Bangladesh University of Engineering and Technology (BUET)

Department of Computer Science and Engineering (CSE)

Course Outline

PART A: General Information

1. **Course Title** : Numerical Methods
2. **Type of Course** : Sessional
3. **Offered to** : Department of CSE
4. **Pre-requisite Course(s)** : None
5. **Credit hours** : 2.0 credit hours (4hrs/week)

PART B: Course Details

1. Course Content (As approved by the Academic Council)

This course is the study of numerical methods to solve mathematical problems. The course teaches in-depth knowledge of the mathematical formulations of numerical methods and the computer algorithms for generating numerical solutions. The topics expected to be covered include the following: i) Solution of Non-linear Equations: Fixed Point Iteration, Bi-Section method, False Position method, Newton-Raphson method, Bairstow's Method; ii) Solution of Linear equations: Triangular systems and back substitution, Gauss-Jordan elimination method, Pivoting, LU-factorization, Cholesky's method, Dolittle and Crout factorization; iii) Interpolation and Approximation: Taylor's Series, Lagrange interpolation, Divided differences formula, Newton's forward and backward interpolation, Spline interpolation; iv) Differentiation: Numerical differentiation, Richardson's extrapolation; iv) Integration: Newton's-Cote integration, Trapezoidal rule, Simpson's rule, Romberg's integration; vi) Ordinary Differential Equations: Euler's method, Picard's method, Milne's method, Taylor's series method, Runge-Kutta method; vii) Curve Fitting: Least squares lines, Least square polynomials, Non-linear curve fitting; viii) Numerical Optimization: Golden Ratio search, Newton's search, Powell's method, Gradient search.

2. Course objectives

The main objectives of this course are as follows -

i. To teach students the fundamental knowledge of numerical methods and their applications in engineering discipline.

ii. To enable students to analyze mathematical and engineering problems, find solutions, and evaluate the outcomes using the approaches of numerical methods.

iii. To teach students how to write computer programs to implement numerical method solutions.

3. Knowledge required

Technical

- Basic programming knowledge (C/C++/similar)

Analytical

- Problem solving and creating thinking

4. Course Outcomes

CO No.	CO Statements After undergoing this course, students should be able to-	Corresponding PO(s)*	Domains and Taxonomy level(s)**	Delivery Method(s) and Activity(-ies)	Assessment Tools
CO1	Analyze numerical method formulations for different mathematical and engineering problems.	-	C4	Lecture	Final quiz
CO2	Apply numerical methods to find solutions of mathematical problems.	-	C3	Lecture, Problem Solving	Final quiz, Assignment
CO3	Write computer programs to implement numerical methods in Python.	-	C4	Lecture, Problem Solving	Assignment
CO4	Evaluate the accuracy of numerical method solutions.	-	C3	Lecture, Problem Solving	Assignment, Final quiz

***Program Outcomes (POs)**

PO1: Engineering knowledge; PO2: Problem analysis; PO3: Design/development of solutions; PO4: Investigation; PO5: Modern tool usage; PO6: The engineer and society; PO7: Environment and sustainability; PO8: Ethics; PO9: Individual work and teamwork; PO10: Communication; PO11: Project management and finance; PO12: Life-long learning.

****Domains**

C-Cognitive: C1: Knowledge; C2: Comprehension; C3: Application; C4: Analysis; C5: Synthesis; C6: Evaluation
A-Affective: A1: Receiving; A2: Responding; A3: Valuing; A4: Organizing; A5: Characterizing
P-Psychomotor: P1: Perception; P2: Set; P3: Guided Response; P4: Mechanism; P5: Complex Overt Response; P6: Adaptation; P7: Organization

5. Mapping of Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

COs	K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
CO1		√	√																	
CO2		√	√																	
CO3				√																
CO4		√		√																

K-Knowledge Profile:

K1: A systematic, theory-based understanding of the natural sciences applicable to the discipline; **K2:** Conceptually based mathematics, numerical analysis, statistics and the formal aspects of computer and information science to support analysis and modeling applicable to the discipline; **K3:** A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline; **K4:** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline; **K5:** Knowledge that supports engineering design in a practice area; **K6:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline; **K7:**Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the engineer's professional responsibility to public safety; the impacts of engineering activity; economic, social, cultural, environmental and sustainability; **K8:** Engagement with selected knowledge in the research literature of the discipline

P-Range of Complex Engineering Problem Solving:

P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8 which allows a fundamentals-based, first principles analytical approach; **P2:** Involve wide-ranging or conflicting technical, engineering and other issues; **P3:** Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models; **P4:** Involve infrequently encountered issues; **P5:** Are outside problems encompassed by standards and codes of practice for professional engineering; **P6:** Involve diverse groups of stakeholders with widely varying needs; **P7:** Are high level problems including many component parts or sub-problems

A-Range of Complex Engineering Activities:

A1: Involve the use of diverse resources (and for this purpose resources include people, money, equipment, materials, information and technologies); **A2:** Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues; **A3:** Involve creative use of engineering principles and research-based knowledge in novel ways; **A4:** Have significant consequences in a range of contexts,

characterized by difficulty of prediction and mitigation; **A5:** Can extend beyond previous experiences by applying principles-based approaches

6. Lecture/Activity Plan

Weeks	Topics / Content / Assignment	Corresponding COs
1	Theory: Introduction *Lab*: Lecture-1 on Python	CO1
2	*Theory*: Solution of Non-linear equations *Lab*: Lecture-2 on Python	CO1
3	*Theory*: Solution of Non-linear equations *Lab*: Lecture-3 on Python. Home assignment 1 on solution of non-linear equations	CO1 – CO4
4	*Theory*: Solution of Linear equations *Lab*: Evaluation of Home Assignment 1	CO1
5	*Theory*: Solution of Linear equations *Lab*: Home Assignment 2 on Solution on Linear Equations. Extra lecture on Thursday of this week Topic: Solution of Linear Equations	CO1 – CO4
6	*Theory*: Interpolation and Approximation *Lab*: Evaluation of Home Assignment 2	CO1
7	Theory: Interpolation and Approximation *Lab*: Online assignment 1 on Solving Linear and Non-Linear Equations	CO1 – CO4
8	Theory: Interpolation and Approximation *Lab*: Online assignment 2 on Interpolation and approximation	CO1 – CO4
9	Theory: Integration Lab: Home Assignment on Integration Extra lecture on Thursday of this week Topic: Integration	CO1
10	Theory: Curve Fitting Lab: Evaluation of Home Assignment on Integration	CO1
11	Theory: Curve Fitting Extra lecture on Thursday of this week	CO1

	Topic: Curve Fitting (if required)	
12	Theory: Ordinary Differential Equations Lab: Online assignment on Curve Fitting	CO1 – CO4
13	Theory: Numerical Optimization: Golden Ratio search, Newton's search, Powell's method, Gradient search. Lab: Final Quiz	CO1 – CO4

7. Assessment Strategy

i. Home assignments and in-class assignments: There will be a minimum of 3 (three) home assignments and 3 (three) in-class online assignments.
ii. Final quiz: A comprehensive final quiz exam will be held at the end of the course.

8. Distribution of Marks

Assignments	70%
Final quiz:	30%
Total:	100%

9. Textbook/ Reference

i. Numerical Methods with Applications by Autar K Kaw and Egwu Eric Kalu
ii. Numerical Methods for Engineers 7th Edition by Steven Chapra and Raymond Canale

10. Course Teacher(s):

Name:	**Office/Room:**	**E-mail and Telephone:**
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