Hong Kong Baptist University
Faculty of Science
Department of Mathematics

Title (Units): MATH 1140 COMPUTATIONAL MATHEMATICS (3,3,0)

Course Aims: This course aims to introduce Computer Science Major students to the basic concepts in modern computational mathematics and its application. It provides various solid fundamental concepts and knowledge for modeling, real life application and optimization. Topics include number system, solution of single nonlinear equation, approximation and integration, linear systems, various numerical methods, power method, and numerical optimization. Practical applications and programming techniques are both emphasized.

Prerequisite: (i) MATH1000 Supplementary Mathematics (Calculus and Linear Algebra) or
(ii) Grade D or above in AL Pure Math

Prepared by: W. S. Don

Learning Outcomes (LOs):
Upon successful completion of this course, students should be:

No.	Learning Outcomes (LOs)
	Knowledge
1	Able to understand the source and consequences of computational errors
2	Able to solve for roots of single nonlinear equation
3	Able to approximation and interpolate function with polynomial
4	Able to differentiate and integrate function numerically
5	Able to understand the concepts of norms and condition numbers
6	Able to understand the concepts and estimation method of eigenvalues and eigenvectors
7	Able to understand various iterative methods and their convergence rates.
8	Able to develop the concepts of linear systems and its application
9	Able to understand the basic concepts of optimization
	Skill
10	Able to find the solution of nonlinear equation
11	Able to approximate, interpolate, differentiate and integrate function numerically
12	Able to solve a system of linear equations by using both direct and indirect methods
13	Able to solve linear programming problems by using simplex method
14	Able to formulate some real-life problems as linear programming problems
	Attitude
15	Able to appreciate the diversity of the applications of optimization theory on various real life problems

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Assessment:

No.	Assessment Methods	Weighting	Remarks
1	Continuous Assessment (assignments and tests)	30%	Assignments and tests are designed to measure how well the students have learned the basic concepts and fundamental theory of computational mathematics and their applications.
2	Final Examination	70%	Final Examination questions are designed to see how far students have achieved their intended learning outcomes. Questions will primarily be analysis and skills based to assess the student's versatility in computational mathematics.

Learning Outcomes and Weighting:

Content	LO No.	Teaching (in hours)
I. Number Systems and Errors	1,10	2
II. Solution of single nonlinear equation	2,10,11	2
III. Polynomial approximation and interpolation	3,10	2
IV. Numerical differentiation and integration	4,10	3
V. Linear Systems	5,7,12	17
VI. Computation of Eigenvalues and Eigenvectors	6,7,12	6
VII. Numerical Optimization	8,9,13,14,15	8

Textbook:

R.L. Burden and J.D. Faires, Numerical Analysis, 8th edition, Brooks/Cole, 2005.

References:

A. Ralston, A First Course in Numerical Analysis, Dover, 2001.

C. Gerald and P. Wheatley, Appl. Numer. Analysis, Pearson Addison Wesley, 1998.

F. Cucker, P. Ciarlet and J. Lions, Handbook of Numerical Analysis : Special Volume: Foundations of Computational Mathematics, North-Holland, 2003.

C. Van Loan, An Introduction to Computational Science and Mathematics, Jones and Bartlett, 1996.

Software:

MATLAB, High level programming languages (C, C++, FORTRAN 90/95)

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Course Content in Outline:

	Topic	Hours
I.	Introduction • Round-off errors and computer arithmetic • Rate of convergence of sequences and functions • Short reviews of Calculus (Limit/Continuity/Differentiation/Integral + some useful theorems) • Taylor Polynomials and Truncation errors	2
II.	Solution of a Single Nonlinear Equation • Bisection method, Fixed point method and Newton's method • Convergence analysis	2
III.	Polynomial Approximation and Interpolation • Lagrange interpolation and error analysis	2
IV.	Numerical Differentiation and Integration • Finite difference scheme for differentiation • Trapezoidal rule and Simpson's rule for integration	3
V.	Direct Methods for Solving Linear System of Equations • Vector and Matrix • Gaussian Elimination with Pivoting Strategies • Matrix determinant and Inversion	9
VI.	Iterative Methods for Solving Linear System of Equations • Error and residual • Norms and Condition number • Iterative methods	8
VII.	Computation of Eigenvalues and Eigenvectors • Power method • Householder's method • QR algorithm	6
VIII.	Numerical Optimization • Example of optimization problems • Simplex method and Applications	8