CEE 795/895
Special Topics: Environmental Fluid Mechanics
Spring 2016

Instructor: Dr. Navid Tahvildari
130C Kaufman Hall
Email: ntahvild@odu.edu
Phone: 757-683-3549

Lectures: Tuesdays 7:10-9:50 pm Room: Kaufman 225

Office Hours: Thursdays 3:00 - 5:00 pm, or by appointment

Course Description:
This course studies the transport and mixing in flows in rivers, lakes, estuaries, and the ocean. The course starts by reviewing the necessary mathematics and an overview of the fundamentals of fluid motion and continues to discuss diffusion and transport and shear flow dispersion. Furthermore, an introduction to turbulence in homogeneous and stratified flows and how turbulence is approximated in numerical models will be discussed. Applications to riverine, estuarine, and ocean mixing will be outlined. Specific topics include: Eulerian and Lagrangian Description of Fluid Motion, Fick's Law, Diffusion Equation, Shear Flow Dispersion, Reynolds-averaged Equations, Turbulent Kinetic Energy (TKE) Equation, the Turbulent Cascade, Turbulence Spectra, the Taylor-Goldstein Equations, Breaking Internal Waves, the Richardson Number, Thorpe and Ozmidov Length Scales, Mixing Efficiency, Turbulence at Air-water and Sediment-water Interfaces, Mixing in Rivers, Estuaries and the Ocean.

Learning Objectives:
- Governing equations of turbulent fluid motion
- The effect of diffusion, dispersion, and advection on concentration
- Turbulence in homogenous fluids
- Properties of turbulence in stratified flows
- Mixing in stratified flows
- Turbulent processes at sediment/water and air/water interfaces
- Riverine, estuarine, and ocean mixing
- Numerical modeling of turbulence

Textbook:
No textbook is required. The primary reference will be the class notes and the journal articles that will be assigned for reading and discussion. The following references have been used in preparation of the lecture notes and are recommended for further reading.

(A) *Special Topics on Mixing and Transport in the Environment,* Socolofsky, S. A., and Jirka, G. H., 2005. Available at https://ceprofs.civil.tamu.edu/ssocolofsky/CVEN489/.
(B) *Mixing in Inland and Coastal Waters*, Fischer, H. B., List, J. E., Koh, R. C. Y., Imberger, J. and Brooks, N. H., Academic Press, New York, NY, 1979.
(C) *Turbulent Flows,* Pope, S. B. , Cambridge university press, 2000.
(D) *Fluid Mechanics,* third edition, Kundu, P. K., Cohen, I. M., 2004.

(E) Chin, D. A. (2000), *Water Quality Engineering in Natural Systems,* Wiley Interscience, Hoboken, New Jersey.

Lecture Notes:
Notes and other course materials will be available on Blackboard: www.blackboard.odu.edu

Prerequisite: Fluid Mechanics, Undergraduate Level Mathematics

Homework:

- Homework will be assigned periodically and will be due on the announced dates.
- Late homework will have a 10% penalty each day after the due date and will not be graded if it is more than three days late.
- Completed assignments must be submitted to Blackboard in PDF format. Group work is accepted but blind copying is not allowed.

Exams:
One mid-term exam is scheduled.

Paper Discussion:
Each student will choose a journal article from a number of articles provided in the beginning of the class. The student will lead a class discussion on the paper. All students are expected to read the papers and participate in the discussions.

Course Grade:
Homework 40%, Mid-term exam 30%, Paper Discussion 30%

Tentative Course Outline:

Meeting	Date	Topics
1	Jan. 12	Course Introduction, Eulerian and Lagrangian Description of Fluid Motion
2	Jan. 19	Governing Equations of Fluid Motion, Fick's Law, Diffusion Equation
3	Jan. 26	Turbulence in Homogenous Fluids, Reynolds-averaged Equations, TKE Equation, Turbulence Cascade
4	Feb. 2	Wall Bounded Shear Flow, The Law of the Wall, The Log-layer, Parameterizations of Bottom Roughness
5	Feb. 9	Turbulence in Stratified Flows, The Taylor Goldstein Equation, The Richardson Number
6	Feb. 16	The Thorpe Length Scale, The Ozmidov Length Scale, Mixing Efficiency
7	Feb. 23	Riverine mixing, Shear Flow Dispersion
8	Mar. 1	**Mid-term Exam, in Class**
	Mar. 8	**Spring Break, No Class**

9	Mar. 15	Turbulence and Exchange at the Air-water and Sediment-water Interface, Estuarine Mixing
10	Mar. 22	Internal Waves, Mixing due to Breaking Internal Waves
11	Mar. 29	Paper Discussion 1 and 2
12	Apr. 5	Numerical Modeling of Turbulence
13	Apr. 12	Paper Discussion 3 and 4
14	Apr. 19	Course Summary, Review
	Apr. 26	**Reading Day, No class**
15	May 3	**Final Exam 7:00-10:00 pm**