ME EN 3700: FLUID MECHANICS

(Fall 2003)

Lecturer: Eric R. Pardyjak

Lecture: MTWThF 7:30am - 8:20am Room 104 EMCB

Office Hours: (9:00am - 10:30am M W F, Room 169 KEN

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Text: *Introduction to Fluid Mechanics* by R. W. Fox, A. T. McDonald and P.J. Pritchard, sixth Edition, John Wiley and Sons, Inc. 2004.

Scope of the Course: The lecture material will cover part or most of the material in chapters 1 through 9. In addition, chapters 11 and 12 will be used to introduce compressible flow. Lastly, a series of lectures on turbulence will be given later in the course. In addition some supplemental material may be handed out. The reading assignments (see schedule below) are arranged such that they are made prior to when the material in the lecture will be covered. It is a good idea to read the assigned sections before coming to lecture. Weekly homework assignments will be made and collected. Late homework will generally not be accepted. Homework solutions will be provided. Test material will include all assigned homework, as well as text examples and material covered in the lecture. A concurrent lab accounts for 25% of the grade. There are six labs. The relevant theory will be covered in lecture prior to the associated lab experiment. Lab reports consist of a technical memo format that is described in the laboratory notebook. A computer-based assignment will count as one lab.

Grading and Exams: The total course grade is derived from two contributions: 75% lecture grade, and 25% laboratory grade. <u>It is important to note, however, that it is the policy of the instructor that one must pass the lab in order to pass the course</u>. The grading scheme is summarized below.

Homework: 10%
Laboratory: 25%
Exam I: 20%
Exam II: 20%
Comprehensive Final: 25% (or if better than one of exams I or II, 45%)

In the case of the Final, grading will be assessed under each scheme and the student will receive the better grade. In general, no make-up tests will be given. If special circumstances exist, however, the student is expected to communicate these as soon as possible. The instructor reserves the right to modify the above grading scheme, as well as allow other factors (such as test score trends and class participation) to enter into the assessment of overall performance. (Note that in the past these modifications have always worked to benefit the students.) The syllabus for the course is given below.

SYLLABUS

Lecture	Date		Topic	Text Sections
1	8/20	W	Introduction, Math Review	------------
2	8/21	Th	Fundamental Concepts	Ch 1
3	8/22	Fri	Streamline, Streakline, Pathline	Ch 2.1, 2.2
4	8/25	M	Fluid Stresses	Ch 2.3, 2.4
5	8/26	T	Fluid Flow Classification	Ch 2.5
6	8/27	W	Pressure and Manometry	Ch 3.1 - 3.3
7	8/28	Th	Plane Submerged Surfaces	Ch 3.5.1
8	8/29	Fr	Curved Submerged Surfaces	Ch 3.5.2
9	9/2	T	Lab Lecture 1	
10	9/3	W	Rigid Body Motion	Ch 3.7
11	9/4	Th	Bernoulli Equation	Ch 6.3
12	9/5	F	Bernoulli Equation	Ch 6.3, 6.4
13	9/8	M	Intro to Integral Methods	Ch 4.1
14	9/9	T	Reynolds Transport Theorem	Ch 4.2
15	9/10	W	Integral Conservation of Mass	Ch 4.3
16	9/11	Th	Integral Momentum	Ch 4.4
17	9/12	Fr	Integral Momentum	Ch 4.4
18	9/15	M	Lab Lecture 2	
19	9/16	T	Integral Momentum	Ch 4.4
20	9/17	W	Integral Momentum	Ch 4.4
21	9/18	Th	Integral Energy	Ch 4.8
22	9/19	F	Integral Energy	Ch 4.8
23	9/22	M	Integral Energy	Ch 4.8
24	9/23	T	Differential Mass	Ch 5.1
25	9/24	W	Differential Mass	Ch 5.1
26	9/25	Th	Velocity Gradients	Ch 5.3
27	9/26	F	Differential Force Balance	Ch 5.4
28	9/29	M	Navier-Stokes Equation	Ch 5.4
29	9/30	T	Review Lect/Problem Session	
30	10/1	W	Exam I Material through lecture 23	
31	10/6	M	Lab Lecture 3	
32	10/7	T	Navier-Stokes Equation	Ch 5.4
33	10/8	W	Exact N.-S. Solutions	Ch 8.1, 8.2
34	10/9	Th	Laminar Pipe Flow	Ch 8.3
35	10/10	F	Dimensional Analysis	Ch 7.1 - 7.3

