Gyanmanjari

Syllabus
Gyanmanjari Institute of Technology
Semester-1 (B.Tech)

Subject: Calculus and Algebra(BET2XX11201)

Type of course: Major (Core)

Prerequisite: Basic algebra, trigonometry, coordinate geometry, elementary functions, and system of linear equations.

Rationale: This course is designed to build a strong mathematical foundation for first-year engineering students by integrating essential topics from linear algebra, differential calculus, power series, and multivariable calculus. The course enables learners to understand matrix-based methods for solving systems, analyze rates of change using derivatives, apply mean value theorems for functional behavior, approximate functions through series expansions, and handle transformations in multi-variable systems using Jacobians. These topics support later studies in core engineering areas such as mechanics, electronics, data analysis, modeling, optimization, and computational methods.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
4	0	0	4	100	50	150

Course Content:

Sr. No	Course Content	Hrs.	% Weightage
1	**Chapter 1: Linear Algebra I: Basic Matrix Operations and Systems** Introduction to matrices: types and notation; Matrix operations: addition, subtraction, scalar multiplication, and matrix multiplication; Properties of matrix operations; Determinants: definition, properties, and evaluation; Cofactors and adjoint of a matrix; Inverse of a matrix using the adjoint method; System of linear equations: matrix representation (AX=B); Solving small systems using Cramer's Rule and Matrix Inverse method.		

		12	20%

Sr No.	Evaluation Methods	SEE	CCE
1	The Matrix Logic Test	20	
2	**ALA:** The System Solver Clinic		10
	Total:	**20**	**10**

Description of ALA: The System Solver Clinic (10 Marks)
Students work as "Math Support Analysts" in small groups. Each group is given a system of equations arising from a practical engineering setting and must solve it using matrix methods.
The activity includes:

- Representing the system in matrix form.
- Identifying the most suitable solving method.
- Solving using inverse or Cramer's Rule.
- Explaining why the selected method is appropriate.
- Submitting a short summary of the method, calculations, and result.

2		12	20%

Chapter 2: Linear Algebra II: Advanced Matrix Theory
Elementary row and column transformations; Rank of a matrix: computation using Echelon form and Normal form; Consistency and Inconsistency of linear systems; Solving large systems using Gauss Elimination method; Characteristic equation; Eigenvalues and Eigenvectors; Properties of Eigenvalues; Cayley–Hamilton theorem: verification and its applications to find A^{-1} and A^n.

Sr No.	Evaluation Methods	SEE	CCE
1	The Rank and Eigen Audit	20	
2	**ALA:** The Eigen-Structure Workshop		10
	Total:	**20**	**10**

Description of ALA: The Eigen-Structure Workshop (10 Marks)
Students prepare a structured learning artifact explaining eigenvalues, eigenvectors, and matrix rank through a real engineering analogy such as vibration modes, data directions, or transformation scaling.
The activity includes:

- Creating a concept chart or poster.
- Showing how row operations simplify system solving.
- Demonstrating one example of eigenvalue/eigenvector computation.
- Explaining one application of the Cayley–Hamilton theorem.
- Peer discussion and short oral explanation.

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Chapter 3: Foundations of Differential Calculus
Concept of limits; left-hand and right-hand limits; Evaluation of limits using standard limits; Continuity and Differentiability; Derivatives of standard functions; Rules of differentiation: product, quotient, and chain rule; Indeterminate forms; L'Hôpital's Rule.
<table>
<tr><th>Sr No.</th><th>Evaluation Methods</th><th>SEE</th><th>CCE</th></tr>
<tr><td>1</td><td>Error Identification Solver</td><td>20</td><td></td></tr>
<tr><td>2</td><td>ALA:
The Derivative Rule Challenge</td><td></td><td>10</td></tr>
<tr><td></td><td>Total:</td><td>20</td><td>10</td></tr>
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Description of ALA: The Derivative Rule Challenge (10 Marks)
Students work individually or in pairs to solve a timed set of problems focused on correct rule selection in differentiation.
The activity includes:

Identifying the correct differentiation rule.
Solving step-by-step.
Explaining why alternative rules would fail.
Presenting one corrected example to peers.
Preparing a short "rule map" for common derivative forms.

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Chapter 4: Mean Value Theorems and Power Series
Rolle's Theorem; Lagrange's Mean Value Theorem (LMVT); Cauchy's Mean Value Theorem; Taylor's series expansion of functions; Maclaurin's series expansion; Expansion of standard functions; Applications of series in approximations.
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<tr><th>Sr No.</th><th>Evaluation Methods</th><th>SEE</th><th>CCE</th></tr>
<tr><td>1</td><td>The Theorem Integrity and Series Precision Test</td><td>10</td><td></td></tr>
<tr><td>2</td><td>ALA:
The Human Approximation Relay</td><td></td><td>10</td></tr>
<tr><td></td><td>Total:</td><td>20</td><td>10</td></tr>
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Description of ALA: The Human Approximation Relay (10 Marks)
Students participate in a collaborative approximation activity where each member computes one stage of a Taylor or Maclaurin expansion.
The activity includes:

Generating terms in sequence.
Recording how the approximation improves term by term.
Comparing approximate and actual values.
Calculating the error after each step.
Submitting a convergence log and group summary.

