MCEN 5021 Introduction to Fluid Dynamics

Fall 2015

Tu, Th 08:00-09:15 p.m. KOBL 375

Dr. Thomas S. Lund

Office:	ECME 107 (after Sept. 15)
	Engineering Center Lobby (prior to Sept. 15)
Hours:	9:30-11:00 a.m. Tu, Th
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Course Web Site: www.cora.nwra.com/∼lund/mcen5021

Text: *Fundamental Mechanics of Fluids, 4th Edition* by I.G. Currrie

Prerequisites:

A strong background in mathematics is required. You should be proficient in the areas of Linear Algebra, Differential Calculus, Integral Calculus, Multivariable Calculus, Ordinary Differential Equations, and Partial Differential Equations.

An undergraduate level fluid dynamics (or related topic) course would be helpful, but is not required.

Purpose of the course

To provide an in-depth understanding of the fundamental aspects of fluid dynamics. Emphasis will be placed both on a physical understanding and on a mathematical description of fluid process.

Course Outline

1. Conservation laws

   Description of fluid motion, conservation of mass, momentum, and energy, description of viscous forces.

2. Flow Kinematics

   Streamlines, pathlines, and streaklines, circulation and vorticity

3. Special forms of the conservation laws

   Kelvin's theorem, the Bernoulli equation, Crocco's equation, the vorticity equation.

4. Inviscid and incompressible flow (ideal fluid flow)

   Potential flow framework, the superposition principle, elementary flow solutions, flow over a circular cylinder with and without circulation, conformal transformations lift and moment on bodies including airfoils.

5. Incompressible viscous flow

   Simplified equations, exact solutions involving flows in pipes and channels, and on semi-infinite domains bounded by a solid wall.

6. Viscously-dominated flow (creeping flow)

   Creeping flow framework, analogy with ideal fluid flow, creeping flow over a sphere and cylinder.

7. Boundary layers

   The boundary layer equations, exact solution for zero pressure gradient, more general approximate solutions, flow separation, boundary layer stability.

8. Flows involving buoyancy

   The Boussinesq approximation, thermal convection, stability and instability in the atmosphere.

9. Introduction to turbulence

   Characterization of turbulence, the Reynolds averaged equations, the turbulent closure problem, turbulence modeling.

Course Mechanics

Homework:	Approximately 10 homework assignments will be given. Homework exercises will involve mainly mathematical analysis, with occasional very light computational tasks such as generating data from functions and drawing plots.
Exams:	Midterm exam 1: Tuesday, September 29, 08:00-0:915 Midterm exam 2: Tuesday, November 3, 08:00-0:915 Final exam: Monday, December 14, 7:30-10:00 p.m.

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Grades:

Homework	25%
Midterm Exam 1	20%
Midterm Exam 2	20%
Final Exam	35%
	100%

note on homework

You are encouraged to form study groups in order to collaborate on the homework problems. If you do this, please make sure you understand the solution process and write it up in your own words. Blatant copying of homework solutions will result in scores of zero for all parties involved.

Extra credit

You can receive extra credit by attending the Boulder Fluids Seminar, which typically meets every other Tuesday between 3:30-4:30 in Bechtel Collaboratory in the Discovery Learning Center (DLC). Your overall score in the course will be increased by one half a percentage point for every seminar that you attend. For example, if you attend 4 seminars and your final cumulative score in the course at the end of the semester is 88%, your overall score will be raised to 90%. You will need to sign in before the seminar begins and you may be required to complete a short quiz on the seminar material. See www.boulderfluidsseminar.org for a seminar schedule and for more information regarding the seminar.