Mathematics 4311 -- Numerical Analysis

**Student Learning Outcomes**

1. **The student will demonstrate factual knowledge including the mathematical notation and terminology used in this course.** Students will read, interpret, and use the vocabulary, symbolism, basic definitions used in numerical analysis including those related to topics learned in calculus and algebra and revisited in this course; limits, continuity, numerical integration, numerical differentiation, ordinary differential equations, and polynomial interpolation.

1. **The students will describe the fundamental principles including the laws and theorems arising from the concepts covered in this course.** Students will identify and apply the properties and theorems that result directly from the definitions as well as statements discovered in calculus and extended in this course; for example, Rolle’s Theorem, Mean Value Theorem, Intermediate Value Theorem, Taylor’s Theorem, theorems on convergence and existence and their error terms.
2. **The students will apply course material along with techniques and procedures covered in this course to solve problems**. Students will use the facts, formulas, and techniques learned in this course to develop and use algorithms and theorems to find numerical solutions and bounds on their error to various types of problems including root finding, polynomial approximation, numerical differentiation, numerical integration.
3. **The students will develop specific skills, competencies, and thought processes sufficient to support further study or work in this field or related fields**. Students will gain the ability to use a software package such as MATLAB to solve numerical problems and acquire a level of proficiency in the fundamental concepts and applications necessary for further study in academic areas requiring numerical analysis as a prerequisite for graduate work or for work in occupational fields. These fields might include further study in mathematics, engineering, computer science, or the physical sciences.

**Course Content**

**Textbook:** *Elementary Numerical Analysis*, Third Edition, by K. Atkinson and W. Han. Selected material from the following topics will be studied.

**0. MATLAB Programming and Monte Carlo Simulation.** MATLAB Input and Output, MATLAB Codes, Monte Carlo Simulation.

**1. Taylor Polynomials.** Review of Calculus, Taylor’s Theorem.

**2. Errors and Computer Arithmetic.** Round-off Errors and Computer Arithmetic, Sources of Error.

**3. Rootfinding.** Bisection method, Newton’s Method, Secant Method, Fixed-Point Iteration, Error Analysis.

**4. Interpolation and Approximation**. Polynomial Interpolation and Error Analysis, Interpolation Using Splines, Best Approximation, Minimax Approximations, Chebyshev Polynomials, Least Squares Approximation.

**5. Numerical Differentiation and Integration.** Trapezoidal and Simpson Rules and Error Analysis, Gaussian Quadrature, Numerical Differentiation.

**8. Ordinary Differential Equations.** Theory of Differential Equations, Euler’s Method and Convergence Analysis, Taylor and Runge-Kutta Methods