36	10/13	M	Dimensional Analysis	Ch 7.1 - 7.3
37	10/14	T	Similitude	Ch 7.4
38	10/15	W	Similitude	Ch 7.5, 7.6
39	10/16	Th	Turbulent Pipe Flow	Ch 8.4, 8.5
40	10/17	F	Turbulent Pipe Flow	Ch 8.6, 8.7
41	10/20	M	Lab Lecture 4	
42	10/21	T	Major/Minor Losses	Ch 8.7
43	10/22	W	Intro to Boundary Layers	Ch 9.1
44	10/23	Th	Vorticity and Boundary Layers	
45	10/24	F	Boundary Layer Equations	
46	10/27	M	Momentum Integral Equation	Ch 9.2, 9.4
47	10/38	T	Momentum Integral Equation	Ch 9.5
48	10/29	W	Blasius Solution	Ch 9.3
49	10/30	Th	Blasius Solution	Ch 9.3
50	10/31	F	Pressure Gradients and Separation	Ch 9.6
51	11/3	M	Lab Lecture 5	
52	11/4	T	Forces on Immersed Bodies	
53	11/5	W	Skin Friction Drag	Ch 9.7.1
54	11/6	Th	Pressure Drag	Ch 9.7.2
55	11/7	F	Flow Around a Cylinder	Ch 9.7.3
56	11/10	M	Drag Reduction	Ch 9.7.4
57	11/11	T	Drag Problems	
58	11/12	W	Circulation and Lift	Ch 9.8
59	11/13	Th	Airfoils	Ch 9.8
60	11/14	F	Airfoil problems	
61	11/17	M	Lab lecture 6	
62	11/18	T	Intro to compressible/Mach Number	Ch.11.1,11.2
63	11/19	W	T-s Diagrams/Shock waves	Ch.11.3
64	11/20	Th	Uniform flow in a conduit	Ch.12.1-3
65	11/21	F	Oblique Shock waves	
66	11/24	M	Nozzle flow	
67	11/25	T	Review Lect/Problem Session	
68	11/26	W	Exam II	Material through lecture 50
69	12/1	M	Properties of Turbulence	
70	12/2	T	Properties of Turbulence	
71	12/3	W	Reynolds Decomposition	
72	12/4	Th	Problem Session	
73	12/5	F	Final Exam Review	

Final Exam Monday, December 8, 8:00am - 10:00am in 104 EMCB

CD-ROM MATERIALS:

The CD-ROM, *Multi-Media Fluid Mechanics*, is provided as part of this course. The intent of the CD is to supplement and reinforce the text, lab and lecture material. In particular, many of the physical concepts discussed in the lectures (and their connections to the mathematics used to described them) are illustrated through visualizations and/or animations. The CD is divided into five main sections (KINEMATICS, DYNAMICS, BOUNDARY LAYERS, VIDEO LIBRARY and HISTORY). Within these main sections are sub-menus. Below is a listing of topics on the CD, scheduled such that they are relevant to the text, lab and lecture information. As you will quickly realize, there is much more material on the CD than referenced below. In particular, there is a *Gallery of Flows* section that shows a number of examples of the beautifully complex flows that pervade the everyday world around us. Hopefully, as you learn about the material in this class you will begin to better recognize and have a deeper appreciation for these phenomena. Like any educational material, however, if you do not use it, it will not do you any good. Please take some time to explore the CD. I am pretty certain you will find it interesting and informative.

Weeks 1-3

KINEMATICS:

- Kinematics of Point and Fluid Particles
- Fields, Particles and Reference Frames
- Material Derivative
- Flow Lines and Flow Visualization
- Pathlines
- Streaklines
- Timelines
- Streamlines

BOUNDARY LAYERS:

- Separation:
  - Effect of vortex shedding on structures

HISTORY:

- Leonardo da Vinci
- Joseph-Louis Lagrange
- Leonhard Euler

Week 6

KINEMATICS:

- Compressibility

DYNAMICS:

- Newton's Second Law of Motion

HISTORY:

- Sir Isaac Newton

Week 7

DYNAMICS:

- Navier-Stokes Equations
- Boundary Conditions

HISTORY:

- Claude Louis Marie Henri Navier
- Sir George Gabriel Stokes

Weeks 8 & 9

DYNAMICS:

- Reynolds Number: Inertia and Viscosity
- Low Reynolds Number Flow
- Dependence of Forces on Reynolds Number and Geometry

HISTORY:

- Osborne Reynolds
- Jean-Louis Marie Poiseuille
- M. Maurice Couette

Weeks 10 & 11

BOUNDARY LAYERS:

- Boundary Layer Concepts
- Impulsively Started Flow
- Laminar Boundary Layers

HISTORY:

- Jean LeRond D'Alembert
- John Willam Strutt, Third Baron Rayleigh
- Ludwig Prandtl
- Theordore Von Karman

Week 12

BOUNDARY LAYERS:

- Separation

Week 14

BOUNDARY LAYERS:

- Instability, Transition and Turbulence

HISTORY:

- Sir Geoffrey Ingram Taylor