PHYS 940.01 (EOS 940)

Physics of Fluids

Spring Semester 2006

Time:	12:10-13:00 Monday, Wednesday, Friday
Location:	DeMeritt, Room 304.
Instructor:	Profs Charles J. Farrugia, Chung-Sang Ng Institute for the Study of Earth, Oceans, and Space.
Office:	Morse Hall, Room 414 (Farrugia), Rm 245B (Ng) Phone: 862-4596; 862-1280 E-mail: charlie.farrugia@unh.edu; chung-sang.ng@unh.edu
Office Hours:	Tues: 2:00-4:00 PM. (Other times: by prior arrangement)
Textbook:	*Fluid Mechanics, 3nd Edition* by P. K. Kundu and Ira M. Cohen, Academic Press, 2004 Course book. Select Chapters only (see below)
Homework:	• Will be assigned orally in class after each lecture. • The accumulated homework of each week will be collected on the first lesson of the following week and graded. • A class correction will be given.
Tests:	There will be a written test on each chapter. This will be graded.
Grading:	The final grade will be based on: • Homework (30%), • Written tests (25%), • Class activity (15%), and • Final Exam (30%).

LITERATURE

Course Book:

Fluid Mechanics, 3nd Edition
P. K. Kundu and I. M. Cohen
Academic Press, 2004
Select Chapters/Sections only (see page 3)

Leisure Reading:

1. **Elementary Fluid Dynamics**
D. J. Acheson
Oxford University Press, 1990.

2. **Fluid Dynamics for Physicists**
T. E. Faber
Cambridge University Press, 1995.

3. **A Gallery of Fluid Motions**
M. Samimy *et al.*
Cambridge University Press, 2003.

4. **Introduction to Geophysical Fluid Dynamics**
B. Cushman-Roisin
Prentice Hall, 1994.

5. **Introduction to Plasma Astrophysics and Magnetohydrodynamics**
Marcel Grossens
Kluwer Academic Publishers, 2003.

6. **Numerical Simulation in Fluid Dynamics: a Practical Introduction**
Michael Griebel, T. Dornseifer, T. Neuenhoeffer,
Society for Industrial and Applied Mathematics, 1998.

Book 1 is a very fascinating and instructive book. It is highly recommended as a quick and clear review on the subject. Book 3 illustrates by splendid and sometimes breathtaking pictures the variety of fluid phenomena we encounter in real life. Books 4-6 provide further developments of topics dealt with in the second part of the course. They are thus better appreciated if consulted in the second half of the course. (These books are held on a 1-day reserve in the Physics library.)

COURSE GOALS

The **aim** of the course is twofold (1) to learn the basics of fluid mechanics, a traditional subject which received fresh impetus in the 20th century with Ludwig Prandtl's 1904 theory of the boundary layer, and with modern applications of compressible flows to supersonic flight, and (2) to acquire a feeling for the power of the subject by discussing its applications to diverse phenomena. Working problems is an essential part of the course because we learn physics by working examples. We shall work many problems in class to illustrate and consolidate ideas in the course work. Several others will be set as homework and test exercises. The tests and final exam will be of the "open-book" variety.

The **final grading** is a weighted average of a number of student activities so as to be able to assess better the student's overall performance. In addition to the final exam, there are written tests, homework and classroom activity. The homework plays an important role in covering the material of the course and hence its high share of the overall grading. By classroom activity we mean the general impression we get as to the interest shown by the student. Particular credit in this regard is given to constructive initiatives taken by the student in class, for example through suggestions and questions. Occasionally, we shall also be asking students to work out problems on the blackboard during class discussions.

COURSE CONTENT

The course will cover the following chapters from Kundu and Cohen's book. The order of presentation is as given below, though it might change somewhat as need dictates.

Chapter 2:	Overview; Elements of tensor analysis ALL
Chapter 3:	Motivating the Navier-Stokes (N-S) equation. Kinematics: Lagrange/Euler coord.; Material derivative; Relative motion. Sections 3.1 - 3.3 and 3.6 - 3.12
Chapter 4:	Reynolds transport theorem, continuity equation, momentum equation and stress tensor. Newtonian Fluid, Navier-Stokes equation; energy equation. Sections 4.1-4.7 and 4.10-4.14
Chapter 5:	Vorticity equation and Kelvin's theorem Sections 5.1 - 5.6
Chapter 3 and 4:	Streamfunction, velocity potential, Bernouilli equation Sections 3.4, 3.13, 4.16
Chapter 6:	2-dim. inviscid flow and the complex potential; circular cylinder: drag and lift. Sections 6.1-6.11 11
Chapter 8:	Dimensionless form of N-S equation Section 8.2
Chapter 9:	Exact solutions of N-S equation; Integral form of N-S equation. Sections 9.1-9.11, 4.8
Chapter 10:	Boundary layers (BL). Blasius flow. Effect of pressure gradients and BL separation Sections 10.1-10.11
Chapter 11:	Computational fluid dynamics (mostly on finite difference method only). ALL, excluding sections on finite element method
Extra topic:	Magnetohydrodynamics (MHD)
Chapter 12:	Instabilities; MHD instabilities Sections 12.1-12.6

Chapter 13:	Turbulent flow; MHD turbulence Sections 13.1-13.4; 13.8-13.9
Chapter 14:	Geophysical fluid dynamics Sections 14.1-14.15; 14.18 ll
Chapter 16:	Elements of compressible flow Sections 16.1-16.2; 16.9.