GE-4: Numerical Methods (with Practicals)

Total Marks: 150 (Theory: 75, Internal Assessment: 25, and Practical: 50)
Workload: 4 Lectures, 4 Practicals (per week) **Credits:** 6 (4+2)
Duration: 14 Weeks (56 Hrs. Theory + 56 Hrs. Practical) **Examination:** 3 Hrs.

Course Objectives: The goal of this paper is to acquaint students' various topics in Numerical Analysis such as solutions of nonlinear equations in one variable, interpolation and approximation, numerical differentiation and integration, direct methods for solving linear systems, numerical solution of ordinary differential equations using Computer Algebra System (CAS).

Course Learning Outcomes: After completion of this course, students will be able to:
i) Find the consequences of finite precision and the inherent limits of numerical methods.
ii) Appropriate numerical methods to solve algebraic and transcendental equations.
iii) Solve first order initial value problems of ODE's numerically using Euler methods.

Unit 1: Errors and Roots of Transcendental and Polynomial Equations
Floating point representation and computer arithmetic, Significant digits; Errors**:** Roundoff error, Local truncation error, Global truncation error; Order of a method, Convergence and terminal conditions; Bisection method, Secant method, Regula−Falsi method, Newton−Raphson method.

Unit 2: Algebraic Linear Systems and Interpolation
Gaussian elimination method (with row pivoting), Gauss−Jordan method; Iterative methods**:** Jacobi method, Gauss−Seidel method; Interpolation**:** Lagrange form, Newton form, Finite difference operators, Gregory−Newton forward and backward difference interpolations, Piecewise polynomial interpolation (linear and quadratic).

Unit 3: _umerical Differentiation, Integration and ODE
Numerical differentiation**:** First and second order derivatives, Richardson extrapolation method; Numerical integration**:** Trapezoidal rule, Simpson's rule; Ordinary differential equation**:** Euler's method, Modified Euler's methods **(**Heun's and midpoint).

References:
1. Chapra, Steven C. (2018). *Applied 'umerical Methods with* MATLAB *for Engineers and* Scientists (4th ed.). McGraw-Hill Education.
2. Fausett, Laurene V. (2009). *Applied 'umerical Analysis Using* MATLAB. Pearson. India.
3. Jain, M. K., Iyengar, S. R. K., & Jain R. K. (2012). *'umerical Methods for Scientific and Engineering Computation* (6th ed.). New Age International Publishers. Delhi.

Additional Reading:
i. Bradie, Brian (2006). *A Friendly Introduction to 'umerical Analysis*. Pearson Education India. Dorling Kindersley (India) Pvt. Ltd. Third Impression, 2011.

Practical /Lab work to be performed in the Computer Lab:
Use of Computer Algebra System (CAS), for example MATLAB/Mathematica/Maple/Maxima/ Scilab etc., for developing the following Numerical Programs:
1. Bisection method
2. Secant method and Regula−Falsi method
3. Newton−Raphson method

4. Gaussian elimination method and Gauss−Jordan method
5. Jacobi method and Gauss−Seidel method
6. Lagrange interpolation and Newton interpolation
7. Trapezoidal and Simpson’s rule.
8. Euler methods for solving first order initial value problems of ODE’s.