Course Outcomes	CSC 2262

CSC 2262: Numerical Methods

Credit Hours: 3 hours

Frequency: Fall and Spring semesters

Prerequisites:

MATH 1552 and CSC 1254 or 1351.

Prerequisites by Topics:

Calculus (mean value theorem, differentiation and integration of a single real variable, ordinary differential equations, partial derivatives, series and sequences, trigonometry, maximum and minimum values of functions)
Programming (basic program design, implementation and testing, data types, arrays, loops, conditionals, functions)

Catalog Course Description:

Credit will be given for only one of the following: CSC 2262, 2533 or IE 2060. Computer-oriented methods for solving numerical problems in science and engineering; numerical solutions to systems of simultaneous linear equations, nonlinear algebraic equations (root solving), differentiation and integration, ordinary differential equations, interpolation, and curve fitting.

Course Outcomes

1. Be aware of the use of numerical methods in modern scientific computing,
2. Be familiar with finite precision computation,
3. Be familiar with numerical solutions of nonlinear equations in a single variable,
4. Be familiar with numerical interpolation and approximation of functions,
5. Be familiar with numerical integration and differentiation
6. Be familiar with numerical solution of ordinary differential equations
7. Be familiar with calculation and interpretation of errors in numerical methods,
8. Be familiar with programming with numerical packages like MATLAB.

Texts and Other Course Materials

Elementary Numerical Analysis, Atkinson and Han, Third Edition, Wiley Publishers ISBN: 0-471-43337-3

Major Topics

- Discussion of the use of numerical methods for real world problems in science, engineering and the humanities.
- General Skills (Definition of and calculation of error terms, convergence rate, interpretation of general error properties given the expression for an error. Derivation of pseudo-code for any numerical method. Graphical representation of numerical methods and their application. Sources of error and their contribution to numerical solution of real world scientific problems. Knowledge of different ways that a problem may be ill-behaved. Mathematics including equation of a line, basic integration and differentiation, chain rule for differentiation, integration by parts, form of basic functions (exp , ln , cos, sin), tridiagonal systems, solution of quadratic equations, mean value theorem, matrix determinants.)
- Computer Arithmetic (Floating-point numbers, scientific notation, single precision and double precision IEEE floating-point formats, binary numbers, hexadecimal numbers, conversion between formats, accuracy of floating point representation. Rounding and chopping of numbers, loss of significant figures, noise in evaluating functions, underflow and overflow, summation of numbers, loop errors.)
- Taylor Polynomials (Derivation of general Taylor polynomials of arbitrary order about a particular point of approximation, Taylor's remainder theorem, calculation of and use of error bounds, calculating Taylor polynomials for simple expressions, Taylor's series.)
- Root Finding (Derivation of algorithm for bisection method, error bounds and rate of convergence for bisection method. Derivation of algorithm for false position and secant method, error bounds and rate of convergence for both methods. Derivation of algorithm for Newton's method. General properties of its application and error. General method of fixed point interation. Application of the contraction mapping theorem and its corollary. Aitken error estimation and extrapolation. Ill-behaving root finding, general understanding of multiple roots and stability of roots. Graphical representation and interpretation of root finding methods.)
- Interpolation and Approximation (Definition of polynomial interpolation. Difference between interpolating and approximating polynomials. Detailed derivation and application of linear polynomial interpolation. Definition of piecewise interpolating polynomials. Form of, and use of the general Lagrange polynomial interpolation formula. Properties of errors in polynomial interpolation. Motivation for and use of the near-minimax approximation. Definition and use of divided differences, including their use in formulae for interpolation. Definition of and motivation for cubic splines. Ability to calculate and identify natural cubic splines.)
- Integration and Differentiation (Derivation and use of trapezoidal rule, use of Simpsons rule, midpoint rule, graphical interpretation, properties of errors for methods. Deriving number of node points to use for a particular error tolerance. Corrected trapezoidal/Simpsons rule. Derivation and use of Richardson extrapolation formula. Gaussian integration, derivation for cases n=1 and n=2, change of variable for general ranges. Numerical derivatives, derivation of forward and backward difference formulae, method for differentiation using interpolation, method of undetermined coefficients.)

- Linear Systems (Examples of linear systems, e.g. polynomial interpolation, difference between direct and iterative methods. Matrices: order, notation, transpose, arithmetic and algebra, row operations, inverse, singular matrices, determinant, norms. Solvability theorem. Direct methods: Gaussian elimination, pivoting, LU decomposition, operations count, calculating matrix inverse, tri-diagonal systems. Iterative methods: General scheme, Jacobi, Gauss-Seidel, convergence criteria and behaviour of general iterative solvers, role of diagonally dominant matrices, role of matrix eigenvalues, residual correction for a general scheme, pseudo-code algorithms for Jacobi and Gauss-Seidel
- Ordinary Differential Equations (Examples of ODEs, e.g. harmonic oscillator. Definition of order, linear, nonlinear and examples. Derivation of Eulers method using Taylors series and discussion of error term.)

Assignments/Projects/Laboratory Projects/Homework

Weekly assignments during the semester including problem solving, as well as programming and investigations with MATLAB package.

Curriculum Category Content (estimated in semester hours)

Area	Core	Advanced	Area	Core	Advanced
Algorithms	40		Data Structures		
Software Design	7		Prog. Languages		
Computer Arch.					

Relationship to Criterion 3 Outcomes

A	B	C	D	E	F	G	H	I	J	K
*	*	*		*				*	*	*

Math Fundamentals: Computer arithmetic and errors (3), taylor polynomials (3), root finding (5), interpolation and approximation (5), integration and differentiation (3), linear systems (6), ordinary differential equations (3), advanced topics (2)

Data Structures:

Algorithms and Software: Algorithms design for numerical methods (7), algorithm implementation (7)

Computer Organization and Architecture:

Concepts of Programming Languages:

Social and Ethical Issues: Use of numerical methods for real world applications (1)

Oral Communication (presentations) – none

Written Communication: Weekly assignments involving numerical analysis, algorithm development, and written interpretation of numerical investigations.

Course Coordinator: Dr. Gabrielle Allen
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