National University of Computer and Emerging Sciences - FAST Lahore Campus

Course Name: CS2008: Numerical Computing
Semester: Fall - 2023
Credit hours: 3+0
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Objective: Main objectives of this course are:
1. To provide suitable and effective Numerical Methods for obtaining approximate results.
2. To solve mathematical models encounter in various fields of science and engineering which requires numerical computing using certain raw data.
3. To solve complex mathematical problems using only simple arithmetic operations. The approach involves formulation of mathematical models of physical situations that can be solved with arithmetic operations.
4. To deal with various topics like root finding in equations, solving systems of linear algebraic equations, interpolation and regression analysis, numerical integration & differentiation, solution of differential equation (IVPs), boundary value problems, solution of matrix problems.
5. To facilitate numerical computing and code writing for the below mentioned techniques.

At the end of the course, it is expected from students to obtain a working knowledge of how to apply numerical methods to real-world problems and a basic understanding of the mathematics and properties of these methods.

Text Books / Reference Books:
Numerical Analysis by Burden Faires
Applied Numerical Analysis by Gerald / Wheatley
An Introduction to Numerical Analysis (2nd Edition) by Kendall E. Atkinson
Computer-Oriented Numerical Methods by P. Thangaraj
Numerical Methods Using MATLAB by John H. Mathews and Kurtis D. Fink
Numerical Methods by S Kalavathy.

Grading Policy:
Grads will be awarded on the basis of continuous assessment through quizzes, assignment, two midterm exams and a final exam. The distribution of marks is as under:
Assignment (10), Quizzes (10), Midterm exams 1 & 2 (15+15) and Final exam (50)

Grading Scheme: Absolute

Note: Tentative topics in Sessional I and II are highlighted in yellow and pink respectively. Final exam will contain full course outline.

Topics

Introduction to Numerical Computing

What is numerical computing and numerical analysis. Error, Different types of errors, convergence of computer arithmetic, Algorithms, Numerical soft wares (working platforms – Mathematica, Matlab, Python), Mathematica implementation of different numerical techniques.

Interpolation with equally spaced data

The difference table, Newton's forward and backward difference formulae, Gauss formula, stirling's interpolation formula, Bessel's interpolation formula, Inverse Interpolation.

Interpolation with unequally spaced data

Lagrange's formula, divided differences, divided–difference table, Newton Divided difference formula.
(Additioanl: Curve fitting by method of least square)

Numerical differentiation

Numerical differentiation based on forward and backward differences, Numerical differentiation based on Gauss forward, Gauss backward, Sterling's, Bessel's and Laplace Everet formula, Newton divided difference and Lagrange's formulae.

Numerical integration

The composite trapezoidal rule, composite Simpson's rule,
Romberg Integration based on Trapezoidal and Simpson's rules
P1a: Multivariate interpolation, numerical differentiation and integration.

The solution of nonlinear equations

Bisection method, Regula-Falsi method, Newton-Raphson method, Fixed point iteration, Secant method, Error and convergence analysis for iterative methods.

Solution of system of linear equations

(direct method):
Gauss's elimination method based on partial and total pivoting, LU decomposition, Doolittle's method, Crout's method, Cholesky's method.

(Indirect method)
Iterative methods: Gauss Jacobi iterative method, Gauss Seidel iterative method.

Numerical solution of ordinary differential equations

Taylor's series method for single ODE and system of ODEs, Picard method, Euler's method, Improved Euler's method, Modified Euler method, Runge-Kutta methods of order 1,2,3 and 4 for single ODE and system of ODEs,

Multistep methods: Predictor-Corrector schemes including Adams-Bash-Forth technique, Adams-Molten technique, Milan's technique.
Higher order equations and systems of differential equations.

Numerical Solution of BVPs:

Finite difference method, Stability, convergence and consistency of the methods.

Additional Topics

Review of some advanced numerical schemes for the solution of ODEs including Homotopy based schemes (Homotopy Perturbation Method, Optimal Homotopy Asymptotic Method, Homotopy Analysis Method, He-Laplace Method and Least Square optimizer with Homotopy Perturbation Algorithm, and Modifications of RK family of methods (Implicit and Explicit RK Methods, RK45 Methods) etc.