University of Toronto
Department of Mathematics
Mat1062H
Introductory Numerical Methods for PDE
Winter 2015

Instructor: Mary Pugh `mpugh@math.utoronto.ca`

Meeting time and place: The class meets on Mondays 12:10am-1:30pm and Wednesdays 2:30am-3:50pm in BA 2179. The first lecture will be on on Monday January 11 and the last on Wednesday April 6.

Office Hours: By appointment, BA 6268

Course description: We will study numerical methods for solving partial differential equations that arise in physics and engineering applications. Special attention will be paid to how the design of effective numerical methods relates to the mathematical structure of the equation. Most of the course will be for 1-d equations. Lecture notes and sample code will be posted on the course webpage: `http://www.math.utoronto.ca/mpugh/Teaching/Mat1062/mat1062.html`

Prerequisites: You should be familiar with the material that would be taught in a serious undergraduate PDE course. Sample programs will be provided in matlab. If you know matlab, great! If you don't, you're expected to be sufficiently comfortable with computers that you can learn matlab on the fly. Which isn't actually hard at all, unless you fear or hate computers.

Assessment: Midterm exam 40%, term project 20%, HW 40% (about every two weeks, with programming).

Recommended Reading: Two nice books which provide background reading on numerical analysis, including numerical linear algebra, ODEs, finite difference methods, accuracy, and the like are "An introduction to numerical analysis" by Kendall E. Atkinson (grad level) and "Elementary numerical analysis" by Kendall Atkinson and Weimin Han (undergrad level). Five numerical PDE books that are especially useful are "Numerical methods for evolutionary differential equations" by Uri M. Ascher, "Finite difference schemes and partial differential equations" by John C. Strikwerda, "Numerical solution of partial differential equations, with exercises and worked solutions" by Gordon D. Smith, "Numerical analysis of spectral methods: theory and applications" by David Gottlieb and Steven A. Orszag, and "Numerical methods for conservation laws". The books are being put on 24-hour reserve at the CS/Engineering library in Sanford Flemin.

Programming: I will be using matlab in class and will provide matlab code for you to use and modify. You can program in whatever language you want. For your homeworks and exams, you will be asked for graphs and other output; I usually won't want to see your code. Matlab is proprietary. You can buy a student version of it for much less than I have to pay for it; around $120. If you're in the math department, you have access to matlab on the computer "sphere". Log in to coxeter and from there log in to sphere. If you aren't in the math department then you have to hope that matlab's installed on the machine you have access to. There are various free matlab clones that you can install on your computer if you wish. An open-source software that's well worth looking into is SciPy. It's a python-based scientific computing environment. Our physics department has a lovely python wiki which includes lessons on how to use python as well as an easy-to-install python package.

Approximate Outline:

- Parabolic equations
  - Finite Difference Methods
  - Boundary conditions
  - Time-stepping methods (implicit, explicit, multi-step)
  - Consistency, stability, and convergence
- Elliptic equations
  - Variational formulations and finite element methods
- Hyperbolic equations
  - CFL stability
  - Finite Volume Method
  - Nonlinear conservation laws
- Special topics (as time permits)
  - Spectral methods
  - Pseudo-spectral methods
  - Chebyshev polynomials