CE 476 – SOLID AND HAZARDOUS WASTES
Spring 2023

Lecture: 1:35 – 2:50 pm TR, 022 Deike

Instructor: Rachel A. Brennan, Ph.D., P.E.
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TA: Patrick Hoover, Ph.D. student
pxh70@psu.edu

Office hours: Tu/Th 2:50 – 3:30pm: 231K Sackett (Dr. Brennan)
Wed 3:30 – 4:30pm: 213 Sackett (Patrick)
You may also email questions directly to us (please cc: both of us on all correspondence).

Texts required: None.

Reference texts (on reserve at the Engineering Library, 325 Hammond Building):


Primary learning objectives: 1) To develop a knowledge of contemporary solid and hazardous waste issues and how they are relevant to you; 2) to discuss the social and political issues surrounding solid and hazardous waste management; 3) to perform basic landfill design calculations including quantification of bioreactions, leachate production, and gas collection; 4) to calculate the fate and transport of hazardous chemicals in soil and groundwater, including equilibrium partitioning, advection, dispersion, sorption, and reaction; and 5) to develop basic designs for several currently available hazardous waste remediation technologies and to discuss the physical, chemical, and biological properties which control their application.

Lecture materials: Lectures will be conducted using PowerPoint on a Tablet PC, with fill-in-the-blank sections for problem solving, etc. Copies of the PowerPoint slides (without the blanks filled in!) will be provided on the course web page (canvas.psu.edu) at least one day in advance of each lesson. You are strongly encouraged to follow along with these during class, as they will significantly reduce your time spent on taking notes, and (hopefully) increase your time spent thinking about the material.

Grading:

<table>
<thead>
<tr>
<th>Component</th>
<th>Points</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Exams (2)</td>
<td>200</td>
<td>20%</td>
</tr>
<tr>
<td>Quizzes (6)</td>
<td>300</td>
<td>30%</td>
</tr>
<tr>
<td>Homework (11)</td>
<td>500</td>
<td>50%</td>
</tr>
<tr>
<td>Participation</td>
<td>30</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>1030</td>
<td>100%</td>
</tr>
</tbody>
</table>

The standard grading system will be used to assign final letter grades in the course (A = 94 – 100%; A- = 90 – 93%; B+ = 87 – 89%; B = 84 – 86%; B- = 80 – 83%; C+ = 76 – 79%; C = 70 – 75%; D = 60 – 69%; F = 0 – 59%).
Homework: Homework assignments will be given approximately every week and are due on Fridays by 11:59pm. Some larger homework assignments are linked, and are designated as parts A and B in the syllabus. All homework assignment write-ups should be uploaded to Canvas as a Word document or PDF by 11:59pm on the due date. Supporting spreadsheets must also be submitted as Excel documents. Late homework assignments will be penalized 20% for each 24 hour period (or any fraction of 24 hours, not pro-rated) that they are late (for example, if you submit an assignment 10 minutes late, you will receive -20%). Quantitative homework problems should either be typed or completed neatly by hand on engineering paper (or the equivalent) with a box placed around the final answer. You must show your work (i.e., each step) to receive credit. Spreadsheets must be professionally formatted (ex., column headings, units, borders, significant digits, etc.). Columns of unlabeled, unformatted numbers are useless and will receive ZERO credit. Essay questions must be typed. Professional language style, grammar, punctuation, and neatness count, and may be penalized at the discretion of the grader.

Quizzes: Six quizzes will be given approximately every other week and are due on Tuesdays by 11:59pm on Canvas. Makeup quizzes will only be arranged for students with valid excuses provided at least one week before the scheduled quiz. If you have a valid conflict, please let me know as soon as possible.

Participation & professional evaluation: All students are encouraged to participate actively in class discussions. You may also email questions/comments/feedback to me. If you come to class regularly and give me the impression that you are listening (i.e., ask and answer questions in or out of class) then you will get full credit. If not, you will get less. In addition to evaluating your participation directly in class, I will also give you points for the following:

Muddiest Points: Each Thursday after class, all students will be asked to write out a short (1-2 sentence) question concerning a topic covered in class that week that they felt was not well-explained, and/or to provide constructive feedback for the instructor. These will be worth 1 point each and are due by 11:59pm. "No questions" or "Everything's ok" = no credit. At the beginning of class the following Tuesday, the most commonly asked question(s) will be discussed.

