Programme	BS Computational Statistics and Data Analytics	Course Code	CSTA-304	Credit Hours	3
Course Title	Machine Learning				

Course Introduction

Machine learning is one of the fastest growing areas of computer science, with far-reaching applications. The aim of this course is to: a) Present the basic machine learning concepts; b) Present a range of machine learning algorithms along with their strengths and weaknesses; c) Apply machine learning algorithms to solve problems of moderate complexity.

Learning Outcomes

By the end of this course, students will be able to:

1. Learn the basic concepts and techniques of Machine Learning.
2. Develop the skills of using recent machine learning software for solving practical problems.
3. Gain hands-on experience of doing independent study and research.

Course Content		Assignments/Readings
Week 1	**Unit – I** Introduction to Machine Learning: Overview of machine learning concepts, algorithms, and applications Understanding the importance of machine learning in pattern recognition and data analysis	
	Unit – II Machine Learning and Pattern Recognition: Exploring the relationship between machine learning and pattern recognition Understanding how machine learning algorithms recognize patterns in data	
Week 2	**Unit – III** Supervised Learning: Linear and Non-linear Regression: Introduction to supervised learning and regression analysis	
	Unit – IV Implementation of linear regression for modeling linear relationships in data	
Week 3	**Unit – V** Non-parametric Methods: Overview of non-parametric methods such as k-nearest neighbors (k-NN) and kernel density estimation	
	Unit – VI Application of non-parametric methods for modeling complex data distributions	

Week 4	**Unit – VII** Support Vector Machines: Understanding support vector machines (SVMs) and their use for classification and regression tasks	
	Unit – VIII Exploring the concept of large-margin classifiers in SVMs	
Week 5	**Unit – IX** Model/Feature Selection: Techniques for selecting optimal models and features in machine learning	
	Unit – X Introduction to regularization methods for preventing overfitting	
Week 6	**Unit – XI** Kernel Methods: Deep dive into kernel methods and their role in non-linear classification and regression Understanding kernel functions and their properties	
	Unit – XII Clustering Algorithms: K-means: Introduction to unsupervised learning and clustering algorithms	
Week 7	**Unit – XIII** Implementation of the K-means algorithm for partitioning data into clusters	
	Unit – XIV Expectation-Maximization: Understanding the expectation-maximization (EM) algorithm for fitting probabilistic models	
Week 8	**Unit – XV** Application of EM algorithm in mixture model estimation	
	Unit – XVI Gaussian Mixture Models: Overview of Gaussian mixture models (GMMs) and their use for modeling complex data distributions Implementation of GMMs for clustering and density estimation tasks	
Week 9	**Unit – XVII** Anomaly Detection: Techniques for detecting anomalies or outliers in data	
	Unit – XVIII Application of anomaly detection algorithms such as isolation forests and one-class SVMs	

Week 10	**Unit – XIX** Artificial Neural Networks: Introduction to artificial neural networks (ANNs) as a powerful machine learning paradigm	
	Unit – XX Understanding the architecture and training process of ANNs	
Week 11	**Unit – XXI** Reinforcement Learning: Overview of reinforcement learning (RL) and its application in sequential decision-making tasks	
	Unit – XXII Introduction to Markov decision processes (MDPs) as a framework for RL	
Week 12	**Unit – XXIII** Ensemble Learning: Bagging: Explanation of ensemble learning techniques and their benefits	
	Unit – XXIV Introduction to bagging as an ensemble method for improving model performance	
Week 13	**Unit – XXV** Random Forests: Understanding random forests as an ensemble learning method based on decision trees	
	Unit – XXVI Random Forests Continued	
Week 14	**Unit – XXVII** Implementation of random forests for classification and regression tasks	
	Unit – XXVIII Boosting: Introduction to boosting algorithms such as AdaBoost and Gradient Boosting	
Week 15	**Unit – XXIX** Advanced Topics in Ensemble Learning: Exploration of advanced ensemble learning techniques such as stacking and gradient boosting variants	
	Unit – XXX Discussion on the advantages and limitations of ensemble methods	
Week 16	**Unit – XXXI** Practical Applications and Case Studies: Real-world applications of machine learning algorithms through case studies and projects	

	Unit – XXXII Hands-on experience with implementing and evaluating machine learning models using popular libraries like scikit-learn or TensorFlow	

Textbooks and Reading Material

Text Book

1. Bishop, C. M. (2006). *Pattern recognition and machine learning.* Springer.

Suggested Readings

1. Alpaydin, E. (2014). *Introduction to machine learning*. MIT press.
2. Marsland, S. (2011). *Machine learning: an algorithmic perspective*. Chapman and Hall/CRC.

Teaching Learning Strategies

Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

Assignments: Types and Number with Calendar

According to the choice of respective teacher.

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2.	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.