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|---|---|---|---|
| Course Title: | Mathematics for Mechanical Engineering Stream | | |
| Course Code: | 22MATM11 | CIE Marks | 50 |
| Course Type(Theory/Practical/Integrated) | Integrated | SEE Marks | 50 |
| | | Total Marks | 100 |
| Teaching Hours/Week (L:T:P:S) | 2:2:2:0 | Exam Hours | 03+02 |
| Total Hours of Pedagogy | 40hoursTheory+10-12Lab slots | Credits | 04 |

Course objectives: The goal of the course Advanced Calculus, Transforms and Numerical methods (22MATM11) is to

- Familiarize the importance of series expansion and Vector calculus essential for Mechanical engineering.
- Analyze Mechanical engineering problems applying Partial Derivatives and understand the value of limit (continuity) of function by using indeterminate forms.
- Develop the knowledge of polar curves to trace different types of curves.
- Applications of first order first degree differential equations.
- To develop the knowledge of matrices and linear algebra in a comprehensive manner.

**Teaching-Learning Process**

**Pedagogy(General Instructions):**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the delivered lessons shall develop student's theoretical and applied mathematical skills.
2. State the need for Mathematics with Engineering Studies and Provide real-life examples.
3. Support and guide the students for self–study.
4. You will also be responsible for assigning homework and quizzes, and documenting students' progress.
5. Five assignment problems on each module.
6. Encourage the students for group learning to improve their creative and analytical skills.
7. Show short related video lectures in the following ways:
    - As an introduction to new topics (pre-lecture activity).
    - As a revision of topics (post-lecture activity).
    - As additional examples (post-lecture activity).
    - As an additional material of challenging topics (pre-and post-lecture activity).
    - As a model solution of some exercises (post-lecture activity).

**Course outcome (Course Skill Set)**

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

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|---|---|
| **CO1** | Learn the notion of partial differentiation to compute rate of change multivariate functions and understand the concept of Indeterminate forms. |
| **CO2** | Illustrate the applications of multivariate calculus to understand the solenoidal and irrotational vectors and know the expansions of functions in power series form. |
| **CO3** | Apply the knowledge of calculus to solve problems related to polar curves and graphical representation of different curves. |
| **CO4** | Solve first order linear/nonlinear differential equation analytically using standard methods and express the solution in graphical form. |
| **CO5** | Make use of matrix theory for solving for system of linear equations and |

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| | CO6 | Learn with modern mathematical tools namely SCILAB /PYTHON /MATLAB / MATHEMATICA | |

**Bloom's level of the course outcomes:**

| CO# | Bloom's Level | | | | | |
|---|---|---|---|---|---|---|
| | Remember (L1) | Understand (L2) | Apply (L3) | Analyze (L4) | Evaluate (L5) | Create (L6) |
| CO1 | √ | √ | √ | | | |
| CO2 | √ | √ | √ | | | |
| CO3 | √ | √ | √ | | | |
| CO4 | √ | √ | √ | | | |
| CO5 | √ | √ | √ | | | |

**Course Articulation Matrix / Course mapping :**

| CO# | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | | 1 | | | | 1 | | | 1 | | | |
| CO2 | 3 | 2 | 2 | | 1 | | | | 1 | | | 1 | | | |
| CO3 | 3 | 2 | 2 | | 1 | | | | 1 | | | 1 | | | |
| CO4 | 3 | 2 | 2 | | 1 | | | | 1 | | | 1 | | | |
| CO5 | 3 | 2 | 2 | | 1 | | | | 1 | | | 1 | | | |

Note: 1-Low mapped, 2-Medium mapped, 3-High mapped

## MODULE-1 : INDETERMINATE FORMS AND PARTIAL DIFFERENTIATION

**Introduction to Indeterminate forms and Partial differentiation relating to Mechanical Engineering.**

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. Problems.

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

**Applications:** Computation of stress and strain, Errors and approximations in manufacturing process, Estimating the critical points and extreme values, vector calculus.

(RBT Levels: L1, L2 and L3) (8 Hours)

## MODULE-2 : SERIES EXPANSION AND VECTOR CALCULUS

**Introduction to Series expansion and Vector Calculus in Mechanical Engineering applications.**

Taylor's and Maclaurin's series expansions for one variable (statements only)- Problems

Vector Differentiation: Scalar and vector fields. Gradient, directional derivative, divergence and curl - physical interpretation, Solenoidal and rrotational vector fields and Problems.

