ORI 390Q.8
Systems Modeling
Spring 2023

Professor

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ETC 5.128D

Course Description

Many of the most pressing policy challenges of our time transcend traditional disciplinary boundaries and necessitate the use of systems models to analyze possible solutions. This course will show how methodological approaches from operations research and industrial engineering can be applied to construct such models. Particular emphasis will be devoted to models that combine concepts from engineering, economics, natural sciences, and policy. The featured models will showcase a broad range of methodological approaches, such as optimization, simulation, dynamic programming, decision analysis, stochastic processes, and dynamical systems. Example applications will be drawn from fields including energy and climate change, health policy, transportation, and national security. More generally, the course will train students to build mathematical models that represent complex real-world problems.

Prerequisites

To take this course, students should have at least one prior course in optimization — for example, a course in linear programming (ORI 391Q.5). Some familiarity with economics is helpful but certainly not expected. For other methods such as decision analysis, stochastic processes, and simulation, this course is designed to introduce you to these modeling approaches rather than cover them in great technical depth, so no prior coursework is expected.

Lecture Time and Format

Lectures will be held on Tuesdays and Thursdays from 9:30 – 11:00 AM in ETC 7.111.

Office Hours

I will hold office hours from 1:00 – 2:00 PM on Tuesdays and from 4:00 – 5:00 PM on Thursdays in ETC 5.128D. If you would like to meet with me outside of my normal office hours, then please email me and state the specific issue or topic you wish to discuss.

Required Textbook

There is no required textbook. Readings will be provided via the course website and will consist mainly of scholarly articles from the academic literature.

Materials and Equipment

Part of the lecture time will often be reserved for you to practice developing a model to represent and analyze some real-world problem. For this reason, you should have a notebook, something to write with, and a scientific calculator / computer available during the lectures. On some of the assignments you will likely want to implement your model as a computer program. The particular format you choose (e.g., Excel, MATLAB, AMPL, GAMS, etc.) is up to you.

Course Website

All course materials will be posted on *Canvas*. I will generally post lecture slides after each lecture. My pedagogical view informed by experience is that students benefit more from lectures when I do not provide the slides beforehand, for several reasons. The ability to filter and organize information in real time is an important skill, and taking notes this way helps students fully absorb concepts. Furthermore, participation and open discussion are more important components in this course than they are in more standard lecture courses, so the slides themselves will not reflect all of the knowledge, ideas, and insights that arise in the classroom.

Grading

Your final grade will be calculated using the following weights:

Modeling Assignments – 50%
Team Project Presentation – 15%
Team Project Report – 25%
Participation – 10%

Letter grades will be determined according to the following conversion:

A	93% or greater
A−	90% to <93%
B+	87% to <90%
B	83% to <87%
B−	80% to <83%
C+	77% to <80%
C	73% to <77%
C−	70% to <73%
D+	67% to <70%
D	63% to <67%
D−	60% to <63%
F	<60%

I may choose to raise your final grade by curving or some other method. However, these adjustments will never lower your grade.

Attendance and Participation

I will not take attendance or formally penalize you for missing a lecture. However, at the end of the semester, participation will count as 10% of your final grade in the course. Systems models are best developed through a team effort in which individuals with different skills and areas of expertise work together. Many of the application areas we will cover are simply too broad and interdisciplinary for any individual to tackle alone. The purpose of including participation in your final grade is to encourage you to exchange ideas with your fellow students and build better models through effective teamwork.

Modeling Assignments

A total of four modeling assignments will be given over the course of the semester. You are not allowed to work on these assignments in teams. You must complete them individually and submit your own write-ups. Each modeling assignment will provide a brief overview of some real-world problem, and ask you to develop a model that enables you to analyze the problem and arrive at useful insights and solutions.

Your write-up should include the following elements and be approximately 5 – 7 pages in length. The maximum length is 7 pages and any additional content beyond 7 pages will not be factored into your grade.

1. **Issue Summary**
   Give a brief overview of the problem or issue you are modeling and why it is important.
2. **Model**
   Provide a clear, formal, mathematical description of your model.
3. **Results**
   Show the results you are able to derive and generate using your model.
4. **Conclusions**
   Acknowledge the strengths and weaknesses of your model. Summarize what you have learned from it.

If you implement your model as a computer program, you may wish to include the code. However, the code will never be treated as a substitute for any of the write-up components listed above. For example, even if you include your code, you must still have a clear, formal, mathematical description of your model in the write-up. The grades you receive on the modeling assignments will reflect the appropriateness of your model for the problem at hand; the relevance and accuracy of your results; your ability to properly interpret the model and results; and the quality and clarity of your writing and presentation.

Team Project

A major part of the course is the team project. You will work on the project in teams of three or four students over the course of about a month. For the team project, you are free to choose the problem or issue you want to model and analyze (subject to my approval). Be creative, and have fun with it! At the end of the semester there will be two deliverables associated with the team project. First, you will present your project to the class in lecture. Second, you will submit a report as a team. This report should be structured similarly to the modeling assignment write-ups, but should be more extensive and include additional components such as a literature review and sensitivity analysis.

