Mech 380: Fluid Dynamics
2010-2011

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Lectures: MWF 13:00, McLeod, Room 202

Office hours: M 14:00-16:00

TAs:
1. Nader Noroozi, ICICS X227, noroozi@interchange.ubc.ca

Office hours: Thursdays, 10-12

2. Kristy Wiens, ICICS X227, kwiens@gmail.com

Office hours: Tuesdays, 12.30-14.30

Tutorial: McMillan 166 - F 14:00

Purpose of the course

Mech 222/280 focused on basic analysis techniques and solving internal, incompressible flow problems. Mech 380 applies those same analysis techniques to solve problems in external flow (for example, planes, trains, and automobiles) and compressible flow (for example, planes, explosions, jet and rocket engines, and gas pipelines).
The overall goal of the course is for each student to develop the ability and the confidence to solve relatively challenging problems in fluid mechanics. Reaching this goal will require you to understand the underlying physical principles of fluid mechanics and to be able to manipulate the basic equations that mathematically describe these principles. These skills are necessary, but not sufficient, for good problem solving ability. In addition, you will need to learn how to work your way from a description of a complex flow problem to determining the applicable physical principles to grinding numbers to come up with an answer. To address this issue, we will spend a significant amount of time and effort during the term specifically on problem solving techniques and exercises.

Prerequisites: Differential equations, thermodynamics, and introductory fluid mechanics.
If there's any doubt about your eligibility, please contact me.

Textbook: *Fluid Mechanics: Fundamentals and Applications,* by Yunus Çengel and John Cimbala. (For topic 4 (Compressible flow) - "Fluid Mechanics" by Frank White – the chapter will be posted on Vista)

Learning activities: It is expected that you will come to class prepared and ready to learn, which requires you to *read* and to *study* the assigned reading before you come to class. Being prepared for class enables you to construct a knowledge base on which subsequent learning rests.

What does it mean to be prepared for class?

• Complete assigned readings. This does *not* mean simply passing your eyes over the page, but actively trying to understand the material in the readings. When there are things in the reading that you don't understand, you should try to formulate, as explicitly as possible, questions that will move you towards full understanding. Take the reading quizzes (on Vista). For all correct answers a bonus will be considered for the corresponding quiz.

• Complete problem sets. The course includes weekly problem sets. The problems in these assignments are of two types: quantitative questions that require simple calculations for situations where it is reasonably clear which concepts are applicable, and conceptual questions that will require you to apply basic concepts qualitatively. The overall goal in forcing you to actively prepare for class is to shift the learning of the simplest material outside the classroom so that class time can be spent on higher-level learning. In comparison, traditional lectures with students who haven't prepared well for class succeed mostly in getting across the simple material in class, leaving students to digest the complex stuff on their own.

Marking scheme: In addition to the reading quizzes and problem sets, the course will also include quizzes, a midterm, and a final. The quizzes will include both quantitative and conceptual questions, which will be more complex than the problem sets. The midterm and final will have problems that aim at assessing your ability to apply what you have learned about fluid mechanics to solve problems (the tutorial problems, the applications from lectures and the quizzes will give you practice with this sort of problem).

Activity	Approximate number	Weight (passed exams)	Weight
Survey	1	1 %	1 %
Problem Sets	9	9 %	-
Quizzes	4	18 %	-
Midterm	1	24 %	33 %
Final		48 %	67 %

You must pass the midterm and the final for other parts of the course assessment to count towards your course mark. Also, in each of the two categories (problem sets and quizzes), your mark will be based on the best $N-1$ out of N (that is, the lowest mark will be dropped). *Note well, however, that the last quiz, on compressible flow, will count double compared with the other, so at most only half of its mark will be dropped.*

Course Outline

1. Differential methods in fluid dynamics

   (a) Relating the math in the Navier-Stokes equations to flow physics

   (b) Simple laminar flows

2. Boundary Layers (BL)

   (a) Why BL's are thin (Rayleigh's problem)

   (b) Physical reasoning and scaling for BL's

   (c) Solving the Navier-Stokes equations for the case of a boundary layer

   (d) Laminar BL velocity profile, thickness, and skin friction

   (e) Turbulent BL velocity profile, thickness, and skin friction

3. Realistic external flows and separation

   (a) Why do streamlines look the way they do?

   (b) Inviscid flow and lift

   (c) What is flow separation, and why does it occur?

   (e) Predicting separation

   (f) Drag of non-streamlined objects

4. Compressible flow

   (a) Sound speed, Mach number, and isentropic variations of thermodynamic properties

   (b) Isentropic nozzle flow

(c) Nozzle flow with normal shock waves

5. Review of Mech 380

Learning Objectives

After completing Mech 380, you will be able to:

• Correctly simplify the Navier-Stokes equations on the basis of assumptions about flow physics.

• Solve simple laminar flow problems analytically.

• Understand mechanisms for growth of laminar and turbulent boundary layers, and be able to relate boundary layer properties to drag

• Have some intuitive understanding of how the pressure and velocity fields around an object depend on its shape for inviscid flow.

• Understand why boundary layer separation occurs, and the effect separation has on drag for non-streamlined bodies.

• Have an intuitive understanding of the differences between incompressible and compressible flow physics, and be able to apply this to solve problems in compressible flow.