT2
3	39	Deep Learning	Abstractions of Features using Deep Layers: Part 1	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT2
3	40	Deep Learning	Abstractions of Features using Deep Layers: Part 2	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT2
3	41	Deep Learning	Hyper Parameter Tuning: Part 1	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO4	BT4,BT5
3	42	Deep Learning	Hyper Parameter Tuning: Part 2	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO4	BT4,BT5
3	43	Deep Learning	Hyper Parameter Tuning: Part 3	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO4	BT4,BT5
3	44	Deep Learning	Regularization for Deep Learning	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT4
3	45	Deep Learning	Dropout	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulati on,Video Lecture	CO3	BT4

## Lecture Plan Preview-Practical

Unit No	ExperimentNo	Experiment Name	Text/ Reference Books	Pedagogical Tool**	Mapped with CO Number(s)	BT Level
1	1	Implementation of Simple Linear Regression Algorithm with Error Metrics using Python.	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulation,Vid eo Lecture	CO3	BT3,BT4
1	2	Implementation of Multiple Linear Regression Algorithm with Error Metrics using Python.	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulation,Vid eo Lecture	CO3	BT3,BT4
1	3	Implementation of Polynomial Regression Algorithm with Error Metrics using Python.	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulation,Vid eo Lecture	CO4	BT4,BT5
1	4	To implement and compare Batch Gradient Descent, Stochastic Gradient Descent, and Mini-Batch Gradient Descent for linear regression using Python.	,T-Regression analysis with Pytho,R-Statistical regression and cla	PPT,Simulation,Vid eo Lecture	CO4	BT4,BT5



2	5	To implement the K-Nearest Neighbor (KNN) classifier and evaluate its performance on a simple classification dataset by varying the value of K and studying its effect on accuracy and decision boundaries using Python.	,T-Classification, clustering, an,R-Classification, clustering, an	PPT,Simulation,Vid eo Lecture	CO4	BT4,BT5
2	6	To implement a Support Vector Machine (SVM) classifier on a classification dataset and study the effect of different kernels and hyperparameters on the classification accuracy using Python.	,T-Classification, clustering, an,R-Classification, clustering, an	PPT,Simulation,Vid eo Lecture	CO4	BT4,BT5
2	7	To implement a Naive Bayes classifier on a classification dataset and evaluate its performance, understanding how it uses Bayes' Theorem with the naive (independence) assumption between features using Python.	,T-Classification, clustering, an,R-Statistical regression and cla	Case Study,PPT,Simulati on,Video Lecture	CO5	BT4,BT5
3	8	To implement a Multilayer Neural Network (Multilayer Perceptron - MLP) for a classification problem and study the effect of hidden layers, number of neurons, activation functions, and epochs on accuracy.	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulation,Vid eo Lecture	CO5	BT4,BT5
3	9	To implement a deep neural network using deep learning to classify handwritten digits (0–9) from the MNIST dataset.	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulation,Vid eo Lecture	CO5	BT4,BT5
3	10	To develop and train a deep neural network for image classification on your own selected dataset that automatically learns meaningful features from images and achieves high accuracy on test data.	,T-Deep learning: Foundations and,R-An introduction to deep learni	PPT,Simulation,Vid eo Lecture	CO5	BT4,BT5

Assessment Model			
Sr No	Exam Name	Max Marks	Weighted Marks
1	Practical Evaluations	40	20
2	End Term Hybrid Theory	60	30
3	Attendance Marks	2	2



4	Surprise Test	12	4
5	Practical MST	10	4
6	Practical Worksheet/Projects 1	30	2
7	Practical Worksheet/Projects 2	30	2
8	Practical Worksheet/Projects 3	30	2
9	Practical Worksheet/Projects 4	30	2
10	Practical Worksheet/Projects 5	30	2
11	Practical Worksheet/Projects 6	30	2
12	Practical Worksheet/Projects 7	30	2
13	Practical Worksheet/Projects 8	30	2
14	Practical Worksheet/Projects 9	30	2
15	Practical Worksheet/Projects 10	30	2
16	Quiz	4	4
17	Assignment/PBL	10	6
18	MST-1 Hybrid	20	5
19	MST-2 Hybrid	20	5

