

# Syllabus for ACMS 40390: Numerical Analysis

Andrew J. Sommese

The material covered will include the following (sometimes in a slightly different order) sections from Burden, Faires, and Burden *Numerical Analysis* (tenth edition).

## Chapter 1: Preliminaries

- 1.1: Review of Calculus
- 1.2: Roundoff Errors and Computer Arithmetic
- 1.3: Algorithms and Convergence

## Chapter 2: Solutions of Equations in One Variable

- 2.1: The Bisection Method
- 2.2: Fixed Point Iteration
- 2.3: The Newton-Raphson Method
- 2.4: Error Analysis for Iterative Methods
  - : Basics on roots of polynomials

## Chapter 3: Interpolation and Polynomial Approximation

- 3.1: Interpolation and the Lagrange Polynomial
- 3.3: Divided Differences
- 3.4: Hermite Interpolation
- 3.5: Cubic Spline Interpolation

## Chapter 4: Numerical Differentiation and Integration

- 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
  - : Brief Discussion of Randomness and Monte Carlo Integration

## 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
- 5.9: Higher-Order Equations and Systems of Differential Equations
- Chapter 6: Direct Methods for Solving Linear Systems
  - 6.1: Linear Systems of Equations
  - 6.3: Linear Algebra and Matrix Inversion
  - 6.5: Matrix Factorization
  - 6.6: Special Types of Matrices
- Chapter 7: Iterative Techniques in Matrix Algebra
  - 7.1: Norms of Vectors and Matrices
  - 7.3: Iterative Techniques for Solving Linear Systems
  - 7.4: Error Estimates and Iterative Refinement
- Chapter 8: Approximation Theory
  - 8.1: Discrete Least Squares Approximation
  - 8.2: Orthogonal Polynomials and Least Squares Approximation
  - 8.3: Chebyshev Polynomials
- Chapter 9: Approximating Eigenvalues
  - 9.1: Linear Algebra and Eigenvalues
    - : The Power Method, the QR Algorithm, and the Singular Value Decomposition
- Chapter 10: Numerical Solutions of Nonlinear Systems of Equations
  - 10.1: Fixed Points for Functions of Several Variables
  - 10.2: Newton's Method
  - 10.5: Homotopy and Continuation Methods
- Chapter 11: Boundary-Value Problems for Ordinary Differential Equations
  - 11.1: The Linear Shooting Method
  - 11.2: The Shooting Method for Nonlinear Problems
  - 11.3: The Finite-Difference Method for Linear Problems
  - 11.4: The Finite-Difference Method for Nonlinear Problems
- Chapter 12: Numerical Solutions of Partial-Differential Equations
  - 12.1: Elliptic Partial-Differential Equations