Math 521: Finite Element Methods
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Course Description:
Over the last few decades, finite element methods have been used for the approximation of solutions to large classes of partial differential equations arising in fluid dynamics, solid mechanics, and electromagnetics. This course is an introduction to the mathematical theory of finite element methods. We will introduce finite element discretizations for equations of various types and discuss how these discrete problems can be solved efficiently. We will address mathematical questions related to the concepts of consistency, stability, convergence, and error estimation. Implementation will be done with freeware finite element packages.

The outline of the course is as follows:

- Basic ideas of consistency, stability and convergence presented in the context of Finite Difference Methods for a simple, model problem.
- ODE boundary value problems:
  - Weak formulation
  - Sobolev spaces
  - Finite Element Method (FEM) specification
  - FEM convergence analysis
  - Quadrature
- FEM for 2D and 3D elliptic problems:
  - Elements
  - Analysis
  - Implementing boundary conditions
- Time-dependent problems
- Numerical Linear Algebra topics
- Final topic choices:

- Finite element methods for incompressible fluid flow
- Discontinuous Galerkin methods
- Error estimation and adaptive methods

Text:
There will be no prescribed text, but there will be lecture notes available for most parts of the course material. Some optional references will be listed.

Prerequisites:
Some undergraduate level training in at least one of: partial differential equations, analysis, or numerical analysis.

Assessment:
There will be several challenging homework assignments involving both analysis and computation. In addition, students can choose whether to do a course project or have an oral final exam. Assignments are worth 60% of the final grade, the project or oral exam 40%.