OFFICIAL SYLLABUS
462 APPLIED NUMERICAL ANALYSIS
Adopted - Fall 2019 (Committee: Drs. Leem, Liu, Pelekanos)

Course Description: Floating point numbers, Polynomial interpolation and approximations, numerical integration and differentiation, direct and iterative methods for linear systems and eigenvalue problems. Introduction to numerical solutions for ODEs and PDEs. MATLAB programming is required.

Prerequisites: MATH 250, 305, CS 140 or CS141 or MATH165 or consent of instructor.

Textbook: Numerical Analysis, 3rd edition, by Timothy Sauer. ISBN 9780134697376

Course Outline:

Instructor may need to review Appendix A and/or B if needed.

Chapter 0, Fundamentals
0.1 Evaluating a Polynomial
0.2 Binary Numbers
0.3 Floating Point Representation of Real Numbers
0.4 Loss of Significance

Chapter 1, Solving Equations
1.1 The Bisection Method
1.2 Fixed-Point Iteration
1.3 Limits of Accuracy
1.4 Newton's Method
1.5 Root-Finding without Derivatives (Optional)

Chapter 2, Systems of Equations
2.1 Gaussian Elimination
2.2 The LU Factorization
2.3 Sources of Error
2.4 The PA = LU Factorization (Optional)
2.5 Iterative Methods
2.6 Methods for symmetric positive-definite matrices (Optional)
2.7 Nonlinear Systems of Equations

Chapter 3, Interpolation
3.1 Data and Interpolating Functions
3.2 Interpolation Error
3.3 Chebyshev Interpolation (Optional)
3.4 Cubic Splines

Chapter 4, Least Squares (Optional)
4.1 Least Squares and the Normal Equations
4.2 A Survey of Models
4.3 QR Factorization
4.4 Generalized Minimum Residual (GMRES) Method
4.5 Nonlinear Least Squares

Chapter 5, Numerical Differentiation and Integration
5.1 Numerical Differentiation
5.2 Newton–Cotes Formulas for Numerical Integration
5.3 Romberg Integration (Optional)
5.4 Adaptive Quadrature
5.5 Gaussian Quadrature

Chapter 6, Ordinary Differential Equations
6.1 Initial Value Problems
6.2 Analysis of IVP Solvers (Optional)
6.3 Systems of Ordinary Differential Equations
6.4 Runge–Kutta Methods and Applications
6.5 Variable Step-Size Methods
6.6 Implicit Methods and Stiff Equations
6.7 Multistep Methods (Optional)

Chapter 7, Boundary Value Problems
7.1 Shooting Method
7.2 Finite Difference Methods
7.3 Collocation and the Finite Element Method (Optional)

Chapter 8, Partial Differential Equations
8.1 Parabolic Equations
8.2 Hyperbolic Equations
8.3 Elliptic Equations
8.4 Nonlinear partial differential equations (Optional)

Chapter 12, Eigenvalues and Singular Values
12.1 Power Iteration Methods
12.2 QR Algorithm
12.3 Singular Value Decomposition
12.4 Applications of the SVD (Optional)

Chapter 13, Optimization (Optional)
13.1 Unconstrained Optimization without Derivatives
13.2 Unconstrained Optimization with Derivatives