Syllabus

MAE 9110/9510-1: Intermediate Fluid Mechanics with Environmental Fluid Dynamics and Heat Transfer

University of Colorado at Colorado Springs
Mechanical and Aerospace Engineering
Spring 2007

Meets: R 7:15-9:50 p.m. UH 317

Instructor: Dr. Jason Roney
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Textbook**:** Environmental Fluid Mechanics (Hardcover) by Hillel Rubin,Hardcover: 752 pages
Publisher: CRC (August 17, 2001), Language: English
ISBN: 0824787811

Grading: Homework: 30%
Projects: 30%
Midterm Covers Part I: 20%
Final Covers Part II: 20%

There will be approximately one homework assignment per major topic area.

Projects will consist of laboratory or numerical investigations assigned as well as some projects chosen from a list of available projects open to the student.

Course Outline:

Intermediate Fluid Dynamics with an Introduction to Environmental Fluid Dynamics and Heat Transfer

This course will introduce the student to fluid flow phenomena important to natural and man-made environments. The first part of the course will be an overview of underlying fundamental advanced fluid dynamics principles including turbulence and thermal convection. In the second part of the course, these fundamental concepts will be applied to specific problems in natural and man-made environments. The focus will be on planetary atmospheres where atmospheric turbulence, geophysical flows (rotating flows), two-phase flow transport, and gravity flows will be studied. Applications of these types of flows include planetary meteorology (Earth, Mars, etc), wind engineering (turbines and structures subject to wind loading), and air pollution (dust storms, exhaust treks, particulate haze). Many of these fundamental concepts have direct affect on many of the man-made aerospace applications as many of the vehicles developed (planetary landers and aircraft) travel through this fluid media.

Prerequisites: MAE 3130 Fluid Mechanics, this course should be a senior/junior level technical elective (second course in fluid mechanics) or can be used as a graduate level course. If taken as a graduate, this course will have additional requirements beyond those required of the undergraduates.

Outline of Topics:

PART I: 6-7 Weeks

1. Equations of Viscous Fluid Motion
    a. Navier-Stokes Equations
    b. Non-Dimensional Numbers
    c. Euler and Bernoulli Equations
    d. Boundary Layer Flows

2. Turbulence
    a. Physical Description
    b. Reynold's Equations
    c. Turbulent Boundary Layer
    d. Turbulent Diffusion

3. Wave Theory
    a. Intro. and Definitions
    b. Longitudinal Waves
    c. Transverses Waves
    d. Mach Cones

4. Thermal Convection
    a. Heat Conduction
    b. Thermal Instability
    c. Geometry of Convection
    d. Governing Heat Equation

PART II: 5-8 Weeks

5. Overview of Planetary Atmospheres
    a. Rotating Flows/Geophysical Flows
    b. Atmospheric Turbulence
    c. Two-Phase Flow
    d. Gravity Flows

6. Applications in Wind Engineering
    a. Slope Flows and Wind Turbines
    b. Urban Environmental Winds

7. Applications to Planetary Meteorology
    a. Martian dust storms
    b. Jupiter's Great Red Spot
    c. Atlantic Hurricane Season
    d. Microbursts
    e. Clean Air Turbulence (CAT)

8. Air Pollution
    a. Transport of Pollutants

b. Deposition of Pollutants
c. Air Quality Modeling

Additional References:

Tritton, D.J., Physical Fluid Dynamics, Oxford Science Publications, 1988.

Cushman-Roisin, Benoit, Introduction to Geophysical Fluid Dynamics, Prentice Hall, 1994.

White, Bruce R., Lecture Notes from "Aerodynamics in Nature and Technology", University of California at Davis Mechanical and Aeronautical Engineering.

Middleton, G.V., and Wilcock, P.R., Mechanics in Earth and Environmental Sciences, Cambridge University Press, 1996.