Linear Algebra I

Course Syllabus

Course Title	Linear Algebra I
Course Code	MTH 212
Course Type	Core
Course Status	Theory
Course Hour	3.0 Hr./Week
Credit Value	3.0
Prerequisite	None
Total Marks	100
ISCED Code	0541–212
Batch & Department	19th, Department of Mathematics, Comilla University
Course Teacher	Shaiful Islam Arafat (SIA), shaifulislamarafat@cou.ac.bd

Course Description

Linear Algebra I is one of the most fundamental compulsory courses for the undergraduate B.Sc. (Honours) programme. The course carries three credit hours and consists of approximately 42 hours of effective classroom teaching over fourteen weeks. Students are assessed through class participation, presentations, quizzes, assignments, two midterm examinations and a comprehensive final examination.

The course combines both the theoretical and computational aspects of linear algebra. It introduces vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$, matrices, systems of linear equations, vector spaces, basis and dimension, linear transformations, eigenvalues and eigenvectors together with their applications.

Linear algebra provides the mathematical foundation for numerous disciplines, including computer science, data science, machine learning, signal processing, compressed sensing, physics, chemistry, biology, economics, psychology, engineering and environmental sciences. Matrix methods are indispensable in optimization, operations research and scientific computing. Consequently, Linear Algebra I serves as one of the core courses for every mathematics major.

Course Rationale

The course develops the theoretical foundations and computational techniques of linear algebra that are essential for higher studies in mathematics and its applications. Students learn to model and solve systems of linear equations, perform matrix computations, study vector spaces and linear transformations, and apply these concepts to real-world scientific and engineering problems.

Course Objectives

Upon successful completion of this course, students will be able to:

1. Understand vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$ together with their algebraic operations.
2. Perform matrix operations and compute determinants and matrix inverses.
3. Solve systems of linear equations using matrix methods.
4. Understand vector spaces, subspaces, basis and dimension.
5. Study linear transformations and their matrix representations.
6. Compute eigenvalues and eigenvectors and apply them in practical problems.
7. Understand orthogonality, inner products and vector projections.
8. Develop mathematical reasoning and proof-writing skills.
9. Use appropriate mathematical software for computational problems in Linear Algebra.

Course Learning Outcomes (CLOs)

After successful completion of the course, students will be able to:

CLO	**Learning Outcome**
CLO1	Define vector spaces and perform basic operations on vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$. Define different types of matrices and determinants, perform elementary matrix operations, compute transposes and inverses, and reduce matrices to echelon and reduced echelon forms.
CLO2	Calculate determinants using row operations, column operations and cofactor expansion. Solve homogeneous and non-homogeneous systems of linear equations using Gaussian and Gauss–Jordan elimination methods.
CLO3	Use matrix operations to solve systems of equations, determine the nature of their solutions, and understand linear combinations, linear span, linear independence and dependence of vectors.
CLO4	Describe the kernel, image, rank and nullity of linear transformations. Construct matrix representations of linear transformations with respect to standard and non-standard bases.
CLO5	Compute eigenvalues, eigenvectors and eigenspaces of matrices, diagonalize matrices when possible and apply these concepts to practical problems.

Course Contents

Course Contents	Hours	CLOs
Vectors in $\mathbf{R^n}$ and $\mathbf{C^n}$ Review of geometric vectors in $\mathbb{R}^2$ and $\mathbb{C}^2$; Vectors in $\mathbb{R}^n$ and $\mathbb{C}^n$; Inner product, Norm and Distance in $\mathbb{R}^n$ and $\mathbb{C}^n$.	3 Hrs.	CLO1
Matrices and Determinants Definition of matrices; Different types of matrices; Laws of matrix algebra; Determinants and their properties; Minors and Cofactors, Expansion and Evaluation of determinants; Cramer's rule; Adjoint matrix; Invertible matrices and their inverses with applications; Elementary row and column operations; Echelon forms; Block matrices; Row rank and Column rank and their equivalence.	8 Hrs.	CLO1
System of Linear Equations Introduction to systems of linear equations; Solutions of the system of linear equations (homogeneous and non-homogeneous systems); Implementation of matrix operations and determinants to solve the system of linear equations (Gaussian elimination, Gauss–Jordan elimination, Matrix methods etc); Applications of systems of linear equations; Nature of solutions.	9 Hrs.	CLO2, CLO3
Vector Spaces Groups and Fields (basic review); Vector spaces; Subspaces; Linear combinations; Linear span; Linear independence and dependence; Basis; Dimension; Solution spaces of systems of linear equations; Row space; Column space; Null space.	8 Hrs.	CLO2, CLO3, CLO5
Linear Transformations Linear transformations; Kernel and Image of linear transformation and their properties; Rank; Nullity; Matrix representation of linear transformation.	6 Hrs.	CLO4, CLO5
Eigenvalues and Eigenvectors Definitions and Properties; Characteristic equation; Cayley–Hamilton theorem; Diagonalization and its applications.	8 Hrs.	CLO4, CLO5

Mapping of Course Learning Outcomes (CLOs) to Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11	PLO12
CLO1	✓	✓	✓	–	–	–	–	–	–	–	–	–
CLO2	✓	✓	✓	✓	–	–	–	–	–	–	–	–
CLO3	✓	✓	✓	✓	✓	–	–	–	–	–	–	–
CLO4	✓	✓	✓	✓	✓	✓	–	–	–	–	–	–
CLO5	✓	✓	✓	✓	✓	✓	✓	–	–	–	–	–

Learning Materials

Recommended Reading

1. Howard Anton and Chris Rorres, *Elementary Linear Algebra: Applications Version*, 11th Edition, John Wiley & Sons, 2013.
2. Sheldon Axler, *Linear Algebra Done Right*, 4th Edition, Springer, 2024.
3. Lipschutz, S., *Linear Algebra*, 9th Edition, McGraw–Hill Education, 2019.

Supplementary Readings

1. Gilbert Strang, *Introduction to Linear Algebra*, 5th Edition, Wellesley-Cambridge Press, 2016.

Teaching–Learning and Assessment Strategy

CLO	**Teaching–Learning Strategy**	**Assessment Strategy**
CLO1	Lecturing and Student Activities	Quiz and Assignment
CLO2	Lecturing and Discussion	Mid-Semester Examination and Summative Examination
CLO3	Lecturing and Discussion	Mid-Semester Examination and Summative Examination
CLO4	Student Activities and Discussion	Summative Examination
CLO5	Lecturing and Discussion	Presentation, Assignment and Summative Examination

Assessment Scheme

Component	**Weight (%)**
Attendance	5
Assignment	5
Presentation (or Viva)	10
Midterm Examinations	20
Final Examination	60
Total	**100**