Virginia Tech
Department of Civil and Environmental Engineering

CEE 5304: Environmental Fluid Mechanics
(Spring 2018)

Description: This course focuses on the transport of mass and momentum in natural fluid systems. It is designed as an entry-level graduate course in fluid mechanics for students studying in engineering and earth science disciplines. The first two thirds of the course are devoted to developing a foundation in basic incompressible fluid mechanics with an emphasis on turbulent channel flow. The last third of the course deals with transport of scalar quantities in rivers and unstratified plumes. The course touches on experimental methods and flows driven by density gradients.

Prerequisites: C- or better in CEE 3314

Instructor: Kyle Strom, Associate Professor
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GTA: Elizabeth Angel
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office hours: TBD
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Course Material:

1. Required material will be distributed through Canvas or in class.
2. Recommended Books:
   - *Fluid Mechanics**, by Kundu and Cohen (2008), Elsevier
   - *Environmental Fluid Dynamics**, by Jörg Imberger (2013), Academic Press

Reference Material:

Students are encouraged to learn from a variety of sources. Here are a few additional recommended books, journals, and movies.

*electronic access through the VT library

1. Text Books
   (a) *MIXING in Inland and Coastal Waters*, Fischer et al. (1979), Academic Press
   (b) *Environmental Fluid Mechanics*, H. Rubin and J. Atkinson (2001), CRC Press.
   (c) [†]*Handbook of Environmental Fluid Dynamics, Volumes I &II*, ed. H. J. S. Fernando (2012), CRC Press
   (d) *Mechanics of Fluids*, Potter and Wiggert (2002), Brooks/Cole.
   (e) *Viscous Fluid Flow*, White (1991), McGraw-Hill.
   (f) *An Introduction to Turbulent Flow*, Mathieu and Scott (2000), Cambridge Press.

2. Course Notes
   (a) *Special Topics in Mixing and Transport Processes in the Environment*, Scott A. Socolofsky and Gerhard H. Jirka (2005), webpage with chapter pdfs
   (b) *Water Quality Control*, Eric Adams, MIT OpenCourseWare.

3. Journals
   (a) *Journal of Hydraulic Engineering*, American Society of Civil Engineers
   (b) *Journal of Hydraulic Research*, International Association of Hydraulic Research
   (c) *Journal of Fluid Mechanics*, Cambridge
   (d) *Environmental Fluid Mechanics*, Springer
   (e) *Journal of Geophysical Research - Oceans*, AGU/Wiley
   (f) *Annual Review of Fluid Mechanics*, Annual Reviews
   (g) *Continental Shelf Research*, Elsevier

4. Movies
   (a) NSF Sponsored series on fluid mechanics (playlist can be found here).
   (b) University of Iowa Hunter Rouse video series (playlist can be found here).
   (c) Other fluid mechanics playlist on the same YouTube channel.
   (d) The APS Division of Fluid Dynamics's Gallery of Fluid Motion.

5. Computing and plotting resources
   (a) A few links and examples to help you get going with Python
   (b) Introductory lectures on computing with python by Robert Johansson

Course Topics:

1. Introduction
2. Tools
   (a) Introduction to Python and Jupyter notebooks
   (b) Tensor Basics
   (c) Index and Comma-Subscript Notation
3. Governing Equations
   (a) Mass

[†]The library has access to the electronic versions of volume one and volume two

   (b) Momentum and Navier-Stokes
   (c) Simple Laminar Flow Solutions
4. Introduction to Turbulent Flow
   (a) Phenomenological Description
   (b) Reynolds Decomposition and the RANS equations
   (c) Introduction to Turbulence Modeling
5. Application to particular flows (simplification of the RANS equations)
   (a) 2D Channel Flow Theory
   (b) Introduction to the Shallow-Water Equations
6. Introduction to Experimental Methods for Velocity Measurements
7. Scalar Transport
   (a) Introduction
   (b) The Advection and Diffusion Equation
   (c) Dispersion and Mixing in Natural Rivers
   (d) Solutions and Application
8. Introduction to Stratified Flow
   (a) Simple Stratified Hydraulics
   (b) Turbidity Currents

Homework:

Homework will be handed out through Canvas approximately every other week. Collaboration is acceptable when working through the homework, but each student must turn in a full set of their own completed work. Specific dates for homework will be given along with the handout. There will be approximately 8 assignments.

Homework Requirements:

1. Discussion of homework and collaboration with peers is encouraged. However, each student must submit their own **unique** work for credit. Anything deemed of "suspicious origins" will not be graded, and Honor Code violations will be addressed.
2. Homework submissions must be **legible** and **well organized**. Any illegible homework will not be graded. Homework solutions should be handwritten or printed on the front side of each piece of paper only (i.e., do not write on the front and back of a page). Please give an overview of the problem statement before presenting your work and solution. All final solutions should be boxed.

Laboratory Experiment:

There will be one laboratory session associated with the experimental methods portion of the class. The lab will explore the use of Acoustic Doppler Velocimetry (ADV) for quantifying turbulent flows. One of the homework assignments will focus on analyzing the data collected in the experiment.

Project & Presentation:

The final assignment of the course will be a team mini project and presentation. Each

project team will consist of approximately 3 people. During the last month of the semester, I will assign the teams and give each team a research question to answer for the assignment. Each team will then think through the question, outline the basic theory associated with the question, develop a hypothesis, and come up with a method to test the hypothesis. Some of the projects will be more laboratory based and some will be more analytical or computational. After developing a plan, each team should schedule a meeting with me to discuss how they plan to test their idea. Following this, the team will carry out their experiments or simulations and analyze the results. Teams are not required to turn in a written report. However, each team must give a 10 to 15 min presentation on their project during the last week of class. I will consider both the work and presentation quality when assigning grades. All members of a given team will receive the same grade.

Exam:

There will be one exam in this course; a closed-book comprehensive final. The final is scheduled for May 08, 2018 from 7:45 am to 9:45 am in the lecture room.

Grading

Contributions Towards Final Grade	
Homework	60%
Project & Presentation	10%
Final Exam	30%
Total	100%

Letter Grade	Overall Avg.	Letter Grade	Overall Avg.
A	94-100%	C	73-76%
A-	90-93%	C-	70-72%
B+	87-89%	D+	67-69%
B	83-86%	D	63-66%
B-	80-82%	D-	60-62%
C+	77-79%	F	<60%

Honor Code:

The Undergraduate Honor Code pledge that each member of the university community agrees to abide by states: **"As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."**

Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code. For additional information about the Honor Code, please visit: www.honorsystem.vt.edu.

The Virginia Tech Honor Code applies to all work in this class, including homework, laboratory reports, and examinations. When written work is submitted for grading, it is implied that the work is the sole effort of the person, or persons, whose name(s) appears on the paper. You may seek help on the principles and applications involved in the major

assignments, and you may talk to each other about these principles and applications, but you are not to simply copy the work of another person or allow another person to work a problem for you.

Special Accommodations Statement:

If you need adaptations or accommodations because of a disability, if you have emergency medical information to share with me, or if you need special arrangements in case the building must be evacuated, please make an appointment with me within the first two weeks of classes.