COURSE TITLE	**APPLIED LINEAR ALGEBRA**
COURSE CODE	**01CT2510**
COURSE CREDITS	**4**

Objective:

1 Linear Algebra is the study of vector spaces and linear transformations on vector spaces. Linear Algebra is central to both pure and applied mathematics. Techniques from linear algebra are also used in analytic geometry, engineering, physics, natural science, computer science, and the social sciences. Topics include the use and application of matrices in the solution of systems of linear equations, determinants, real n-dimensional vector spaces, abstract vector spaces and their axioms, linear independence, span and bases for vector spaces, linear transformations, eigenvalues and eigenvectors, matrix factorizations, and orthogonality. Computer explorations using MATLAB or Python is an integral component of this course.

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

1 Understand the use of matrices in solving linear systems of equations (Understand).

2 Determine the approximate solution of any system of linear equations using projection (Apply).

3 Matrix representations of linear transformations and use them in applied problems (Apply).

4 Applying the concept of eigenvalues, eigenvectors to solve real life problems (Apply).

5 Study and analyze various matrix factorization techniques (Analyze).

Pre-requisite of course: Understanding of elementary linear algebra, MATLAB/PYTHON

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**Vectors and vector spaces** Scalars: real numbers, complex numbers, examples of vector spaces, linear independence, span, basis vectors, rank, subspace, the null space of A: solving Ax = 0 and Rx = 0, the Complete Solution to Ax = b	4
2	**Linear Transformations** Matrix representation, change of basis, products of linear maps, null space, range, fundamental subspaces, rank-nullity theorem, invertibility, isomorphism, operators, invertible linear maps, change of basis for a linear map/operator, simplifying linear operators by changing basis	14

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Contents : Unit	Topics	Contact Hours
3	**Eigenvalues and eigenvectors of linear operators** Characteristic polynomial, eigenvalues/eigenvectors, generalized eigenvectors/eigenspaces, similarity transformation, diagonalization, determinant, applications of eigen values: convolution and DFT, stability, inding expressions for A^k - fibonacci, counting paths in graphs, oogle search - popularity measures in a network	9
4	**Projection and least squares** Projection to a subspace, distance from a subspace and projection least squares solution to a linear equation, application: MMSE estimation application: linear regression in machine learning	8
5	**Singular value decompositions** Singular values and singular vectors, singular value decomposition, application: MIMO communications, low-rank approximations, recommendation systems	7
Total Hours		**42**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment 1** Solving the maze using set of vectors to reach from start to end using restricted movements	2
2	**Experiment 2** Image Filtering using Convolution operation	2
3	**Experiment 3** Image Rotation using Matrix operations	2
4	**Experiment 4** Encryption and Decryption of secret messages using cryptography	2
5	**Experiment 5** Correct or recover the codes that have been tampered with while transmission or processing	2
6	**Experiment 6** Determining the word representation based on embeddings of diffrent words using word2vec	2
7	**Experiment 7** Solving the system of Linear Equations for exact solution	2
8	**Experiment 8** Solving the system of Linear Equations for Approximate solution	2
9	**Experiment 9** Using QR decomposition for solving linear equations	2
10	**Experiment 10** Find the equation of hypothesis to fit the set of datapoints	2
11	**Experiment 11** Obtain the linearly transformed image/structure of a given image/structure	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
12	**Experiment 12** Application of Radiography images using Projection	2
13	**Experiment 13** Calculating the matrix-power using matrix diagonalization	2
14	**Experiment 14** Ranking algorithm in search engines using eigenvalues	2
15	**Experiment 15** Dimensionality Reduction using Eigenvalues and Eigenvectors	2
16	**Experiment 16** Finding the Fibonacci series using eigenvalues and eigenvectors	2
17	**Experiment 17** Image compression using Matrix Factorization	2
18	**Experiment 18** Content Based Filtering Recommendation system using Singular Value Decomposition	2
19	**Experiment 19** Merging multiple images using linear algebra to look as natural image	2
Total Hours		**38**

Textbook :

1 Introduction to Linear Algebra, Gilbert Strang, Wellesley-Cambridge Press, 2016

2 Linear Algebra for Everyone, Gilbert Strang, Wellesley-Cambridge Press, 2020

References:

1 Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares, Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares, Stephen Boyd, Cambridge University Press, 2018

2 Linear Algebra Done Right, Linear Algebra Done Right, Sheldon Axler, Springer, 2015

3 Linear Algebra and Learning from Data, Linear Algebra and Learning from Data, Gilbert Strang, Wellesley- Cambridge Press, 2019

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
10.00	10.00	40.00	20.00	10.00	10.00

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Instructional Method:

1. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
2. Practical examination will be conducted at the end of the semester for evaluation of performance of students in laboratory.
3. Students may use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory, etc.
4. The course delivery method will depend upon the requirement of content and need of the students. The teacher in addition to conventional teaching method (Chalk and Talk) may use any of the tools such as demonstration, role play, Quiz, brainstorming, Flipped class, Project based learning, Collaborative learning, MOOCs etc. for effective teaching.

Supplementary Resources:

1. https://math.mit.edu/~gs/linearalgebra/
2. https://web.stanford.edu/~boyd/vmls/

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