MTS 404	Numerical Analysis	4 Credits (48 hours)

Course Objectives

1. **Solving Transcendental and Polynomial Equations:** Understand methods for solving transcendental and polynomial equations, including convergence rates.
2. **Solving Linear Equations and Eigenvalue Problems**: Learn direct and iterative methods for solving systems of linear equations and eigenvalue problems.
3. **Interpolation and Approximation Techniques:** Study interpolation techniques and polynomial approximations, including least square approximations.
4. **Numerical Differentiation and Integration Methods:** Explore numerical differentiation and integration methods, including extrapolation and Newton-Cotes methods.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. Use bisection, secant, Newton-Raphson, and other iteration methods, analyzing their convergence rates.
2. Apply direct methods (e.g., Gauss Elimination) and iterative methods (e.g., Jacobi, Gauss-Seidel), understanding convergence analysis and the power method.
3. Use Lagrange, Newton interpolations, finite differences, and Hermite interpolation for constructing interpolating polynomials and approximations.
4. Implement methods based on interpolation, finite differences, undetermined coefficients, and extrapolation for numerical differentiation.
5. Apply interpolation-based methods, Newton-Cotes formulas, and composite integration methods for accurate numerical integration.

Contents

Unit I - Transcendental and Polynomial Equations (12 Hours)

Introduction, The bisection method, Iteration methods based on first degree equation, Iteration methods based on second degree equation, Rate of convergence, Rate of convergence of Secant and Newton-Raphson method. Iteration methods - First order method, Second order method, Higher order methods. Polynomial equations, Descartes' Rule of Signs, The Birge-Vieta method, Ramanujan's method to find real /complex roots.

Unit II - System of Linear Equations and Eigen value problems (12 Hours)

Introduction, Direct Methods - Gauss Elimination Method, Gauss-Jordan Method, Triangularization Method, Cholesky Method. Iteration Methods - Jacobi Iteration method, Gauss-Seidel Iteration method, Convergence analysis, Eigen values and Eigen vectors. The Power Method.

Unit III - Interpolation and Approximation (12 Hours)

Introduction, Lagrange and Newton interpolations, Linear and Higher order interpolation, Finite difference operators, Interpolating polynomials using finite differences, Hermit interpolation, Approximations –Least Square Approximations.

Unit IV - Numerical Differentiation and Numerical Integration (12 Hours)

Numerical Differentiation: Introduction, Methods based on Interpolation, Methods based on finite differences, Methods based on undetermined coefficients, Extrapolation methods.

Numerical Integration: Methods based on Interpolation, Newton-Cotes methods, Composite Integration Methods.

References

[1] M. K. Jain, S. R. K. Iyengar, R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 6th Ed., New Age International, 2012.

[2] C. F. Gerald and P. O. Wheatly, *Applied Numerical Analysis*, Pearson Education, Inc., 1999.

[3] A. Ralston and P. Rabinowitz, *A First Course in Numerical Analysis*, 2nd Ed., McGraw - Hill, New York, 1978.

[4] K. Atkinson, *Elementary Numerical Analysis*, 2nd Ed., John Wiley and Sons, Inc., 1994.

[5] P. Henrici, *Elements of Numerical Analysis*, John Wiley and Sons, Inc., New York, 1964.

MTS 407	Theory of Combinatorics	4 Credits (48 hours)

Course Objectives

1. **Understand Fundamentals of Logic and Proofs**: Learn propositional logic, predicates, quantifiers, and various proof methods and strategies.
2. **Apply Counting Techniques**: Master basic counting principles, permutations, combinations, and advanced techniques such as inclusion-exclusion and derangements.
3. **Utilize Generating Functions and Recurrence Relations**: Study generating functions, their calculation techniques, and solve recurrence relations using various methods.
4. **Apply Group Theory to Counting Problems**: Understand group actions, the Orbit-Stabilizer Theorem, and apply Polya's Counting Principle and Cycle Index Polynomial.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. Use propositional logic, predicates, quantifiers, and various proof methods to solve problems and construct rigorous arguments.
2. Apply basic counting principles, permutations, combinations, and advanced methods like inclusion-exclusion and derangements to solve complex counting problems.
3. Compute and apply generating functions, including exponential generating functions, and use summation operators for problem-solving.
4. Solve first-order and second-order linear recurrence relations with constant coefficients, including non-homogeneous cases, using generating functions.
5. Utilize group actions, the Orbit-Stabilizer Theorem, Polya's Counting Principle, and Cycle Index Polynomial to solve counting and enumeration problems.