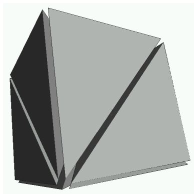
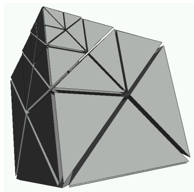
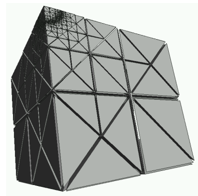
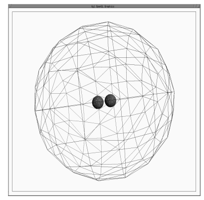
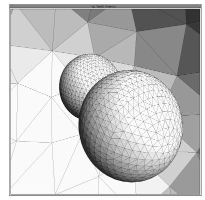
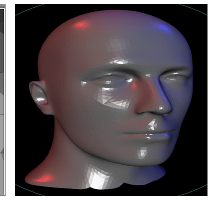
Math 292C (Applied Mathematics), 1998 Spring Quarter

Course Topic: Finite Element Methods for PDEs III

Instructor: Michael Holst, Assistant Professor, UCI Department of Mathematics
Contact: PS 471, (714) 824-3155, mholst@uci.edu
Lecture: PST 100, 4:00pm-4:50pm, MWF (UCI course number 44905)
Lab: PS 390 (CAMLAB), 5:00pm-5:50pm, MWF
Texts: *Computat. Diff. Eqn.* [1], Eriksson, Estep, Hansbo, and Johnson.

Math 292C is the third quarter of a three-quarter course on finite element techniques for the numerical solution of partial differential equations. Following the approach taken in the first two quarters, we will use the lectures and theoretical homeworks to build a solid foundation in numerical analysis, partial differential equations, and finite element approximation theory. Using programming assignments, we will explore data structures, computational geometry algorithms, iterative methods, and other finite element implementation issues.

There are no prerequisites for 292C beyond the ability to understand and construct analysis (epsilon-delta) arguments (e.g., Math 140A-B-C or equivalent background), minimal background in linear algebra (e.g., Math 3A or Math 6C), and some experience with one programming language (e.g., MATLAB or C). The course will be self-contained, and structured so that students interested in either the analysis or the engineering aspects of the finite element method can both do well in the course.

We studied methods for elliptic (Poisson-like) equations the first quarter (292A), and we studied parabolic (heat-like) equations the second quarter (292B), along with iterative methods for algebraic systems. Picking up where the second quarter left off, everyone will be given a working finite element implementation (which we developed the first two quarters for general classes of nonlinear elliptic and parabolic equations). Our programming assignments will involve extending the implementation to include adaptive mesh techniques for elliptic and parabolic problems using *a posteriori* error estimation along with simplex subdivision. We will also extend the implementation to handle scalar nonlinear hyperbolic equations and first-order nonlinear hyperbolic systems, and time permitting, we will consider some techniques for handling nonlinear problems with folds or bifurcations. The lectures will cover the following topics:

- *A posteriori* error estimation for elliptic and parabolic problems
- Non-degenerate simplex subdivision in two and three dimensions
- First-order hyperbolic systems and the structure of solutions
- Petrov-Galerkin finite element methods for hyperbolic equations
- The stream-line diffusion and discontinuous Galerkin methods
- Finite element error analysis in the hyperbolic case
- Numerical methods for nonlinear problems with folds and bifurcations

Although this is the third quarter of a year-long sequence, each quarter is self-contained, and you can join in at any time. Implementation will be stressed as strongly as theory, in both the lectures and in the homework assignments. We will have access to the SGI/LinuxPC CAMLAB (http://camlab.math.uci.edu) for our programming work in the course.

References

[1] K. Eriksson, D. Estep, P. Hansbo, and C. Johnson. *Computational Differential Equations.* Cambridge University Press, Cambridge, MA, 1996.