Course Description

This is a course in technique that is designed as a complement to other substantive and theoretical courses you have taken or will take in public policy and/or the social sciences. We will learn how to model the real world with three goals:

1. to better understand how things work
2. to use our ideas about how things work to make predictions about the consequences of alternative courses of action
3. to communicate ideas about how things work in a manner that helps people understand and supports critical discourse about how things work and choosing between alternatives

(Th 1.20) What is a Model? What is Simulation?

1. Class I -- Beginnings
   ○ See also Wikipedia articles on System, conceptual model, economic model, ecosystem model, mathematical model, enterprise modelling, system dynamics, systems thinking.
   ○ Problem Set : Pre-Course Final Exam due Monday 9 a.m.

(Tu-Th 1.25-27) Flow Charts as a deterministic model of process and protocol

1. Lecture I
   ○ Read Wikipedia articles on Flow Charts
   ○ Read (and work through examples)
     ■ Flow Charts for Simple Tasks: Tutorial with exercises at Univ Plymouth, UK
     ■ Flow Charts for Classification: Tutorial with exercises at Univ Plymouth, UK
   ○ Read An overview by HCl consulting in Australia
2. Problems 1-5
3. Lab
   ○ Read Excel help on the "if" function. (About.COM)
   ○ Skim through all the entries on MS Excel Help page for Entering and editing data
Read MS Excel Help: Overview of formulas
Read MS Excel Help: Switch between relative, absolute, and mixed references

4. Problems 8, 9, 10
5. Lecture II
6. Problems 14

- hide details

(Tu-We 2.1-2) Charts and Diagrams

1. Class I: Standard Statistical Charts (Bar, Column, Line, Scatterplots, Pie Charts); Tables vs. Charts; a Menagerie of Diagrams
   - Read Charts in Wikipedia
   - Watch http://www.gapminder.org/videos/the-joy-of-stats/

2. Lab: Excel charts; Chart art and discipline; Charts in documents
   - Read TBA
   - Problems

(Th 2.3) Project Management

1. Class I: Some Tools for Project Management
   - Read MindTools. Critical Path Analysis and PERT Charts
   - Read NetMBA. PERT
   - Read Wikipedia. Gannt Charts
   - Read Wikipedia. Program Evaluation and Review Technique (PERT)
   - Read Wikipedia. Project Management
   - Read Glossary of project management
   - Problems

2. Lab
   - Read TBA

Problem Set Math Prereqs

(Tu-Th 2.8-10) Back of the Envelope Calculations

1. Class I: Ballpark Guesses are not Guesses
   - Read Mitchell N Charity <mcharity@lcs.mit.edu> A View from the Back of the Envelope
   - Read Wikipedia. "Back of the envelope calculation"
   - Read Louisiana Lessons. 1996. Classic Fermi Questions with annotated solutions
   - Read Wikipedia. Fermi Problem
   - Read mittechtv. 2010. BLOSSOMS - The Art of Approximation in Science and Engineering: How to Whip Out Answers Quickly
   - Problems

(no lab)
(Tu-We 2.15-23) Decision Analysis

1. Class I: Decision Trees and Flow Charts; Probability Refresher; Expected Value; Conventions: choice, chance, and payoffs
   ○ Read Wikipedia on Decision Analysis
   ○ Read Stokey & Zeckhauser, ch. 12, pp. 201-215
   ○ Problems
2. LAB
3. Class II: Working Backward
   ○ Read Stokey & Zeckhauser, ch. 12, pp. 215-221
   ○ Problem Set 2
4. Class III: Including Risk; The Value of Testing; Tree flipping and Imperfect Tests
   ○ Read Stokey & Zeckhauser, ch. 12, pp. 221-236
   ○ Problem Set 3
5. Optional
   ○ Read Stokey & Zeckhauser, ch. 12, pp. 236-254

(Th 2.24) EXAM I

(2.22) Cost/Benefit Analysis

1. Class I Cost Benefit Analysis
   ○ Read Wikipedia on Cost Benefit Analysis
   ○ Read Stokey & Zeckhauser, ch. 9, pp. 134-45
   ○ Problems
2. LAB
   ○ Problems
3. Class II
   ○ Read Stokey & Zeckhauser, ch. 9, pp. 146-58.
   ○ Problems

