

**Tennessee Technological University
Mathematics Department**

MATH 4210-4220/5210-5220: Numerical Analysis I-II

I. COURSE DESCRIPTION FROM CATALOG:

Iterative methods for nonlinear equations, computational error analysis, convergence of iterative techniques, interpolation, numerical differentiation and integration, approximate solutions of initial-value problems, boundary-value problems, and nonlinear systems, direct and iterative methods for linear systems. Lec. 3-3. Cr. 3-3.

II. PREREQUISITE(S):

MATH 4210/5210: C or better in MATH 1920 (or consent of instructor for MATH 5210).
MATH 4220/5220: C or better in MATH 2120 or consent of instructor.

III. COURSE OBJECTIVE(S):

This course is designed to introduce the student to iterative techniques, approximation, error analysis, solutions of equations in one variable, and numerical differentiation and integration.

IV. STUDENT LEARNING OUTCOMES:

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Upon successful completion of the course students will understand the meaning of convergence, accuracy, and stability, and how they are related to numerical methods; use polynomials as a means to approximate continuous functions; and be able to approximate solutions of single-variable algebraic equations, approximate derivatives, and approximate integrals by utilizing appropriate technology.

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Upon successful completion of the course students will be able to derive numerical methods for approximating the solution of initial value problems and matrix algebra problems; analyze the aforementioned numerical methods in terms of convergence; and implement a variety of numerical algorithms utilizing appropriate technology.

V. TOPICS TO BE COVERED:

(4210/5210) Chapter 1: Mathematical Preliminaries and Error Analysis

- 1.1 Review of Calculus
- 1.2 Round-off Errors and Computer Arithmetic
- 1.3 Algorithms and Convergence
- 1.4 Numerical Software

Chapter 2: Solutions of Equations in One Variable

- 2.1 The Bisection Method
- 2.2 Fixed-Point Iteration
- 2.3 Newton's Method and Its Extensions
- 2.4 Error Analysis for Iterative Methods

- 2.5 Accelerating Convergence
- 2.6 Zeros of Polynomials and Müller's Method
- 2.7 Numerical Software and Chapter Review

Chapter 3: Interpolation and Polynomial Approximation

- 3.1 Interpolation and the Lagrange Polynomial
- 3.2 Data Approximation and Neville's Method
- 3.3 Divided Differences
- 3.4 Hermite Interpolation
- 3.5 Cubic Spline Interpolation
- 3.6 Parametric Curves
- 3.7 Numerical Software and Chapter Review

Chapter 4: Numerical Differentiation and Integration (as time permits)

- 4.1 Numerical Differentiation
- 4.2 Richardson's Extrapolation
- 4.3 Elements of Numerical Integration
- 4.4 Composite Numerical Integration
- 4.5 Romberg Integration
- 4.6 Adaptive Quadrature Methods
- 4.7 Gaussian Quadrature
- 4.8 Multiple Integrals
- 4.9 Improper Integrals
- 4.10 Numerical Software and Chapter Review

(4220/5220) Chapter 6: Direct Methods for Solving Linear Systems

- 6.1 Linear Systems of Equations
- 6.2 Pivoting Strategies
- 6.3 Linear Algebra and Matrix Inversion
- 6.4 The Determinant of a Matrix
- 6.5 Matrix Factorization
- 6.6 Special Types of Matrices
- 6.7 Numerical Software

Chapter 7: Iterative Techniques in Matrix Algebra

- 7.1 Norms of Vectors and Matrices
- 7.2 Eigenvalues and Eigenvectors
- 7.3 The Jacobi and Gauss-Seidel Iterative Techniques
- 7.4 Relaxation Techniques for Solving Linear Systems
- 7.5 Error Bounds and Iterative Refinement
- 7.6 The Conjugate Gradient Method
- 7.7 Numerical Software

Chapter 9: Approximating Eigenvalues

- 9.1 Linear Algebra and Eigenvalues
- 9.2 Orthogonal Matrices and Similarity Transformations

- 9.3 The Power Method
- 9.4 Householder's Method
- 9.5 The QR Algorithm
- 9.6 Singular Value Decomposition
- 9.7 Numerical Software

Chapter 5: Initial-Value Problems for Ordinary Differential Equations

- 5.1 The Elementary Theory of Initial-Value Problems
- 5.2 Euler's Method
- 5.3 Higher-Order Taylor Methods
- 5.4 Runge-Kutta Methods
- 5.5 Error Control and the Runge-Kutta-Fehlberg Method
- 5.6 Multistep Methods
- 5.7 Variable Step-Size Multistep Methods
- 5.8 Extrapolation Methods
- 5.9 Higher-Order Equations and Systems of Differential Equations
- 5.10 Stability
- 5.11 Stiff Differential Equations
- 5.12 Numerical Software

Chapter 10: Numerical Solutions of Nonlinear Systems of Equations (as time permits)

- 10.1 Fixed Points for Functions of Several Variables
- 10.2 Newton's Method
- 10.3 Quasi-Newton Methods
- 10.4 Steepest Descent Techniques
- 10.5 Homotopy and Continuation Methods
- 10.6 Numerical Software

Chapter 11: Boundary-Value Problems for Ordinary Differential Equations (as time permits)

- 11.1 The Linear Shooting Method
- 11.2 The Shooting Method for Nonlinear Problems
- 11.3 Finite-Difference Methods for Linear Problems
- 11.4 Finite-Difference Methods for Nonlinear Problems
- 11.5 The Rayleigh-Ritz Method
- 11.6 Numerical Software

VI. ADDITIONAL INFORMATION:

Graduate credit is earned on the basis of additional work required by the instructor per TTU Graduate Catalog.

VII. POSSIBLE TEXTS AND REFERENCES:

Numerical Analysis, 10th edition, by Richard L. Burden, Douglas J. Faires, and Annette M. Burden.

VIII. ANY TECHNOLOGY THAT MAY BE USED:

Matlab

IX. STUDENT ACADEMIC MISCONDUCT POLICY:

Maintaining high standards of academic integrity in every class at Tennessee Tech is critical to the reputation of Tennessee Tech, its students, alumni, and the employers of Tennessee Tech graduates. The Student Academic Misconduct Policy describes the definitions of academic misconduct and policies and procedures for addressing Academic Misconduct at Tennessee Tech. For details, view the Tennessee Tech's Policy 217 – Student Academic Misconduct at [Policy Central](#).

X. DISABILITY ACCOMMODATION:

Students with a disability requiring accommodations should contact the Office of Disability Services (ODS). An Accommodation Request (AR) should be completed as soon as possible, preferably by the end of the first week of the course. The ODS is located in the Roaden University Center, Room 112; phone 372-6119. For details, view the Tennessee Tech's Policy 340 – Services for Students with Disabilities at [Policy Central](#).