Code: MA 564

Numerical Methods for Partial Differential Equations

Lecturer: D. Barkley

Terms: 1-2 15 CATS

This two-term course will cover basic methods for solving partial differential equations numerically. Both finite difference and spectral methods will be covered. There will be both lectures covering principles of the methods used and practical laboratory sessions and seminars covering issues such as programming and testing.

Numerous working examples will be given out in the course. Assignments will be required to be in C or C++ programming languages and students not already familiar with one of these languages will be expected to learn one quickly through examples given out in the course. The use of Unix/Linux is strongly encouraged (although not required). Those students using Unix/Linux will have the opportunity to use a library of graphics routines for real-time visualisation.

Syllabus:

1. C/C++ programming. The first three weeks of the course will be devoted to a rapid review of C/C++ programming as well as the Unix operating system, Makefiles, compiled libraries etc.

1. Preliminaries. The fourth week will be devoted to a review of basic materials on PDE's: classification of linear and quasilinear second order PDE's, and solution by separation of variables technique.
2. Note: The first 4 weeks are required only for Financial Mathematics students, but other students on the course may attend if they wish.
3. Finite-Difference Methods.
4. Finite-difference formulas. Explicit Euler method for diffusion equation. Error analysis and importance for testing. Example programs. Stiffness and implicit methods: backwards Euler and Crank-Nicolson. Treatment of general boundary conditions. Nonlinearity: difficulties of nonlinear equations. Explicit methods for treating certain types of nonlinear equations. Example programs. Methods for testing numerical solutions of nonlinear equations. Project I.
5. Spectral Methods.
6. General introduction: advantages and disadvantages, relationship to separation of variables. General weighted residue method. Galerkin, collocation, and pseudospectral methods. Specialisation to case of periodic boundary conditions: Fourier transforms and the FFT. Treatment of nonlinearity in the pseudospectral method. Example programs. Project II.

Books.

K. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge University Press

W. A. Strauss, Partial Differential Equations, an Introduct