CE597 – Environmental Fluid Mechanics
Purdue University, School of Civil Engineering
Spring Semester 2012

General course information

GENERAL COURSE DESCRIPTION

This course presents the basic fluid mechanics of numerous environmental flows in oceans, rivers, lakes, and the atmosphere. A key focus is on reconciling observations and properties of environmental flows with simplified versions of the differential equations governing environmental fluid flows; students will additionally learn to obtain these simplified equations using scaling. The class will also utilize and collect field and laboratory data to complement introduced theories. Additionally, Matlab will be used to visualize and animate data and solutions.

LECTURES: MWF 12:30-1:20pm, CIVL2123; some classes will be held in the Hydraulics and Hydrology Laboratory "Wet Classroom" (CIVL B115F).
OFFICE HOURS: TBA

PREREQUISITES

High level of proficiency in elementary fluid mechanics and calculus. Graduate standing is preferable, but undergraduates with a firm understanding of first-level fluid mechanics and differential equations are welcome. Matlab programming experience is desirable, but not required.

INSTRUCTOR: Cary Troy, Assistant Professor, School of Civil Engineering
email: troy@purdue.edu
office: CIVL1101D (Hydraulics Area)
phone: 494-3844
website: http://web.ics.purdue.edu/~troy

REQUIRED TEXT

Fluid Mechanics (Kundu, Cohen, and Dowling), 5th Edition – a recent edition will likely suffice, but students are responsible for all assigned readings/homework problems.

TENTATIVE LIST OF TOPICS

Introduction: environmental systems and processes; common features of environmental flows; scales, dimensionless numbers, dimensional analysis, and scaling; fundamental fluid properties and relations; hydrostatics and gravitational stability.
Governing conservation equations and common assumptions for environmental flows: variables and vector analysis; conservation of mass/heat/salt; conservation of momentum; Boussinesq approximation; hydrostatic balance; total vs. material derivative (Eulerian vs. LaGrangian frameworks).
Gravity water waves: Derivation of surface gravity/capillary waves; properties of surface gravity/capillary waves; wave dispersion; energy and phase propagation.
Viscous and viscous-like flows: Laminar flows; constitutive relation; turbulent (eddy) viscosity; Poiseulle/Couette flow.
Environmental boundary layers: Classical smooth plate turbulent boundary layer structure (log law, viscous sublayer, etc.); effects of roughness, stratification, unsteadiness, turbulence, rotation, and free surfaces); observations of environmental boundary layers;
Internal waves: 2-layer internal waves, barotropic vs. baroclinic modes, and extension to n-layers; properties of 2-layer internal waves; internal wave rays in continuous stratifications;
Density-stratified flows (internal waves, gravity currents, plumes)
Environmental Turbulence
Rotational (geophysical) flows: Governing equations; inertial oscillations; geostrophic flow; thermal wind; Ekman layer/transport;
Instabilities: Conceptual introduction to perturbation analysis; canonical flow instabilities and governing dimensionless numbers (pipe flow; Rayleigh-Taylor instability; Kelvin-Helmholtz instability, etc.); Kelvin-Helmholtz instability; baroclinic instability
Environmental Turbulence: Turbulent energy cascade; scales and spectra; stratified turbulence.

PRIMARY READING SOURCES:

Fluid Mechanics. 5th edition (Kundu et al.)
Geophysical Fluid Dynamics (Cushman-Roisin & Beckers)
Micrometeorology (Arya)
Atmosphere-Ocean Dynamics (Gill)
Environmental Fluid Mechanics (Rubin & Atkinson)
Mixing in Inland and Coastal Waters (Fischer et al.)
Wave Mechanics for Scientists and Engineers (Dean & Dalrymple)
http://thayer.dartmouth.edu/~cushman/books/EFM.html

COURSE WEBSITE: Blackboard

COURSE OBJECTIVES:

- Obtain a conceptual and mathematical familiarity with a wide range of physical processes in environmental fluid flows
- Consider various processes/forces important for environmental flows, and quantify their relative (nondimensional) importance in various environmental flows.
- Simplify the governing equations for environmental flows using scaling and nondimensionalization
- Solve simplified versions of the governing equations for a wide range of idealized environmental flows
- Improve intuition of environmental flows, and quickly identify which factors may be relevant for a given flow.

COURSE GRADING SCHEME:

Homework: 20% (assigned on an approximately weekly basis) – designed to practice skills learned. Homeworks turned in less than 72 hours following the due date/time will receive 50% of whatever grade they would have received. Extensions will only be granted for issues that fall under university policy (e.g. documented illness, etc.).

Quizzes: 5% (either online or in class) – designed to make sure you are regularly engaged with material. These quizzes may cover the weekly readings assigned, or may involve short calculations/manipulations.

Exams (2-3): 40% (either in class or take home) – the material and format for the exams will be announced prior to each exam. Requests for conflict exams will only be granted if the circumstances fall under university policy for makeup exams.

Laboratory Experiment / Demonstration (1): 5% - each student will be responsible for the proctoring and presentation of 1 laboratory experiment/demonstration. Students will work in groups. The format for the presentation of these experiments will be distributed in class will include an experiment and the presentation of this experiment to the class.

Final exam: 30% - The final exam will be comprehensive but slightly weighted toward recent material.

Participation and effort: Qualitatively assessed by the instructor.

In the event of a campus emergency, the above policies are subject to change, and communication will be carried out over email and through the Blackboard website.