BEE 4750/5750 (Environmental Systems Analysis) Syllabus

Fall 2023

Course Overview

This is a 3 credit course which is required for the Environmental Engineering major, and can only be taken for a letter grade.

Course Information

Instructor

- Vivek Srikrishnan
- viveks@cornell.edu
- 318 Riley-Robb
- MW 10-11am, Th 1-2pm

TA

- Gabriela Ackermann Logan
- ga345@cornell.edu
- 319 Riley-Robb
- Tu 10-11am

Meetings

- MWF
- 1:25-2:15pm
- 105 Riley-Robb

Course Description

Environmental systems involve multiple interacting processes, uncertainties, and potentially conflicting objectives. These dynamics can complicate analyses which focus on a single component of the system, such as an individual pollution source, or a single outcome of interest. In this course, we will adopt a systems approach to environmental quality modeling and management, including applications in air and water pollution control and solid waste management. In particular, we will:

- define systems and their boundaries;
- simulate system dynamics using computer models;
- formulate and solve decision problems for systems management;
- analyze and assess risk;
- make decisions under uncertainty; and
- explore trade-offs across competing objectives.

Learning Objectives

At the end of this class, students will:

1. Construct mathematical models of environmental systems;
2. Use systems models to simulate dynamics and outcomes;
3. Analyze environmental system risk and vulnerabilities.
4. Determine strategies for managing systems using optimization;
5. Identify the trade-offs that result from competing objectives in environmental decision -making;
6. Evaluate modeled outcomes with respect to model assumptions and limits.

Prerequisites & Preparation

The following courses/material would be ideal preparation:

- Environmental Processes (BEE 2510 or BEE 2600)
- Engineering Computation (ENGRD/CEE 3200)
- One course in probability or statistics (ENGRD 2700, CEE 3040, or equivalent)

In the absence of one or more these prerequisites, you can seek the permission of instructor.

> **What If My Programming or Stats Skills Are Rusty?**
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> If your programming or statistics skills are a little rusty, don't worry! We will review concepts and build skills as needed.

Topics

- Introduction to environmental systems,
- Modeling system dynamics
- Multiple objectives and trade-offs
- Uncertainty and risk (Monte Carlo analysis)
- Dissolved oxygen in streams and rivers; waste load allocation (system simulation)
- Modeling of watersheds & lakes (defining objectives, constraints)
- Modeling for air pollution control (model linearization; linear programming)
- Location of waste disposal facilities (integer linear programming)
- Robustness of solutions and sensitivity analysis

Course Meetings

This course meets MWF from 1:25–2:15 in 105 Riley-Robb Hall. In addition to the course meetings (a total of 42 lectures, 50 minutes each), the final project will be due during the university finals period. In addition to the work during the semester, students can expect to devote, on average, 4 hours of effort during the exam period.

Course Philosophy and Expectations

The goal of our course is to help you gain competancy and knowledge in the area of environmental systems analysis. This involves a dual responsibility on the part of the instructor and the student. As the instructor, my responsibility is to provide you with a structure and opportunity to learn. To this end, I will commit to:

- provide organized and focused lectures, in-class activities, and assignments;
- encourage students to regularly evaluate and provide feedback on the course;
- manage the classroom atmosphere to promote learning;
- schedule sufficient out-of-class contact opportunities, such as office hours;
- allow adequate time for assignment completion;
- make lecture materials, class policies, activities, and assignments accessible to students.

Students are encouraged to discuss any concerns with me during office hours or through a course communications channel.

Students can optimize their performance in the course by:

- attending all lectures;
- doing any required preparatory work before class;
- actively participating in online and in-class discussions;
- beginning assignments and other work early;
- and attending office hours as needed.

Community

Diversity and Inclusion

Our goal in this class is to foster an inclusive learning environment and make everyone feel comfortable in the classroom, regardless of social identity, background, and specific learning needs. As engineers, our work touches on many critical aspects of society, and questions of inclusion and social justice cannot be separated from considerations of systems analysis, objective selection, risk analysis, and trade-offs.

In all communications and interactions with each other, members of this class community (students and instructors) are expected to be respectful and inclusive. In this spirit, we ask all participants to:

- share their experiences, values, and beliefs;
- be open to and respectful of the views of others; and
- value each other's opinions and communicate in a respectful manner.

Please let me know if you feel any aspect(s) of class could be made more inclusive. Please also share any preferred name(s) and/or your pronouns with me if you wish: I use he/him/his, and you can refer to me either as Vivek or Prof. Srikrishnan.

> **!** Please, Be Excellent To Teach Other
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> We all make mistakes in our communications with one another, both when speaking and listening. Be mindful of how spoken or written language might be misunderstood, and be aware that, for a variety of reasons, how others perceive your words and actions may not be exactly how you intended them. At the same time, it is also essential that we be respectful and interpret each other's comments and actions in good faith.

Student Accomodations

Let me know if you have any access barriers in this course, whether they relate to course materials, assignments, or communications. If any special accomodations would help you navigate any barriers and improve your chances of success, please exercise your right to those accomodations and reach out to me as early as possible with your Student Disability Services (SDS) accomodation letter. This will ensure that we have enough time to make appropriate arrangements.

