PHYD37: Fall 2017
Introduction to Fluid Mechanics

Tuesday 10-11:30 am IC 328, Thursday 10-11:30am AC332
(on some occasions we'll be meeting until noon)

Description
This course is an introduction to the analysis of motion of fluids such as water, air, magma, as well as an introduction to transport phenomena such as heat and mass transfer. We will cover the topics of mass, momentum and energy conservation. We will derive and discuss several important dimensionless numbers that can help us understand the type of flow and study in more detail two types of regimes: inviscid and highly-viscous flow. We will also cover the theory of waves and instabilities.

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Office hours Tuesdays 12-1pm and by appointment

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Prerequisites: It is expected that the student is familiar with vector calculus and basic solutions to ordinary and partial differential equations. Some knowledge of thermal physics may be helpful.

Problem sets: There will be homework assigned on a regular basis. The only ground rule is that you may not consult solutions on the Internet and that the work you turn in must be your own. You are encouraged to discuss ideas with other students. If you have worked with another student, make sure you write her/his name as collaborator on the first page of the work you hand in.

Showing your work: On your problem sets, make sure you show all the work that went into solving each question. This will allow the grader to follow your method, to know if you understand the material and where you are having difficulties. Don't be afraid to explain what you are doing. Your solution should look like an explanation to someone about how you solve the problem. t is not the grader's job to decipher your work, so make sure your work is neat, legible, complete and organized. A concluding statement is generally a good idea.

Final project: At the end of the term there will be one final project where you will give a 15-20 minute presentation on a fluid mechanics research article of your choice and write a 5 single space page report (on LaTeX). Please make sure to run it by your instructor a few weeks before hand to make sure the level and emphasis of the article is adequate. The two most widely read journals describing current research in fluid dynamics are the *Journal of Fluid Mechanics* and *Physics of Fluids,* with *Annual Review of Fluid Mechanics* a great source for students to get an overview picture.

Grading:
Problem sets ….. 30%
Midterm ………. 20%
Final project ….. 15%
Final Exam ……. 35%

Books:
There is no required textbook. I will provide you with notes through out the term, and coming to class and taking notes will be very important to ensure your success.
Here is a list of recommended books:
Fluid Mechanics by Pijush K. Kundu and Ira M. Cohen (recommended)
Fluid Mechanics by Frank White
An Introduction to Fluid Dynamics by G.K Batchelor

Online resources:
In the 60's MIT produced a series of educational fluid mechanics videos that are still highly regarded today for their quality and instructional value:
http://web.mit.edu/hml/ncfmf.html
You will be required to watch some of them and discuss them in class.

Syllabus: (tentative schedule, we'll try to cover all topics listed time permitting)

1. Introduction: Examples, Dimensional Analysis, Bucking-Pi Theorem, Tensor Notation
2. Heat and mass transfer
3. Derivation of governing equations, mass conservation, material derivative
4. Derivation of momentum and energy equations, constitutive equations
5. Exact solutions to Navier-Stokes equations
6. High Reynolds number flows
7. Low Reynolds number flows (boundary layers)
8. Numerical solutions to N-S equations
9. Waves and instabilities
10. Rayleigh-Bernard Convection

Important Dates:
October 7-13 – Reading Week
October 19 - Midterm
Nov 28 -30 – Week to hand in your final report and presentations
December 4 – Last day of classes
December 7-20 – Final Exam schedule

Learning Outcomes:

By the end of this course the student shall be able to:

- Be able to non-dimensionalise physical problems and extract the relevant parameters
- Understand and implement tensor notation with ease
- See the connection between the microscopic and macroscopic treatment of transport properties and fluid dynamics
- Be able to derive conservation equations starting from written statements
- Be able to solve the conservation law equations for mass and energy transfer with no motion, including the three different types of boundary conditions
- Understand the conservation quantities in mass and energy transfer in 1D, 2D, and 3D
- Follow the derivation of the equations governing fluid motions: mass, momentum and energy conservation equations
- Understand how F=ma is applied to a fluid and be able to identify each of the terms in the fluid equations
- Understand the differences between the Eulerian and Lagrangian treatments
- Understand the meaning of the Reynolds number and other dimensionless numbers (e.g. Rayleigh number)
- Point to the differences of the high and low Reynolds number flows and the derivations of the simplified equations
- Be able to analytically solve equations pertaining to both regimes, including identifying the boundary conditions
- Understand qualitatively the emergence of turbulence, and the difference with laminar flows