Course Outline

Course	**CS2008: Numerical Computing**	
Lectures Days, Time,	Tuesday and Thursday	***11:30AM –1:00PM***
		1:00PM –2:30PM
class room location		***Room CS13***
Semester	Fall 2024	***First Day of Classes: August 19, 2024***
Course Instructor	**Prof. Dr. Mubashir Qayyum**	
Office	HOD S&H (Block C)	
Office Telephone	+92 42 111 128 128 (283)	
E mail	mubashir.qayyum@nu.edu.pk	
Consulting hours	Tuesday, Thursday	***3:30 PM -4:30 PM***
	Any other days	By appointments
Required Text & Recommended Additional Readings, Books and Other Material	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.	
Course Credit hours	3+0	
Other Course Pack Material	Shall be made available through photocopier or through SLATE/Google classroom	
Pre requisites of the Course	Nil	
Methodology	Primarily Lecture method based on Lectures including the explanations of different topics and solutions of numerical problems related to topics.	

Course Objectives, Expected outcome & Policy

Course Objectives:

1. Provide effective numerical methods for obtaining approximate solutions.
   Solve mathematical models in science and engineering using numerical computing with raw data.
2. Tackle complex mathematical problems using simple arithmetic operations by formulating and solving models of physical situations.
3. Cover topics such as root finding, solving linear algebraic systems, interpolation, curve fitting, numerical differentiation and integration, and solving differential equations (IVPs/BVPs), and numerical linear algebra.
4. Facilitate numerical computing and code writing using tools like Mathematica, MATLAB, or Python.

By the end of the course, students will have practical knowledge of applying numerical methods to real-world problems and a foundational understanding of the underlying mathematics.

Course Evaluation and Rewards

Quizzes **10 %**

There shall be at least 3 quizzes from the assigned and lecture topics, No Makeup quizzes shall be allowed whatsoever.

10 %

Assignments

There shall be at least 3 individual assignments which may include theoretical as well as numerical problems. Also, evaluation of the assignment may be through assignment quiz.

(15% + 15%) = 30 %

Mid Term

First Mid Term will be conducted in 6th Week and second Mid Term will be in 12th Week of the semester.

50 %

Final Comprehensive Examination

The final examination could be mixture of short questions and long questions. Students should also expect questions from the assignments & quizzes.

Grading Policy

Absolute Grading

Contents

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), Implementation of different numerical techniques.

Interpolation with equally spaced data
The difference table, Newton forward and backward difference formulae, Gauss formula, sterling interpolation formula, Bessel interpolation formula, Inverse Interpolation.

Interpolation with unequally spaced data
Lagrange formula, divided differences, divided–difference table, Newton Divided difference formula.
(Additional topic: *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, Bessel and Laplace Everet formula, Newton divided difference and Lagrange`s formulae.
T1: *Implementation/code writing of discussed numerical methods in suggested platform.*

Numerical integration
The composite trapezoidal rule, composite Simpson rule,
Romberg Integration based on Trapezoidal and Simpson rules
B1: *Multivariate interpolation, numerical differentiation and integration.*
T2: *Implementation/code writing, analysis of numerical methods in suggested platform.*

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.
T3: *Implementation/code writing, analysis of numerical methods in suggested platform.*

Numerical Solution of System of Linear Equations
Direct methods:
Gauss elimination method based on partial and total pivoting, LU decomposition, Doolittle method, Crout method, Cholesky method.

Indirect method or Iterative methods:
Gauss Jacobi iterative method, Gauss Seidel iterative method.
T4: *Implementation/code writing, analysis of numerical methods in suggested platform.*

Numerical Solution of Ordinary Differential Equations
Taylor series method for single ODE, and system of ODEs, Picard method, Euler method, Improved Euler method, Modified Euler method,

Runge-Kutta methods of order 1,2,3 and 4 for single ODE and system of ODEs.
T5: *Implementation/code writing, analysis of numerical methods in suggested platform.*

Multistep methods: Predictor-Corrector schemes including Adams-Bash-Forth technique, Adams-Molten technique, Milan's technique.
Additional topic: *Higher order equations and systems of differential equations.*
T6: *Implementation/code writing, analysis of numerical methods in suggested platform.*

Numerical Solution of BVPs:
Finite difference method, Stability, convergence and consistency of the methods.
T7: *Implementation/code writing, analysis of numerical methods in suggested platform.*

Additional Advanced Numerical/Semi-Numerical Schemes:
Review of Homotopy based schemes including Homotopy Perturbation Method (HPM), Optimal Homotopy Asymptotic Method (OHAM), Homotopy Analysis Method (HAM), He-Laplace Method (HLM) and Least Square optimizer with Homotopy Perturbation Algorithm (LSHPM).
Review of Modifications of RK family of methods (Implicit and Explicit RK Methods, Fehlberg RK Methods) etc.

Note: Advanced schemes are not included in the syllabus and this portion will be for information.