Title	**Linear Algebra**
Code	**MS-202**
Credit Hours	3
Category	Math and Science Foundation
Prerequisite	None
Co-Requisite	None
Follow-up	None
Learning Outcomes	Students should: • Be able to solve linear systems of equations • Understand fundamental concepts in Linear Algebra such as linear transformations, dimensionality, rank, linear independence, eigen decomposition, SVD etc. • Comprehend vector spaces (subspaces) • Be able to test the learned concepts in MATLAB • Be able to apply linear algebra concepts to model, solve, and analyze real-world situations • After the completion of this course students should get the right background to study follow-up courses e.g., computer vision, image processing, machine learning and data science
Course Description	**Topics**: **Linear Equations in Linear Algebra:** Systems of Linear Equations, Row Reduction and Echelon Forms, Vector Equations, The Matrix Equation Ax = b, Solution Sets of Linear Systems, Applications of Linear Systems, Linear Independence, Introduction to Linear Transformations, The Matrix of a Linear Transformation, Linear Models in Business, Science, and Engineering**. Matrix Algebra:** Matrix Operations, The Inverse of a Matrix, Characterizations of Invertible Matrices, Partitioned Matrices, Matrix Factorizations, Applications to Computer Graphics, Subspaces of $\mathbb{R}^n$, Dimension and Rank. **Determinants:** Introduction to Determinants, Properties of Determinants, Cramer's Rule, Volume, and Linear Transformations. **Vector Spaces:** Vector Spaces and Subspaces, Null Spaces, Column Spaces, and Linear Transformations, Linearly Independent Sets; Bases, Coordinate Systems, The Dimension of a Vector Space, Rank, Change of Basis. **Eigenvalues and Eigenvectors**: Eigenvectors and Eigenvalues, The Characteristic Equation, Diagonalization, Eigenvectors and Linear Transformations, Complex Eigenvalues, Discrete Dynamical Systems. **Orthogonality and Least Squares:** Inner Product, Length, and Orthogonality, Orthogonal Sets, Orthogonal Projections, The Gram–Schmidt Process, Least-Squares Problems, Applications to Linear Models, Inner Product Spaces, Applications of Inner Product Spaces. **Symmetric Matrices and Quadratic Forms**: Diagonalization of Symmetric Matrices, Quadratic Forms, Constrained Optimization, The Singular Value Decomposition, Applications to Image Processing and Statistics. **The Geometry of Vector Spaces:** Affine Combinations, Affine Independence, Convex Combinations, Hyperplanes. **Optimization:** Matrix Games, Linear Programming—Geometric Method, Linear Programming—Simplex Method, Duality.
Text Book(s)	1. Linear Algebra and Its Applications by David C. Lay, Steven R. Lay, Judi J. McDonald, 5th Edition, 2015, ISBN-13: 978-0321982384, ISBN-10: 032198238X

Reference Material	1. Introduction to Linear Algebra by Gilbert Strang, Fifth Edition, 2016, ISBN-13: 978-0980232776, ISBN-10: 0980232775 2. Elementary Linear Algebra by Howard Anton, 10th Edition, 2013, ISBN-13: 978-0470458211, ISBN-10: 0470458216 3. Coding the Matrix: Linear Algebra through Applications to Computer Science by Philip N. Klein, 1st Edition, 2013, ISBN-13: 978-0615880990, ISBN-10: 0615880991 4. Linear Algebra Labs with MATLAB by David Hill and David Zitarelli, 3rd Edition, 2003, ISBN-13: 978-0131432741, ISBN-10: 0131432745
Assessment Criteria	Homework 05 Quizzes 15 Attendance/Class Participation 05 Midterm 35 Final 40

Week No.	Lecture No.	Topic	Source Book-Chapter No. (Sections / Pages)	Recommendations for Learning Activities (Mention Assignments, Test, Quizzes, Practical, Case Study, Projects, Lab Work or Reading Assignments)
1	1	**Linear Equations in Linear Algebra** • Systems of Linear Equations • Row Reduction and Echelon Forms	Text. Ch1(1.1 to 1.2) Ref. 2 Ch1	Books Reading
	2	**Linear Equations in Linear Algebra** • Vector Equations • The Matrix Equation Ax = b	Text. Ch1(1.3 to 1.4) Ref. 1 Ch1 Ref. 2 Ch1	Books Reading
2	3	**Linear Equations in Linear Algebra** • Solution Sets of Linear Systems • Applications of Linear Systems	Text. Ch1(1.5 to 1.6) Ref. 1 Ch2 Ref. 2 Ch1	Books Readings
	4	**Linear Equations in Linear Algebra** • Solution Sets of Linear Systems • Applications of Linear Systems	Text. Ch1(1.5 to 1.6) Ref. 1 Ch2 Ref. 2 Ch1	Quiz#1 Books Readings
3	5	**Matrices in MATLAB (Hands On)** • Getting Data into MATLAB • Hilbert matrix • Dot product vs. cross product in MATALB	Ref. 4 Ch1 (1.1)	Books Readings
	6	**Linear Equations in Linear Algebra** • Linear Independence	Text. Ch1(1.7) Ref. 1 Ch3	
4	7	**Linear Equations in Linear Algebra** • Introduction to Linear Transformations	Text. Ch1(1.7) Ref. 1 Ch8 Ref. 2 Ch8	Books Readings
	8	**Linear Equations in Linear Algebra** Introduction to Linear Transformations	Text. Ch1(1.8) Ref. 1 Ch8 Ref. 2 Ch8	Books Readings
5	9	**Linear System (Hands On)** • Row Operations Using MATLAB • Visualizing Row Operations • Symbolic Row Operations	Ref. 4 Ch1 (1.1)	Books Readings
	10	**Linear Equations in Linear Algebra** • Introduction to Linear Transformations • The Matrix of a Linear Transformation, Linear Models in Business, Science, and Engineering	Text. Ch1(1.8 to 1.9)	Assignment#1 Quiz#2 Books Readings
6	11	**Matrix Algebra** • Matrix Operations	Text. Ch2 (2.1)	Books Readings
	12	**Matrix Algebra** • The Inverse of a Matrix • Characterizations of Invertible Matrices	Text. Ch4 (2.2 to 2.3) Ref. 1 Ch1 Ref. 2 Ch1	Books Readings
7	13	**Matrix Algebra** • Partitioned Matrices	Text. Ch2 (2.4)	Books Readings
	14	**Matrix Algebra** • Matrix Factorizations	Text. Ch2 (2.5, 2.7)	Assignment#2 Quiz#3 Books Readings

