ORI 390Q.8
Systems Modeling
Spring 2021

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

There are no formal prerequisites for this course other than a solid quantitative background and enthusiasm for mathematical modeling. A prior course in optimization (e.g., linear programming) is highly advantageous. Some familiarity with economics is helpful but certainly not expected. The first week of the semester will include a crash course in these subjects to serve as a review for some and an introduction for others. 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 3:30 – 5:00 PM. Due to the ongoing COVID-19 pandemic, all lectures will be held virtually using the Zoom platform within Canvas. I will record videos of all lectures and make these recordings available on the course website, so that you can view them at any time. However, as explained below under Attendance and Participation, participating in the class discussions during lecture is an important part of Systems Modeling and participation is included in your grade to reflect this.

Office Hours

I will hold virtual Zoom office hours from 1:00 – 2:00 PM on Tuesdays and from 2:00 – 3:00 PM on Thursdays. If you need to meet with me outside these office hours, please email me stating the specific problem or topic you wish to discuss.

In-Person Meetings by Request

While the core components of this course will be conducted virtually, you may request a one-on-one, in-person meeting with me if you would like. The availability of this option throughout the

semester will depend on the current state of the COVID-19 pandemic at any given time. For any in-person meeting, face coverings must be worn properly at all times.

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 and video recordings after each lecture.

Grading

Your final grade will be calculated using the following weights:

Modeling Assignments – 40%
Team Project Presentation – 15%
Team Project Report – 30%
Participation – 15%

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 15% 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 five pages in length:

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.

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. Given that this course will primarily take place online this semester, I view this responsibility as more important than ever, and I strongly urge you to do the right thing and speak up if you know of any Honor Code violations taking place in this course. For more information, please see: http://deanofstudents.utexas.edu/conduct/index.php

Disability Statement
Students with disabilities who require special accommodations need to get a letter that documents the disability from the Services for Students with Disabilities area 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. Five business days before an exam the student should remind me of any testing accommodations that will be needed.

Services for Students with Disabilities
512-471-6259
ssd@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 College of Engineering evaluation form. I would greatly appreciate if you could complete this evaluation 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	

Date	Application Area	Topic	Items Assigned	Items Due
1/19	Introductory Material	Introduction to Modeling		
1/21	Introductory Material	Crash Course in Economics		
1/26	Modeling Practice	Group Exercise: Subway Ticket Enforcement	Modeling Assignment 1	
1/28	Ecological Systems	Population Ecology **[DS]**		
2/2	Natural Resource Management	Fossil Fuel Extraction **[OC]**		
2/4	Natural Resource Management	Forestry **[ME]**		
2/9	Health Policy	HIV Transmission **[DS]**		Modeling Assignment 1
2/11	Health Policy	COVID-19 **[OP]**	Modeling Assignment 2	
2/25	Electricity	Capacity Planning **[OP]**	Modeling Assignment 3	Modeling Assignment 2 (Original)
	Electricity ***Canceled — Weather***	Electricity Storage **[OP]**		
3/2	Energy and Climate Change	Climate Change Mitigation **[OP]**		
3/4	Modeling Practice	Group Exercise:		Modeling

		Carbon Leakage		Assignment 2 (Extended)
3/9	Energy and Climate Change	Carbon Capture and Storage **[OP]**		
3/11	Natural Disasters	Prevention, Preparedness, Response **[OP]**		Modeling Assignment 3
3/23	Transportation	Shared Autonomous Vehicles **[SI]**		
3/25	Transportation	Ridesharing Platform **[EQ]**	Modeling Assignment 4	Team Project Proposal
3/30	Modeling Practice	Group Exercise: Look Back at Assignment 2		
4/1	Cities	Urban Form **[EQ]**		
4/6	Cities	Open Space **[EQ]**		
4/8	Cities	Urban Planning and GHG Emissions **[OP]**		Modeling Assignment 4
4/13	Technological Change	Top-Down Diffusion Models **[SI,DS,MD]**		
4/15	Technological Change	Bottom-Up Adoption Models **[DP]**		
4/20	Modeling Practice	Group Exercise: Marketing Strategy		
4/22	National Security	Cargo Screening **[DA]**		
4/27	National Security	Attacker-Defender Models **[OP]**		
	Sports ***Canceled — Weather***	Baseball **[DA]**		
	Sports ***Canceled — Weather***	Football **[DP]**		

4/29	Wrap-Up	Tips for Final Presentations and Reports		
5/4	Wrap-Up	Reflection on Course Themes		
5/6	Final Deliverables	Team Project Presentations		Team Project Presentations
5/11	Final Deliverables	* No lecture *		Team Project Reports