(3.1) Discounting

1. Class I: Discounting Basics; The Math of Present Value and Future Value
   ○ Read Stokey & Zeckhauser Ch. 10, "The Valuation of Future Consequences: Discounting"
   ○ Problems
2. LAB
   ○ Problems
3. Class II: Concepts: internal rate of return, payback; Where do discount rates come from?
   ○ Read TBA
   ○ Problems

(Th 3.17) Midterm EXAM DT,CBA, D

Spring Break 21-25 March
1. **Class I: Stock and Flow**
   - Read Wikipedia articles on Stock and Flow and Systems Dynamics Models
   - Read Kirkwood, Ch. 1 "System Behavior and Causal Loops"
   - Read Kirkwood, Ch. 2 "A Modeling Approach"
   - Problems

2. **LAB**
   - Problems

### (4.5) Monte Carlo Simulation

1. **Class I: Monte Carlo Simulation**
   - Read Wikipedia article on Monte Carlo Method. Especially sections on Overview, applied statistics, and "what-if" scenarios
   - Read MS Excel Help: "Introduction to Monte Carlo simulation"
   - Read Microsoft. Introduction to Monte Carlo simulation
     - Describes technique and how to implement in Excel. Includes downloadable spreadsheet and problem set.
   - Read Sedgwick & Wayne. Monte Carlo Simulation, Section 9.8 in *Introduction to Programming in Java*.
   - Read Wolfram Mathworld. Monte Carlo Method
   - Problems

2. **LAB**
   - Problems

### (4.12) Markov Models

1. **Class I:Markov Models**
   - Problems

2. **LAB**
   - Problems

### (4.19) EXAM on SaF, MC, M
Maybe

**Queuing Models**

1. **Class I: Queuing Models**
     - Note that r.v. = "random variable"
   - Problems
2. **LAB**
   - Problems

**Agent Models**

1. **Class I: Agents + World = Simulation**
   - Read TBA
   - Problems
2. **LAB**
   - Problems

**Linear Programming**

1. **Class I: Linear Programming**
   - Read Stokey & Zeckhauser, Ch.11, "Linear Programming"
   - Problems
2. **LAB**
   - Problems

**Difference Equations**

1. **Class I: Difference Equations**
   - Read TBA
   - Problems
2. **LAB**
   - Problems

**Course Policies**

+ Attendance
+ Class Preparation and Assignments

**Grading Policy**
Your grade for this course will be based on 1) your ability to understand and analyze the various topics and perspectives presented in the readings and during class, and 2) to communicate in writing effectively and with sophistication. Failure to complete all course assignments ON TIME may result in a failing grade. In general, no late papers or make-up work will be permitted. If there is an emergency, an exception to the late policy may be made. In this case, late assignments may be accepted with a grade deduction per day they are late (extreme emergencies excepted).

**How will my work be evaluated and graded?**

The evaluated work for this course will consist of problem sets, mid-semester exams, and a final exam.

**Labs/Problem Sets**

Each lecture/lab session may have an associated problem set covering material from a section of the course and employing techniques introduced. Overall, each problem set will be graded on a scale of ten points with 12 = demonstrated excellence, 10 = demonstrated competence, 7 = satisfactory, but less than full competence, 4 = insufficient, 0 = not submitted. Insufficient results must be resubmitted within one week of their return for a satisfactory grade.

**Definitions**

Please keep in mind that grades are not measures of effort, stress, time, or other personally variable factors. They represent an assessment of competence demonstrated in the artifact of problem solutions or answers on an exam.

Final course grades will be translations of semester achievement into the conventional scale:

A = Excellent. The work (1) consistently demonstrated competence in skills under consideration, (2) results essentially correct; the final product (3) communicated clearly what was done, how, and why, and is presented in a (4) professional manner. Probably a weighted average over 8 on course assignments/exams.

B = Satisfactory. Fundamentally sound as far as demonstration of competence, but falls short on one or more of above criteria. Probably a weighted average between 6 and 8 on course assignments/exams.

B- = Weak Satisfactory. Uneven performance or consistently middling performance with significant gaps. Probably a weighted average of 5-6 on course assignments.

C,D = Unsatisfactory. Unacceptably low achievement. Probably a weighted average under 5 on course assignments/exams.

Keep in mind that the purpose of these exercises is two-fold. First, you are practicing applying this material to your own project. Second, it is an opportunity to demonstrate your competence. With the latter in mind you need to shift from thinking of it in terms of "what is required?" and "what does the teacher want?" to "what have I learned how to do and how can I demonstrate it?" Everything you submit should be complete and stand on its own as a document. NEVER submit "naked" answers. Never omit your reasoning. Never assume that the reader (me), knows something and doesn't need to read it again.