If you need more immediate accomodations, but do not yet have a letter, please let me know and then follow up with SDS.

Course Communications

Most course communications will occur via Ed Discussion. Public Ed posts are generally preferred to private posts or emails, as other students can benefit from the discussions. If you would like to discuss something privately, please do reach out through email or a private Ed post (which will only be viewable by you and the course staff).

Announcements will be made on the course website and in Ed. Emergency announcements will also be made on Canvas.

> **!** Ed Tips
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> - If you wait until the day an assignment is due (or even late the previous night) to ask a question on Ed, there is a strong chance that I will not see your post prior to the deadline.
> - But if you see unanswered questions and you have some insight, please answer! This class will work best when we all work together as a community.

Mental Health Resources

We all have to take care of our mental health, just as we would our physical health. As a student, you may experience a range of issues which can negatively impact your mental health. Please do not ignore any of these stressors, or feel like you have to navigate these challenges alone! You are part of a community of students, faculty, and staff, who have a responsibility to look for one another's well-being. If you are struggling with managing your mental health, or if you believe a classmate may be struggling, please reach out to the course instructor, the TA, or, for broader support, please take advantage of Cornell's mental health resources.

> **!** Mental Health And This Class
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> I am not a trained counselor, but I am here to support you in whatever capacity we can. You should never feel that you need to push yourself past your limits to complete any assignment for this class or any other. If we need to make modifications to the course or assignment schedule, you can certainly reach out to me, and all relevant discussions will be kept strictly confidential.

Course Policies

Attendance

Attendance is not *required*, but in general, students who attend class regularly will do better and get more out of the class than students who do not. Your class participation grade will reflect both the quantity and quality of your participation, only some of which can occur asynchronously. I will put as many course materials, such as lecture notes and announcements, as possible online, but viewing materials online is not the same as active participation and engagement. Life happens, of course, and this may lead you to miss class. Let me know if you need any appropriate arrangements ahead of time.

> **!** What If I'm Sick?
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> Please stay home if you're feeling sick! This is beneficial for both for your own recovery and the health and safety of your classmates. We will also make any necessary arrangements for you to stay on top of the class material and if whatever is going on will negatively impact your grade, for example by causing you to be unable to submit an assignment on time.

Mask Policies

Masks are encouraged but not required in the classroom, per university policy. However, the University *strongly encourages* compliance with requests to mask from students, faculty, and staff who are concerned about the risk of infection. Please be respectful of these concerns and requests if you cannot wear a mask.

Academic Integrity

> **!** Important
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> **TL;DR**: Don't cheat, copy, or plagiarize!

This class is designed to encourage collaboration, and students are encouraged to discuss their work with other students. However, I expect students to abide by the Cornell University Code of Academic Integrity in all aspects of this class. **All work submitted must represent the students' own work and understanding**, whether individually or as a group (depending on the particulars of the assignment). This includes analyses, code, software runs, and reports. Engineering as a profession relies upon the honesty and integrity of its practitioners (see *e.g.* the American Society for Civil Engineers' Code of Ethics).

External Resources

The collaborative environment in this class **should not be viewed as an invitation for plagiarism**. Plagiarism occurs when a writer intentionally misrepresents another's words or ideas (including code!) as their own without acknowledging the source. **All** external resources which are consulted while working on an assignment should be referenced, including other students and faculty with whom the assignment is discussed. You will never be penalized for consulting an external source for help and referencing it, but plagiarism will result in a zero for that assignment as well as the potential for your case to be passed on for additional disciplinary action.

AI/ML Resource Policy

As noted, all work submitted for a grade in this course must reflect your own understanding. The use and consulation of AI/ML tools, such as ChatGPT or similar, must be pre-approved and clearly referenced. If approved, you must:

- reference the URL of the service you are using, including the specific date you accessed it;
- provide the exact query or queries used to interact with the tool; and
- report the exact response received.

Failure to attain prior approval or fully reference the interaction, as described above, will be treated as plagiarism and referred to the University accordingly.

Late Work Policy

In general, late work will be subjected to a 10% penalty per day, *which can accumulate to 100% of the total grade*. However, sometimes things come up in life. Please reach out *ahead of time* if you have extenuating circumstances (including University-approved absences or illnesses) which would make it difficult for you to submit your work on time. Work which would be late for appropriate reasons will be given extensions and the late penalty will be waived.

Assessments

Grading Scale

The following grading scale will be used to convert the numerical weighted average from the assessments (below) to

Grade	Range
A	93–100
A-	90–92
B+	87–89
B	83–86
B-	80–82
C+	77–79
C	73–76
C-	70–72
D+	67–69
D	63–66
D-	60–62
F	< 59

Lab Notebooks: 20%

Some classes will involve hands-on exercises (which we will call "labs") which will give you guided practice applying the concepts and methods from class. These classes will be announced on the course website ahead

of time so anyone who is able can bring a laptop to class, and notebooks will be provided on GitHub. These labs can be done in groups; if you cannot bring a laptop to class for whatever reason, you will be able to (and are encouraged to) work with other students, though you must turn in your own notebook for grading.

