Numerical Methods

1.1 Course Number: MA221

1.2 Contact Hours: 2-1-0 Credits: 08

1.3 Semester-offered: 2nd 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

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.