

MATH 451 Numerical Analysis I

1. Catalog Description

MATH 451 Numerical Analysis I

4 units

Prerequisite: MATH 206 and MATH 242, or MATH 241 and MATH 244, and an introductory college-level programming course.

Topics in interpolation and approximation methods, initial value problems, and boundary value problems of ordinary differential equations. 4 lectures.

2. Required Background or Experience

Math 206 and Math 242, or Math 241 and Math 244, or equivalent, and an introductory college-level programming course.

3. Learning Objectives

Upon completion of this course a student should:

- a. Predict, detect, understand, and control errors when approximating solutions to problems using numerical algorithms with computers and modern off-the-shelf tools.
- b. Understand numerical algorithms for interpolation and approximation of functions, their derivatives and integrals from discrete data using polynomials, spline functions, orthogonal and non-orthogonal functions with best approximation methods.
- c. Have knowledge of issues in calculating roots of nonlinear and linear systems of equations, including pivoting strategies for the solution of a linear system of equations.
- d. Understand convergence, accuracy and stability of numerical algorithms.
- e. Have an understanding of some additional topics selected from Initial and Boundary value problems, eigenvalues and eigenvectors, Monte Carlo simulation, linear programming, and optimization.

4. Text and References

Text to be chosen by the instructor. Suggested texts include:

- Cheney, E Ward and Kincaid, David R, Numerical Mathematics and Computing (excellent text with mathematics rigor, plenty of exercises, very good student and instructor solutions manual, uses pseudo-code and popular tools like Maple, Matlab, and Mathematica)
- Kincaid, David R. and Cheney, E Ward, Numerical Analysis (excellent text, but material and exercises are at a graduate level)
- T. Sauer, Numerical Analysis
- A useful reference text: F. Acton, Real Computing Made Real: Preventing Errors in Scientific and Engineering Calculations

5. Minimum Student Materials

Access to computer facilities.
Students need regular/easy access to Matlab.

6. Minimum University Facilities

Appropriate computer facilities.

7. Content and Method

Content

Topics selected from:

- a. Basic Numerical Methods
Numerical solution and pivoting strategies of systems of linear and nonlinear equations, numerical differentiation, numerical integration.
- b. Interpolation and Approximation
Divided differences, polynomial interpolation, B-splines, cubic splines, trigonometric polynomials, least square methods for non-orthogonal and orthogonal functions, etc., including error estimates.
- c. Initial Value Problems of Ordinary Differential Equations
Single-step methods, multi-step methods, predictor-corrector methods, step-size control, stability regions, higher order systems, and stiff differential equations. Optional Math 452 to cover together with boundary value problems if necessary.
- d. Additional Topics
Boundary value problems (shooting methods, finite difference techniques, collocation, Galerkin and Rayleigh-Ritz methods, and finite element methods); eigenvalue, eigenvectors; Monte Carlo methods and simulation; linear programming; optimization.

8. Methods of Assessment

The primary methods of assessment are: essay examinations, computing projects, quizzes and homework. Typically, there will be one or more hour-long examinations during the quarter, and a required comprehensive final examination. Students are required to show their work and are graded not only on the correctness of their answers, but also on their understanding of the concepts and techniques.