**Accessibility**

To request academic accommodations due to a disability, students should contact Services for Students with Disabilities in the Cowell Building. If you have a letter indicating you have a disability which requires
academic accommodations, please present the letter to me so that I will be able to provide the accommodations that you need in this class.

**Assessment**

Students in this class will learn the following skills. Ample opportunity to demonstrate these skills will be available in labs, in-class exercises, and exams.

**What is a Model? What is Simulation?**

- Hide list

1. Give an ordinary language explanation of what a model is.
2. Describe range of things that function as models in the world
3. Describe range of models used in social and policy sciences.
4. Distinguish simulation from modeling.
5. Give an example of simulation in social and policy sciences

**Excel**

- Hide list

1. Basics
   - Use formula to calculate values based on other cells.
   - Autofill (values and formulae), use of relative and absolute cell references in formulae for autofill
   - Formatting. Alignment, font, borders and fill, number format, decimal places, conditional formatting.
   - Workspace control. Row and column width, merging cells, hiding columns, split panes, wrapping text, inserting newline in cell, text
   - Rename, move, copy worksheets.
   - Name a cell or cell range
2. Simple Tasks
   - Create a percentage table from a data count table.
   - Use frequency() to convert list of data values into histogram
   - Use formulas, relative/absolute references, and autofill to create a "times table"
   - Pivot tables
     - Create. One, two and multidimensional. Select different value field settings. Convert to text appropriate table. Use to clean data.
     - Basic descriptive statistics with sum(), average(), mode(), median(), stddev(), frequency(), correl functions.
3. Charts
   - Simple data range to column, bar, pie, scatter. Label and format axes, chart titles, legends, gridlines.
   - Add, remove, edit data series. Format data series (change line, point styles, add/customize labels)
   - Add/remove/format/label trendlines
○ De-junkify charts.
○ Copy charts to Word. Remove borders, select colors for greyscale reproduction.
○ Copy charts to PowerPoint.

4. Advanced
○ Add controls for interaction (sliders, spinners, etc.) to a worksheet

MS Word

- Hide list

1. Power Formatting
   ○ Styles
   ○ Page numbers
   ○ Sections, headers, footers
2. Professional Bits
   ○ Captions and crossreferences
   ○ Drawing
   ○ Inserting images, charts, etc. and formatting text flow around them.
   ○ Tables
   ○ Equations
3. Power Editing
   ○ Sophisticated search and replace
   ○ Paste options
   ○ Customizing autocorrect
   ○ Footnotes/endnotes
4. Power Tools
   ○ Tables of contents, etc.
   ○ Track changes, versions, comments
   ○ Mailmerge
   ○ Citation and Bibliography tool

Flow Charts

- Hide list

1. Basic rules
2. Stepwise Refinement
3. Time and Division of Labor
4. Translate complicated instruction sequence into standard flowchart
5. Use flowchart to demonstrate stepwise refinement and blackboxing
6. Interpret complex flow chart that includes multiple divisions of labor
7. Offer critique and correction to a poorly form flowchart
8. Identify and respond to typical concerns and caveats

Decision Analysis
1. Apply basic concepts of probability (events and outcomes, and, or, conditional)
2. Calculate expected monetary value
3. Translate verbal description of decision process into descriptive decision tree and vice versa
4. Use simple tree to assess a set of alternatives under uncertainty
5. Use decision tree to calculate the value of information provided by a test (how much should we be willing to pay for information?)
6. Solve a problem that incorporates risk aversion
7. Solve a problem that incorporates imperfect tests
8. Explain relationship of decision trees and utility theory
9. Explain/distinguish related concepts: choice/chance nodes, exhaustive/mutually exclusive, folding-back, imperfect tests, risk-aversion, the value of information, utility theory
10. Describe indications and contraindications
11. Identify and respond to typical concerns and caveats

Charts, Tables, and Diagrams

1. Identify when bar, column, line, pie, and scatter plots are appropriate
2. Construct and fully document charts of various types
3. Distinguish charts and tables
4. Articulate and implement a protocol for naming data tables
5. Ability to create table in Excel, transfer to Word and elegantly format and correctly document
6. Interpret basic PERT, Gantt, and Sankey diagrams
7. Identify and respond to typical concerns and caveats

