Numerical Solutions of Differential Equations, II
MATH 802, Spring 1999

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SUBJECT: Many natural processes in sciences and engineering are described by differential equations. Very few of these equations can be solved exactly. For some equations, fairly complete qualitative theory has been developed; for others, even such a theory does not exist. In many applications, we are not content with the qualitative information but require highly accurate solutions. In this situation, one must depend on numerical methods. Numerical solutions are also very useful in the investigations of the qualitative properties of the solutions of the differential equations.

Numerical solutions of differential equations form a vast field in numerical analysis and scientific computation. In the Math 801 of the fall semester, 1998, we study numerical methods for ordinary differential equations. In Math 802 we will focus on finite difference methods for partial differential equations. **Math 802 is independent of Math 801.** Hence, you do not have to take Math 801 before taking Math 802.

The subjects of the course can be divided into two parts. In the first part of the course, we will cover the beautiful and fairly complete theory of numerical methods for linear differential equations. The fundamental concepts of convergence, consistency and stability of the finite difference schemes and the relationships among them are the central subjects of the theory. Accuracy and efficient implementation are also important topics. In the second part, we discuss numerical methods for nonlinear problems. In this area, there has been no complete theory but important break-throughs have been achieved in the last few decades, especially in numerical solutions of hyperbolic conservation laws. This part of the course will expose the students to some aspects of the current research frontiers. A tentative outline of the course is as follows:

I. Linear problems.
   1.1. Parabolic equations.
   1.2. Hyperbolic equations.
   1.3. Well-posed initial value problems.
   1.5. Stability criteria based on the Fourier method.
   1.6. Initial boundary value problems.

II. Nonlinear problems.
   II.1. Numerical methods for problems with smooth solutions
   II.3. Shock capturing methods.

   II.4. Sharpening of contact discontinuities.

PREREQUISITE: Advanced calculus, linear algebra. Some knowledge of partial differential equations can be very helpful, but is not a requirement, for we will cover the material about PDEs that is necessary for the course. The students need to do some computer programming. Any computer language for large scale scientific computations will do the job well. **M801 is NOT a prerequisite for this course.**