8	15	**Matrix Algebra** • Applications to Computer Graphics	Text. Ch2 (2.5, 2.7)	Books Readings
	16	**Matrix Operations, Homogeneous Systems, Echelon Forms, and Inverses (Hands On)** • Matrix Algebra • Generating Matrices • Display Formats • Homogeneous Systems • Reduced Row Echelon Form • Inverses	Ref.4	Books Readings
	MID TERM			
9	17	**Vector Spaces:** • Vector Spaces and Subspaces • Null Spaces • Column Spaces • Linear Transformations	Text. Ch4 (4.1 to 4.2) Ref. 2 Ch3 Ref. 3 Ch3	Books Readings
	18	Midterm paper show		
10	19	**Vector Spaces:** • Linearly Independent Sets • Bases • Coordinate Systems	Text. Ch4 (4.3 and 4.4) Ref. 2 Ch3 Ref. 3 Ch3	Books Readings
	20	**Vector Spaces:** • The Dimension of a Vector Space • Rank • Change of Basis	Text. Ch4 (4.5 to 4.7) Ref. 2 Ch3 Ref. 3 Ch3	Books Readings
11	21	**Eigenvalues and Eigenvectors**: • Eigenvectors and Eigenvalues • The Characteristic Equation • Diagonalization	Text. Ch5 (5.1 to 5.3) Ref. 1 Ch6 Ref. 2 Ch3 Ref. 3 Ch12	Books Readings Assignment#3 Quiz#4
	22	**Eigenvalues and Eigenvectors**: • Eigenvectors and Linear Transformations • Complex Eigenvalues • Discrete Dynamical Systems	Text. Ch5 (5.4 to 5.6) Ref. 1 Ch6 Ref. 2 Ch3 Ref. 3 Ch12	Books Readings
12	23	**Orthogonality and Least Squares:** • Inner Product • Length and Orthogonality • Orthogonal Sets • Orthogonal Projections	Text. Ch6 (6.1 to 6.3) Ref. 1 Ch1 Ref. 2 Ch6	Books Readings
	24	**Orthogonality and Least Squares:** • The Gram–Schmidt Process • Least-Squares Problems • Applications to Linear Models • Inner Product Spaces • Applications of Inner Product Spaces	Text. Ch6 (6.4 to 6.8) Ref. 1 Ch4 Ref. 2 Ch6	Books Readings

13	25	**Symmetric Matrices and Quadratic Forms**: • Diagonalization of Symmetric Matrices • Quadratic Forms • Constrained Optimization	Text. Ch7 (7.1 to 7.3) Ref. 1 Ch6 Ref. 2 Ch7	Books Readings Assignment#4 Quiz#5
	26	**Symmetric Matrices and Quadratic Forms**: • The Singular Value Decomposition • Applications to Image Processing and Statistics.	Text. Ch7 (7.4.to 7.5) Ref. 1 Ch7 Ref. 2 Ch9 Ref. 3 Ch11	Books Readings
14	27	**Symmetric Matrices and Quadratic Forms**: • The Singular Value Decomposition • Applications to Image Processing and Statistics.	Text. Ch7 (7.4.to 7.5) Ref. 1 Ch7 Ref. 2 Ch9 Ref. 3 Ch11	Books Readings
	28	**The Geometry of Vector Spaces:** • Affine Combinations • Affine Independence • Convex Combinations • Hyperplanes	Text. Ch8 (8.1.to 8.4) Ref. 2 Ch10	Books Readings
15	29	**Optimization:** • Matrix Games, • Linear Programming—Geometric Method	Text. Ch9 (9.1.to 9.2) Ref. 2 Ch10 Ref. 3 Ch13	Books Readings
	30	**Optimization:** • Linear Programming—Simplex Method • Duality	Text. Ch9 (9.3.to 9.4) Ref. 3 Ch13	Books Readings
16	31	**Vector Spaces (Hands On)** • Experimenting with Vector Space Properties • Linear Combinations • Span • Linear Independence/Dependence • Basis	Ref.4 Sections (5.1) Sections (6.1 to 6.4)	Quiz#6
	32	**Course review**		

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