

CIV ENV 440 Environmental Transport Processes

Class Tuesday/Thursday 9:30 – 10:50, Annenberg Hall G01

Discussion section Tuesday 12:30 – 1:50, Tech LG66

Instructor: Aaron Packman
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Office Hours: After class or by appointment

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Textbook: Clark, *Transport Modeling for Environmental Engineers and Scientists, 2nd Edition*

Course Description:

This course presents the *fundamental processes* that control the transport of constituent substances in fluids, and the *implications of these processes* for a variety of important applications in natural and engineered environmental systems. Basic physical conservation principles will be introduced and initially applied to understand the behavior of important classes of environmental flows. Fundamental hydrodynamic transport processes will then be analyzed, and the differential equations that describe mass transport in environmental systems will be solved for various boundary and initial conditions. The inter-relationship of hydrodynamic transport with biological and biogeochemical processes will be discussed, and these concepts will be unified within the context of case studies involving the transport of reactive species in complex environmental systems.

After taking this course, you should:

- Understand the fundamental processes responsible for fluid flow, mixing, chemical mobility, and mass transport in the environment.
- Understand the important types of environmental flows and the processes that control them.
- Identify the key physical and chemical features of major environmental systems, and the implications of these features for overall system dynamics.
- Be able to develop appropriate mathematical representations of transport processes, and obtain solutions for cases commonly found in environmental systems.
- Be able to apply basic models for mixing and transport of reactive substances in environmental systems, and recognize and address the additional complexities that can occur in specific cases.

Grading and Expectations:

- **You may freely discuss homework, lab assignments, and literature with other students in the class, but you must turn in your own work.**
- Final reports must be all original work. NU plagiarism standards will be strictly enforced.
- Homework (5): 30%. Laboratories (3): 30%. Written evaluation and verbal discussion of papers from the literature (7): 15%. Final report (case study): 25%.
- You should participate in class discussions.

Academic Integrity Statement:

Students in this course are required to comply with the policies found in the booklet, "Academic Integrity at Northwestern University: A Basic Guide". All papers submitted for credit in this course must be submitted electronically unless otherwise instructed by the professor. Your written work may be tested for plagiarized content. For details regarding academic integrity at Northwestern or to download the guide, visit: www.northwestern.edu/provost/policies/academic-integrity/index.html

Accessibility Statement:

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (email: accessiblenu@northwestern.edu; phone: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability

accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

Classroom COVID-19 Expectations Statement:

Students, faculty and staff must comply with University expectations regarding appropriate classroom behavior, including those outlined below and in the COVID-19 Expectations for Students. With respect to classroom procedures, this includes:

- Policies regarding masking, social distancing and other public health measures evolve as the situation changes. Students are responsible for understanding and complying with current University, state and city requirements.
- In some classes, masking and/or social distancing may be required as a result of an Americans with Disabilities Act (ADA) accommodation for the instructor or a student in the class even when not generally required on campus. In such cases, the instructor will notify the class.

If a student fails to comply with the COVID-19 Expectations for Students or other University expectations related to COVID-19, the instructor may ask the student to leave the class. The instructor is asked to report the incident to the Office of Community Standards for additional follow-up.

Class Teaching Modality:

Class sessions for this course will occur in person. Individual students will not be granted permission to attend remotely except as the result of an Americans with Disabilities Act (ADA) accommodation as determined by AccessibleNU. Should public health recommendations prevent in person class from being held on a given day, the instructor or the university will notify students.

Maintaining the health of the community is our priority. **If you are experiencing any symptoms of COVID do not attend class. Follow NU guidelines for testing, isolation and reporting a positive case.**

If you experience any COVID symptoms, contact the instructor as soon as possible to arrange to complete coursework. Students who experience a personal emergency should also contact the instructor as soon as possible to arrange to complete coursework.

Class Recordings:

This class will be recorded by the instructor for educational purposes. Recordings will be available via Canvas and Panopto. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

Students are prohibited from recording class sessions and are also prohibited from the distribution of class recordings. Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University’s Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

Support for Wellness and Mental Health:

Northwestern University is committed to supporting the wellness of our students. Student Affairs has multiple resources to support student wellness and mental health. If you are feeling distressed or overwhelmed, please reach out for help. Students can access confidential resources through the Counseling and Psychological Services (CAPS), Religious and Spiritual Life (RSL) and the Center for Awareness, Response and Education (CARE). Additional information on all of the resources mentioned above can be found here:

<https://www.northwestern.edu/counseling/>

<https://www.northwestern.edu/religious-life/>

<https://www.northwestern.edu/care/>

CIV ENV 440 Environmental Transport Processes

Outline of Topics:

Introduction to Environmental Problems and Systems

Mixing and Mass Balance Concepts.

Principles of Fluid Mechanics

Environmental Fluid Flows

Mixing and Transport Processes: Diffusion and the Advection-Diffusion Equation

Transport in Turbulent Flows

Dispersion in Rivers and Groundwater

Surface Water / Groundwater Interactions

Anomalous Transport: Breakdown of the Advection-Diffusion-Dispersion Framework

Biogeochemical and Ecological Dynamics: Nutrients, Carbon, Microorganisms