GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Subject Code: BE03000191
Subject Name: Numerical Methods for Electrical Engineering

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Basic Science Course

Prerequisite:	Basics of algebra, differentiation and integration, Basic operations of Matrices, Determinants
Rationale:	The mathematical models of electrical systems generate set of linear equations, nonlinear equations, differential or partial differential equations etc. Design and analysis of the electrical systems requires the repeated performing of various basic mathematical procedures such as solving systems of linear algebraic equations, solving systems of nonlinear algebraic equations, numerical integration of set of ordinary differential equations, integration of partial differential equations etc. These types of numerical methods play very important roles in understanding the insights of the systems. These methods are useful in the real world applications of electrical engineering like fault analysis of power systems, power flow of power systems, stability of power systems, design of drives, controller designs, simulation of power electronic circuits, optimization of power systems operations, simulation of insulation materials used in transformers etc. Numerical methods invariably involve large numbers of tedious arithmetic calculations. The role of numerical methods in engineering problem solving has increased dramatically in recent years due to fast efficient digital computers.

Course Outcomes:

The students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Solve set of linear algebraic equations for steady state solution of electric circuits by using direct and indirect numerical methods and LU factorization	15
CO-2	Learn how to obtain numerical solution of set of nonlinear equations using Bisection, GS method, Newton – Raphson and fixed-point iteration methods	20
CO-3	Do the numerical integration of ordinary differential equations using Euler's method, modified Euler's method, trapezoidal rule and RK4 method	25
CO-4	Apply the numerical methods for simple optimization problems	20
CO-5	Apply fundamental principles of FEM techniques to analyze complex electromagnetic fields	20

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs.	% Weightage
1	**Approximations and Round-off errors** : Significant figures, accuracy and precision, error definitions, Round-off errors, Truncation errors	2	5
2	**Numerical Solution of Linear Equations:** Direct Methods: The Gauss Elimination Method, The Gauss–Jordan Elimination Method, The LU Matrix Decomposition Method, The Method of Inverse Matrix, Indirect or Iterative Methods: The Direct Iteration Method, Jacobi and Gauss–Seidel Methods, Examples of Applications in Electrical Engineering: 1. Steady state solution of AC ladder circuit using mesh currents 2. Steady state solution of AC circuit with double T using nodal analysis	8	20
3	**Roots of Non-linear Algebraic and Transcendental Equations**: Bisection, false position, Secant method, Gauss-Seidel method, Newton-Raphson methods, Fixed Point Iteration, Rate of convergence, Applications to electrical engineering problems	10	20
4	**Numerical Integration of ODE:** The Initial Value Problem and Related Solution Method, The One-Step Methods: The Euler Method and its Modified Version, The Heun Method, Trapezoidal rule, The Runge–Kutta Method (RK 4), Examples of Using the RK 4 Method for Integration of Differential Equations Formulated for Some Electrical Rectifier Devices: 1. The Unsymmetrical Voltage Doubler 2. The Full-Wave Rectifier Integrated with the Three-Element Low-Pass Filter	10	25

5	**FEM :** Introduction, FEM procedure : Finite Element Discretization, Element Governing Equations, Assembling all the Elements, Solving the Resulting Equations, Examples based on Magnetostatic Fields	**6**	**15**
6	**Optimization:** Introduction to Optimization, Mathematical formulation, Continuous versus Discrete optimization, Constrained and unconstrained optimization, Global and local optimization, Stochastic and deterministic optimization, Convexity, Optimality Criteria, Exhaustive Search Method, Interval halving method, Fibonacci search method.	**6**	**15**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**25**	**25**	**20**	**10**	**-**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C:Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actualdistribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Numerical Methods for Engineers, Steven C. Chapra & Raymond P. Canale,6th Edition, McGraw Hill
2. Fundamental Numerical Methods for Electrical Engineering, Stanisław Rosłoniec, Springer
3. Introductory Methods of Numerical Analysis, S. S. Sashtry, 5th edition, PHI Learnings,
4. Principles of Electromagnetics, Matthew N. O. Sadiku, Dr. S V Kulkarni, Oxford Higher Education, Oxford University Press, 6th edition, Asian Edition
5. Numerical and Analytical Methods with MATLAB for Electrical Engineers, William Bober & Andrew Stevens, CRC Press
6. Numerical Optimization, Jorge Nocedal & Stephen Wright, 2nd edition, Springer
7. Optimization for Engineering Design, Kalyanmoy Deb, 2nd edition, PHI

List of Experiments:
This is a suggestive list only:

1. To solve linear system of equations using Gauss elimination (without pivoting) method
2. To solve linear system of equations using Gauss- seidel method
3. To integrate a function numerically using trapezoidal and Simpson's rule.
4. To solve the initial value problem using modified Euler's and Runge-kutta methods.
5. To solve the set of non-linear equations using GS method.
6. To find the root of f(x)=0 using Newton-Raphson and fixed point iteration methods.
7. To integrate the set of ODEs numerically using Euler's method and modified Euler's method.
8. To integrate the set of ODEs numerically using RK4 method.
9. To solve a power electronic circuit using suitable numerical integration method.
10. To solve single variable optimization problem using Exhaustive Search Method
11. To solve optimization problem using Fibonacci Search Method
12. Using the PDE toolbox, write an FEM code to determine the potential at any point between the parallel plates of capacitor. Consider the left edge of the bottom plate of the capacitor is at (0,0).
13. The triangular element having coordinates – node 1(2,-1), node 2 (1, 4), and node 3 (0,0) is a part of a finite element mesh. If V1 = 8 V, V2 = 12 V, V3 = 10 V, find the potential at (1,2) and at the center of the element.

Major Equipment:

List of Open Source Software/learning website:

1) Python
2) GNU Octave

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