ME EN 7710: Environmental Fluid Mechanics

Spring 2011

Instructor: Eric R. Pardyjak

Lecture Time/Location: Tuesday, Thursday 10:45 pm-12:05 pm WEB L110

Office Hours: 12:05pm-1:05pm Tuesday ,Thursday Room 171 KENN B

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Text: *An Introduction to Boundary Layer Meteorology*, R.B. Stull, Klewer Academic Publishers, 1988.

Supplementary Texts:

- *Structure of the Atmospheric Boundary Layer*, Z. Sorbjan, Second Edition, METEOR Publishing, 2011.
- *Introduction to Micrometeorology*, S.P. Arya, Second Edition, Academic Press, 2001.
- *The Atmospheric Boundary Layer*, J.R. Garratt, Cambridge University Press, 1992.
- *Atmospheric Boundary Layer Flows*, J.C. Kaimal and J.J. Finnigan, Oxford University Press, 1994.
- *Boundary Layer Climates* by T.R. Oke, Second Edition, Routledge 1987.
- *Handbook of Micrometeorology*, (Eds.) X. Lee, W. Massman and B. Law, Klewer Academic Publishers, 2004.
- *Micrometeorology*, T. Foken, Springer, 2008.

Description of the Course: An introduction to Environmental Fluid Mechanics focusing primarily on micrometeorological processes occurring in the atmospheric boundary layer (the lower 1-3km of the troposphere). Since this is the part of the atmosphere that humans are directly in contact with, it is of great importance to both engineers and atmospheric scientists. For example, the small-scale motions responsible for pollution dispersion are related to surface fluxes of heat and momentum. The class will mostly focus on the micrometeorological processes in the atmospheric boundary layer in both rural and urban settings. The content will include turbulent flow and dispersion around buildings.

Prerequisites: ME EN 3700 Undergraduate Fluid Mechanics (or equivalent) and ME EN 6700 Intermediate Fluid Dynamics

Scope of the Course: The lecture material will cover much of the material in the textbook, however significant supplemental journal articles will also be used. The basic transport equations for mass, momentum and energy will be developed and will include rotation and stratification effects. In addition, to the classroom lecture material students will also be involved in a basic atmospheric boundary layer experiment using a tethered meteorological balloon and sonic anemometer. These data will form the basis for a project on "probing the atmospheric boundary layer."

Homework: Periodic homework assignments will be given during class and then posted on the web site. Homework will be collected in class on the due date. Late homework will generally not be accepted.

Computer Skills: It is expected that at all students will have basic computing skills and knowledge of a programming language (FORTRAN, C, C++, etc) or scientific computing software package (Maple, Matlab, EES, etc).

Grading and Exams: The total course grade is comprised of homework, a midterm and final exams. The midterm exam will be composed of a take home and in class exam. The grading scheme is summarized below.

Homework: 40%
Midterm: 25%
Final Project: 35%

No make up exams will be given unless arrangements are made prior to the exam.

Exemptions: The University of Utah conforms to all standards of the Americans with Disabilities Act. If you wish to qualify for exemptions under this act, notify the instructor and the Center for Disabled Students Services, 160 Union.

1. Introduction
    - The atmospheric boundary layer – basic definitions and concepts, scales of motion, diurnal cycles and introduction to rotation and stratification.
    - Equilibrium and Departures from it.
    - Atmospheric thermodynamics – potential temperature, virtual potential temperature, buoyancy frequency, potential energy.

2. Energy Balances – radiation characteristics, near surface exchanges (fluxes), energy budget near surface, radiation budget near surface.

3. Basic Equations including rotation and stratification – boundary layer simplifications

4. The Atmospheric boundary layer scaling – Monin-Obukhov similarity theory
    - Neutral boundary layer
    - Convective boundary layer
    - Stable boundary layer

5. Atmospheric Boundary Layer Turbulence – introduction to the turbulence in environment and the critical effects of buoyancy on turbulence. Turbulent entrainment and stability effects.
    - Measuring Techniques – introduction to various measuring techniques including sonic anemometry, balloon borne measurements and remote sensing techniques.
    - Analysis of Turbulence Data sets and application to a real world field experiment

6. Introduction to Atmospheric Dispersion
    - Random Walk
    - K-theory
7. Nonhomogeneous Boundary Layers – Vegetative Canopies, Urban Fluid Mechanics
    - Surface inhomogeneities (roughness effects, both complex terrain and urban). Terrain induced flows.
    - Atmospheric dispersion concepts and models (ranging from simple Gaussian plume to Lagrangian Dispersion models)
    - Urban Heat Island