APMA 990–4
Immersed Boundary Method and Applications
Spring 2013

Instructor.

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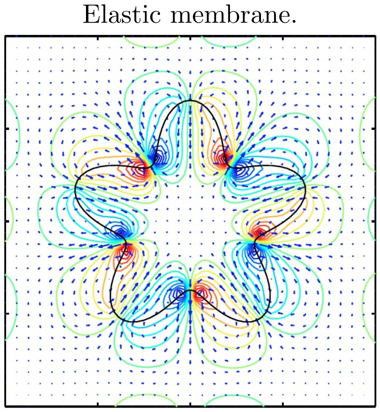
Classes.

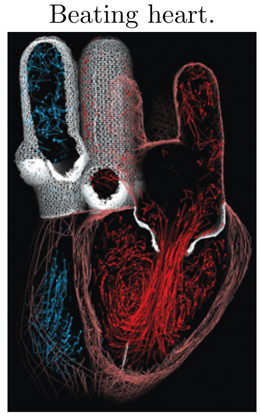
Time:	Wednesday 10:30-12:20
	Friday 10:30-12:20
Location:	TASC2 8500

Description. The immersed boundary method is a very popular numerical approach for solving fluid-structure interaction problems involving an elastic, deformable surface or solid body immersed within a viscous, incompressible fluid. It has been shown to be practical and efficient particularly for problems in biofluid dynamics where the solid body has a complex geometry and possibly also time- or flow-dependent material parameters. The course will place a roughly equal emphasis on: (1) theoretical aspects, including a rigorous derivation of the governing equations and a study of approximate analytical solutions and their underlying properties; and (2) computational aspects, introducing a simple finite difference approximation of the governing equations and applying the method to the study of practical problems from biology and engineering. Some examples of 2D and 3D immersed boundary simulations are shown below.

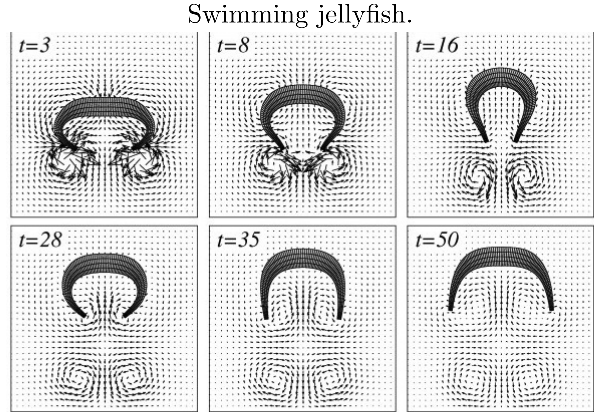
Elastic membrane.



Beating heart.



Swimming jellyfish.



Prerequisites. Some knowledge of partial differential equations and numerical methods are required.

Grading. The grade for this course will be made up of homework assignments (50%) and a project (50%). There will be no final examination.

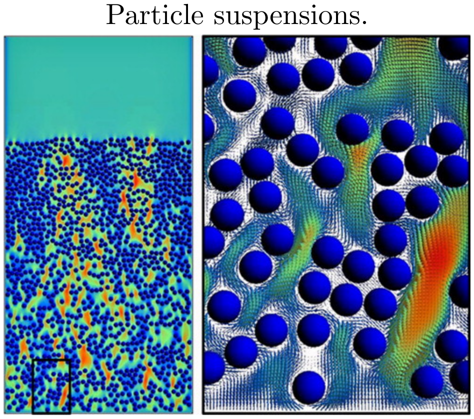
Textbook. There is no textbook for this course. Material will be drawn mostly from journal articles in the open literature. The key reference is

C.S. Peskin, "The immersed boundary method," *Acta Numerica* 11:1–39, 2002.

Outline (tentative).

- Incompressible flow and Navier-Stokes equations (NSEs).
- Immersed boundary model and governing equations; properties of the Dirac delta function.
- 1D analogue; approximate analytical solutions; stability analyses.
- Review of finite difference methods; projection method for solving NSEs; fast Fourier transform; public-domain software.
- Immersed boundary model variations and extensions; practical applications; immersed interface method (and other related methods).

Particle suspensions.



Microbes moving via chemotaxis.