MATH-332 Numerical Analysis-I

Credit Hours: 3-0

Prerequisite: None

Course Objectives: Numerical Analysis deals with the approach to develop numerical algorithms for the mathematical problems which are not easily solvable with exact or analytical methods. The key topics of this subject include arithmetic errors, interpolation, numerical integration, numerical solution of algebraic linear and nonlinear equations, and short introduction of numerical solutions for ODEs.

Core contents: Approximations and Errors, Tridiagonal Matrices, Interpolating Polynomial, Quadrature rules, Euler's Method, Runge-Kutta Methods.

Course Contents: Approximations and Errors; Bisection method, Secant Method, False-Position Method, Newton-Raphson Method, Fixed Point Iteration; Gauss-Elimination and Gauss-Jordan Methods, LU-Factorization, Cholesky Decomposition, Vector and Matrix Norms, Condition Number for Matrices, Tridiagonal Matrices; Interpolation, Linear and Quadratic Interpolation, Lagrange Polynomials, Newton's Interpolating Polynomial; Divided Differences, Forward and Backward Differences, Splines, Cubic Splines; Method of Least Squares; Numerical Integration, Trapezoidal Rule for Equally Spaced Data, Simpson's One-Third and Three-Eighth Rules for Equally Spaced Data; Derivation of Two-Point Gauss-Legendre Formulas, Higher Point Formulas, Error Analysis; Euler's Method and Second Order Runge-Kutta Methods for ODEs.

Course Outcomes: On successful completion of this course students will be able to:

- familiar with the fundamental concepts of numerical analysis.
- learn and implement programming of different numerical methods in MATLAB

Text Book: Numerical Analysis by Richard L. Burden and J. Douglas Faires, 9th Edition, Publisher: Cengage Learning, 2010. (BF)

Reference Books

1. Applied Numerical Analysis by Curtis F. Gerald and Patrick O. Wheatley, 7th Edition, Publisher: Pearson, 2003.
2. Numerical Methods for Engineers by Steven C Chapra and Raymond P Canale, 6th Edition Publisher: McGraw-Hill, 2009

Weekly Breakdown		
Week	***Section***	***Topics***
1	1.2 1.3, 2.1	Round-off Errors and Computer Arithmetic: Definition 1.15 and Definition 1.16 Algorithms and Convergence: Definition 1.17, Definition 1.18 The Bisection Method: Bisection Technique
2	2.2, 2.3	Fixed-Pont Iteration: Fixed-Point Iteration Newton's Method and Its Extensions: Newton's Method, Convergence using Newton's Method, The Secant Method
3	2.3, 2.4, 2.6	Newton's Method and Its Extensions: The Method of False Position, Error Analysis for Iterative Methods: Order of Convergence Zeros of Polynomials and Muller's Method:

		Algebraic Polynomials, Horner's Method
4	3.1, 3.3	Interpolation and the Lagrange Polynomials: Lagrange Interpolating Polynomials Divided Differences: Newton's Divided Difference Formula, Forward Differences, Newton's Forward Difference Formula
5	3.3, 3.4	Divided Differences: Backward Differences, Newton's Backward-Difference Formula, Centered Differences Hermite Interpolation: Hermite Polynomials, Hermite Polynomials Using Divided Differences
6	3.5, 4.1	Cubic Spline Interpolation: Piecewise-Polynomial Approximation, Cubic Splines, Construction of a Cubic Spline, Natural Splines Numerical Differentiation: Three-Point Formulas, Three-Point Endpoint Formula, Three-Point Midpoint Formula
7	4.2, 4.3	Richardson's Extrapolation: Richardson's Extrapolation. Elements of Numerical Integration: The Trapezoidal Rule, Simpson's Rule, Closed Newton-Cotes Formulas, Open Newton-Cotes Formulas
8	4.4, 4.7	Composite Numerical Integration: Composite Numerical Integration. Gaussian Quadrature: Legendre Polynomials, Gaussian Quadrature on Arbitrary Intervals
9	**Mid Semester Exam**	
10	4.9, 6.5	Improper Integrals: Left Endpoint Singularity, Right Endpoint Singularity, Infinite Singularity Matrix Factorization: LU Factorization
11	6.6	Special Type of Matrices: Cholesky Factorization, Band Matrices, Tridiagonal Matrices, Crout Factorization for Tridiagonal Linear Systems
12	7.1, 7.3, 7.4	Norms of Vectors and Matrices: Vector Norms, Distance between Vectors in R^n, Matrix Norms and Distances The Jacobi and Gauss-Seidal Iterative Techniques: Jacobi's Method, The Gauss-Seidal Method, General Iteration Methods Relaxation Techniques for Solving Linear Systems: Successive Over Relaxation (SOR)
13	7.5	Error Bounds and Iterative Refinement: Condition Numbers, Iterative Refinement
14	8.1	Discrete Least Square Approximation: Linear Least Squares, Polynomial, Least Squares
15	5.1, 5.2	The Elementary Theory of Initial Value Problems: The Elementary Theory of Initial Value Problems, Well-Posed Problem. Euler's Method: Euler's Method
16	5.4	Runge-Kutta Methods: Runge-Kutta Methods of Order Two
17		Review
18	**End Semester Exam**	