GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Mechanical Engineering (Thermal Engineering)

Course / Subject Code : ME01000421

Course / Subject Name : Computational Methods for Mechanical Engineers

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PCC

Prerequisite:	Nil
Rationale:	The course intends to provide mathematical foundations to graduate students. The course should enhance their ability to develop mathematical models and solve problems using analytical and numerical methods.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	To analyze ordinary and partial differential equations analytically as well as numerically for Mechanical engineering applications	Analyze
2	To examine Laplace transforms for solution of ODE for Mechanical engineering applications	Analyze
3	To evaluate linear algebra , vector calculus and numerical methods for Mechanical engineering problems	Evaluate
4	To apply Fourier transformation to Mechanical systems	Apply
5	To make use of statistics and probability for nondeterministic Mechanical systems	Apply

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Differential Equations:** Modelling, Differential Equations, Ordinary and Partial differentiation, Order of the equation, Solution, Existence and Uniqueness of Solution, Initial Value problem, Boundary Value Problem, Linear and Non-Linear Equation. 1st Order ODE: Geometric Meaning of y'= f(x, y), Direction Fields, Euler's Method; Separable ODEs; Exact ODEs (Integrating Factors Method, Existence and Uniqueness of Solution); Linear ODEs(Homogeneous and Non-Homogeneous, Reduction to Linear problems); Orthogonal Trajectories. 2nd Order ODE: Linear Dependence and Linear Independence; Homogeneous Linear ODEs of Second Order (Principal of Superposition, Initial Value Problem, Boundary Value Problem); Homogeneous Linear ODEs with Constant Coefficients (Euler's formula and review of the circular and hyperbolic function, Exponential Solutions, Repeated Roots and Stability); Differential Operator; Modelling of Free Oscillations of Spring-Mass System; Homogeneous Linear ODEs with Non-constant Coefficient (Cauchy-Euler Equation, Existence and Uniqueness of Solutions)	9	20%
2.	**Laplace Transforms:** Laplace Transform, Linearity, First Shifting Theorem (s-Shifting); Transforms of Derivatives and Integrals, ODE; Unit Step Function (Heaviside Function), Second Shifting Theorem (t-Shifting); Short Impulses, Dirac's Delta Function, Partial Fractions; Convolution, Integral Equations; Differentiation and Integration of Transforms, ODEs with Variable Coefficients; Systems of ODEs.	5	10%
3.	**Linear Algebra:** Matrices and Vectors: Vectors in 2-Space and 3-Space; Addition and Scalar Multiplication, Matrix Multiplication; Linear Systems of Equations and Gauss Elimination, Ill-Conditioning, Linear Independence, Rank of a Matrix, Solutions of Linear Systems: Existence and Uniqueness; Determinants and Cramer's Rule; Inverse of a Matrix, Gauss–Jordan Elimination; Solution by Iteration. Vector Spaces, Inner Product Spaces, Norms, Linear Transformations; Matrix Eigenvalues, Determining Eigenvalues-Eigenvectors and their	8	15%

	applications; Power Method for Eigenvalues; Symmetric, Skew-Symmetric, and Orthogonal Matrices		
4.	**Vector Calculus:** Vector Product; Vector and Scalar Functions and Their Fields, Vector Calculus: Derivatives; Curves, Arc Length, Curvature, Torsion; Gradient of a Scalar Field, Directional Derivative; Divergence of a Vector Field, Curl of a Vector Field. Line Integrals, Path Independence of Line Integrals; Green's Theorem in the Plane, Surfaces for Surface Integrals, Surface Integrals; Triple Integrals, Divergence Theorem of Gauss, Further Applications of the Divergence Theorem, Stokes' Theorem.	6	12%
5.	**Fourier Analysis and PDE:** Fourier Series; Arbitrary Period, Even and Odd Functions, Half-Range Expansions; Forced Oscillations; Approximation by Trigonometric Polynomials; Sturm–Liouville Problems, Orthogonal Functions; Orthogonal Series, Generalized Fourier Series; Fourier Integral; Fourier Cosine and Sine Transforms; Fourier Transform, Discrete and Fast Fourier Transforms. Basic Concepts of PDEs; Modeling: Vibrating String, Wave Equation; Solution by Separating Variables; Use of Fourier Series; D'Alembert's Solution of the Wave Equation, Characteristics; Modelling: Heat Flow from a Body in Space, Heat Equation: Solution by Fourier Series. Steady Two-Dimensional Heat Problems	8	15%
6.	**Numeric Analysis:** Introduction, Solution of Equations by Iteration, Interpolation, Newton's Divided-Difference Interpolating Polynomials, Lagrange Interpolating Polynomials, Coefficients of an Interpolating Polynomial, Inverse Interpolation; Spline Interpolation, Numeric Integration and Differentiation. Numeric Methods for: First-Order ODEs, Multistep Methods, Systems and Higher (up to second) Order ODEs, Elliptic PDEs	*	10%
7.	**Probability:** Data Representation, Average, Spread; Experiments, Outcomes, Events; Probability, Permutations and Combinations; Random Variables. Probability Distributions; Mean and Variance of a Distribution; Binomial, Poisson, and Normal Distribution	3	8%
8.	**Statistics:** Random Sampling; Point Estimation of Parameter, Confidence Intervals; Testing Hypotheses, Decisions; Goodness of Fit, χ^2 - Test, Regression: Linear Regression, Polynomial Regression, Nonlinear Regression, Correlation	6	10%
	Total	**45**	**100**

* Topic 6 of above content must be covered during laboratory sessions

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
--	**20**	**50**	**20**	**5**	**5**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Advanced Engineering Mathematics, 9/e, By Erwin Kreyszig, John Wiley & Sons Inc.
2. Advanced Engineering Mathematics, 2/e, By M D Greenberg, Pearson Education
3. Numerical Methods for Engineers, S C Chapra, and R C Canale, McGraw-Hill

(b) Open-source software and website:

1. Scilab software

Suggested Course Practical List:

Students are required to prepare computer program (using any computer software) for following topics:

1. Solution of first order differential equation using numerical techniques.
2. Solution of nonlinear equation using bisection method, false position and Newton Raphson method.
3. Interpolation by Lagrange, Newton's divided-difference and spline method.
4. Numerical integration by trapezoidal and Simpson's rules.
5. Matrix operations and power method for Eigen values and Eigen vectors.
6. Finding DFT of one-dimensional signal.
7. Solving linear systems of equation using elimination and iteration methods.
8. Solution of PDE by finite difference method.
9. Fitting a straight line and quadratic curve to the given data.
10. Finding mean and variance of binomial and Poison distribution.

* * * * * * *