Course Title: Numerical Methods
Course Code: MCSC 202
Credit Hours: 3

Course Description:

The course will introduce the fundamentals of numerical methods for engineering and applied science streams. The goal of the course is to provide a broad background in numerical methods with theoretical discussion and available computer programming language for theoretical components discussed in the class. Topics include basic introduction to programming language used for the course, errors in numerical computation, root finding for algebraic (linear and non-linear equations) and transcendental equation, interpolation, integration of IVP of ODE, solving IVP for ODE, numerical differentiation, solution of system of linear equations and curve fitting.

Course Contents:

Unit 1: Basic Introduction of Computer programming Language

Course goals and organization, Introduction to Numerical methods, Basic introduction of programming language

Unit 2: Errors in Numerical Computation

Mathematical preliminaries (statement only), Exact and approximate numbers, Significant digits, Error, Absolute, relative and percentage errors, Absolute error for the sum, product and quotient of any two numbers, Upper limit for absolute error, General error formula

Unit 3: Root Findings

Introduction, Bisection method, The Secant method, False position method (The Regula-Falsi method): Convergence of False Position method and Secant method,; Newton – Raphson method: Quadratic convergence of Newton - Raphson method, Generalised Newton – Raphson method; The General Iteration method: Linearly convergence of iteration method, Acceleration of convergence (Aitken's Δ^2- process); Solution to system of nonlinear equations: Iteration method , Newton-Raphson method

Unit 4: Finite Differences and Interpolation

Finite differences: forward difference, backward difference, central difference ; Detection of errors by the use of difference tables , Differences of a polynomial, Introduction for interpolation, Linear and quadratic interpolation and its extension for Newton interpolation formulae (Forward and backward), Central difference interpolation formulae (Derivation not required): Gauss's, Sterling's, Bessel's and Everett's formulae, p-value or interval for p-value for the above formulae; Lagrange interpolation formula and its inverse interpolation formula, Divided differences: Newton's general interpolation formula

Unit 5: Solving ODE (IVP)

Introduction, Solution based on: Series solution method (Taylor and Picard), Tabulated values (Euler, Modified Euler and Runge-Kutta method of second and fourth order); Solution of BVP using Finite difference method

Unit 6: Numerical Differentiation and Integration

Introduction, Numerical differentiation based on interpolation: Using Newton's forward difference interpolation formula, Using Newton's backward difference interpolation formula; Numerical integration based on interpolation (Derivation using Newton's forward difference formula): Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule; Numerical double integration: Trapezoidal rule, Simpson's rule

Unit 7: Matrices and System of Linear Equations

Review of matrices, Consistency of a linear system of equations, Solution of linear system of equations: LU decomposition method, Tri-diagonal system method, Iterative method (Gauss-Jacobi method and Gauss-Siedel method)

Unit 8: Curve Fitting

Introduction, least square fitting: Straight line fitting, Non linear fitting (power function, polynomial of nth degree, exponential function)

References:

1. S. S. Sastry, *Introductory Methods of Numerical analysis*, PHI Learning Private Limited, New Delhi, 5th edition, 2012.
2. M. K. Jain, S. R. K Iyengar & R. K. Jain, *Numerical Methods for Scientific and Engineering computation*, New Age International Publisher, 4th edition, 2005