Finite Difference Methods for Partial Differential Equations

Math/CS 712–Milewski–Spring 99-00

Tuesday, Thursday 11:00–12:15, Comp Sci. & Stat. 1325

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Office Hours: Tues. 3:30–4:30, Thurs. 2:30 – 3:30, and by appointment.

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Text: Strikwerda, Finite Difference Schemes and Partial Differential Equations, latest edition, Chapman and Hall.

Course Description: This course presents the basic material on finite difference methods for solving partial differential equations. Methods for solving hyperbolic, parabolic and elliptic differential equations will be covered. Emphasis will be given to making judgments on the accuracy, efficiency and implementation of numerical methods. Some topics on partial differential equations will be reviewed as needed. For more information, please contact the instructors.

Prerequisite: Some knowledge of partial differential equations and numerical methods is desirable. Experience with computer programming is essential.

Grades: The course grade is based on 7 homeworks which involve both programming and analytical work. There are no examinations. You may use any platform/software for the homeworks: please hand in your code. MATLAB is a simple yet powerful language, and is recommended. A student edition is available. For extra credit, students may read and report on a recent paper in the field.

Some further information, including an errata for the book is available on Prof. Strikwerda's home page at http://www.cs.wisc.edu/ strik

Approximate Syllabus

Week 1 (January 25,27): Chapter 1

Week 2 (February 1,3): Chapter 1

Week 3 (February 8,10): Chapter 2
Homework 1 due February 10.

Week 4 (February 15,17): Chapter 2 and Chapter 3

Week 5 (February 22,24): Chapter 3
Homework 2 due February 24.

Week 6 (February 29, March 2): Chapter 4 (except 4.3)

Week 7 (March 7,9): Chapter 5
Homework 3 due March 9.

SPRING BREAK (March 11-19)

Week 8 (March 21,23): Chapter 6

Week 9 (March 28,30): Chapter 6 (except 6.5) and Chapter 7
Homework 4 due March 30.

Week 10 (April 4,6): Chapter 7 (7.3 if time permits)

Week 11 (April 11,13): Chapter 12 (selected topics)
Homework 5 due April 13.

Week 12 (April 18,20): Chapter 12 and Chapter 13 (13.5 if time permits)

Week 13 (April 25,27): Chapter 13
Homework 6 due April 27.

Week 14 (May 2,4): Chapter 14

Week 15 (May 9,11): Chapter 14 (except 14.6)
Homework 7 due May 11.

Reference Books for 712

This is a somewhat old list of reference books.

Numerical Methods

Richtmyer & Morton, *Difference Methods for Initial Value Problems*, Second Edition, Interscience, 1967.

This is the standard reference for this subject area. However, it is a bit dated and is more advanced than the level of the course.

LeVeque, *Numerical Methods for Conservation Laws*, Birkhäuser, 1992.

This is an excellent introduction to finite difference schemes for nonlinear hyperbolic equations.

Forsythe & Wasow, *Finite Difference Methods for Partial Differential Equations.*

Although this book is rather old, it does well what it does. It is easy to read.

Mitchell & Griffiths, *The Finite Difference Method in Partial Differential Equations*, 1980.

This book covers the same topics as CS712, but is not as precise in the treatment of stability and convergence. It is a good reference for parabolic and elliptic equations.

Lapidus & Pinder, *Numerical Solution of Partial Differential Equations in Science and Engineering.*

This book is encyclopedic in its treatment of parabolic and elliptic equations. It is not precise in its discussion of consistency, stability, and convergence.

Sod, *Numerical Methods in Fluid Dynamics*, Cambridge, 1985.

This book has many interesting examples and covers many of the topics discussed in CS712. It does not cover elliptic equations.

Partial Differential Equations.

Mizohata, *Partial Differential Equations.*

The approach taken by this p.d.e. book is similar in spirit to that of CS712.

Theoretical Numerical Methods for P.D.E.

Meis & Marcowitz, *Numerical Solution of Partial Differential Equations*, Springer-Verlag, 1981.

This book is very abstract, perhaps too much so.

Parter, (editor), *Numerical Methods for Partial Differential Equations.*

This is a collection of papers. The article by Kreiss is a good discussion of the theory of boundary conditions for hyperbolic p.d.e.s and finite difference schemes.

Engineering Applications.

Anderson, Tannehill, & Pletcher, *Computational Fluid Mechanics and Heat Transfer*, McGraw Hill, 1984.

This is a good text for engineering applications. It does less on the theory than is done in CS712.

Roache, *Computational Fluid Dynamics*, Hermosa Publishers, 1972.

This book discusses very many methods for fluid dynamics. Some of its comments are controversial.