FIRST SEMESTER 2025-26
COURSE HANDOUT

Date: 05.07.2025

In addition to Part I (General Handout for all courses appended to the Timetable), this portion gives further specific details regarding the course.

Course No. : **CE F324**
Course Title : **NUMERICAL ANALYSIS**
Instructor In-charge : **MD RUSHDIE IBNE ISLAM**
Instructor : **NA**

1. Course Description

Solution of Linear Algebraic System of Equations, Storage Schemes and techniques to a System of Large number of Equation, Numerical Solutions by Interpolation, Integration of Functions containing Singularities, Finite Element Method, Solutions of Initial and Boundary Value Problems, Boundary Integral Element Method, Solution of Non-Linear System of Equations.

2. Scope and Objectives

This course introduces the fundamental numerical techniques required to solve mathematical problems that frequently arise in engineering and applied sciences. It focuses on the development, analysis, and implementation of algorithms for root-finding, solving systems of equations, interpolation, approximation, numerical differentiation and integration, and solving ordinary and partial differential equations. The course also emphasizes the role of computational errors and stability in numerical methods. Through this course, students will gain practical skills in applying numerical algorithms to real-world engineering problems using computational tools.

3. Course Learning Outcome

On successful completion of this course, a student should be able to learn the following things:

- Understanding of various types of errors appeared in numerical computations and how to fit an approximate polynomial from a given data set.
- Understanding how to compute roots of algebraic equations using direct and iterative numerical schemes.
- Understanding how to determine solutions of a large system of linear equations numerically.
- Learning numerical discretization using finite difference techniques for various order derivatives and how to compute numerical integration.
- Learning how to solve a differential equation numerically.

4. Prescribed Textbook and Reference Books

TB1.- G. Dahlquist and A. Bjorck, Numerical Methods, First Edition (Reprint), Dover Publications, 2003.

RB1. - K. E. Atkinson, An Introduction to Numerical Analysis, First Edition, John Wiley & Sons, 1978.

RB2. - P. Moin, Fundamentals of Engineering Numerical Analysis, First Edition, Cambridge University Press, 2010.

5. Method of conduct of the course

The course will be conducted through a mix of blackboard teaching and PowerPoint presentations to explain key concepts and numerical techniques. All class notes and lecture materials will be shared with students after each session. Emphasis will be placed on clear understanding and practical implementation using computational tools such as MATLAB or Python.

6. Course Plan

Week/ Module Number	Lecture session	Reference	Learning Outcome
1. Errors in computation (2 Lectures, Week 1)	Source and types of errors, Error propagation. Computer representation of numbers: Floating point representation, Rounding error and floating-point arithmetic.	T1-1,2; R1-1	Analyze computational errors and floating-point effects in numerical methods.
2. Roots of nonlinear equations (3 Lectures, Week 1 & 2)	Direct and iterative methods, Order of convergence, Iterative methods for roots of nonlinear system of equations.	T1-6; R1-2	Solve nonlinear equations using iterative methods and assess convergence.
3. Linear systems of equations (4 Lectures, Week 2 & 3)	Direct and iterative methods, Rate of convergence of iterative methods, Condition number and ill-conditioned systems.	T1-5; R1-8	Solve linear systems and assess stability using condition numbers.
4. Interpolation and approximation (3 Lectures, Week 4)	Lagrange, Newton divided difference formula, Newton's interpolations, Errors in interpolation. Least square and uniform approximations.	T1-3,4,7; R1-3,4; R2-1	Apply interpolation and approximation methods to estimate functions and errors.
5. Differentiation (4 Lectures, Week 5 & 6)	Differentiation using interpolation formulas.	T1-7; R2-2	Compute numerical derivatives using interpolation-based formulas.
7. Integration (4 Lectures, Week 6 & 7)	Newton-Cotes formulas, Gauss quadrature rules.	T1-7; R1-5; R2-3	Perform numerical integration.

8. Numerical solutions of ordinary differential equations (6 Lectures, Week 7, 8 & 9)	Taylor, Euler and Runge-Kutta methods, Implementation of these methods to initial value problems.	T1-8; R1-6; R2-4	Solve initial value problems for ODEs.
9. Numerical solutions of partial differential equations (9 Lectures, Week 9, 10, 11 & 12)	Classification of PDEs (elliptic, parabolic, hyperbolic): Finite difference method (FDM) for PDEs, Laplace and Poisson equations (elliptic), Heat equation (parabolic), Wave equation (hyperbolic). Stability and consistency of FDM. Introduction to boundary and initial conditions. Basics of implicit and explicit time integration schemes	T1-8; R2-5	Solve basic PDEs using finite difference methods and analyze stability and accuracy for physical problems.
10. Optimization (3 Lectures, Week 12 & 13)	Statement of the problem, definitions and normal form. Simplex method. Duality, transportation problems and some other optimization problems. Nonlinear optimization problems - basic concepts and introductory examples, line search, algorithms for unconstrained optimization, overdetermined nonlinear systems, constrained optimization.	T1-10	Solve linear and nonlinear optimization problems using simplex, duality, and gradient-based methods, and interpret results in applied contexts.
11. Monte Carlo method and simulation (2 Lectures, Week 13 & 14)	Introduction. Random digits and random numbers. Applications – reduction of variance. Pseudo-random numbers	T1-11	Use Monte Carlo methods and pseudo-random numbers for numerical simulation and variance reduction.

6. Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of component (Close Book/ Open Book)
Mid-Semester Test	90 Min.	25	<TEST_1>	Close Book

Comprehensive Examination	3 h	35	<TEST_C>	Close Book
Quizzes (Best 2 out of 4)		20	Spread over the semester	Open Book
Assignments		20	Spread over the semester	Open Book

Criterion for NC: As per institute norms.

7. Chamber Consultation Hour: Wednesday 5PM to 6 PM.

8. Notices: Notices concerning this course will be displayed on Department Notice Board and the course webpage.

9. Make-up Policy: If the student is unable to appear for the Mid-Semester Test/ Comprehensive Examination due to genuine exigencies, the student must refer to the procedure for applying for Make-up Test/Examination. No make up for the Quizzes and assignments.

10. Note (if any):
Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

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