Math 579 - Numerical Differential Equations

January 11, 2012

Lectures

Location: Burnside Hall 1205

Time: Tuesday and Thursday - 10:05 - 11:25

Instructor: Jean-Christophe Nave

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Catalog Description

Numerical solution of initial and boundary value problems in science and engineering: ordinary differential equations; partial differential equations of elliptic, parabolic and hyperbolic type. Topics include Runge Kutta and linear multistep methods, adaptivity, finite elements, finite differences, finite volumes, spectral methods.

Topics Covered

Advanced introduction to applications and theory of numerical methods for solution of partial differential equations, especially of physically-arising partial differential equations, with emphasis on the fundamental ideas underlying various methods. We will Start from fundamental solutions of PDE and move toward numerical methods including finite difference methods, spectral methods. Additional topics arising from the discretization and solution of specific equations will be covered, i.e. stability, consistency, convergence, Preconditioned Conjugate Gradient (PCG), Fast Fourier Transforms (FFT), C and Matlab programming.

Prerequisites

MATH 578, or MATH 375 and MATH 387, or permission of the instructor.

Textbook

There is no required text for this course.

Recommended Reading

- Randall J. LeVeque, Finite Volume Methods for Hyperbolic Problems, Cambridge University Press, 2002
- Randall J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations - Steady State and Time Dependent Problems, SIAM, 2007
- Stanley Osher, Ron Fedkiw, Level Set Methods and Dynamic Implicit Surfaces, Springer, 2002
- Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press, 2007
- Spectral Methods in Fluid Dynamics, Canuto, et al.
- Computational Techniques for Fluid Dynamics (I and II), C.A.J. Fletcher
- Numerical Recipes
- Evans, Partial Differential Equations, GSM 19, AMS
- Quarteroni, Sacco, and Saleri, Numerical mathematics, TAM 37
- Trefethen and Bau III. Numerical linear algebra. SIAM
- Dahlquist and Bjorck. Numerical methods. Dover
- Atkinson and Han. Theoretical numerical analysis. TAM 39. Springer
- Isaacson and Keller. Analysis of numerical methods. Dover

Software and Programming

I expect students enrolled in the class to learn and use Matlab. For projects and homework I will accept also C/C++, FORTRAN,...

Final Projects

I will suggest many final projects' topics. However, I strongly encourage students to come up with their own topic. The project can be related to their own research, but I *WILL NOT* allow recycling or repackaging of previous projects or research. The project has to be original and non-trivial.

Evaluation Scheme

Homework 50% (5 problem sets worth 10% each)

Project 50% (midterm report 10% - oral presentation 10% - written final report 30%)

There will be *no* miterm and *no* final exams.

Final Project Guidelines

The write up should have the format (and professional look) of a journal article (I will provide a latex template - If you do not know latex, download LyX: http://www.lyx.org/). Limit yourself to 20 pages *not* including bibliographical references, appendices, and code. At least the following section should be included:

- Background on the problem chosen, relevance with respect to previous work done, and aim of the present work
- Governing equations
- Discretization / Numerical approach
- Stability / accuracy ...
- Convergence study (grid refinement / time step refinement ...)
- Results
- Conclusion + future work

Final Project Presentation

We will hold an afternoon of presentations in the format of a mini workshop: *"Second McGill Numerical Analysis Workshop"*. The length of each presentation will be 12 minutes, with 3 minutes in between presentations for Q&A and setup. All final papers will tentatively be compiled into a proceeding.

Seminars

I strongly encourage the students enrolled in this course to attend regularly the following seminars:

CRM-ISM Colloquium: http://www.crm.umontreal.ca/Colloques/colloqueMaths.html

CRM-Applied Math. Lab. Seminar: http://www.crm.umontreal.ca/labs/mathappli/en/activites.html