CEE 6360 – ENVIRONMENTAL FLUID MECHANICS

3.0 hours
Edwin A. Cowen (Todd)
119 Hollister Hall, 5-5140
eac20@cornell.edu
http://ceeserver.cee.cornell.edu/eac20/cee636/

This course covers analytic perspectives on environmental fluid flows with an emphasis on lakes and the coastal ocean. Mechanics of layered and continuously stratified fluids: internal waves, density currents, barotropic and baroclinic motions, bounded and free shear flows in the environment, the effects of rotation, jets and plumes and their behavior in the environment.

COURSE MECHANICS

Class – two 75 minute lectures per week, TR 2:55 – 4:10

Examinations – no in-class exams, all assignments will be take-home. I reserve the right to hand out a take-home final and/or final problem set on the last day of class to be due at the end of the regularly scheduled exam time (Wednesday May 16, 9:30pm hence I’ll go with 9:00 am Thursday May 17!) – a minimum of 4 weeks notice will be given if this option is to be exercised.

Homework – Approximately one assignment every 2 – 3 weeks. It is allowable and encouraged to work with fellow students as long as you note on the assignment who you have been working with, and you hand in your own individually worked solutions. If a take-home final is given this will require individual work – no collaboration will be allowed.

Grades – Grades will be based on the homework assignments and final problem set (counts as two homeworks) if option exercised. Each homework is waited equally.

Field and/or Laboratory Experiments – We may perform laboratory or field experiments in our local waters and/or the DeFrees Hydraulics Laboratory (located in the basement of Hollister Hall). Students are expected to participate in the experiments as requested and any data collected will likely be used in assignments.

Text & Notes – Lecture notes will be made available to the class. Several journal articles will be distributed during class and a list of reference texts is at the end of this document. Several of the texts, as noted, are on reserve in the Engineering Library.

Assumed Background – It is assumed that every one has taken at least one undergraduate fluids class (CEE 3310 or equivalent) and is familiar with both ordinary differential equations (ODEs) and partial differential equations (PDEs - MATH 2930 or equivalent). A solid course in linear algebra is also assumed (MATH 2940 or equivalent). CEE 6550 and/or CEE 6010 (or their equivalents) is a prerequisite, although if you have not taken either of these courses discuss your background with me and we can perhaps work something out. A graduate
level introductory course in fluid mechanics (MAE 6010 or equivalent) is not strictly required but is extremely beneficial, as a comfort with manipulating the Navier-Stokes solutions will be assumed.

**Software** – Many of the assignments will require the use of computational based analysis. While it is not required that these assignments be done in any particular software I will be using Matlab, both for examples and solutions. Based on passed experience it is possible to use a variety of software to solve the problems although most students have found that Matlab is the easiest. Matlab, as well as several other standard software analysis packages, are available to students on the computers in the Academic Computing Center Engineering Library (ACCEL – [www.accel.cornell.edu](http://www.accel.cornell.edu)).

**Academic Integrity** – Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. You are encouraged to work together on your assignments but the written work you turn in must be your own. When working together on an assignment you are required to list the name(s) of those you worked with. See the Code of Academic Integrity and Acknowledging the Work of Others (in the Policy Notebook for the Cornell Community and also on the web at [http://cuinfo.cornell.edu/Academic/AIC.html](http://cuinfo.cornell.edu/Academic/AIC.html)) if you are unclear on what constitutes acceptable academic behavior.
OUTLINE – SUBJECT TO CHANGE

Note there is too much material below so we will not cover it all. I will try to keep you apprised of where I’m taking us but your input will be valuable in making these decisions!

I. INTRODUCTION
   • My take on Environmental Fluid Mechanics
   • Math preliminaries – vector/tensor calculus and Einstein notation.
   • Vorticity and circulation.
   • Conservation laws and the equations of motion
   • Scaling
   • Effects of stratification
   • Effects of rotation – the Coriolis force.
   • Turbulence.

II. TWO-LAYERED FLOWS.
   • Introduction – surface waves.
   • Internal waves.
   • Internal hydraulics.
   • Gravity currents.

III. CONTINUOUSLY STRATIFIED FLOWS.
   • Introduction – description in terms of rays.
   • Internal waves
   • Generation and boundary interactions
   • Modal theory
   • Applications to lakes (and by extension estuaries and oceans).

IV. ENVIRONMENTAL SHEAR FLOWS
   • Bounded shear flows – the boundary layer with stratification
   • Stratified free-shear flows – buoyant jets and free-shear
   • Applications to lakes (and by extension estuaries and the coastal ocean).

V. BUOYANCY DOOMINATED FLOWS
   • Double-diffusion
   • Buoyant convection - plumes

REFERENCES FOR CEE 6360

BASIC FLUID MECHANICS
TURBULENCE

ENVIRONMENTAL TRANSPORT

WAVES

STRATIFIED FLOWS

GEOPHYSICAL AND OCEANOGRAPHIC FLUID MECHANICS

†Primary reference text - on reserve at the Engineering Library