

ENVR 205
Engineering Tools for Environmental Problem Solving
Spring 2018

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Office Hours: Tuesday before/after class (Phillips)
9 am Friday (166 Rosenau Hall)
please tell me you are coming

Class Schedule: 9:30 – 10:45 am TuTh 383 Phillips

Grading: 10% class participation; 30% problem sets and oral/written projects; 30% quizzes; 30% final. Effective communication will constitute 25% of the grade of every assessment.

Prerequisite: Calculus

Course Description:

This course is an introduction to environmental systems and tools for effective environmental solutions. We role-play in environmental consulting teams. This course will provide an appreciation of the role of energy in the environment, and an understanding of how the fundamental forces of nature affect contaminant and radiative transport. We will learn how to apply mass, energy and momentum balances to answer practical questions you or your clients may have concerning the effects of contaminants on the environment and human health and to design effective strategies to reduce these effects. Perhaps most importantly, this class will provide guidance on how to simplify extremely complex systems so that solutions can be obtained. Emphasis will be placed on communicating your work.

ESE competencies addressed, in part, by this class:

Identify sources of environmental contaminants and processes that affect the movement, fate, and health effects of such contaminants in environmental/human systems

Develop and/or apply theoretical/computational models to represent important aspects of environmental/human systems and assess their uncertainty

Demonstrate written and oral communication skills related to environmental sciences and engineering issues

Learning Objectives:

After this class, students will be able to:

Apply knowledge of mass, energy and momentum transport principles to solve environmental problems

Function on multidisciplinary teams

Provide quantitative answers to highly complex problems by making assumptions and communicating the knowledge gained and limitations imposed by those assumptions.

Communicate scientific calculations clearly in writing

Students will have a basic understanding of 1) climate change, 2) the relationship between the residence time (or lifetime) of a compound in a reservoir and its concentration (or loading) in that reservoir, 3) the equations governing mass, energy and momentum transport, and 4) the associated commonly used terminology.

Course Materials and Problem Sets:

There is no required textbook for this class. You might choose to purchase Mihelcic (listed below). Important course materials including readings, web references, problem sets, and solutions will be posted on Sakai.

Sakai: <https://sakai.unc.edu/portal/site/envr205.sp2018>

References:

Mihelcic, James R. "Fundamentals of Environmental Engineering," John Wiley and Sons, New York.

Masters, Gilbert "Introduction to Environmental Science and Engineering, Prentice Hall, Upper Saddle River, New Jersey.

Environmental Systems and Processes by Walter J. Weber, Jr. Wiley Interscience, New York

Bird, R. Byron, Stewart, Warren E., and Lightfoot, Edwin N. "Transport Phenomena," John Wiley and Sons, New York.

Policy on Problem Sets:

The primary purpose of weekly problem sets is to facilitate learning. Do not expect to pass this class without doing these problem sets by the specified dates. By doing the problems and comparing your answers to the posted solutions you will understand how to apply the lecture material and you will be prepared for quizzes. Even more importantly you will be more likely to retain the knowledge from this class and be able to apply it in your upper level courses and in your profession.

Problem sets will be posted on Sakai. Solutions will be posted after class on the day the problems are due. Problems are due at the beginning of class. Problem sets will not be accepted after solutions are posted. **Students are expected to compare their solutions for all problems with the posted solution set. This will help ensure success in exams and in learning the material.**

You are encouraged to teach each other, but the work that you turn in must be your own. You are welcome to use computer programs or spreadsheets prepared by yourself. You must

document your work completely. *Copying from other classmates will not be tolerated, and all students involved will receive no credit for that assignment.*

Required Problem Set Format:

Problem sets give the student practice in problem solving and communication of results to others. Many of the problems could be solved multiple ways, and it is up to you to decide what assumptions to make in solving the problem. Therefore, communication of what you did in the problem is critical. For this reason, the following format **must** be used. Effective communication will constitute 25% of each grade:

1. Briefly restate the objective of the problem to make sure it is understood (for example “find:___”).
2. Identify the physical setting of the problem. State information provided and assumptions made (for example “given:___”; “assuming:___”). Whenever possible draw a sketch of the system.
3. Solve the problem stating all assumptions and the basis for those assumptions. Do not skip steps.
4. Any facts that you use that were not provided in the problem should include a reference to indicate where the information was obtained. This includes equations unless you derive them in the problem or they are common knowledge like $F=ma$ or $PV=nRT$. No reference is required for conversion factors.
5. When using an equation, write out the equation first before entering values. Always include units. Making sure your units cancel is a very good quality control check! Also ask, “does my answer make sense?”
6. As needed, include a brief running commentary to explain your thought process. Circle answers and call attention to important intermediate results.
7. Discuss the significance of the results whenever possible. Don’t forget to answer the question that was asked.

Class Participation and Group Work: Class attendance and active participation is required. Class periods will include lectures, discussion and group work.

Warning: This course starts with basics and ends with sophisticated concepts. It also involves group work. Material builds on previous material. Thus class attendance and weekly work are essential.

Quizzes

There will be 3-4 quizzes over the course of the term. Please let me know in advance if there is a school or religious event that would constitute an excused absence.

