Uka Tarsadia University

B. Tech.

CSE / CSE (AI&ML) / CSE (CC) / CSE (CS) / CE / CE (SE) / IT

Semester II

APPLIED LINEAR ALGRBRA IN AI AND ML

OC3003

EFFECTIVE FROM January -2025

Syllabus version: 1.00

Subject Code	Subject Title
OC3003	Applied Linear Algebra In AI and ML

Teaching Scheme				Examination Scheme			
Hours		Credits		Theory Marks		Practical Marks	Total Marks
Theory	Practical	Theory	Practical	Internal	External	CIE	
3	0	3	0	25	75	-	100

Objectives of the course:

- To give outline to deal with analytical and geometrical problems using linear algebra.
- To apply the concepts and methods of linear algebra in computational area.

Course outcomes:

Upon completion of the course, the student shall be able,

CO1: To acquire the basics of vector space, matrices and linear transformation.
CO2: To illustrate the matric decomposition and sensitivity analysis.
CO3: To explain the application of least squares classification.
CO4: To explain the basics of linear systems and optimization.
CO5: To get the numerical skills for Matrix factorization techniques.
CO6: To acquire the basics of Undetermined systems and its application.

Sr. No.	Topics	Hours
	Unit – I	
1	**Vector Spaces and Linear Functionals:** Vectors, Operations on vectors, vector spaces and subspaces, Inner product and vector norm, Linear dependence and independence, Matrices, Linear transformations, Orthogonal matrices, System of linear equations, Existence and uniqueness, Left and right inverses, Pseudo inverse, tTriangular systems	6
	Unit – II	
2	**Matrix Decomposition, Matrix Norms and Sensitivity Analysis:** LU decomposition and computational complexity, Rotators and reflectors, QR decomposition, Gram-Schmidt Orthogonalization, Condition number of a square matrix, Geometric interpretation, norm of matrix, Sensitivity analysis results for the system of linear equations.	8

Unit – III		
3	**Application of Least Squares Classifications:** Linear least squares, Existence and uniqueness, Geometrical interpretation, Gata fitting with least squares, Feature engineering, application to Vector auto-regressive models, Fitting with continuous and discontinuous piecewise linear functions, Application of least squares to classification, Two-class and multi-class least squares classifiers, Polynomial classifiers, application to MNIST data set.	9
Unit – IV		
4	**Linear Systems and Optimization:** Multi-objective least squares, Applications to estimation and regularized inversion, Regularized data fitting and application to image de-blurring, Constrained least squares, Application to portfolio optimization .Eigenvalue eigenvector decomposition of square matrices, Spectral theorem for symmetric matrices.	8
Unit – V		
5	**Matrix Factorization Techniques:** SVD, Relation to condition number, Sensitivity analysis of least squares problems, Variation in parameter estimates in regression. Multicollinearity problem and applications to principal component analysis (PCA) and dimensionality reduction, Power method, application to Google page ranking algorithm.	8
Unit – VI		
6	**Undetermined System of Linear Equations:** Underdetermined systems of linear equations, Least norm solutions, Sparse solutions, Applications in dictionary learning and sparse code recovery, Inverse eigenvalue problem, Application in construction of Markov chains from the given stationary distribution.	6

Books And References:

1. Stephen Boyd and Lieven Vandenberghe - "Introduction to Applied Linear Algebra- Vectors, Matrices, and Least Squares", Cambridge University Press, 2018.
2. Gilbert Strang - "Linear Algebra and Learning from Data", Wellesley-Cambridge Press, 2019.
3. David Watkins - "Fundamentals of Matrix Computations" , Wiley, 2010.
4. Gene Golub, C. F. Van Loan - "Matrix Computations", Hindustan Book Agency, 2015.

Course objectives and Course outcomes mapping:

- To give outline to deal with analytical and geometrical problems using linear algebra: CO1, CO2, CO3, CO4, CO5, CO6.
- To apply the concepts and methods of linear algebra in computational area: CO1,CO2,CO3, CO4, CO5, CO6

Course units and Course outcomes mapping:

Unit No.	Unit Name	Course Outcomes					
		CO1	CO2	CO3	CO4	CO5	CO6
1	Vector Spaces and Linear Functionals	✓					
2	Matrix Decomposition, Matrix Norms and Sensitivity Analysis		✓				
3	Application of Least Squares Classifications			✓			
4	Linear Systems and Optimization				✓		
5	Matrix Factorization Techniques					✓	
6	Undetermined System of Linear Equations						✓

Programme outcomes:

PO 1: Engineering knowledge: An ability to apply knowledge of mathematics, science, and engineering.

PO 2: Problem analysis: An ability to identify, formulates, and solves engineering problems.

PO 3: Design/development of solutions: An ability to design a system, component, or process to meet desired needs within realistic constraints.

PO 4: Conduct investigations of complex problems: An ability to use the techniques, skills, and modern engineering tools necessary for solving engineering problems.

PO 5: Modern tool usage: The broad education and understanding of new engineering techniques necessary to solve engineering problems.

PO 6: The engineer and society: Achieve professional success with an understanding and appreciation of ethical behavior, social responsibility, and diversity, both as individuals and in team environments.

PO 7: Environment and sustainability: Articulate a comprehensive world view that integrates diverse approaches to sustainability.

PO 8: Ethics: Identify and demonstrate knowledge of ethical values in non-classroom activities, such as service learning, internships, and field work.

PO 9: Individual and team work: An ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: 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/receive clear instructions.

PO 11: Project management and finance: An ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: recognition of the need for, and an ability to engage in life-long learning.

Programme outcomes and Course outcomes mapping:

Programme Outcomes	Course Outcomes					
	CO1	CO2	CO3	CO4	CO5	CO6
PO1	✓	✓	✓	✓	✓	✓
PO2	✓	✓	✓	✓	✓	✓
PO3						
PO4		✓	✓	✓	✓	✓
PO5		✓	✓	✓	✓	✓
PO6						
PO7						
PO8						
PO9						
PO10						
PO11						
PO12						