Professional evaluation: I reserve some additional points to evaluate your overall performance (ex., professionalism/integrity) throughout the semester. Although small, these points can sometimes mean the difference between a grade category (for example, a B+ vs. an A-).

Exams: Exams will be based on material from the homework, lecture notes, and quizzes. Exams will be closed-book and closed-notes; however, a single one-sided 8 ½ x 11 inch reference sheet is allowed for each exam. Students who use more than one-side will be penalized from 20 to 100% of the exam grade, depending on the severity of the infraction, and may be subject to an academic integrity violation (at the discretion of the instructor). Reference sheets must be submitted with the exams to receive credit. Exam questions will be patterned after the homework assignments and quizzes. Exams will primarily cover the material discussed in the previous module, but all material covered to date is fair game.

Exam I – Thursday, Feb. 23, in class
Exam II – Finals Week

COVID-19 protocols: Penn State University strongly recommends face masks be worn indoors on campuses in counties designated by the CDC to have high COVID-19 Community Levels. Even on campuses in counties with low or medium COVID-19 Community Levels, the University encourages anyone who wishes to wear a mask indoors to do so. If you test positive for COVID-19, you should not come to class for at least 5 days AND until you are fever-free for 24 hours. If you continue to have symptoms after day 5, you should continue to isolate through day 10. This is to protect your health and safety as well as the health and safety of your classmates, instructor, and the university community. Please see the CDC website for further guidelines.

Cell phone policy: Unless part of an organized in-class activity, cell phone use during class is distracting, disrespectful, and rude. It is expected that students are in class to learn the course material; therefore, all cell phones should be silenced and put away at the beginning of class. Any student who has a cell phone go off during class will be rewarded with a pop quiz for everyone in class.
**Academic Integrity:** Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others. In this course, students are encouraged to work together on homework assignments; however, original solutions from each student are required. If cheating or copying is suspected, all students involved will receive a zero for that assignment. **Cheating or plagiarism** on any graded activity (homework, quiz, or exam) will be penalized with a minimum of a zero points for the assignment, and up to a **failing grade** in the class. I will also place academic integrity violation reports in the offenders’ permanent files. If you are not familiar with what constitutes an academic integrity violation, I encourage you to read Penn State’s policies on the following web site: [http://www.engr.psu.edu/CurrentStudents/acadinteg.asp](http://www.engr.psu.edu/CurrentStudents/acadinteg.asp).

**Disability Accommodation:** Penn State welcomes students with disabilities into the University's educational programs. To receive consideration for reasonable accommodations, you must contact the appropriate Office for Disability Services (ODS) at the campus where you are officially enrolled ([http://equity.psu.edu/ods/dcl](http://equity.psu.edu/ods/dcl)), participate in an intake interview, and provide documentation ([http://equity.psu.edu/ods/doc-guidelines](http://equity.psu.edu/ods/doc-guidelines)). If the documentation supports your request for reasonable accommodations, your campus’s ODS will provide you with an accommodation letter. Please share this letter with me and discuss the accommodations as early as possible.

**Counseling and Psychological Services:** Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

- **Counseling and Psychological Services at University Park (CAPS):** 814-863-0395
- **Penn State Crisis Line** (24 hours/7 days/week): 877-229-6400
- **Crisis Text Line** (24 hours/7 days/week): Text LIONS to 741741

**Educational Equity / Report Bias:** Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harassment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the [Report Bias webpage](http://www.engr.psu.edu/CurrentStudents/educacc.asp).

**Syllabus references:** References in the course schedule (page 4) are not required reading, but are intended to support the lectures if you are having difficulty understanding the material. You will only be tested on the material and concepts discussed in class or in the quizzes. However, external references have good examples that will provide insights into the material being covered.