Some details on lab logistics:

- Some of the labs may some time outside of class, but they will not be as intensive as a homework assignment.
- You will be required to submit a PDF of your completed notebook to Gradescope by 9:00pm by the due date (which will be approximately one week) after the lab session. Tag the answers to each question: points will be deducted if this is not done.
- While your lowest lab grade will not be dropped, late penalties will be waived for appropriate reasons discussed with the instructor (ideally ahead of time when circumstances allow).
- Rubrics will be provided for lab grading as part of the lab assignments.

Homework Assignments: 40%

Approximately 5-6 homework assignments will be assigned throughout the semester; the specifics depend on how quickly we move through the material. You will typically have 10 days to 2 weeks to work on Students are encouraged to collaborate and learn from each other on homework assignments, but each student must submit their own solutions reflecting their understanding of the material. Consulting and referencing external resources and your peers is encouraged (engineering is a collaborative discipline!), but plagiarism is a violation of academic integrity.

Some notes on assignment and grading logistics:

- Homework assignments will be distributed using GitHub Classroom. Students should make sure they update their GitHub repositories as they work on the assignments; this helps with answering questions and gives you a backstop in case something goes wrong and you can't submit your assignment on time.
- Homeworks are due by 9:00pm Eastern Time on the designed due date. Your assignment notebook (which include your writeup and codes) should be submitted to Gradescope as a PDF with the answers to each question tagged (a failure to do this will result in deductions).
- Rubrics will be provided for the homeworks as part of the assignments.
- Your lowest homework grade will be dropped. We can discuss arrangements if multiple assignments will be missed for university-approved reasons, preferably ahead of time.
- Regrade requests for specific problems must be made within a week of the grading of that assignment. However, note that regrades can cut both ways: the TA can take away points as well!

Final Term Project: 40%

This course will culminate with a term project with a topic selected from a suggested list (provided mid-semester). The goal of this project is to apply and extend the tools and approaches we will learn in class. While we encourage drawing on other classes or interests when developing and working on your project, **submitting work from another course or work which was completed prior to the course is not permitted**.

The term project will be completed in small groups (2-3 students) for students enrolled in BEE 4750 and individually for those in BEE 5750. The final deliverable for this project will be a poster summarizing the project and results. Ahead of that, you will submit the following:

- a proposal for feedback on the scope of your project; and
- a 2-3 page report on the status and history of a regulation of interest relevant to the system you are studying.

Rubrics will be provided for the components of the project.

Tentative Schedule

Date	Day	Topic
		Course Introduction
08-21	Mon	Class overview
08-23	Wed	Intro to Julia and GitHub
08-25	Fri	Lab 1: Julia Basics
		Introduction to Systems Analysis
08-28	Mon	Defining System Boundaries
08-30	Wed	Examples of Systems Dynamics
09-01	Fri	Examples of Systems Dynamics cont'd
09-04	*Mon*	*Labor Day*
09-06	Wed	Modeling Systems
		Systems Simulation
09-08	Fri	Simulating Systems with Models
09-11	Mon	Simulation Example: Dissolved Oxygen
09-13	Wed	Simulation Example: Dissolved Oxygen cont'd
09-15	Fri	Lab 2: Systems Simulation
09-18	Mon	Probability and Statistics Review
09-20	Wed	Probability and Statistics Review cont'd
09-22	Fri	Introduction to Monte Carlo
09-25	Mon	Monte Carlo Error Analysis
09-27	Wed	Lab 3: Monte Carlo
09-29	Fri	Risk Analysis for Systems
		Optimization and Systems Management
10-02	Mon	Systems Management Decisions
10-04	Wed	Introduction to Optimization
10-06	Fri	Introduction to Optimization, cont'd
10-09	*Mon*	*Fall Break*
10-11	Wed	Guest Lecture on Researching Regulations
10-13	Fri	Linear Programming
10-16	Mon	Linear Programming cont'd
10-18	Wed	Lab 4: Linear Programming with JuMP
10-20	Fri	Emissions and Plume Models
10-23	Mon	Plume Models cont'd
10-25	Wed	Power Systems Modeling and Economic Dispatch
10-27	Fri	Economic Dispatch cont'd
10-30	Mon	Mixed-Integer Programming
11-01	Wed	Unit Commitment
11-03	Fri	Unit Commitment cont'd
11-06	Mon	Network Models and Solid Waste Management
11-08	Wed	Solid Waste Management cont'd
11-10	Fri	Simulation-Optimization
11-13	Mon	Lab 5: Simulation-Optimization
		Examining Assumptions
11-15	Wed	Robustness
11-17	Fri	Sensitivity Analysis
11-20	Mon	Sensitivity Analysis cont'd
11-22	*Wed*	*Thanksgiving Break*
11-24	*Fri*	*Thanksgiving Break*
11-27	Mon	Multiple Objectives and Trade-Offs
		Decision-Making Under Uncertainty
11-29	Wed	Scenario Trees
12-01	Fri	Decision-Making Under Uncertainty cont'd
12-04	Mon	Value of Uncertainty