`

LINEAR ALGEBRA AND APPLICATIONS

(Common to CSE(AI & ML) and CSE(DS))

Course Code: 22BM1110

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COURSE OUTCOMES:

At the end of the Course the student shall be able to

CO1: determine the eigenvalues and eigenvectors of a square matrix (L3)

CO2: apply Cayley-Hamilton theorem to find the inverse and the power of a square matrix (L3)

CO3: solve linear system of equations by various direct and iterative methods (L3)

CO4: illustrate the Gram-Schmidt Orthogonalization process using the concept of Inner product space (L4)

CO5: determine Singular Value Decomposition of a matrix (L3)

UNIT-I — 10 Lectures

Systems of Linear Equations:

Rank of a matrix (by echelon form and normal form), consistency of linear system of equations, eigenvalues and eigenvectors of a matrix, properties of eigenvalues. (Sections 2.7, 2.10, 2.13, 2.14 of the textbook)

Learning Outcomes: At the end of this unit, the student will be able to

1. discuss the rank of a matrix using elementary operations (L2)
2. examine the consistency of a systems of linear equations (L3)
3. determine the eigenvalues and eigenvectors of a matrix (L3)

UNIT-II — 10 Lectures

Cayley-Hamilton Theorem and Quadratic Forms:

Cayley-Hamilton theorem (without proof), finding the inverse and the power of a matrix by an application of the Cayley-Hamilton theorem, reduction to a diagonal form, reduction of a quadratic form to a canonical form, nature of the quadratic form. (Sections 2.15- 2.18 of the textbook)

Learning Outcomes: At the end of this unit, the student will be able to

1. illustrate the inverse and the power of a matrix using Cayley-Hamilton theorem (L4)
2. determine an orthogonal matrix to obtain the diagonal form (L3)
3. examine the nature of a quadratic form (L3)

UNIT-III — 10 Lectures

Systems of Linear Equations-Special methods:

Direct methods of solution: Gauss elimination method, Gauss Jordan method, Factorization method,

Iterative methods of solution: Jacobi's iteration method, Gauss Seidel iteration method, Rayleigh's power method. (Sections 28.6, 28.7, 28.9 of the textbook 1)

Learning Outcomes: At the end of this unit, the student will be able to

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1. solve linear simultaneous equations, by using LU Factorization (L3)
2. illustrate the solution of the linear simultaneous equations using iterative methods (L4)
3. explain Rayleigh's power method (L2)

UNIT-IV **10 Lectures**

Vector and Inner Product Spaces:

Group, Vector Space, Vector Subspace, Linear Independence, Basis and dimension, Linear Mapping, Matrix Representation of a Linear Mapping, Transformation Matrix, Basis Change, Image and Kernel of a Linear Mapping, Rank-Nullity Theorem. Norms - Manhattan norm, Euclidean norm; inner product, inner product space, Cauchy-Schwarz Inequality, Angles and Orthogonality, orthonormal basis, Orthogonal Complement, Orthogonal Projections, Gram-Schmidt Orthogonalization (Sections 2.4-2.7.2, 3.1-3.2.2, 3.3. 3.5, 3.8.3 of the textbook 2)

Learning Outcomes: At the end of this unit, the student will be able to

1. explain vector and inner product spaces (L2)
2. examine the linear dependency of vectors (L3)
3. illustrate the Gram-Schmidt Orthogonalization process (L4)

UNIT-V **10 Lectures**

Matrix Decompositions:

Determinant and Trace, Cholesky Decomposition, Eigen decomposition, Singular Value Decomposition, Principal component analysis, Gradients of Vector-Valued Functions, Gradients of Matrices

(Sections 4.1, 4.3, 4.4, 4.5, 5.3, 5.4 of the textbook 2 and 7.4, 7.5 of the textbook 3)

Learning Outcomes: At the end of this unit, the student will be able to

1. solve linear simultaneous equations, by using Cholesky Decomposition (L3)
2. determine singular values and singular vectors (L3)
3. explain the concept of Gradients of Matrices (L2)

Text Books:

1. B. S. Grewal, "*Higher Engineering Mathematics*", 44th edition, Khanna Publishers, 2017.
2. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine learning", Cambridge University Press, 2020.
3. David C. Lay, "*Linear Algebra and Its Applications*", 4th edition, Addison-Wesley, 2012
4.

References:

1. Erwin Kreyszig, *Advanced Engineering Mathematics*, 10th edition, John Wiley & Sons, 2011.
2. S.S. Sastry, *"Introductory Methods of Numerical Analysis"*, 5th edition, Prentice Hall India Pvt. Limited, 2012.

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Web References:

1. https://nptel.ac.in/courses/111/104/111104137/
2. https://nptel.ac.in/courses/111/101/111101115/