Final Group Projects

Multidisciplinary teams will formulate and solve a quantitative question of their choice pertaining to a topic of environmental interest using a mass, energy, or momentum balance (i.e., tools learned in this class). This project will demonstrate environmental problem solving skills. Many examples of environmental problem solving will be provided in class lectures. Two weeks will be devoted to the projects including some in-class time and time outside of class for information gathering and to finalize the deliverable. Use of project management software, Sakai groups or *Google Docs* to help your team interact with each other remotely is encouraged. Teams will be assigned early in the term to enable the brainstorming of ideas in advance. The group project will count as 2 problem sets. Grading will take into consideration problem/solution communication, technical accuracy, and level of difficulty.

The delivered report (10 pages plus calculation details) should include 1) title and contributors names, 2) background explaining the motivation for the problem (why it is important; including references, typed), 3) the question you will answer, 4) your defined control volume and assumptions needed to make the problem solvable with tools you learned in this class (mass, energy and or momentum balances), 5) data that you used and what it is based on (with references as appropriate), 6) a drawing of the system, 7) a written mass, energy and/or momentum balance equation, 8) a step-by-step solution of the problem (in appendix), 9) an answer to the question you posed, 10) a written evaluation of how good the assumptions are, the limitations they pose on the answer, and under what circumstances your solution is valid. Please indicate, when appropriate, if your solution is an upper or lower bound.

Every fact stated requires a reference, provided as “(author, date)” immediately after the stated fact in the text. Any equations that you did not derive from first principles also require a reference. A reference list at the end of the report should contain complete citations. You are encouraged to use peer reviewed journal articles, books and web sites. Please critically evaluate the quality/reliability of the available resources. **The reference librarian is there to help you. You are encouraged to discuss your idea with the professor.**

A draft of your report will be first audited within the team, then comments will be provided by the professor. A refined version will be assessed. Students will summarize their projects in an oral “rapid communication” format (one powerpoint slide, 1 min per student), as is done to advertise posters in several scientific conferences. Each student will contribute to the presentation, answer one question from the audience about their work, and ask one question about another project.

General Project Topic Ideas (a specific question must be posed and answered):

Global cycling of DDT, Exposure of children to lead, Cycling of mercury to Hudson River Estuary, Air-water-sediment-fish partitioning, Methane on Titan – Saturn’s moon, Stratospheric ozone, Sources, sinks and concentrations of CFCs, Lawn application of pesticides and drinking water, An aspect of climate change on a planet, Wastewater treatment of BOD, Mercury removal in the air pollution control system of a power plant, Fate of ingested PBDEs in nursing mothers

CLASS SCHEDULE AND DUE DATES

Class #	Date	Topic	HW due
1	Jan 11 Th	The nature of environmental problems. Course objectives, brainstorming (Bemidji derailment)	
2	Jan 16 Tu	Environmental Calculations: environmental concentrations, units, conversions	
3	Jan 18 Th	Ideal gas law, temperature, pressure, density.	
4	Jan 23 Tu	Who employs environmental problem solvers, why? Example events, public support, legislation, roles for EPA, states, industry, consultants, public interest groups, progress and new challenges	
5	Jan 25 Th	Continued	HW1 Conversions, Concentrations
6	Jan 30 Tu	Using properties of compounds to predict fate K_H , K_{OW} , K_{OA} , P_v	
7	Feb 1 Th	Solving problems involving partitioning And returning to Bemidji	HW2 Ideal gas/related
8	Feb 6 Tu	Mass Transport I: Brainstorming: Hg exp. or CFC conservation of mass, point, 1 box (CMFR) conservative substance - steady state and transient	
9	Feb 8 Th	Using mass balance to characterize and solve problems	HW3 partitioning
10	Feb 13 Tu	Analytical solutions to transient mass balances	
11	Feb 15 Th	Examples	HW4 Mass balance1
12	Feb 20 Tu	Multiple Box Models (linked CSTRs): reservoirs and residence times, how many boxes do you need? incorporating partitioning	
13	Feb 22 Th	CFCs and the stratospheric ozone hole	QUIZ 1 Conc./Partitioning
14	Feb 27 Tu	Plug flow	
15	Mar 1 Th	Advection, Dispersion/Intro to predictive modeling	HW5 Mass balance2
16	Mar 6 Tu	Group project meetings	

Class #	Date	Topic	HW due
17	Mar 8 Th	Use of predictive modeling for effective for environmental management (who, what, how)	QUIZ II Mass balance
SPRING BREAK			
18	Mar 20 Tu	Use of predictive modeling for effective for environmental management (who, what, how)	
19	Mar 22 Th	Energy Transport: types of energy, conservation of energy, units of energy, first law of thermodynamics Energy balance techniques - 1 box (CMFR) conservative substance - steady state and transient	HW6 Mass balance and projects
20	Mar 27 Tu	Radiative energy balances, Earth's radiative balance	
21	Mar 29 Th	Climate Change	projects
22	Apr 3 Tu	Energy Continued	
23	Apr 5 Th	Force balances and design of control technology Examples: source control of airborne particles	HW7 <i>Energy</i>
24	Apr 10 Tu	Continued	
25	Apr 12 Th	Class time for group projects	Group Projects Due for internal review
26	Apr 17 Tu	MOMENTUM BALANCES AND FLUID FLOW: General Dynamic Equations come from a momentum balance -- viscosity. Prediction of fluid velocities	QUIZ III Mass/Momentum/fluid flow
27	Apr 19 Th	Similarities between mass, energy and momentum balances; viscosity and velocity	
28	Apr 24 Tu	Review	Revised Group Project Due (project is HW8,9)
29	Apr 26 Th	Project poster presentations	
Fri	8 am May 5	Final Exam - 8 am Friday May 5	Final Exam