William Paterson University of New Jersey
College of Science and Health
Department of Computer Science
Course Outline

I. TITLE OF COURSE, COURSE NUMBER and CREDITS
"Numerical Methods ", CS402, Credits: 3

II. DESRIPTION OF THE COURSE:
An introduction course in numerical methods, theory and application. Emphasizes building algorithms for solution of numerical problems, the sensitivity of these algorithms to numerical errors and efficiency of these algorithm. Topics include: solutions to non-linear equations; system of linear equations, interpolation, polynomial approximations, and quadrature solutions; numerical differentiations and integrations, eigenvalues and eigenvectors.

III. COURSE PRE-REQUISITE: CS260 and Math 161 with grades of C- or better in both

IV. OBJECTIVES OF THE COURSE:
1. To learn topics in basis numerical analysis and methods used to solve physical problems
2. To hone students' programming skill using appropriate programming language(s)
3. To further develop concepts and theories in analysis and construct of algorithms
4. To sharpen students' problem solving techniques as well as their analytical and intellectual thought processes

V. STUDENT LEARNING OUTCOMES:
Upon completion of the course, students will be able to:
1. Acquire basic knowledge in theory and application of numerical methods used to solve physical problems. Measure: exams, surveys, and projects.
2. Gain advanced programming skills in the appropriate programming language(s). Measure: exams and projects.
3. Enhance their ability in analysis and construct of algorithms related to numerical methods. Measure: exams and projects.
4. Improve analytical and intellectual thought process in problem solving. Measure: exams and projects.
5. Strengthen their ability to present material both in oral and written form via homework and project participation. Measure: exams, homework and projects.
6. Enhance problem solving skills Measure: exams, homework and projects.

VI TOPICAL OUTLINE OF THE COURSE CONTENT:

Topic 1: Reviews of programming and mathematical background

Topic 2: Number Representation and Error Analysis:
- Representation of Numbers in Different Bases

- Floating-Point Number System
- Loss of Significance

Topic 3: Solutions of Non-linear Equations: Theory and algorithm construct and Programming Implementation of:
- Simple iterations, Bisection Method, Newton's Method, Secant method
- Fixed Point Iteration

Topic 4: Interpolation and Polynomial Approximation: Theory, algorithm construct and programming Implementation of:
- Polynomial Interpolation: Newton's Interpolating Polynomial, Lagrange Interpolating Polynomial
- Error Analysis in Polynomial Interpolation

Topic 5: System of Linear equations: Theory, algorithm construct and programming implementation of:
- Gaussian Elimination, Gauss-Jordan, LU Factorization Tridiagonal and Other Band Systems, Iterative Solution, Gauss-Seidel Iteration Method, Pathological Conditions, Determinants, Norms and Convergence, Inversion of Matrices, Eigenvalues and Eigenvectors, and Error Analysis

Topic 6: Numerical Differentiation: Theory, Algorithm Constructs and Programming Implementation of:
- Difference Formulas, First Derivative Formula via Taylor Series,
- Richardson Extrapolation, Second-Derivatives via Taylor Series, Formulas for Higher-Order Derivatives, Lozenge Diagrams, Error Analysis

Topic 7: Numerical Integration: Theory, Algorithm Construct and Programming Implementation of:
- Definite Integral, Reimann's Theorem, Newton Cote's Formulas,
- Trapezoidal Rule, Romberg Algorithm, Simpson's Rules,
- Gaussian Quadrature Formulas

VII <u>GUIDELINE/SUGGESTIONS FOR TEACHING METHODS AND STUDENT LEARNING ACTIVITIES</u>:

1. Lectures and problem solving sessions
2. Homework presentation both in written and oral forms
3. Computer programming projects both in individual and group set-up

VIII <u>GUIDELINES/SUGGESTIONS FOR METHODS OF STUDENT ASSESSMENT</u>:

1. Class attendance required
2. Classroom participation heavily counted

3. Scheduled Classroom exams and quizzes
4. Homework assignments
5. Programming Assignments with strict deadline. Individual effort required
6. Project presentation
7. Always accord respect to others and conduct professionally

IX SUGGESTED READING, TEXT, OBJECTS OF STUDY:

"Numerical Methods", J. Douglas Faires and Richard Burden, Third Edition, 2003, Brooks/Cole Publishing Company

Appropriate programming language(s)

X BIBIOGRAPHY OF SUPPORTING TEXTS AND OTHER MATERIALS:

1. "Numerical Methods for Engineers" Steven C. Chapra and Raymond P. Canale, Fifth Edition, 2006, McGraw Hill
2. "Friendly Introduction to Numerical Analysis, A", Brian Bradie, 2006, Prentice Hall
3. "Numerical Analysis", Richard Burden and J.J. Faires, Eighth Edition, 2005, Brooks/Cole Publishing Company
4. "Numerical Analysis and Scientific Computation", Jeffery J. Leader, 2005, Addison and Wesley
5. "Applied Numerical Analysis", Gerald Curtis & Patrick Wheatley, Seventh Edition, 2004, Addison and Wesley
6. "Numerical Mathematics and Computing", Ward Cheney and David Kincaid. Fifth Edition, 2004, Brooks/Cole Publishing Company
7. "Introduction to Scientific Computing Using MATLAB", Alan Law, 2004, Prentice Hall
8. "Applied Numerical Methods for Engineers and Scientists", Singiresu S. Rao, 2002, Prentice Hall
9. "Scientific Computing", Michael T Heath, Second Edition, 2002, McGraw Hill
10. "Applied Numerical Analysis Using MATLAB", Laurene V. Fausett, 1999, Prentice Hall
11. "Fundamentals of Numerical Computing", L.F. Shampine , R.C. Allen and S. Pruess, 1997, John Wiley & Sons, Inc.
12. "Theory and Applications of Numerical Analysis", GM Phillips and PJ Taylor, 1996, Academic Press
13. "Numerical Analysis, Theory and Practice", N. S. Asaithambi, 1995, Saunders College Publishing
14. "Applied Numerical Methods for Engineers", Terrence J. Akai, John Wiley, 1994
15. "Applied Numerical Analysis in C", Shoichiro Nakamura, 1993 , Prentice Hall
16. :Numerical Methods for Engineers and Computer Scientist", Paul Hultquist, 1988, Addison-Wesley
17. "Numerical Analysis", Second Edition, M.J. Maron, 1987, Macmilian
18. "Applied Linear Algebra", B. Noble and J. Daniel, 1977, Prentice Hall

19. "Elementary Numerical Analysis: An Algorithmic Approach", Second Edition, S. D. Conte, and Carl de Boor, 1972, McGraw Hill
20. "Analysis of Numerical Methods", Eugene Issacson and Herbert Keller, 1966, John Wiley
21. "Numerical Analysis", Kaiser Kunz, 1957, McGraw Hill
22. "Introduction to Numerical Analysis", F. B. Hildebrand, 1956, McGraw Hill

XI PREPARER'S NAME AND DATE: Dr. John Najarian; Fall 1996

XII ORIGINAL DEPARTMENTAL APPROVAL DATE: Spring 1997

XIII REVISORS' NAMES AND DATES:
Dr. E. Hu; Spring 2000 and Dr. Li-hsiang (Aria) S. Cheo; Fall 2000;
second revision in Spring 2005

XIV DEPARTMENTAL REVISION APPROVAL DATE: Spring 2005