**Self-Study:** Volume integral and Gauss divergence theorem.

**Applications:** Heat and mass transfer, oil refinery problems, environmental engineering. Analysis of stream lines, velocity and acceleration of a moving particle.

(RBT Levels: L1, L2 and L3) (8 Hours)

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## MODULE-3: DIFFERENTIAL CALCULUS

**Introduction of series expansion and partial differentiation in Mechanical Engineering applications.**

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

**Self-study:** Center and circle of curvature, evolutes, involutes and envelopes.
**Applications:** Computer graphics, Image processing.
(RBT Levels: L1, L2 and L3) (8 Hours)

## MODULE- 4: LINEAR AND NON-LINEAR ORDINARY DIFFERENTIAL EQUATION OF FIRST ORDER

**Introduction to first order ordinary differential equations pertaining to the applications for Mechanical Engineering.**

Exact and reducible to exact differential equations -Integrating factors type-1, linear and reducible linear. Applications of ODE's – Orthogonal trajectories, Conduction of heat, Newton's law of cooling. Problems.

**Self-Study:** Applications of ODE's, Solvable for x, y and p. Clairaut's form.

**Applications :** Rate of Decay and growth and applications to Mechanical Engineering.
(RBT Levels: L1, L2 and L3) (8 Hours)

## MODULE- 5: LINEAR ALGEBRA

**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-Jordan method and approximate solution by Gauss-Seidel method. Eigen values and Eigen vectors, Rayleigh's power method to find the dominant Eigen value and Eigen vector.

**Self-Study:** Solution of a system of linear equations by Gauss-Jacobi iterative method, Gauss-elimination method. Inverse of a square matrix by Cayley-Hamilton theorem.
**Applications :** Network Analysis, Markov Analysis, Critical point of a network system. Optimum solution.
(RBT Levels: L1, L2 and L3) (8 Hours)

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

| | |
|---|---|
| 1 | Finding the sum of the series up to infinity |
| 2 | Finding the given series convergent and divergent |
| 3 | Evaluating the limits |
| 4 | Finding the Partial derivatives of a given function<br>Finding partial derivatives, Jacobian and plotting the graph |
| 5 | Applications to Maxima and Minima of two variables |
| 6 | 2D plots for Cartesian and polar curves<br>Finding of intersection between two polar curves |
| 7 | Finding the angle between the radius vector and the tangent |
| 8 | Finding the pedal equation of the polar curves |
| 9 | Finding radius of curvature of a given curve |
| 10 | Solution of first order differential equation and plotting the graphs |

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| 11 | Program to compute area, volume and centre of gravity |
| 12 | Solving the Linear differential equations |
| 13 | Evaluating the rank of matrix |
| 14 | Numerical solution of system linear equations , test for consistency . |

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

**Assessment Details (both CIE and SEE)**

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing marks for the CIE is 45% of the maximum marks (22.5 marks out of 50). The minimum passing marks for the SEE is 35% of the maximum marks (18 marks out of 50).

A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50) in the semester-end examination (SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation(CIE):**

The CIE shall be conducted by the course teacher throughout the semester. The CIE marks for the theory component of the IC shall be 30 marks and for the laboratory component 20 Marks.

The CIE marks for the theory component shall be 50 marks and scored will be reduced to 30.As below

- Three Tests each of 15 Marks; after the completion of the syllabus of 35-40%, 65-70%, and 90-100% respectively. Average of Best Two performances of the Internal Tests shall be considered for 15 Marks.
- Session wise assignments for 25 marks
- For Seminar and library work 05 marks
- Attendance 5 marks (95% to 100%), 04 marks (85% to 94%)

**CIE for the practical component of the IC:**

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The 35 marks are for conducting the experiment and preparation of the laboratory record, the other 15 marks shall be for the test conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 50 marks. Marks of all experiments' write-ups are added and scaled down to 20 marks.

**Semester End Examination(SEE)**

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question carries 20 marks.
4. There will be two full questions (with a maximum of three sub questions) from each module
5. Each full question will have sub questions covering all the topics under a module.
6. The students will have to answer five full questions, selecting one full question from each module.

**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, 3rdEd., 2016.
3. **N.PBali 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., New york, 6thEd., 2017.
5. **C.B Gupta, S. R Singh 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, 3rdEd., 2014.
7. **James Stewart:** "Calculus" Cengage Publications, 7thEd., 2019.
8. **David CLay:** "Linear Algebra and its Applications", Pearson Publishers, 4th Ed.,2018.
9. **Gareth Williams:** "Linear Algebra with applications", Jones Bartlett Publishers Inc., 6thEd., 2017.