EAS 597 Environmental Systems Analysis

Time 1:00-2:30 Tuesday and Thursday
Location 2024 Dana

Instructors Shelie Miller (she/her)
Professor, SEAS
sheliem@umich.edu
Office Hours: Mon 2-3 (virtual only) & Weds 12-1 (in person or virtual) or by appointment
In-person: Dana 1532 OR Dana 1537 (inside Student Center)
Link to virtual queue: https://officehours.it.umich.edu/queue/508

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Office Hours: TBD

Course Description

This course takes a quantitative approach to decision-making, with particular emphasis on problems that have conflicting objectives such as economic and environmental concerns. Optimal solutions for a variety of different systems will be obtained mathematically using a variety of linear and non-linear techniques.

The purpose of this course is to train students on concrete and rigorous problem-solving tools that provide a mathematical basis for decision-making. By the end of the course, students will be able to define systems and their boundaries, optimize systems for a set of constraints and objectives, determine the sensitivity of decisions and optimal solutions based on changes in constraints, translate complex problems into mathematical frameworks, and define appropriate sets of solutions when there are multiple, competing objectives.

Example problems span natural resource management, traditional environmental engineering processes, and issues in green design and environmental policy. A Michigan Sustainability Case will be used as a course capstone to integrate major course concepts

Course Format, Attendance, and Recording Availability

The course will be taught in person. There is no formal attendance policy. If you are ill, please stay home.

Course lectures will be video recorded and posted on Canvas for any students who need to miss class for any reason or wish to review content. The videos are intended to supplement in person attendance and are not a direct substitute for in-person participation. Class recordings will not be used for any other purpose and should not be shared outside of class. By attending class, you acknowledge your consent to be recorded as a class participant. If you do not wish to be recorded, please contact me the first week of class to discuss alternate arrangements.

Resources

Textbook

There *is* a textbook for this course, available free online:

- Chinneck, J.W. Practical Optimization: A Gentle Introduction
  http://www.sce.carleton.ca/faculty/chinneck/po.html

If you are looking for additional explanations and background, any textbook on Operations Research will cover similar topics although are unlikely to provide environmentally-relevant examples

Software/Technology

We will be using Excel (equipped with the Solver plug-in) and Desmos as the main software platforms for this course. I will provide brief demonstrations of each tool throughout the semester. You should feel free to use other computational software if you wish. *It is recommended that you bring a calculator or calculating device to each class period*.

The class is largely math-based. Course content will be provided via Powerpoint and written on a board. If you already have a device with an associated stylus or touchscreen, you may find it helpful to take notes directly on the provided Powerpoint slides. If you wish to work on homework in a group that meets virtually, you may wish to familiarize yourself with either Jamboard and/or the whiteboard option within Zoom. Note that these options are *entirely optional if you already have the equipment*. **You do NOT need to purchase additional technology for this course**.

Assignments & Assessment

Homework and other activities will be assigned regularly throughout the semester. Unless otherwise indicated, homework sets may be completed by groups no larger than three, with a single solution set handed in. *Due date flexibility*: You may turn in up to 2 homework assignments or exams within 72 hours of their due date without penalty or

explanation. Additional late homework or exams will receive a 10% deduction if not turned in during class, and an additional 10% for every additional day overdue.

Any disputes regarding graded material *must be written*, and turned in with the original copy within one week after it is returned to you.

Assessment Criteria

Assignments	35%
Exams (2 takehome exams)	40%
Final Project	15%
Individual (10%)	
Evaluation of Peer Work (5%)	
Michigan Sustainability Case	5%
Participation (synchronous and/or asynchronous)	5%

Academic Honesty

Academic honesty is expected. Any violation of University of Michigan policy as described in the Student Handbook will not be tolerated and may result in a failing grade. It is expected that all assignments will be completed without consulting previous solutions. It is the responsibility of the student to be familiar with the terms of the academic honesty expectations.

COVID-Specific Information

COVID Flexibility Policies

The pandemic has created any number of personal and logistical challenges. If there is a situation that you feel is particularly impacting your progress in the course and need additional flexibility than what is already designed into the course, we hope that you feel comfortable bringing it to the attention of one of the instructors.

