Math 607E, Section 101, Term 1, Academic Year: 2012-13

Title:
Numerical Methods for Differential Equations

Instructor: A. Peirce: Math 108: ph: 604 822 2104, email: peirce@math.ubc.ca
Prerequisites: Some knowledge of ODE and PDE.
Office Hours: TBA

(A) Objectives of the course:

The primary objective of the course is to introduce the basic numerical techniques for solving ordinary and partial differential equations in a single 3 credit course, which does not require any previous numerical courses as a prerequisite.

The basic numerical methods (e.g. spline interpolation, numerical integration, numerical linear algebra and root finding), usually treated in introductory numerical methods courses, are introduced by applying them to the solution of ordinary and partial differential equations. This approach, in addition to being efficient, helps to contextualize the numerical methods and enables us to focus on applications of the methods to practical problems.

(B) Audience for the course:
The course is intended for graduate students in Science or Engineering who have not yet taken basic numerical methods courses as part of their undergraduate training and who need to learn these skills in order to do their research.

(C) Material to be covered:

0. Introduction to numerical methods: (9 lectures)

Interpolation and splines, numerical differentiation and integration

1. Ordinary Differential Equations:
1.1 Initial value problems (6 lectures)
Euler's method, Linear Multistep, Predictor Corrector, Runge-Kutta methods, Convergence: notions of consistency, stability and convergence, techniques for stiff systems.

1.2 Boundary value problems (10 lectures)
Introduction to a variety of different methods commonly used to solve elliptic PDE: Finite differences, finite elements (interpolation and splines), collocation and spectral methods. Numerical solution of Algebraic equations: LU decomposition, Jacobi, Gauss Seidel, SOR iterative methods, nonlinear Equations - Newton's method and conjugate gradient methods.

2. Partial differential equations:

2.1 Introduction to PDE, classification and characteristics (1 lecture)

2.2 Evolution problems

2.2.1 Parabolic equations (3 lectures)

Spatial discretization by finite differences, explicit methods for time marching and numerical instabilities, implicit methods for time-marching.

2.2.2 Convergence theory: Lax's Theorem: Consistency + Stability => Convergence (1 lecture)

2.2.3 Hyperbolic equations (3 lectures)

Method of characteristics, finite difference and finite element spatial discretizations, upwinding, time marching schemes, Consistency, Fourier analysis of stability and numerical dispersion

2.3 Steady-state equations: elliptic equations (3 lectures)

Finite difference and finite element formulations

(D) Proposed Evaluation:

5 Assignments	40%,	
3 projects	30%,	(for graduate credit)
Tests & Exams	30%	