AEM 494
Introduction to System Dynamics Modeling (4 Credits)
Fall 2005

Instructor:
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Class Hours

Tuesday and Thursday, 2:55-4:10 pm, 163 Morrison Hall

Course Lab

Wednesday, 2:55-4:10pm, 60 Warren Hall (Basement Computer Lab)

A tentative schedule for the course material is attached. The schedule may be modified as necessary during the semester.

Office Hours

Wednesday, 1:30 – 2:45 pm
If you would like to arrange an appointment for some other time, please schedule one in advance by email or phone

Required Text

Sterman, John D. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Irwin McGraw-Hill, 2000. [Don't be mislead by the title of this text. Although many of the applications have to do with business issues, it contains surprising breadth of disciplinary coverage, consistent with the idea that there are various archetypal structures that generate dynamic behaviors].

Supplementary Text
Ford, Andrew. *Modeling the Environment: An Introduction to System Dynamics Modeling of Environmental Systems*. Island Press, 1999. This text may be of particular interest if you are interested in modeling agricultural or environmental systems.

Additional readings are in the packet of course materials. Other readings may be assigned as appropriate during the semester, and will typically be distributed electronically.

Course Objectives and Description

The overall learning objective of this course is for you to develop a basic knowledge of concepts important in system dynamics modeling, facility with Vensim® dynamic simulation software, and basic evaluation of dynamic simulation models. This course will cover the following:

1) The role that dynamic simulation modeling can play in decision making (complementing other tools and "mental models");

2) The basic philosophy (values, beliefs) of modeling using system dynamics;

3) The standard iterative modeling process using SD;

4) Fundamental modes of dynamic behavior and the structures that create them;

5) System diagramming (mapping) tools that can be used to better understand systems and facilitate their mathematical modeling. These include Causal Loop Diagrams (CLD) and Stock-Flow Diagrams (SFD);

6) The dynamics of simple stock-flow structures;

7) The importance and specification of delays in systems;

8) Additional common elements of systems, such as Co-flows and Aging Chains;

9) Introductory concepts in modeling decision making, nonlinear relationships, expectation formulation, and supply chains;

10) The basic mathematics of numerical integration;

11) Basic concepts in model evaluation

Because this is an introductory course, we will not cover all of this material to the level of detail that some of you may be interested in, or require, for your own modeling projects. This course, however, should provide you with sufficient background for further self-study or courses in system dynamics (e.g., there are online courses in various aspects of SD offered at Worcester Polytechnic Institute). Examples of the application of SD concepts will be drawn from a variety of disciplines, but emphasis will be given to applications to agriculture and natural resources.

Assignments

There will be **assigned readings** (sometimes more than one) for each lecture. Because keeping up with the readings will be an important to achieve the learning objectives for the course, *I reserve the right to give unannounced short quizzes to determine whether the class is consistently reading the material prior to the lecture for which it is assigned.*

There will be brief **homework assignments** for nearly every class meeting. These exercises are designed to help reinforce the basic concepts that you will read about in the Sterman text and we will discuss in class. In general, your responses to these should be brief (less than one type-written page)

A **final project paper** will be due one week after the final class meeting on December 1. This paper will involve the evaluation and use of a previously-constructed model of either a) a new and rapidly growing business enterprise, or b) the application of technology to increase productivity in agriculture. Further details on the project will be given in mid-November.

Grading

Your grade in the course will be determined based on the following:

Class participation (i.e., whether you have read the assigned readings and are prepared to contribute to class discussions)..... 10%

Homework assignments..... 30%

Two in-class exams..... 40%
(The exams are scheduled for *29 September* and *3 November;* more information will be provided about the exams closer to the scheduled exam dates.)

Final project report (Due *5pm 8 December*)..... 20%

COURSE SCHEDULE. FALL 2005.

