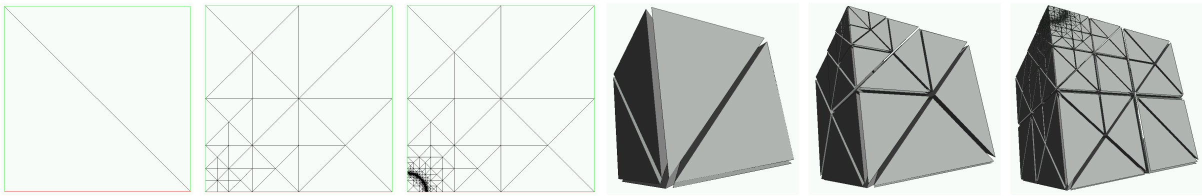
Math 292A (Applied Mathematics), 1997 Fall Quarter

Course Topic: Finite Element Methods for PDEs I



Instructor:	Michael Holst, Assistant Professor, UCI Department of Mathematics
Contact:	PS 471, (714) 824-3155, mholst@uci.edu
Lecture:	PS 184, 4:00pm-4:50pm, MWF (UCI course number 44905)
Lab:	ECT 120 (OAC MAC Lab), 5:00pm-5:50pm, MW
Texts:	*Computat. Diff. Eqn.* [16], Eriksson, Estep, Hansbo, and Johnson.
	Numerical Solution of Partial Differential Equations
	by the Finite Element Method [26], Johnson.

Math 292A is the first quarter of a three-quarter course on computational techniques for the numerical solution of partial differential equations. We will focus primarily on adaptive Petrov-Galerkin finite element methods, a particularly elegant, general, and powerful class of numerical methods. We will follow loosely the advanced undergraduate text listed above throughout the year, supplementing the text with additional graduate-level material. In the class lectures, we will build a solid foundation in numerical analysis, partial differential equations, and finite element approximation theory. In the laboratory (consisting of laboratory lectures and programming time) we will explore, first-hand, ideas such as data structures, computational geometry algorithms, and other finite element implementation issues.

The prerequisites for this course are the ability to understand and construct real analysis (ϵ-δ) arguments (e.g., Math 140A-B-C or equivalent background), background in linear algebra (e.g., Math 3A or Math 6C), and some experience with at least one programming language (e.g., MATLAB or C). A useful, non-enforced, co-requisite is Math 105A-B/107 (basic numerical analysis). The course will be quite self-contained otherwise, and will be structured so that students primarily interested in either the analysis aspects or the software engineering issues of the finite element method can both do well in the course.

We will study and develop methods for elliptic (Poisson-like) equations the first quarter; the class lectures for the first quarter will cover the following topics:

- Introduction to partial differential equations and the finite element method
- Crash course in linear (functional) analysis and some tools from nonlinear analysis
- Approximation theory, polynomials, Fourier and Petrov-Galerkin methods
- Theory of elliptic equations, weak solutions, L^p spaces, and (gasp) Sobolev spaces
- Petrov-Galerkin finite element methods: theory and computer implementation
- Geometry of simplices: mesh generation, simplex subdivision, and mesh conformity
- Adaptivity through simplex subdivision and *a posteriori* error estimation

In the second quarter (292B), we will move on to iterative methods for discretized elliptic equations, methods for nonlinear problems, and extensions to parabolic (heat-like) equations. We study primarily methods for hyperbolic (wave-like) equations the final quarter (292C). If you want to learn how to construct provably accurate and efficient numerical solutions to continuum mechanics problems arising in biology, chemistry, engineering, or physics, using the modern tools of computational mathematics, then this is the class for you!