CH/AD/CD/CE/ CM/CS/EC/EE/ IT/ME/QC111	LINEAR ALGEBRA AND CALCULUS	L	T	P	C	Int	Ext
		3	1	-	4.0	40	60
	Semester I [First Year]						

COURSE OUTLINE:

This course introduces the fundamental mathematical tools of linear algebra and calculus that underpin engineering analysis and design. It covers matrix theory and eigenvalue problems, differential calculus of functions of one and several variables, and multiple-integration techniques. These topics form the mathematical backbone used to model, analyse, and solve complex engineering problems across all branches. The course lays the foundation for higher-semester courses such as Differential Equations & Vector Calculus.

COURSE OBJECTIVES:

1. To develop proficiency in matrix algebra techniques for solving systems of linear equations and analysing eigenvalues and eigenvectors.
2. To enable understanding of advanced matrix theory, including diagonalisation, quadratic forms, and special classes of matrices.
3. To familiarise students with mean value theorems and their application to functions of a single variable.
4. To develop skills in multivariable calculus, including partial derivatives, Taylor series expansion, and constrained/unconstrained optimisation.
5. To enable evaluation of double and triple integrals and their application to area and volume computation.

COURSE OUTCOMES:

After successful completion of the course, the students are able to

CO	Course Outcome	RBTL
CO1	apply matrix algebra techniques to solve systems of linear equations and determine eigenvalues and eigenvectors.	Apply (BL3)
CO2	analyse matrices using the Cayley-Hamilton theorem, diagonalisation, and reduction of quadratic forms to canonical form.	Analyze (BL4)
CO3	apply mean value theorems and Taylor/Maclaurin series to functions of a single variable.	Apply (BL3)
CO4	analyse functions of several variables using partial derivatives and solve optimisation problems using Lagrange multipliers.	Analyze (BL4)
CO5	evaluate double and triple integrals and apply them to compute area and volume.	Evaluate (BL5)

CO - PO / PSO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	-	1	2	-	-	-	-	-	1	-	-
CO2	3	2	-	-	1	-	-	-	-	-	1	-	-
CO3	3	2	-	-	-	-	-	-	-	-	1	-	-
CO4	3	3	1	-	1	-	-	-	-	-	1	-	-
CO5	3	2	-	1	-	-	-	-	-	-	1	-	-

UNIT I [CO:1] **(12)**

Matrix Algebra-I : Types of matrices; rank of a matrix; echelon and normal forms; inverse of non-singular matrices by the Gauss-Jordan method; System of linear equations: solving homogeneous and non-homogeneous systems; iterative method - Gauss-Seidel; Characteristic equation, eigenvalues and eigenvectors.

AI Integration with Contents:

Use computational tools such as Python (NumPy/SciPy) or MATLAB to compute rank, inverse, and eigenvalues of large-order matrices, and AI-assisted tools (e.g., WolframAlpha) to verify hand-calculated results and visualise eigenvector directions.

Unit Learning Outcomes:

1. Determine the rank, inverse, and solution of a linear system using appropriate matrix methods.
2. Compute the eigenvalues and eigenvectors of a given matrix.

Practical Examples for In-Class Explanation:

1. Finding the rank and inverse of a 3x3 matrix using the Gauss-Jordan method.
2. Solving a system of three equations in three unknowns using the Gauss-Seidel iterative method.

Exercise / Practice Problems:

1. Reduce a given matrix to normal form and determine its rank.
2. Solve a non-homogeneous system of linear equations using the Gauss-Seidel method.
3. Find the eigenvalues and eigenvectors of a given 3x3 matrix.

UNIT II [CO:2] **(12)**

Matrix Algebra-II : Cayley-Hamilton theorem (without proof); powers and inverse of matrices using the Cayley-Hamilton theorem; diagonalisation; Quadratic forms and the nature of quadratic forms; reduction of a quadratic form to canonical form by orthogonal transformation; Hermitian, skew-Hermitian and unitary matrices.

AI Integration with Contents:

Use CAS tools (MATLAB Symbolic Toolbox, Python SymPy) to verify Cayley-Hamilton computations and automate matrix diagonalisation, and AI-based visualisation to interpret quadratic-form reduction geometrically.

Unit Learning Outcomes:

1. Apply the Cayley-Hamilton theorem to compute powers and the inverse of a matrix.
2. Reduce a quadratic form to canonical form and classify special matrices.