Week	Date	Topic	Homework Assignment	Readings
				Italics indicates material from Reading Packet
1	25-Aug	Introduction	*None*	None
2	30-Aug	Learning in Dynamic Systems	Unintended consequences and policy resistance	Sterman, Chapter 1
	1-Sep	**No Lab**	--	--
	2-Sep	What is System Dynamics?	Methods, beliefs, values, priorities	Sterman, Chapter 2, *Meadows and Robinson, Chapter 1 and 2, Nicholson, Systems Evolution, Ford Chapter 1*
3	6-Sep	The SD Modeling Process	Problem articulation and the reference mode	Sterman, Chapter 3; *Ford, Chapter 15 & 16*
	7-Sep	Introduction to Vensim	--	*Introduction to Vensim (Repenning)*
	8-Sep	Fundamental Modes of Dynamic Behavior	Identifying feedback structure from system behavior	Sterman, Chapter 4 (4.1)
4	13-Sep	Fundamental Modes of Dynamic Behavior	Identifying the limits to growth	Sterman, Chapter 4 (4.2-4.3)
	14-Sep	Hands-on example (Workforce Inventory)	--	Chapter 3 Vensim User's Guide
	15-Sep	Causal Loop Diagrams	Identifying link and loop polarity	Sterman, Chapter 5 (5.1-5.3) ; *Nutrient Cycling Exercise document*
5	20-Sep	Causal Loop Diagrams	Causal loop diagrams	Sterman, Chapter 5 (5.4); *Richardson "Problems with Causal Loop Diagrams"*
	21-Sep	Causal Loop Diagrams Exercise	--	Chapter 4 Vensim User's Guide
	22-Sep	Stocks and Flows	Identifying stocks and flows	Sterman, Chapter 6 (6.1-6.3.1), *Ford, Chapter 2*
	27-Sep	Stocks and Flows	*None*	Sterman, Chapter 6 (6.3.2-6.4); *Nutrient Cycling Exercise document*

6	28-Sep	Stock and Flow Diagrams	--	Chapter 5 Vensim User's Guide
	29-Sep	**Exam 1**	--	None
7	4-Oct	Review Exam, Dynamics of Stocks and Flows	Graphical integration	Sterman, Chapter 7 (7.1)
	5-Oct	Building a Simulation model	--	Chapter 6 Vensim User's Guide
	6-Oct	Dynamics of Stocks and Flows	Stock-flow dynamics: Nutrient cycling	Sterman, Chapter 7 (7.2-7.4)
8	11-Oct	**FALL RECESS (No Class)**	--	--
	12-Oct	**No Lab**	--	--
	13-Oct	Dynamics of Simple Structures	Goal-seeking behavior	Sterman, Chapter 8 (8.1-8.3)
9	18-Oct	Dynamics of Simple Structures	*None*	Sterman, Chapter 8 (8.4-8.6)
	19-Oct	Chaos in the Population Model	--	None
	20-Oct	Delays	Response of material delays to steps and ramps	Sterman, Chapter 11 (11.1-11.2)
10	25-Oct	Delays	Response of delays to changing delay times	Sterman, Chapter 11 (11.3-11.5)
	26-Oct	Population Model with Delay	--	None
	27-Oct	Guest Speaker	*None*	TBD
11	1-Nov	Co-flows and Aging Chains	*None*	Sterman, Chapter 12 (12.1-12.2)
	2-Nov	Aging Chain Example	--	None
	3-Nov	**Exam 2**	--	None

12	8-Nov	Review Exam, Modeling Decision Making	Finding formulation flaws	Sterman, Chapter 13 (13.1)
	9-Nov	Building a Function with Lookups	--	Chapter 8 Vensim User's Guide
	10-Nov	Modeling Decision Making	Preventing negative stocks	Sterman, Chapter 13 (13.2-13.3)
13	15-Nov	Formulating Nonlinear Relationships	Critiquing nonlinear functions	Sterman, Chapter 14 (14.1, 14.3-14.4)
	16-Nov	The Beer Game		None
	17-Nov	Expectation Formulation	Extrapolation and stablity	Sterman, Chapter 16 (16.1, 16.3-16.4)
14	22-Nov	Supply Chains	Exploring amplification	Sterman, Chapter 17 (all)
	23-Nov	**THANKSIGIVING RECESS (No Class)**	--	--
	24-Nov	**THANKSIGIVING RECESS (No Class)**	--	--
15	29-Nov	Numerical Integration	Choosing a time step	Sterman, Appendix A
	30-Nov	Introduction to the Sheep Market Model & Market Growth Model	--	*Sheep Sector Model Document* OR Sterman, Chapter 15
	1-Dec	Model Evaluation	See final assignment	Sterman, Chapter 21; *Skeptic's Guide to Computer Models*
	8-Dec	**Final assignment, due 5pm** Sheep Sector Technology Policy Market growth model: Chapter 15; Challenge, p. 625 (1) Includes model evaluation		