Math 480, Spring 2007

Some Suggested Project Topics

1. Find a system of differential equations (ordinary or partial) that models some physical phenomenon you are interested in. Solve this system using one or more of the methods we discuss in class, or related methods that you find in the literature. Report on the physical phenomenon being modeled, on how you solved the problem numerically, on how accurate your solution is, and on how efficient your algorithm is. In short, say why you chose the method that you chose. Turn in a written report and give a short talk about your work.

2. In class we are discussing just the basics of the finite element method. Entire books have been written on this subject. A classic is one by Strang and Fix entitled *An Analysis of the Finite Element Method*. A more recent book is by Claes Johnson and is called *Numerical Solution of Partial Differential Equations by the Finite Element Method*. There are many other books or chapters of numerical analysis books on finite element methods. Read about the finite element method, especially for PDE's, and apply it to some problem (maybe Poisson's equation) in two dimensions. Explain how the method works, how accurate the approximate solution is and how you know this. Perhaps you could compare it with the finite difference method.

3. A list of the Top Ten Algorithms of the 20th Century was recently compiled by Jack Dongarra and Francis Sullivan in the Jan./Feb. 2000 issue of *Computing Science in Engineering*. Choose one of these algorithms, report on what it is and where it is used, and, if appropriate, implement the algorithm or find an implementation somewhere and use it to solve some problem of interest. Some of these algorithms, such as the FFT, will be briefly discussed in class. Your report should go beyond what is done in class in describing uses and implementations of the algorithm.

4. *The SIAM 100-Dollar, 100-Digit Challenge*. In the Jan./Feb. 2002 issue of *SIAM News*, Nick Trefethen published a list of ten numerical problems, each of whose answers was a real number. He challenged readers to solve the problems to ten correct digits each, using whatever methods they chose. Since then, many of the solutions have been computed to far more than the original ten decimal places requested, and many solvers have posted their solutions on the web. See, for example,

   `http://web.comlab.ox.ac.uk/oucl/work/nick.trefethen/hundred.html`

   In fact, a book has been written about the solutions: *The SIAM 100-Digit Challenge*, by Bornemann, Laurie, Wagon, and Waldvogel.

   Choose one or two of these problems and either attempt to solve them yourself or look at what others have done and report on their solutions. Or you could do both: First devise your own solution method and see how many decimal places of accuracy you can obtain; then look at what others have done to see if they had any better ideas.

5. Report on and implement a multigrid method for solving Poisson's equation or some other partial differential equation. (Possible reference: Briggs, Henson, and McCormick, *A Multigrid Tutorial*)

6. Describe how partial differential equations are used in modeling financial derivatives. Try implementing one of the models for options pricing. (Possible reference: Wilmott, Howison, and Dewynne, *The Mathematics of Financial Derivatives*)

A typical project length is about 10 pages. You may work alone or with one or two partners. You are encouraged to present your work to the class before the due date, in order to get feedback and to make the class interesting!