

25UEET412	MATHEMATICS FOR MACHINE LEARNING	Category	L	T	P	R	Credit	Year of Introduction
		PEC	3	0	0	0	3	2025

Preamble: This course introduces the mathematical foundations of basic Machine Learning concepts, enabling learners to understand, develop, and analyze ML systems effectively.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to:

CO	Course Outcomes	Knowledge Level
CO1	Make use of the concepts, rules and results about linear equations, matrix algebra, vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems	K3 Apply
CO2	Perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients	K3 Apply
CO3	Utilize the concepts, rules and results about probability, random variables, additive & multiplicative rules, conditional probability, probability distributions and Bayes' theorem to find solutions of computational problems	K3 Apply
CO4	Train Machine Learning Models using unconstrained and constrained optimization methods	K3 Apply

Mapping of course outcomes with program outcomes and program specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	-	1	-	-	-	-	-	2	3	2
CO2	3	2	-	-	2	-	-	-	-	-	2	3	3
CO3	3	2	1	-	2	-	-	-	-	-	2	3	2
CO4	3	2	-	-	3	-	-	-	-	-	2	3	3
Avg	3	2	1	-	2	-	-	-	-	-	2	3	2.5

Mapping of course outcomes with Knowledge and Attitude Profile (WK)

	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CO1	*	*	*	*	*	*	-	-	-
CO2	*	*	*	*	-	*	-	-	-
CO3	*	*	*	*	*	*	-	-	-
CO4	*	*	*	*	-	*	-	-	-

Wks Mapped with the course

WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
*	*	*	*	*	*	-	-	-

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	40	60	2.5 Hours

Continuous Internal Evaluation Pattern:

Attendance	: 5 marks
Continuous Assessment Test	: 20 marks
Continuous Assessment Assignment	: 15 marks

SYLLABUS**Module 1 (10 Hours)**

LINEAR ALGEBRA: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces – Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.

Module 2 (10 Hours)

ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization. Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.

Module 3 (11 Hours)

VECTOR CALCULUS: Differentiation of Univariate Functions - Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation. Higher Order Derivatives- Linearization and Multivariate Taylor Series

Module 4 (11 Hours)

Probability and Distributions: Construction of a Probability Space - Discrete and Continuous Probabilities, Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family - Change of Variables/Inverse Transform. Optimization: Optimization Using Gradient Descent - Gradient Descent With Momentum. Constrained Optimization and Lagrange Multipliers - Convex Optimization - Linear Programming - Quadratic Programming

Text Books:

1. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. (2020). *Mathematics for machine learning*. Cambridge University Press.
2. Strang, G. (2006). *Linear algebra and its applications* (4th ed.). Thomson Brooks/Cole.

Reference Books:

1. . Boyd, S., & Vandenberghe, L. (2018). *Introduction to applied linear algebra: Vectors, matrices, and least squares*. Cambridge University Press
2. Axler, S. (2015). *Linear algebra done right* (3rd ed.). Springer.
3. Bishop, C. M. (2006). *Pattern recognition and machine learning*. Springer.
4. Boyd, S., & Vandenberghe, L. (2004). *Convex optimization*. Cambridge University Press.
5. Schölkopf, B., & Smola, A. J. (2002). *Learning with kernels: Support vector machines, regularization, optimization, and beyond*. MIT Press.
6. MacKay, D. J. C. (2003). *Information theory, inference, and learning algorithms*. Cambridge University Press.

END SEMESTER EXAMINATION – MODEL QUESTION PAPER
(STC 2025 SCHEME)

Course Code	25UEET412
Course Name	MATHEMATICS FOR MACHINE LEARNING
Max. Marks: 60	Duration: 2.5 Hours

Part A <i>(Answer all questions. Each question carries 3 marks)</i>				
Qn No.	Question	Marks	CO	BL
1	Apply the definition of a linear mapping to find $T(1,2)$ if $T(x,y)=(x+y,x-y)$	3	1	L3
2	Apply matrix representation to obtain the matrix corresponding	3	1	L3

	to the transformation $T(x,y)=(2x,3y)$			
3	Execute the Gram–Schmidt orthogonalization procedure to obtain an orthonormal basis from the vectors $(1,0)$ and $(1,1)$.	3	2	L3
4	Compute an orthonormal basis from the vectors $(1,0)$ and $(1,1)$ using the Gram–Schmidt process.	3	2	L3
5	Compute the partial derivatives of $f(x,y)=x^2y+3xy^2$.	3	3	L3
6	Use linearization to approximate the value of $f(x,y)=x^2+y^2$ at $(2.1,1.9)$ about the point $(2,2)$.	3	3	L3
7	Use Bayes' theorem to find the probability that a manufactured item is defective if it is selected from a machine with known defect rates.	3	4	L3
8	Compute the probability density of a Gaussian random variable with mean 0 and variance 1 at $x=0$.	3	4	L3
Part B <i>(Answer any one full question from each Module. Each carry 9 marks)</i>				
Module I				
9	Apply matrix methods to solve the following system of linear equations and determine whether the system has a unique solution: $x+y+z=6, 2x+3y+z=11, x+2y+3z=14$.	9	1	L3
OR				
10	Implement the principles of linear transformations to find the matrix representation, image, and kernel of $T(x,y)=(2x+y, x-y)$.	9	1	L3
Module II				
11	Implement the Gram–Schmidt orthogonalization process to construct an orthonormal basis for the subspace spanned by the vectors $(1,1,0), (1,0,1), (0,1,1)$.	9	2	L3
OR				
12	Compute the orthogonal projection of the vector $(3,2,1)$ onto the subspace spanned by $(1,0,1)$ and $(1,1,0)$.	9	2	L3
Module III				
13	Compute the gradient and Hessian matrix of $f(x,y)=x^2+xy+y^2$. Hence determine the second-order derivatives.	9	3	L3

OR				
14	Use the multivariate Taylor series to obtain the second-order approximation of $f(x,y)=\ln(1+x+y)$ about the point (0,0).	9	3	L3
Module IV				
15	Implement the inverse transform method to generate samples from the exponential distribution with parameter λ .	9	4	L3
OR				
16	Compute the optimal solution of the quadratic programming problem Minimize $f(x)=x^2+2x+5$.	9	4	L3
