CE54700 Transport Processes in Surface Waters (Prof. Cary Troy)
Fall 2015, Purdue University, School of Civil Engineering
10:30 pm - 11:20 pm, MWF, CE2107

Course overview: This course focuses on the description and quantification of the fundamental physical processes that transport substances in surface waters, i.e. rivers and lakes. The initial portion of the course is organized around the appropriate differential equations governing the transport of substances in rivers and lakes; the proper selection of the mixing coefficients in these equations; and the coding of simplified analytical and numerical solutions to these transport equations. The second portion of the course is geared towards applications, where students will apply an actual water quality model to simulate transport of substances in rivers and/or lakes.

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Office hours: TBD

Course prerequisites: A first course in fluid mechanics (e.g. CE34000), and a course in differential equations. Graduate standing is preferred, but not required.

Course objectives:
At the end of this course, students should be able to:

- Determine appropriate transport equations and boundary conditions for the transport and mixing of substances in rivers and lakes.
- Calculate temporal and spatial concentration distributions of substances released into rivers and lakes, using either analytical or numerical means.
- Estimate appropriate turbulent mixing coefficients for mixing in rivers and lakes; apply these coefficients to estimate turbulent diffusion.
- Perform "back of the envelope" calculations to quickly determine the transport and dilution of substances released in natural waters; select the appropriate dimensionality of an estimate (1-,2-, or 3-D; steady vs. unsteady).
- Apply a consulting-grade numerical model to calculate the transport/mixing of substances in rivers and/or lakes.

Textbooks:
1.) Water-Quality Engineering in Natural Systems: Fate and Transport Processes in the Water Environment. Author: David A. Chin (free online through Purdue Library)
2.) Hydrodynamics and Water Quality: Modeling Rivers, Lakes, and Estuaries. Author: Zhen-Gang Ji (free online through Purdue Library)
3.) Mixing in Inland and Coastal Waters. Authors: Hugo Fischer, et al. (1st edition). This book is not required but is strongly recommended to the serious student.

Website: Blackboard Learn

Course Grading

Homework: 20% (approximately every week) – designed to practice skills learned. Extensions will only be granted for issues that fall under university policy (e.g. documented illness, bereavement, etc.). The total homework points will determine the homework grade, and any extra credit will be added as points to this total.

Exams (3): 60% The material and format for the exams will be announced prior to each exam. Requests for conflict exams will only be granted if the circumstances fall under university policy for makeup exams.

WQ modeling project: 15% - Students will complete individual projects as a culmination to this portion of the class. Details of this project will be announced later in the class.

Quizzes: 5% - Short quizzes will be given in class as well as online. These quizzes will be announced prior to being given and are designed to maintain your engagement with lecture material, and to prepare you for lectures.

Participation and effort: $$% (priceless) - Much of the class will involve active discussion and exercises, and you are expected to participate. This category will be subjectively assessed by the instructor and may be used to determined borderline grades.

Grades

Grading will be done on a +/- system, with the following scale. In general, curving will be done on individual assessments (homeworks, exams) so that the student has an accurate perception of his/her standing in the course.

A+	96.67 – 100	B+	86.67 – 90.00	C+	76.67 – 80	D+	66.67 – 70.00
A	93.33 – 96.67	B	83.33 – 86.67	C	73.33 – 76.67	D	63.33 – 66.67
A-	90.00 – 93.33	B-	80.00 – 83.33	C-	70.00 – 73.33	D-	60.00 – 63.33

In the event of a campus emergency, the above policies are subject to change, and communication will be carried out over email and through the Blackboard website. If you receive an urgent text message alert from the campus notification system during class, let me know immediately.

- In the event of a fire alarm, we will immediately evacuate the building together, and meet outside on the lawn next to the building.
- In the event of a "shelter in place" alert, we will barricade and lock the doors, turn out the lights, and remain quiet in the room unless common sense dictates other actions.
- In the event of a tornado siren, we will go to the basement of the building.

Topics covered: This tentative list of topics will evolve as needed, and is broader than what we can reasonably cover in the course, but serves as a rough guide to what I aspire to cover. Reading assignments and learning objectives will be added as appropriate.

Topics
Course overview
I. ADVECTION AND DIFFUSION FUNDAMENTALS
Fickian diffusion: fundamental solution; characteristics of solution
Mathematics of diffusion equation: Superposition
Diffusion equation complexities: boundaries and additional dimensions
Advection-Diffusion
Numerical solutions to advection/diffusion problems
II. TURBULENCE AND DIFFUSION
Fundamentals of turbulence
Statistics and turbulent diffusion
Turbulent diffusion of unbounded clouds
Particle tracking models
Laboratory experiment
III. SHEAR FLOW DISPERSION
Experiment – River mixing / shear flow dispersion
Shear Flow Dispersion I: Basic concept and beginning of derivation
Shear Flow Dispersion II: Full derivation
Shear Flow Dispersion III: Classic shear flow dispersion results
Shear Flow Dispersion IV: Unsteady effects and extensions to additional dimensions
IV. MIXING IN RIVERS
Introduction: Vertical, transverse, and longitudinal mixing
Calculation of concentration distributions
Longitudinal dispersion in rivers
Dispersion in real streams
Example calculations: mixing in rivers
V. MIXING IN LAKES
Thermal cycle in dimictic lakes
Heat transfer mechanisms in lakes
Vertical mixing and stratification
VI. WATER QUALITY MODELING
1-D water quality modeling in rivers and streams (HEC-RAS; QUAL-2E/K)
1-D lake water quality modeling (FLAKE; GLM)