KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF SCIENCE
FACULTY OF PHYSICAL AND COMPUTATIONAL SCIENCES
DEPARTMENT OF MATHEMATICS
CSM 258: NUMERICAL METHODS AND COMPUTATIONS

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Credits: Three (3)
Term: Second Semester 2021/2022

Course Objective

This is an undergraduate course for computer science students. Numerical method is the study of algorithms that use numerical approximation for solving mathematical problems which often has no analytical solution. These computer algorithms are required by computer scientist, physicists, engineers, and mathematicians to explore and solve problems relating to complex systems. This course seeks to help students develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems on the computer. The course aims to help students develop and apply problem solving skills through the introduction of these numerical schemes; given students an opportunity to develop and present an independent project.

Course Outline

1. Introduction to Numerical Methods: Definition, Significant digits, Accuracy and Precision, Rounding and Chopping, Absolute and Relative Errors, Review of Calculus, Taylor and Maclaurin Series.

2. Methods for Solving Algebraic and Transcendental Equations

   Initial Approximation for the Iteration

   (a) Bisection Method

   (b) Method of False Position

   (c) Secant Method

   (d) Newton-Raphson Method

3. Methods for Solving Linear System of Equations by Direct Methods.
    (a) Gaussian Elimination Method
    (b) Gauss-Jordan Elimination Method
4. Methods for Solving Linear System of Equations by iterative Methods.
    (a) Gauss-Jacobi Method
    (b) Gauss-Seidal Method
5. Eigenvalue Problems: Power Method, Inverse Power Method, Power Method with Shift.
6. Interpolation and Approximation with Unevenly Spaced Points:
    (a) Lagrange Interpolation
    (b) Newton's Divided Difference Interpolation
7. Interpolation with Evenly Spaced Points
    (a) Difference Operators
    (b) Newton's Forward Difference Interpolation Formula
    (c) Newton's Backward Difference Interpolation Formula
8. Numerical Differentiation with Finite Difference
    (a) Derivatives Using Newton's Forward Difference
    (b) Derivatives Using Newton's Backward Difference
9. Numerical Integration Rules Based on Uniform Mesh Spacing
    (a) Trapezium Rule
    (b) Simpson's 1/3 Rule
    (c) Simpson's 3/8 Rule, and
    (d) Romberg Method.
10. Integration Rules Based on Non-uniform Mesh Spacing: Gaussian Integration (Quadrature) Rules

11. Numerical Solutions of Ordinary Differential Equations: Single-Step Methods
    (a) Euler or Taylor series Method
    (b) Backward Euler
    (c) Modified Euler or Midpoint Method
    (d) Trapezium Method
    (e) Heun's Method or Euler-Cauchy Method
    (f) Runge-Kutta Method, specifically 4th Order
12. Numerical Solutions of Ordinary Differential Equations: Multi step methods and Predictor-Corrector Methods
    (a) Adams-Bashforth Method
    (b) Adams-Moulton Method
    (c) Milne-Simpson Methods

Assessment

There will be assignments, a mid-semester examination, and an end of semester examination. Assignments and mid semester form 30% of students total scores while end semester examination form 70%.

Resources

1. Gabriel Obed Fosu, Beamer Presentation Slides on Numerical Methods and Computation, 2022 Edition.
2. Iyengar S. R. K. and Jain R. K., Numerical Methods, New Age International, 2009.
3. Timothy Sauer, Numerical Analysis, 3rd Edition, Pearson Education, Inc, 2018.
4. Ward Cheney and David Kincaid, Numerical Mathematics and Computing, 6th edition, Brooks/Cole, 2008.
5. Douglas J. Faires and Richard L. Burden, Numerical Methods, Brooks/Cole, 3rd edition, 2002.
6. Joe E. Hoffman, Numerical Methods for Engineers and Scientist, 2nd edition, Marcel Dekker, Inc., 2001.