**Adherence to course schedule:** I expect that we may deviate slightly from the class schedule depending on the needs and pace of the class; however, significant changes will be discussed and noted in the course syllabus posted on Canvas. In the review sessions prior to each exam I will tell you specifically what will be covered. The following page provides a tentative course schedule for the semester.
<table>
<thead>
<tr>
<th>Wk #</th>
<th>Date</th>
<th>Session Topic</th>
<th>Reading</th>
<th>Deliverable</th>
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</thead>
</table>
| 1    | Jan 10, T Jan 12, R | L1: Introduction/motivation/scope  
L2: Solid/hazardous waste case studies | Vesil. Ch. 1  
LaGrega Ch.1 & 2 |                  |
| 2    | Jan 17, T Jan 19, R Jan 20, F | L3 – 4: Landfill regulations & design standards  
L5: MSW characteristics & landfill planning calc | Vesil., Ch.2-4  
LaGrega Ch.1 & 2 | Quiz #1  
HW #1 Due |
| 3    | Jan 24, T Jan 26, R Jan 27, F | L6: Leachate collection, treatment, & disposal  
L7: Bioreactions in landfills | Vesil., p.336 – 343  
Vesil., p.121 – 151 | HW#2A Due |
| 4    | Jan 31, T Feb 2, R Feb 3, F | L8: Landfill gas collection & use  
L9: Landfill closure, monitoring, & mining | LaGrega Ch.13  
Vesil., Ch.6 | Quiz #2  
HW#2B Due |
| 5    | Feb 7, T Feb 9, R Feb 10, F | L10: Materials separation & recycling  
L11: Thermal destruction (incineration) mthds.  
L12: Combustion & energy recovery calc. | Vesil., Ch.6  
LaGrega Ch.12 | HW#3A Due |
| 6    | Feb 14, T Feb 16, R Feb 17, F | L13: Intro to geohydrology  
Review for Exam I |                  | Quiz #3  
HW#3B Due |
| 7    | Feb 21, T Feb 23, R | L14: Physical-chemical properties affecting remediation; equilibrium partitioning  
**Exam I – Solid Waste Management** | LaGrega, p.105 – 118  
In Class | Exam I |
| 8    | Feb 28, T Mar 2, R | L15: Distribution of chemicals between water, vapor, and soil  
L16: Transport: advection, dispersion, & sorption | Fetter p.117 – 128  
LaGrega, p.162 – 183 |                  |
| 9    | Mar 6 - 10 | **Spring Break – no class** |                  |                  |
| 10   | Mar 14, T Mar 16, R Mar 17, F | L17: Determining hydraulic gradient & drawdown  
L18: Groundwater capture zones | Suthersan, Ch. 11 | HW #4 Due |
| 11   | Mar 21, T Mar 23, R Mar 24, F | L19: Pump & Treat  
L20: Air stripping tower design | Suthersan, Ch. 11 | Quiz #4  
HW #5 Due |
| 12   | Mar 28, T Mar 30, R Mar 31, F | L20: continued  
L21: Air sparging | S. Ch.4; Kuo,Ch. 5 | HW#6 Due  
Quiz #5  
HW#7 Due |
| 13   | Apr 4, T Apr 6, R Apr 7, F | L22: Soil vapor extraction (SVE)  
L22: continued | Suthersan, Ch. 3 | Quiz #6  
HW #8 Due  
HW #9 Due |
| 14   | Apr 11, T Apr 13, R Apr 14, F | L23: Air Stripping and SVE case study: Centre County Kepone Superfund Site  
L24: Permeable Reactive Barriers & ZVI | Suthersan, Ch.7;  
LaGrega, Ch.16 |                  |
| 15   | Apr 18, T Apr 20, R Apr 21, F | L25: Bioremediation & monitored natural attenuation  
L26: Bioremediation case study | Suthersan, Ch. 5 | Quiz #6  
HW #8 Due  
HW #9 Due |
| 16   | Apr 25, T Apr 27, R | No class (Capstone Project Showcase)  
Review for Exam II | Suthersan, Ch. 5 |                  |
| 17   | May 1 - 5 | **Exam II – Hazardous Waste Remediation Technologies** | Date & time TBD | Exam II |