Cost/Benefit Analysis

1. Appreciate and explain basic idea of (global/aggregate) net benefit and potential compensation
3. Identify four choice scenarios and the CB protocol appropriate to each.
4. Produce and interpret flow charts describing these
5. Explain/distinguish related concepts: cost, benefit, net, marginal, benefit/cost ratio, willingness-to-pay, compensation, cost-effectiveness,
6. Identify and respond to typical concerns (especially separation of CB and distributional issues) and caveats

Discounting
Explain in plain language what discounting is and why it is important.
2. Dexterity in application of compound interest formula
3. Given a schedule of costs and benefits and a discount rate, use Excel to calculate NPV both using NPV() and related functions and "by hand"
4. Explain where discount rates come from in practice and identify rates currently used in several well known contexts
5. Qualitatively interpret generic discount rate/PV curves
6. Explain/distinguish related concepts: present value, discount rate, internal rate of return, break even and payback periods, opportunity cost
7. Identify and respond to typical concerns and caveats around discount rates.

Randomness as a Tool: Random Experiments and Monte Carlo Simulation

Apply basic concepts of probability (events and outcomes, and, or, conditional)
2. Craft an argument in favor of random trials as gold standard
3. Demonstrate understanding of random selection from different shape distributions (uniform, normal, Poisson)
4. Use rand() and related functions and data table function in Excel to generate Monte Carlo simulation
5. Suggest indications and contraindications, identify and respond to typical concerns and caveats

Stock & Flow Models

Translate system description into stock and flow diagram
2. Translate diagram into difference equations
3. Describe generic system performance possibilities
4. Find a good source for refresher on system dynamics
5. Concepts and Terms: positive/negative feedback, causal loops, equilibrium
6. Suggest indications and contraindications, identify and respond to typical concerns and caveats

Project Management

Describe components of logic model, interpret and criticize logic model, translate project description into conventional logic model
2. Demonstrate familiarity with existence of broad range of project management
strategies
  ○ Gantt charts, PERT, CPM, stakeholder analysis, ISO 900x Standards
3. Explain/describe what a PERT chart and a Gantt chart are.
4. Explain/describe related concepts: critical path, scope, deliverables, tasks, work breakdown, activities, sequence, resource requirement, time and cost, schedule, budget, business plan, monitoring, control, outcomes assessment, evaluation
5. Identify and respond to typical concerns and caveats

Back of the Envelope Calculations

- Hide list

1. Describe general principle
2. orders of magnitude
3. Apply simple units of analysis assessment to ball park a problem
4. Demonstrate awareness of making parallel assumptions (i.e., all optimistic or all pessimistic) in setting up an approximation
5. Use BOTEC to come up with high and low estimates for a problem
6. Identify and respond to typical concerns and caveats

Markov Models

- Hide list

1. Describe general idea and types of problems that lend themselves to Markov model
2. Describe requirements of a system to be eligible and how to solve "something else" problems
3. Translate between description, transition matrix, diagram
4. From diagram, set up equations in Excel, chart results, identify equilibrium states
5. Terms and concepts: Markov chain vs. Markov process, regular, absorbing, cyclical, state, absorbing state, transient state, eigen vector, transition matrix
6. Suggest indications and contraindications, identify and respond to typical concerns and caveats

Queuing Models

- Hide list

1. Describe general idea and types of problems that lend themselves to queuing model
2. Describe requirements of a system to be amenable to use of QM
3. Translate between description, diagram, equations
4. Explain why wait time is deadweight loss and nominal fees can be efficient
5. Terms and concepts: arrivals, servers, Poisson distribution/process, wait time, deadweight loss
6. Suggest indications and contraindications, identify and respond to typical concerns and caveats
Agent Models

- Hide list

1. Suggest indications and contraindications, identify and respond to typical concerns and caveats

Linear Programming

- Hide list

1. Understand vocabulary and concepts associated with linear programming.
2. Translate word problems into inequalities for use in linear programming model.
3. Be able to solve linear programming model graphically
4. Translate simple linear programming problem into Excel and use solver to find optimum.
5. Suggest indications and contraindications, identify and respond to typical concerns and caveats

Difference Equations

- Hide list

1. Understand notation and be able to write out equations for simple difference equations
2. Translate a problem into difference equations
3. Implement difference equations model in Excel and graphically display outcome
5. Suggest indications and contraindications, identify and respond to typical concerns and caveats