

Numerical Methods

1.1 Course Number: MA 221

1.2 Contact Hours: 2-1-0

Credits: 08

1.3 Semester-offered: 4th Year-Even

1.4 Prerequisite: Real Analysis and Calculus, Linear Algebra, and Computer and Matlab programming

1.5 Syllabus Committee Member: Dr. C. Kundu, Dr. M.K. Rajpoot (Convener) & Dr. A. Kumar

2. Objective:

- i. To introduce a broad range of numerical methods for solving mathematical problems arising in Science and Engineering.
- ii. The goal is to provide a basic understanding of the derivation, analysis, and use of numerical methods, with an understanding of finite precision arithmetic, conditioning, and stability of the various methods.

3. Course Content:

Unit-wise distribution of content and number of lectures

| Unit | Topics | Sub-topic | Lectures |
|------|---|---|----------|
| 1 | Numerical solutions of linear equations using iterative and least-squares techniques | Error Analysis: Exact and approximate numbers, rounding-off numbers, types of errors encountered in computations, propagation of errors. Solution of system of linear equations using direct methods: Gauss elimination and LU-decomposition methods. Solutions to linear system of equations using iterative methods: Jacobi, Gauss-Seidel, and successive relaxation methods with convergence rates. Least-squares, solving least-squares problem, least-squares data fitting and validation, and nonlinear regression. | 11 |
| 2 | Numerical solutions of nonlinear equations | Solutions of non-linear equations in single variable using Bisection, Regula-Falsi and Newton-Raphson methods, convergence criteria, Newton-Raphson method for solution of system of non-linear equations. | 5 |
| 3 | Interpolation techniques and numerical quadrature rules | Interpolation: Finite difference operator and their relationships, difference tables, interpolation formulae, divided differences, Lagrange and Hermite interpolations. Numerical integration: Trapezoidal and Simpsons rules with errors and their combinations, Gauss Legendre 2-points and 3-points formulae. | 8 |

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| 4 | Numerical solutions of differential equations | Solution of first and second order ordinary differential equations: Picard's method, Taylor's series method, Euler, modified Euler, Runge-Kutta methods, case studies. | 4 |
| Total | | | 28 |

4. Readings

4.1 Textbook:

- i. Numerical Methods for Engineers by Steven C. Chapra and Raymond P. Canale; McGraw Hill Education India Private Limited; 7 ed.; 2016
- ii. Applied Numerical Analysis by C. F. Gerald and P. O. Whitely; Pearson Education India; 7 ed.; 2007

4.2 Reference books:

- i. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S. R. K. Iyengar and R. K. Jain; New Age Pvt. Pub, New Delhi; 6 ed.; 2012
- ii. Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares by S. Boyd and L. Vandenberghe; Cambridge University Press; 1 ed.; 2018

5 Outcome of the Course:

This course will help students to choose, develop and apply the appropriate numerical techniques for their problems, interpret the results, and assess accuracy.