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<td>Chapter 5: Multivariable Calculus and Homogeneous Functions
Functions of several variables; Partial derivatives: first and higher order; Euler's theorem for homogeneous functions; Chain rule for multivariable functions; Jacobians: definition, properties, and evaluation; Transformation of variables using Jacobians.
<table>
<tr><th>Sr No.</th><th>Evaluation Methods</th><th>SEE</th><th>CCE</th></tr>
<tr><td>1</td><td>Open Book Exam</td><td>20</td><td></td></tr>
<tr><td>2</td><td>ALA:
The Chain Rule Flowchart</td><td></td><td>10</td></tr>
<tr><td></td><td>Total:</td><td>20</td><td>10</td></tr>
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Description of ALA: The Chain Rule Flowchart (10 Marks)
Students perform "Student construction of diagrams" to map variable dependencies.

Dependency Mapping: Create a Flowchart tracing independent variables through intermediate ones.
Path Logic: Label branches with partial derivatives and solve "Problem solving" cases by summing product paths.
Oral Report: Provide a "Verbal Illustration" of the process (e.g., how input changes affect final system output)

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Suggested Specification table with Marks:

Distribution of Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	10%	15%	30%	25%	10%	10%

Course Outcomes:

After learning the course, the students should be able to:	
CO1	Apply basic matrix operations, determinants, adjoint, and inverse methods to solve systems of linear equations.
CO2	Determine rank, analyze consistency of linear systems, and compute eigenvalues and eigenvectors for matrix-based engineering problems.
CO3	Evaluate limits, test continuity and differentiability, and use derivative rules including L'Hôpital's Rule in function analysis.
CO4	Verify and apply Rolle's, Lagrange's, and Cauchy's Mean Value Theorems, and approximate functions using Taylor and Maclaurin series.
CO5	Compute partial derivatives, apply Euler's theorem and chain rule, and use Jacobians for transformation of multivariable systems.

Instructional Method:

The course will be delivered using classroom teaching supported by active learning, problem-solving, and application-oriented strategies appropriate for first-year engineering students. In addition to blackboard teaching, the instructor may use the following approaches:

- Guided problem-solving sessions for matrices, determinants, row reduction, and system solving.
- Diagnostic exercises to identify common logical errors in limits, differentiation, and theorem application.
- Concept visualization for eigenvectors, function behavior, continuity, and multivariable dependencies.
- Small-group learning activities such as matrix clinics, theorem checks, and approximation relays.
- Poster-based and flowchart-based activities for eigen concepts, Jacobians, and variable mapping.
- Interactive derivation sessions for Taylor/Maclaurin expansions and Cayley–Hamilton verification.
- Open-book or semi-structured problem analysis sessions for multivariable transformations.
- Internal evaluation using SEE and CCE components through practical mathematical tasks, oral explanation, short reports, and peer-supported activities.

Reference Books:

[1]. Advanced Engineering Mathematicsby Erwin Kreyszig, Wiley India Pvt. Ltd.
[2]. **Higher Engineering Mathematics**by B.S. Grewal, Khanna Publishers.
[3]. **Calculus and Analytic Geometry**by G.B. Thomas and R.L. Finney, Pearson.
[4]. Linear algebra and its Applicationsby Gilbert Strang.
[5]. **Basic Engineering Mathematics**by John Bird, Elsevier/Newnes.

Suggestive Rubrics:

Suggestive Assessment Guidelines:
Module 1: ALA: The System Solver Clinic (10 Marks) 10 Marks: Accurate matrix formulation, correct method selection, flawless solution, and clear explanation. 08 Marks: Correct solution with minor presentation or notation errors. 05 Marks: Basic method understood, but procedural mistakes in determinant/inverse work. 02 Marks: Partial attempt with major logical errors. 00 Marks: Not submitted.

Module 2: ALA: The Eigen-Structure Workshop (10 Marks) 10 Marks: Excellent conceptual presentation with accurate eigen-analysis and strong application linkage. 08 Marks: Good explanation and mathematically correct work with minor clarity issues. 05 Marks: Basic understanding shown, but limited application or incomplete interpretation. 02 Marks: Poor conceptual clarity and weak participation. 00 Marks: Not submitted. ESE: The Rank and Eigen Audit (20 Marks) 20 Marks: Perfect rank determination, consistency analysis, eigen computation, and Cayley–Hamilton application. 16 Marks: Strong method with minor algebraic or notation errors. 10 Marks: Basic concepts correct but incomplete execution. 05 Marks: Significant confusion in reduction or eigen-analysis. 00 Marks: Incomplete or off-topic.
Module 3: ALA: The Derivative Rule Challenge (10 Marks) 10 Marks: Correct rule selection throughout with confident explanation and clean derivations. 08 Marks: Mostly correct solutions with small computational errors. 05 Marks: Basic derivative rules understood, but inconsistency in application. 02 Marks: Minimal success in identifying correct rules. 00 Marks: Not submitted.
Module 4: ALA: The Human Approximation Relay (10 Marks) 10 Marks: Accurate term-by-term expansion, clear error tracking, and strong group coordination. 08 Marks: Good approximation process with minor calculation issues. 05 Marks: Basic expansion attempted, but convergence reasoning is weak. 02 Marks: Poor participation or substantial arithmetic errors. 00 Marks: Not submitted.
Module 5: **ALA: The Chain Rule Flowchart (10 Marks)** **10 Marks:** Flawless Flowchart construction; perfect path logic; confident Oral Report. **08 Marks:** Correct flowchart with minor notation gaps; successful partial derivative derivation. **05 Marks:** Flowchart provided but lacks clear branching; struggles to explain the logical flow. **02 Marks:** Poorly structured diagram; cannot link variables correctly. **00 Marks:** Incomplete or off-topic.