University of Colorado
Department of Civil, Environmental, and Architectural Engineering

CVEN 5343 SPRING 2010
Transport and Dispersion in Surface Water

http://ceae.colorado.edu/~crimaldi/teaching/cven5343/index.html

Instructor

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Lectures

Location and times: ECCE 1B47 TR 2-3:15p

Prerequisites

math:	Multi-variable & Vector Calculus Differential Equations
fluids:	Undergraduate Fluid Mechanics
matlab:	Some programming experience

Course Description

This course examines the transport and mixing of contaminants (e.g. toxins, nutrients, heat) in turbulent surface water flows (e.g. rivers, estuaries). Topics will include Fickian and turbulent diffusion, shear dispersion, first-order reaction kinetics, and the development of the reactive advection-diffusion equation. Both analytical and numerical solutions to the equation will be explored. Students will develop numerical transport models using both finite-difference as well as particle-tracking techniques. Students will also learn to use laser-based visualization techniques to study turbulent transport in the Environmental Fluid Mechanics Teaching Laboratory. The course will rely heavily on problem sets to allow you to explore these topics. There will not be any examinations.

Objectives

(1) Develop an understanding of turbulence structure in turbulent flows.

(2) Gain an intuitive physical understanding of molecular and turbulent diffusion processes.

(3) Explore the derivation and analytical solutions to simple cases involving the reactive advection-diffusion equation.

(4) Learn to use numerical modeling techniques to solve more complex problems.

(5) Gain exposure to techniques used to visualize and quantify turbulent transport.

(6) Expand your ability to use a combination of math, pictures, and words to describe complex physical phenomena and communicate them to others.

Suggested Reading

All Titles are On Reserve (Engineering Library)

Kundu, P.K. and I.M. Cohen, *Fluid Mechanics* (3rd ed.), Academic Press, 2004

Pope, S.B., *Turbulent Flows*, Cambridge University Press, 2000

Bendat, J.S. and A.G. Piersol, *Random Data: Analysis and Measurement Procedures*. Wiley, 2000

Fischer, H.B., et. al. *Mixing in Inland and Coastal Waters*, Academic Press, 1979

Rubin, H. and J. Atkinson, *Environmental Fluid Mechanics*, Marcel Dekker, Inc., 2001

Clark, M.M., *Transport Modeling for Environmental Engineers and Scientists*. Wiley, 2009

Chapra, S.C., *Surface Water-Quality Modeling*. McGraw-Hill 1997

Rutherford, J.C., *River Mixing*. Wiley, 1994

Course Requirements

Attendance: Your attendance at all lectures is expected and required. Please see me for any exceptions.

Participation: A principal tenet of this course is that we can all learn from each other, and that we can learn most effectively in an interactive setting. Therefore, one of the requirements for this class is a commitment on your part to be an active participant in the lectures.

Problem Sets: There will be approximately five problem sets assigned during the semester. You are encouraged to discuss the problem sets with your classmates. However, the work that you submit should be uniquely your own. Do not fall into the trap of using a classmate as a crutch for your own independent thinking.

Course Communications

I will use email as the primary means of communicating with you outside of class or office hours. I may send modifications to assignments, hints, etc., as necessary. You are responsible for checking your email on a regular basis.

Course Outline

I. Molecular Diffusion
   A. Random walk and Fick's law
   B. The Gradient-flux relationship

II. Turbulent Diffusion

III. The Advection-Diffusion Equation
   A. Derivation
   B. Analytical Solutions

IV. Shear Dispersion

V. Reactive Scalars
   A. 1^{st}-order reaction kinetics
   B. The reactive advection-diffusion equation
   C. Analytical Solutions

VI. Numerical Modeling of the A-D Equation
   A. Finite-difference techniques
   B. Particle-tracking techniques
   C. Cell-in-series model
   D. Existing Models

VII. Laboratory Techniques for Measuring Transport
   A. Acoustic-Doppler Velocimetry (ADV)
   B. Planar Laser-Induced Fluorescence (PLIF)