

Course Title: Mathematics-I for Mechanical Engineering stream

[As per Choice Based Credit System (CBCS) scheme]

(From the academic year 2022-23)

Course Code	22MATM11	CIE Marks	50
Credits	04	SEE Marks	50
Course Type	Integrated		
Contact Hours/Week (L-T-P)	2-2-2	Total Marks	100
Contact Hours of Pedagogy	42 hours Theory +10 Lab slots	Exam Hours	03

Course objectives: The goal of the course **Mathematics-I for Mechanical Engineering stream (22MATM11)** is to

- **Familiarize** the importance of calculus associated with one variable and two variables, the importance of Integral calculus for Mechanical engineering.
- **Analyze** Mechanical engineering problems applying Ordinary Differential Equations.
- **Develop** the knowledge of Linear Algebra refereeing to matrices.

Module-1 Calculus**(5L+3T)****Introduction to polar coordinates and curvature relating to Mechanical engineering.**

Polar coordinates, Polar curves, angle between the radius vector and the tangent, and angle between two curves. Pedal equations. Curvature and Radius of curvature - Cartesian, Parametric, Polar and Pedal forms. Simple Problems.

Self-study: Center and circle of curvature, evolutes and involutes.

Applications: Applied Mechanics, Structural design and paths, Strength of materials, Elasticity.

(RBT Levels: L1, L2 and L3)

Module-2 Series Expansion and Multivariable Calculus**(6L+3T)****Introduction to series expansion and partial differentiation in the field of Mechanical engineering applications.**

Taylor's and Maclaurin's series expansion for one variable (Statement only) – problems. Indeterminate forms : L-Hospital's rule, problems.

Partial differentiation, total derivative - differentiation of composite functions. Jacobian and problems. Maxima and minima for a function of two variables – Simple Problems.

Self-study: Euler's theorem and problems. Method of Lagrange's undetermined multipliers with single constraint.

Applications: Computation of stress and strain, Errors and approximations, Estimating the critical points and extreme values

(RBT Levels: L1, L2 and L3)

Module-3 Ordinary Differential Equations (ODEs) of first order (6L+2T)

Introduction to first-order ordinary differential equations pertaining to the applications for Mechanical engineering.

Linear and Bernoulli's differential equations. Exact and reducible to exact differential equations -Integrating factors on $\frac{1}{N} \left(\frac{\partial M}{\partial y} - \frac{\partial N}{\partial x} \right)$ and $\frac{1}{M} \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y} \right)$

Orthogonal trajectories and Newton's law of cooling.

Nonlinear differential equations: Introduction to general and singular solutions, Solvable for p only, Clairaut's equations, reducible to Clairaut's equations - Problems.

Self-Study: Applications of ODEs in Mechanical Engineering problems like vibration problems, solution of non-linear ODE by the method of solvable for x and y.

Applications: Rate of Growth or Decay, Conduction of heat.

(RBT Levels: L1, L2 and L3)

Module-4 Integral Calculus (6L+3T)

Introduction to Integral Calculus in Mechanical Engineering applications.

Multiple Integrals: Evaluation of double and triple integrals, evaluation of double integrals by change of order of integration, changing into polar coordinates. Applications to find Area and Volume by double integral. Problems.

Beta and Gamma functions: Definitions, properties, relation between Beta and Gamma functions. Problems.

Self-Study: Volume by triple integration, Center of gravity.

Applications: Applications to mathematical quantities (Area, Surface area, Volume), Analysis of probabilistic models.

(RBT Levels: L1, L2 and L3)

Module-5 Linear Algebra

(5L+3T)

Introduction of linear algebra related to Mechanical Engineering applications.

Elementary row transformation of a matrix, Rank of a matrix. Consistency and solution of a system of linear equations - Gauss-elimination method, Gauss-Jordan method and approximate solution by Gauss-Seidel method. Eigen values and Eigenvectors, Rayleigh's power method to find the dominant Eigen value and Eigenvector.

Self-Study: Solution of a system of linear equations by Gauss-Jacobi iterative method. Inverse of a square matrix by Cayley- Hamilton theorem.

Applications: Structural Analysis, Balancing equations.

(RBT Levels: L1, L2 and L3)

List of Laboratory experiments (2 hours/week per batch/ batch strength 15) 10 lab sessions + 1 repetition class + 1 Lab Assessment

1	2D plots for Cartesian and polar curves
2	Finding angle between polar curves, curvature and radius of curvature of a given curve
3	Finding partial derivatives, Jacobian and plotting the graph
4	Applications to Maxima and Minima of two variables
5	Solution of first-order differential equation and plotting the graphs
6	Program to compute surface area, volume and centre of gravity
7	Evaluation of improper integrals
8	Numerical solution of system of linear equations, test for consistency and graphical representation
9	Solution of system of linear equations using Gauss-Seidel iteration
10	Compute eigen values and eigenvectors and find the largest and smallest eigen value by Rayleigh power method

Suggested software's: Mathematica/MatLab/Python/Scilab

Semester End Examination (SEE):

Theory SEE will be conducted by Institute as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO 1	Apply the knowledge of calculus to solve problems related to polar curves
CO 2	Learn the notion of partial differentiation to compute rate of change of multivariate functions
CO 3	Analyze the solution of linear and nonlinear ordinary differential equations
CO 4	Apply the knowledge of multiple integrals to compute area and volume.
CO 5	Make use of matrix theory for solving for system of linear equations and compute eigen values and eigen vectors. Familiarize with modern mathematical tools namely MATHEMATICA/ MATLAB/ PYTHON/SCILAB

Suggested Learning Resources:**Books (Title of the Book/Name of the author/Name of the publisher/Edition and Year)****Text Books**

1. **B. S. Grewal:** "Higher Engineering Mathematics", Khanna publishers, 44th Ed., 2021.
2. **E. Kreyszig:** "Advanced Engineering Mathematics", John Wiley & Sons, 10th Ed., 2018.

Reference Books

1. **V. Ramana:** "Higher Engineering Mathematics" McGraw-Hill Education, 11th Ed., 2017
2. **Srimanta Pal & Subodh C. Bhunia:** "Engineering Mathematics" Oxford University Press, 3rd Ed., 2016.
3. **N.P Bali and Manish Goyal:** "A textbook of Engineering Mathematics" Laxmi Publications, 10th Ed., 2022.
4. **C. Ray Wylie, Louis C. Barrett:** "Advanced Engineering Mathematics" McGraw – Hill Book Co., Newyork, 6th Ed., 2017.
5. **Gupta C.B, Sing S.R and Mukesh Kumar:** "Engineering Mathematic for Semester I and II", Mc-Graw Hill Education(India) Pvt. Ltd 2015.
6. **H. K. Dass and Er. Rajnish Verma:** "Higher Engineering Mathematics" S. Chand Publication, 3rd Ed., 2014.
7. **James Stewart:** "Calculus" Cengage Publications, 7th Ed., 2019.
8. **David C Lay:** "Linear Algebra and its Applications", Pearson Publishers, 4th Ed., 2018.
9. **Gareth Williams:** "Linear Algebra with applications", Jones Bartlett Publishers Inc., 6th Ed., 2017.

Web links and Video Lectures (e-Resources):

- <http://nptel.ac.in/courses.php?disciplineID=111>
- [http://www.class-central.com/subject/math\(MOOCs\)](http://www.class-central.com/subject/math(MOOCs))
- <http://academicearth.org/>
- VTU e-Shikshana Program
- VTU EDUSAT Program

Activity-Based Learning (Suggested Activities in Class)/Practical-Based Learning

- Quizzes
- Assignments
- Seminar