Practical Examples for In-Class Explanation:

1. Verifying the Cayley-Hamilton theorem for a 3x3 matrix and using it to find the inverse.
2. Reducing a given quadratic form to canonical form using orthogonal transformation.

Exercise / Practice Problems:

1. Using the Cayley-Hamilton theorem, find the inverse of a given matrix.
2. Diagonalise a given symmetric matrix.
3. Determine the nature of a given quadratic form.

UNIT III [CO:3] **(12)**

Mean Value Theorems and Infinite Series : Mean value theorems: Rolle's theorem, Lagrange's mean value theorem with geometrical interpretation, Cauchy's mean value theorem (without proofs);Taylor's and Maclaurin's theorems with remainders (without proof); problems and applications;Taylor's and Maclaurin's series

AI Integration with Contents:

Use graphing/AI tools (Desmos, GeoGebra, Python Matplotlib) to visualise the geometrical interpretation of mean value theorems and to generate and compare Taylor-polynomial approximations interactively.

Unit Learning Outcomes:

1. Verify the mean value theorems for a given function.
2. Expand functions using Taylor's and Maclaurin's series.

Practical Examples for In-Class Explanation:

1. Verifying Lagrange's mean value theorem for a given function on a specified interval.
2. Expanding e^x using Maclaurin's series up to four terms.

Exercise / Practice Problems:

1. Verify Cauchy's mean value theorem for two given functions.
2. Expand log(1+x) using Maclaurin's series.
3. Find the Taylor series expansion of a given function about a specified point.

UNIT IV [CO:4] **(12)**

Functions of Several Variables : Functions of several variables: continuity and differentiability, partial derivatives, total derivatives, chain rule, Euler's theorem;Taylor's and Maclaurin's series expansion of functions of two variables;Maxima and minima of functions of two variables without constraints and with constraints - method of Lagrange multipliers.

AI Integration with Contents:

Use 3-D plotting/AI-based visualisation tools (Python Matplotlib/Plotly, GeoGebra 3D) to visualise surfaces, partial derivatives, and critical points, aiding intuition in optimisation problems.

Unit Learning Outcomes:

1. Compute partial derivatives and apply Euler's theorem for homogeneous functions.
2. Determine maxima and minima of functions of two variables with and without constraints.

Practical Examples for In-Class Explanation:

1. Verifying Euler's theorem for a given homogeneous function.
2. Finding the maxima/minima of a function of two variables using Lagrange's method of multipliers.

Exercise / Practice Problems:

1. Find the partial derivatives and verify the chain rule for a given composite function.
2. Expand a given function of two variables using Taylor's series.
3. Find the extreme values of a given function using Lagrange's multiplier method.

UNIT V [CO:5] **(12)**

Multiple Integrals : Double integrals: evaluation in Cartesian coordinates over Type I and Type II regions; change of order of integration;Evaluation of double integrals in polar coordinates; change of variables from Cartesian to polar;Triple integrals; area by double integrals; volume by triple integrals.

AI Integration with Contents:

Use computational tools (Python SciPy, MATLAB) to numerically evaluate double/triple integrals and cross-check analytical results, and AI-based visualisation to illustrate regions of integration in Cartesian and polar form.

Unit Learning Outcomes:

1. Evaluate double integrals in Cartesian and polar coordinates.
2. Apply double and triple integrals to compute area and volume.

Practical Examples for In-Class Explanation:

1. Evaluating a double integral over a region bounded by given curves.
2. Finding the volume of a solid using triple integration.

Exercise / Practice Problems:

1. Change the order of integration in a given double integral and evaluate it.
2. Evaluate a given double integral by converting to polar coordinates.
3. Find the volume of a given solid using triple integrals.

LEARNING RESOURCES:

TEXT BOOK(s):

1. Kreyszig, E. (2011). Advanced engineering mathematics (10th ed.). John Wiley & Sons.
2. Grewal, B. S. (2017). Higher engineering mathematics (44th ed.). Khanna Publishers.

REFERENCE BOOK(s):

1. Jain, R. K., & Iyengar, S. R. K. (2016). Advanced engineering mathematics (5th ed.). Narosa Publishing House.
2. Thomas, G. B., & Weir, M. D. (2018). Thomas calculus (14th ed.). Pearson.

WEB RESOURCES:

1. MIT OpenCourseWare. (n.d.). Linear algebra. Massachusetts Institute of Technology. https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/
2. NPTEL. (n.d.). Engineering mathematics. https://nptel.ac.in/