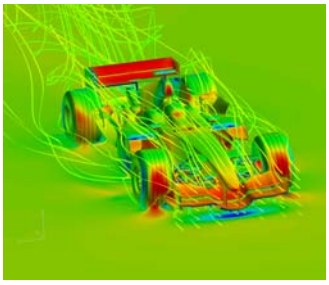
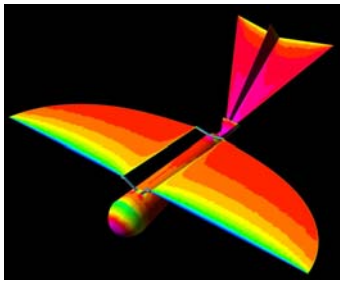
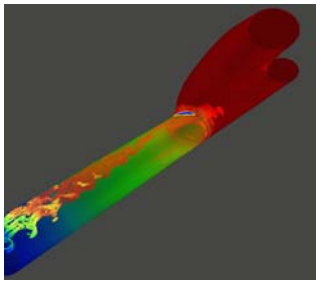
STANFORD ENGINEERING

CME358: The Finite Element Method for Fluid Mechanics

Schedule

Tuesdays and Thursdays 1:15 PM to3:05 PM Units : 4

Course Description

This course presents the basic mathematical theory of the finite element method for incompressible flows. It also covers related computational algorithms and computer implementation details. It is intended primarily for graduate students interested either in developing modern and rigorous skills in the numerical solution of fluid mechanics problems, or in developing further their basic skills in the finite element methodology. Using the Poisson equation as a background problem, the course begins with a fast review of the basic finite element method for simple elliptic problems. Next, it explains why this basic theory is insufficient for problems such as the mixed formulation of elliptic equations, incompressible flows, the advection-diffusion problem, and the Navier-Stokes equations. To address such problems, the course continues with notions of the mathematical analysis of non coercive partial differential equations, the inf-sup (or Babuska-Brezzi) condition and its application to the Stokes and Darcy problems, and a presentation of stable mixed finite element methods and corresponding algebraic solvers. Stabilization approaches are then discussed in the context of the advection-diffusion equation. Finally, the numerical solution of the incompressible Navier-Stokes equations by a suitable finite element method is covered. The course material described above is complemented by a balanced set of theoretical, computational, and Matlab computer programming homeworks.

Course Outline

Review of the finite element method for coercive problems – Insufficiency of the coercive framework for incompressible fluid mechanics and other applications – Finite element theory and inf-sup condition for mixed problems – Stable finite element methods for mixed problems: convergence analysis, Uzawa's algorithm, conditioning, Fortin's lemma – Locking – Stabilized finite element methods – Introduction to projection algorithms for the finite element solution of the Navier-Stokes equations.

Instructor

Professor Charbel Farhat
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Office : Durand Building, Room 257

Prerequisites

- Solid foundations in multi-variable calculus.
- ME335A or equivalent.
- Also, graduate students interested in this course are advised to take ME412/CME356 during the previous quarter or earlier.

Textbook

- No required textbook.
- Lecture notes and reading materials provided by instructor.

Homeworks

- Assigned every two weeks.
- Subject to the Stanford Honor Code.

Exam

- Open notes final exam only.

Grading

- Based 50% on performance for homework assignments.
- Based 50% on performance for final exam.