University of Arkansas – Fort Smith
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General Syllabus

MATH 4703 Numerical Analysis

Credit Hours: 3 Lecture Hours: 3 Laboratory Hours: 0

Prerequisite: MATH 2914 Differential Equations

Effective Catalog: 2020-2021

I. Course Information

A. Catalog Description

Development, analysis, computer implementation and application of basic numerical algorithms for solving scientific problems. Topics include fundamentals of numerical computation, error analysis, numerical solutions of nonlinear equations, direct and iterative methods for solving linear systems, interpolation and approximation of functions, numerical differentiation and integration, and numerical solution of ordinary differential equations. Computer programming as well as the use of software packages is required.

II. Student Learning Outcomes

A. Subject Matter

Upon completion of this course, the student will be able to:

1. Select and apply an appropriate numerical method to find the approximate solution of an equation or systems of equations of these types: algebraic, ordinary differential, linear or nonlinear.
2. Interpolate data points with polynomials and spline.
3. Fit curves and approximate functions using least squares and Lagrangian methods.
4. Estimate the numerical values of derivatives and integrals.
5. Identify sources of errors in a numerical solution, estimate and bound them.
6. Interpret numerical results.
7. Compare and contrast the performance of different algorithms with regard to efficiency and accuracy.
8. Write and implement a well-documented computer program to solve problems for which numerical solution has clear advantages over analytical techniques.

9. Utilize current software tools to implement an algorithm.
10. Develop and present an analysis and interpretation of a numerical solution to a mathematical problem.

B. University Learning Outcomes

This course enhances student abilities in the following general education areas:

Analytical Skills

Critical Thinking Skills: Students will analyze various mathematical concepts that arise in the study of numerical analysis and to draw conclusions and make generalizations based on these concepts.

Communication Skills (written and oral)

Students will compose coherent documents that effectively communicate applications of numerical algorithms to solve problems.

Ethical Decision Making

Students will identify ethical dilemmas wherever present and apply ethical frameworks to resolve such dilemmas.

III. Major Course Topics

A. Basics of numerical computation and mathematical software, sources and propagation of errors, stability of algorithms
B. Numerical solutions of nonlinear equations
   1. Bisection Method
   2. Fixed Point Iteration
   3. Newton's Method
   4. Secant Method
C. Direct and iterative methods for solving linear systems
   1. Naïve Gaussian Elimination
   2. LU-Fractorization
   3. Tridiagonal and Banded Systems
D. Interpolation
   1. Lagrange Interpolation Polynomials
   2. Newton's Divided Differences
   3. Errors in Polynomial Interpolation
   4. Convergence of Polynomial Interpolation
E. Function approximation and curve fitting
   1. Linear Splines
   2. Quadratic Splines
   3. Natural Cubic Splines
   4. Method of Least Squares with General Functions
   5. Non-linear Method of Least Square
   6. Method of Least Square for Continuous Functions

F. Numerical differentiation and integration
    1. Trapezoid Rule
    2. Simpson's Rule
    3. Recursive Trapezoid Rule
    4. Romberg Algorithm
    5. Gaussian Quadrature Formula
G. Numerical solution of ordinary differential equations.
    1. Taylor Series Methods for ODEs
    2. Runge-Kutta Methods
    3. Multi-Step Methods
    4. Numerical Solution of Systems of First Order ODEs