COVID Precautions and Guidelines

For the safety of all students, faculty, and staff on campus, it is important for each of us to be mindful of safety measures that have been required for our protection. We are all responsible for protecting the collective health of all members by being mindful and respectful in carrying out the guidelines laid out in our Wolverine Culture of Care and the University's Face Covering Policy for COVID-19. Individuals seeking to request an accommodation related to the face covering requirement under the Americans with Disabilities Act should contact the Office for Institutional Equity.

In our classrooms all students are expected to adhere to the required safety measures and guidelines of the State of Michigan and the University of Michigan, wearing a face

covering that covers the mouth and nose in all classrooms, and not coming to class when ill or in quarantine. It is important to also be thoughtful about group gatherings as well as about classroom activities and exercises that require collaboration.

Any student who is not able and willing to comply with campus safety measures for this course should contact the course instructor or their academic advisor to discuss alternate participation or course options. Students who do not adhere to these safety measures while in a face-to-face class setting, and do not have an approved exception or accommodation, may be asked to disenroll from the class.

Commitment to Help You Succeed

This can be a challenging course and your instructors are committed to helping you succeed. If you are experiencing any challenges that you believe that we can help with or provide accommodations for, please bring those to our attention as soon as possible so we can work with you.

You should always feel free to approach your instructors with any suggestions, comments, or concerns. There is also an anonymous feedback form that can be used at any point in the semester. If you would like a response, please be sure to include your name. The link to the form is: https://forms.gle/9dURSzvzrKY7UbwY8

Tentative Course Outline- assignments, content, and course structure may change to adapt to various external factors

Week

Unit 1: Systems Optimization

8/31 - 9/2

Introduction
The Systems Approach:
Establishing Objectives, Decision Variables, and Constraints
Exploring Different Types and Scales of Systems

Reading: Chapter 2: Introduction to Linear Programming

9/7 - 9/9

Solving Basic Linear Systems Problems
Graphing Decision Space and Objective Functions
Governance of the Commons as an Optimization Problem
Intro to Microsoft Solver

Reading: Chapter 3: Towards the Simplex Method

9/14 - 9/16

Introduction to Sensitivity Analysis
Binding and Non-Binding Constraints
Slack and Surplus Variables
Basis and Non-Basis Variables

Reading: Chapter 4: The Mechanics of the Simplex Method (skim)

9/21 – 9/23

Constraint Sensitivity
Discussion of solution algorithms
Finding New Optimum under Changing Constraints

Reading: Chapter 5:Solving General Linear Problems
Reading: Chapter 6: Sensitivity Analysis

9/28 – 9/30

Objective Function Sensitivity
Problems with Many Decision Variables
Non-linear problems

Reading: Chapter 16: Introduction to Non-Linear Programming

10/5 – 10/7

Non-linear problems
Sensitivity Review

10/12-10/14
Continuing non-linear problems
Take Home Exam #1

Unit 2: Decision Analysis

10/19- 10/21 - NO CLASS on 10/19 (Fall Break)

Bias in Mathematical Models

Reading: Cathy O'Neil, Weapons of Math Destruction, "Bomb Parts: What is a Model?" Broadway Books, New York NY, 2016 (See Canvas)

10/26 – 10/28
Multi-attribute problems in decision-making
Multi-criteria Decision Analysis (MCDA)
Solutions Using Alternate Objectives
Defining non-inferior sets (Pareto optimality)

Reading: See Canvas

11/2 – 11/4
MCDA (con't)
Trade-off Evaluation (Environmental, Economic, Social Criteria)
Constraint Methods
Cost-Benefit Analysis
Weighted-score/utility methods

Reading: See Canvas

11/9 - 11/11

MCDA (con't)

Analytical Hierarchy Process

Methods for generating weights and scores

11/16 – 11/18

Dynamic Programming – Solving Multi-Stage/Multi- Decision Problems

Reading: Chapter 8: An Introduction to Networks
Reading: Chapter 15: Dynamic Programming

11/23 Final Project Phase 1

11/25 Thanksgiving; NO Class

11/30- 12/2

Michigan Sustainability Case

Reading: Model T Michigan Sustainability Case:
Assembling Our Transportation Future: How could policies in the early 20th century have shaped more sustainable transportation systems?

12/7-12/9

Life Cycle Assessment and using Systems tools for Improvement Analysis

Reading: See Canvas

Take Home Exam #2