**ENVR 205**
**Engineering Tools for Environmental Problem Solving**
**Spring 2017**

| | |
|---|---|
| ***Instructor***: | Dr. Barbara Turpin, Professor<br>Environmental Science and Engineering<br>Gillings School of Global Public Health<br>University of North Carolina at Chapel Hill<br>135 Dauer Drive<br>140 Rosenau Hall, CB #7431<br>Chapel Hill, NC 27599-7431<br>bjturpin@email.unc.edu<br>919-966-3013 |

| | |
|---|---|
| ***Office Hours:*** | Mondays 11 am |
| ***Class Schedule:*** | 9:30 – 10:45 am TuTh 125 Hanes |
| ***Grading:*** | 40% problem sets and oral/written projects; 30% quizzes; 40% final. Effective communication will constitute 25% of the grade of every assessment. |

***Course Description:***
This course is an introduction to environmental systems. Mass, energy and momentum balances will be used to quantitatively describe environmental systems and provide information needed to mitigate human impacts on these systems. The 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. 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.

***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 <u>in advance</u> 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 such as *Teamness* (on our Sakai site), 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 12 Th | **The nature of environmental problems**. Course objectives, Units, conversion, basis | |
| 2 | Jan 17 Tu | **Environmental Calculations**: temperature, pressure. Ideal gas law | |
| 3 | Jan 19 Th | density, environmental concentrations | |
| 4 | Jan 24 Tu | **Phase partitioning/phase changes:** $P_{vap}$ | HW1 Conversions, Concentrations, ideal gas |
| 5 | Jan 26 Th | $K_H$, $K_{OW}$, $K_{OC}$, etc. | |
| 6 | Jan 31 Tu | Solving problems involving partitioning | HW2 Conc., Condensation |
| 7 | Feb 2 Th | **Energy Transport**: types of energy, conservation of energy, units of energy, first law of thermodynamics | |
| 8 | Feb 7 Tu | Energy balance techniques - 1 box (CMFR) conservative substance - steady state and transient | HW3 Condensation/partitioning |
| 9 | Feb 9 Th | Second law of thermodynamics, thermal efficiency Energy Examples | |
| 10 | Feb 14 Tu | Radiative energy balances, Earth's radiative balance – Climate | HW4 Energy |
| 11 | Feb 16 Th | Climate Change | |
| 12 | Feb 21 Tu | Climate Change | HW5 Energy |
| 13 | Feb 23 Th | **Mass Transport I**: conservation of mass, point, 1 box (CMFR) conservative substance - steady state and transient | ***QUIZ I*** **Conc./Partitioning** |
| 14 | Feb 28 Tu | Analytical solutions to transient mass balances | |
| 15 | Mar 2 Th | Using mass balance to characterize and solve problems | |
| 16 | Mar 7 Tu | **Mass Transport II:** Advection, Dispersion/Intro to predictive transport modeling | HW6 Energy |

| Class # | Date | Topic | HW due |
|---|---|---|---|
| 17 | Mar 9 Th | **Final group project time** | ***QUIZ II*** Energy |
| | | **SPRING BREAK** | |
| 18 | Mar 21 Tu | **Plug flow** | |
| 19 | Mar 23 Th | **Multiple Box Models (linked CSTRs):** reservoirs and residence times, incorporating partitioning | |
| 20 | Mar 28 Tu | Multiple Box Model Examples: greenhouse gases or CFCs, P cycle | HW7 Mass Balance |
| 21 | Mar 30 Th | Continued | |
| 22 | Apr 4 Tu | **MOMENTUM BALANCES AND FLUID FLOW TRANSPORT:** Similarities between mass, energy and momentum balances; viscosity - Fluid flow between parallel plates | HW8 *Mass Balance* |
| 23 | Apr 6 Th | General Dynamic Equations come from a momentum balance | ***QUIZ III*** Mass Balance |
| 24 | Apr 11 Tu | Predicting air/water velocities in a system | HW9 Plug Flow And work on group projects |
| 25 | Apr 13 Th | Use of the GDE for solution of fluid flow problems. | |
| 26 | Apr 18 Tu | Bernoilli's Equation, Q=Av, Laminar and turbulent flow (Re) | |
| 27 | Apr 20 Th | Environmental prediction/modeling for effective air and water quality management | **QUIZ IV** Mass/Momentum/fluid flow |
| 28 | Apr 25 Tu | Environmental prediction/modeling for effective air and water quality management and Review | Revised Group Project Due (project is HW10,11) |
| 29 | Apr 27 Th | Review and project presentations | |
| **Fri** | **8 am May 5** | **Final Exam - 8 am Friday May 5** | **Final Exam** |