Hong Kong Baptist University
Faculty of Science
Department of Mathematics

Title (Units): **SCI 3530 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS** (3,3,0)

Course Aims: This course introduces the major numerical techniques for solving partial differential equations. Emphasis is placed on finite difference methods and finite element methods. Some typical engineering problems, such as shock waves, are analyzed.

Prerequisite: MATH 2220 Partial Differential Equations OR MATH 1511-2 Mathematical Methods for Physical Science I & II

Prepared by: T. Tang, X.N. Wu, W.M. Xue

Learning Outcomes (LOs):

Upon successful completion of this course, students should be:

No.	Learning Outcomes (LOs)
	Knowledge
1	Able to explain the fundamental concepts and principles of the finite difference method
2	Able to develop a concepts of consistency, convergence and stability
3	Able to express a partial differential equation with an equivalent finite element scheme
4	Able to use Matlab, its instructions and its programming language
	Skills
5	Able to apply numerical methods to solve partial differential equations
6	Able to solve hyperbolic equations numerically by finite difference scheme
7	Able to solve convection-diffusion equations numerically using finite difference schemes
8	Able to solve general two-dimensional problems by finite difference approach
9	Able to analyse some typical engineering problems by numerical methods

Assessment:

No.	Assessment Methods	Weighting	Remarks
1	Continuous assessment	20%	Continuous assessment is designed to measure how well the students have learned the numerical techniques for solving partial differential equations.
2	Midterm Examination	20%	Examination questions are designed to see how far students have achieved their intended learning outcomes. Questions will primarily be understanding and skills based to assess the student's versatility in using numerical techniques to solve partial differential equations.
3	Final Examination	60%	

Learning Outcomes and Weighting:

Contents		LO No.	Teaching (in hours)
I	Finite Differences and Parabolic Equations	1,2,4,5,7,9	9
II	Hyperbolic Equations and Characteristics	1,4-6,9	6
III	Elliptic Equations	1,4,5	10
IV	Finite Element Method for Ordinary Differential Equations	2-5,8,9	9
V	Finite Elements for Partial Differential Equations	3-5,9	6

Textbook: G. Evans, J. Blackledge, and P. Yardley, Numerical Methods for Partial Differential Equations, Springer, 2000.

References: Charles A. Hall and Thomas A. Porsching, Numerical Analysis of Partial Differential Equations, Prentice-Hall, 1990.

J.W. Thomas, Numerical Partial Differential Equations, Springer, 1995.

A. Quarteroni, Numerical Approximation of Partial Differential Equations, Springer-Verlag, 1994.

Course Contents in Outline:

	Topics	**Hours**
I.	Finite Differences and Parabolic Equations	9
	A. Finite Difference Approximations to Derivatives	
	B. Parabolic Equations	
	C. Local Truncation Error	
	D. Consistency	
	E. Convergence	
	F. Stability	
	G. The Crank-Nicolson Implicit Method	
	H. Parabolic Equations in Cylindrical and Spherical Polar Coordinates	
II.	Hyperbolic Equations and Characteristics	6
	A. First Order Quasi-linear Equations	
	B. Lax-Wendroff and Wendroff Methods	
	C. Second Order Quasi-linear Hyperbolic Equations	
	D. Rectangular Nets and Finite Difference Methods for Second Order Hyperbolic Equations	
III.	Elliptic Equations	10
	A. Laplace's Equation	
	B. Curved Boundaries	
	C. Solution of Sparse Systems of Linear Equations	
	D. Iterative Solution of Linear Algebraic Equations	
IV.	Finite Element Method for Ordinary Differential Equations	9
	A. Introduction	
	B. The Collocation Method	
	C. The Least Squares Method	
	D. The Galerkin Method	
	E. Symmetric Variational Formulation	
	F. Finite Element Method	
	G. Some Worked Examples	
	H. Determine/Estimate the Order of Convergence	
V.	Finite Elements for Partial Differential Equations	6
	A. Introduction	
	B. Variational Methods	
	C. Some Specific Elements	
	D. Assembly of the Elements	
	E. Worked Example	
	F. A General Variational Principle	
	G. Assembly and Solution	
	H. Solution of the Worked Example	
	I. Further Interpolation Functions	
	J. Quadrature Methods and Storage Consideration	
	K. Boundary Element Method	