Learning Outcomes

By the end of this course, students will be able to …

- Develop original mathematical models of complex decision-making problems and analyze them to obtain useful solutions and insights.
- Combine methods from operations research and industrial engineering with concepts from other disciplines to analyze potential solutions to societal grand challenges.

- Summarize some seminal contributions to the academic literature in numerous application domains and understand their relevance to current problems.
- Critically reflect on all of the assumptions and choices that underlie a particular mathematical model.
- Consider the pros and cons of using different modeling paradigms (e.g., optimization, simulation, dynamical system) to analyze a particular problem and choose the most appropriate paradigm.
- Implement and solve mathematical models in the computer programming platform(s) of their choice.
- Work effectively in teams on complex, open-ended problems.
- Clearly present a mathematical model and the results obtained from analyzing it in written and oral forms.

Honor Code

I expect everyone to follow the UT Honor Code, which states:

"The core values of the University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community."

All suspected violations of the Honor Code will be referred to the Administration for adjudication. If you witness or become aware of other students committing academic integrity violations, please report the issue to me, or directly to Student Conduct and Academic Integrity. For more information, please see: http://deanofstudents.utexas.edu/conduct/index.php

I have formally disciplined students for Honor Code violations in the recent past, and I will do so again without hesitation if any incidents occur in this course. Violating the Honor Code undermines the quality and integrity of your academic experience and degree and is unfair to the majority of students who go about their work the right way. Cheating can easily result in probation, suspension, or expulsion from the University. Trust me – it's not worth it!

Disability Statement

Students with disabilities who require special accommodations need to get a letter that documents the disability from the Disability and Access office within the Division of Diversity and Community Engagement (contact information below). This letter should be presented to me at the beginning of the semester and necessary accommodations should be discussed at that time.

Disability and Access
512-471-6259
access@austin.utexas.edu
http://diversity.utexas.edu/disability/

Feedback

I want all of you to have a top-notch learning experience and want to be the most effective instructor I can be. I would be happy to receive any feedback you might have throughout the

semester and promise to give careful consideration to any suggestions you provide. At the end of the term you will all be asked to fill out the standard Course Evaluation survey. I would greatly appreciate if you could complete this survey thoroughly. It serves as an important indication of my teaching ability and will allow me to improve this course for future students.

Tentative Course Schedule

The course schedule below is subject to change and will be updated as frequently as possible.

Legend for Methodologies Showcased

OP = Optimization	**DA** = Decision Analysis
ME = Microeconomics	**EQ** = Equilibrium
DP = Dynamic Programming	**OC** = Optimal Control
SI = Simulation	**DS** = Dynamical System
MD = Markov Decision Process	**PR** = Probability

Date	Application Area	Topic	Items Assigned	Items Due
1/10	Introductory Material	Introduction to Modeling		
1/12	Introductory Material	Crash Course in Economics		
1/17	Modeling Practice	Group Exercise: Subway Ticket Enforcement	Modeling Assignment 1	
1/19	Ecological Systems	Population Ecology **[DS]**		
1/24	Natural Resource Management	Fossil Fuel Extraction **[OC]**		
1/26	Natural Resource Management	Forestry **[ME]**		
1/31	Winter weather cancellation		Modeling Assignment 2	Modeling Assignment 1
2/2	Winter weather cancellation			
2/7	Electricity	Capacity Planning **[OP]**		
2/9	Electricity	Electricity Storage **[OP]**		
2/14	Energy and Climate Change	Carbon Capture and Storage **[OP]**	Modeling Assignment 3	Modeling Assignment 2
2/16	Energy and Climate	Climate Change		

	Change	Mitigation **[OP]**		
2/21	Transportation	Shared Autonomous Vehicles **[SI]**		
2/23	Modeling Practice	Group Exercise: Look Back at Assignment 2		
2/28	Transportation	Ridesharing Platform **[EQ]**		Modeling Assignment 3
3/2	Cities	Urban Form **[EQ]**	Modeling Assignment 4	Team Project Proposal Friday 3/3, 5pm
3/7	Cities	Open Space **[EQ]**		
3/9	Technological Change	Top-Down Diffusion Models **[SI,DS,MD]**		
3/21	Technological Change	Bottom-Up Adoption Models **[DP]**		
3/23	Electricity	Grid Resilience **[PR, SI]**		Modeling Assignment 4
3/28	Modeling Practice	Group Exercise: Marketing Strategy		
3/30	Health Policy	HIV Transmission **[DS]**		
4/4	National Security	Cargo Screening **[DA]**		
4/6	National Security	Attacker-Defender Models **[OP]**		
4/11	Wrap-Up	Tips for Final Presentations and Reports		
4/13	Wrap-Up	Reflection on Course Themes		
4/18	Final Deliverables	Team Project Presentations		Team Project Presentations

4/20	Final Deliverables	Team Project Presentations		Team Project Presentations
4/25	Final Deliverables	* No lecture *		Team Project Reports