Syllabus

Course Administration

Lecturer	**Graduate Assistant**
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Office hours: MW 3:30 PM – 5:00 PM
Lectures: MW 2:00 – 3:15 PM
Bechtel 537

Welcome to MECH 760!

The term "advanced" refers to the approach rather than the level of the material dicussed. The objective of this course is to equip the student with an instrumental modeling approach that enables a quick and efficient solution of various real fluid mechanics problems starting from the underlying principles. Fundemantal understanding and mastery of the first principles is therefore key to the development and acquisition of the intended problem solving mindset. The approach is realized through a series of lectures that focus on the fundamental laws in conjunction with modeling and approximation methods applied to a variety of problems. It has been proven by experience that practice and intensive problem solving is the most fruitful route to achieving the desired objectives. The student is encouraged to tackle as many problems as possible from the textbook as well the accompanying (problems) textbook. The two books were selected primarily for their unique collection of problems.

The governing equations of fluid mechanics will consistently be presented both in differential and integral forms starting from the continuum hypothesis. Physics-based approaches for the derivation of these equations is given priority to mathematical techniques. The underlying assumptions and the corresponding range of applicability are given special attention.

Educational objectives

At the completion of this course the student should

1. have a solid background in the fundamentals and basic principles of fluid mechanics and an understanding of the various flow regimes.

2. have gained familiarity with the governing conservation equations in differential and integral forms along with the underlying assumptions. The student should also have acquired the physical meaning and relevance of each term.

3. have developed a problem-solving methodology through identification of the dominant physical mechanism(s) in a fluid problem, formulation of the problem, and subsequent solution and analysis.

4. be well prepared for further studies/research in fluid mechanics or related area.

Prerequisites

Introductory Fluid Mechanics
Thermodynamics
Vector Calculus

Textbook

- The suggested text is *Introduction to Fluid Mechanics* by James A. Fay (MIT Press, 1994). Required readings in Fay's book are specified in the outlines for each section. Additional recommended readings from Batchelor's and Tritton's are also specified. Fay's book is at the advanced undergraduate level, but covers most of the topics dealt with in the lectures. The lectures will cover some material with greater rigor or different emphasis; special notes are provided for selected topics, as indicated in the outlines. Students are responsible for material covered in class or indicated in the course outlines.

- A second book, *Advanced Fluid Mechanics Problems* by Ascher H. Shapiro and Ain A. Sonin, is required for all students.

Electronic Mail and Moodle

We expect to use email for course announcements. Please let us know if you do not have a reliable email address. The mailing list will be maintained through Moodle. To add or remove yourself from the mailing list, please send an email to the GA. If you give us your email address on the first day of class we'll add it to the list for you.

Course handouts, Problem Set solutions, Exams solutions and additional material will be available in "pdf" formats form Moodle in a timely fashion.

Problem sets, projects, exams and grading

The final grade in the course will be based upon analytical homework assignments, 2 quizzes, a final exam, and class performance weighted as follows:

- 15 % Homework assignments: Problem Sets will be assigned at two weeks intervals and collected at the end of the lecture on the due date. Note that some of the problems assigned will be complementary to the material presented in class. The final problem set will not be collected.
- 20 % Quiz 1: will be given in class (1 cheat sheet).
- 25 % Quiz 2: will be given in class (2 cheat sheets).
- 35 % Final exam: will be open book (3 cheat sheets).
- 5 % Class performance: The performance will be evaluated according to the individual's contribution to the discussion.

Office Hours

Your are encouraged (and even expected) to come by and see me during office hours to ask any questions you have. Please be advised that I will not be able to answer or discuss course related questions outside the office hours.

Collaboration and honesty rules

- No collaboration or cheating is allowed in the exams.
- You can collaborate on problem sets as long as (1) you acknowledge your collaborator(s) on each problem, (2) you spend independently enough time on each problem, and (3) you write the solution in your

language in a manner that reflects your understanding and problem solving approach. Collaboration is encouraged in the sense of discussing topics and problems among your fellow students as well as approaches to solving these problems.

- Collaboration in the project is restricted to your teammates.

Approach

The course will be presented as a series of lectures accompanied by visual aids (images and movies). Reading material is assigned when necessary. Example problems will be solved in class. Separate problem solving sessions will be held when necessary. The Problem Sets are an essential part of the course and the students is therefore strongly required to spend enough time in solving the problems. In addition to the Problem Sets, additional problems from the textbooks will be recommended.

From experience, students who do not spend enough time on the Problem Sets end up not doing well in the class.

Course outline

1. Continuum Viewpoint and the Equation of Motion (1 week)

2. Static Fluids (1 week)

3. Mass Conservation (1 week)

4. Inviscid Flow - Differential Approach: Euler's Equation, Bernoulli's Integral and the Effects of Streamline Curvature, the General Form of Bernoulli's Integral (1 week)

5. Control Volume Theorems (Integral Approach): Linear Momentum Theorem, Angular Momentum Theorem, and First and Second Laws of Thermodynamics (1 week)

6. Navier-Stokes Equation and Viscous Flow (1 week)

7. Similarity and Dimensional Analysis (1 week)

8. Boundary Layers, Separation and the Effect on Drag and Lift (1 week)

9. Vorticity and Circulation (1 week)

10. Potential Flows: Lift, Drag, and Thrust Production (1 week)
11. Surface Tension and its Effect on Flows (1 week)
12. Introduction to Turbulence (1 week)

References

The first two referrences are major references from which there will be assigned readings.

1. Tritton, D. J. 1988. Physical Fluid Dynamics, 2nd ed., Oxford University Press.
2. Batchelor, G. K. 1973. An Introduction to Fluid Mechanics, Cambridge.
3. Currie, I. G. 1993. Fundamental Mechanics of Fluids, 2nd ed., McGraw-Hill.
4. Lamb, H. 1932. Hydrodynamics, Dover.
5. Milne-Thomson, L. M. 1968. Theoretical Hydrodynamics, Dover.
6. Prandtl, L. and Tietjens, O. G. 1934. Fundamentals of Hydro- and Aeromechanics, Dover.
7. Prandtl, L. and Tietjens, O. G. 1934. Applied Hydro- and Aeromechanics, Dover.
8. Schlichting, H. 1979. Boundary Layer Theory, 7th ed., McGraw-Hill.
9. Sherman, F. S. 1990. Viscous Flow, McGraw-Hill.
10. White, F. M. 1991. Viscous Fluid Flow, McGraw-Hill.
11. Probstein, R. F. 1989. Physicochemical Hydrodynamics: An Introduction, Butterworth-Heinemann.

Weblinks

- CFD Online:

  `http://www.cfd-online.com`

- Fluids Lab at the University of Iowa:

  `http://css.engineering.uiowa.edu/fluidslab/`

- MIT 2.25:

  `http://ocw.mit.edu/OcwWeb/Mechanical-Engineering/2-25Advanced-Fluid-MechanicsFall2002/CourseHome/index.htm`

- Educational tools at efluids:

  `http://www.efluids.com/efluids/pages/edu_tools.htm`

- Fluids dynamics at wikipedia:

  `http://en.wikipedia.org/wiki/Fluid_dynamics`

- Maarten Rutgers' web site:

  `http://home.earthlink.net/~marutgers/`