SIO 214A Fall 2021

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Course website: http://pordlabs.ucsd.edu/rsalmon/

Lectures: Tuesday & Thursday 9:30-10:50 4500 Hubbs
There will be NO regularly scheduled discussion session.

Synopsis

An introduction to fluid mechanics assuming that you have already had a bit of it, or experience with something similar (e.g. E&M), and some basic knowledge of partial differential equations.

Apart from Newton's gravity, fluid mechanics is the oldest field theory. The basic equations have been known since about 1750. Progress has been slow because the fluid equations, unlike Maxwell's equations, are nonlinear, and because mathematical tools had to be invented along the way. The development of electronic computation has had enormous impact. Current research in fluid mechanics relies heavily on computers.

The course will cover the following topics:

1. The fluid equations and their derivation, beginning from the abstract idea of a fluid continuum, and (from the opposite point of view) by averaging over molecular motions. Stability in the state of rest

2. Sound waves, and the incompressible limit.

3. Inviscid, irrotational, incompressible flow in two and three dimensions. D'Alembert's paradox and the need for viscosity and vorticity.

3. Vorticity as the central feature of fluid mechanics. The vorticity theorems. Vortex dynamics.

4. The molecular origin of viscosity. Navier-Stokes viscosity. Macroscopic averaging, Reynolds fluxes, and eddy viscosity.

5. Turbulence in 2 and 3 dimensions. Kolmogorov theory and critique. Implications for computational fluid dynamics.

6. Surface waves in Eulerian and Lagrangian coordinates. Advantages of Lagrangian coordinates.

7. Vorticity creation by breaking waves. Gerstner waves. Generalizations.

Textbooks

There is no official text. Three of the classics are:

1. Lamb. *Hydrodynamics.* 1932, Dover re-publication 1945.
2. Batchelor. *An Introduction to Fluid Dynamics.* Cambridge, 1967.
3. Landau & Lifschitz. *Fluid Mechanics.* Pergamon, 1959.

Of these 3, I much prefer Landau & Lifschitz.

A gentler introduction is offered by:

4. Kundu, Cohen & Dowling. *Fluid Mechanics.*, free online at: http://www.sciencedirect.com/science/book/9780123821003

Many of the topics covered in this course can be found in my own book:

5. Salmon. *Lectures in Geophysical Fluid Dynamics* [LGFD]. Oxford, 1998. The relevant chapters are 1 and 4. I will put these two chapters up at my website. LGFD has a sequel in preparation, *More Lectures in Geophysical Fluid Dynamics* [MLGFD], also available at the website. I hope to cover the first chapter of MLGFD near the end of our course.

The lectures will reference the appropriate pages in Kundu or in LGFD.

For a concise history of fluid dynamics, see:

6. Darrigol, *Worlds of Flow*, Oxford, 2005. Worth reading if only to realize that the stuff we expect you to understand immediately actually took some brilliant people many years to figure out.