Course Type	Course Code	Name of Course	L	T	P	Credit
DC	**NMCC305**	**MATHEMATICAL FOUNDATION FOR MACHINE LEARNING**	3	1	0	4

Prerequisite: Linear Algebra, Calculus, Probability and Statistics

Course Objective
To introduce the key mathematical concepts and develop fundamentals that form the foundations of machine learning.

Learning Outcomes
Students will be able to (i) understand the fundamentals of linear algebra like inner product spaces, singular value decomposition to implement machine learning algorithms like principal component analysis (ii) employ the principal concepts of multivariate calculus to apply in basic neural networks (iii) understand statistical and optimization concepts to apply in different regression and classification algorithms

Unit No.	Topics to be Covered	Lecture (L) +Tutorial (T) Hours	Learning Outcome
1	Eigenvalue and eigenvector, Eigen decomposition and Diagonalization, Least Square Method, Singular value decomposition (SVD), Construction of the SVD Matrix Approximation, Inner product spaces, Orthogonal projections, Gram Schmidt Process, Principal component analysis, Dimensionality Reduction with Principal Component Analysis	10L+3T	This unit will enable students to learn and appreciate the theory of linear algebra in machine Learning and data-driven applications.
2	Partial Differentiation and Gradients, Chain Rule, Gradients of Vector-Valued Functions, Gradients of Matrices, Backpropagation and Automatic Differentiation, Linearization and Multivariate Taylor Series, Several activation functions with properties and applications, Geometric Interpretation with basics of Neural Networks, Gradient Descent algorithm, Forward and Backpropagation algorithm, Error and Loss functions	10L+3T	Students will learn to apply basic multivariate calculus to implement a basic neural network architecture and employ numerical optimization algorithms to solve it.
3	Review of Discrete and Continuous Probabilities, Bayes' Theorem, Means and Covariances. Empirical Means and Covariances, Statistical Independence, Multinomial distribution, Dirichlet distribution, Gaussian Distribution, Exponential Family, Mixture Model, Maximum likelihood function, Expectation Maximization Algorithm, Linear Regression, Logistic Regression, Lasso and Ridge Regression, Naive Bayes classifiers and application to text classification, Cross-validation and bootstrapping	11L+4T	Students will understand the statistical models applied in machine learning and develop mathematical theory to solve some regression and classification techniques.
4	Optimization Using Gradient Descent, Step-size, Gradient Descent with Momentum, Stochastic Gradient Descent, Constrained Optimization and Lagrange Multipliers, Linear Programming, Quadratic Programming, Concept of basic convex optimization, Lagrange duality, Classification with support Vector machines, Soft and Hard Margin classifiers	11L+4T	This unit will help students to understand the mathematical theory behind Continuous Optimization and **support** vector machines. It will also aid students to assess the effectiveness of the models through cross validation techniques.
	Total	**42L+14T**	

Textbooks:

1. Mathematics for Machine Learning. Marc Peter Deisenroth A. Aldo Faisal Cheng Soon Ong. Cambridge University Press, 2020
2. Machine Learning: A Probabilistic Perspective. Kevin Murphy. MIT Press, 2012.

References:

1. Hands-On Mathematics for Deep Learning. Jay Dawani. Packt Publishing Ltd. Birmingham, UK, 2020
2. Pattern Recognition and Machine Learning. Christopher Bishop. First Edition, Springer, 2006