

Systems Thinking for Sustainable Development and Enterprise

Syllabus

Course Number: EAS550; Strategy 566

Term: Winter 2022

Course Time: Mondays, 8:30-11:30am

Location: Dana Building, Room 2024

Instructor: Ming Xu
Professor, School for Environment and Sustainability &
Department of Civil and Environmental Engineering
mingxu@umich.edu

Instructor Office Hours: By appointment

Graduate Student Instructor: Colton Babladelis (coltonba@umich.edu)

GSI Office Hours: Wednesday 2pm – 4pm, Thursday 9am – 11am or by appointment

Course Objectives:

- (1) Students will develop critical skills in **global systems thinking**, with global defined as relating to the entire world, as well as embracing all considerations of complex systems.
- (2) Students will develop skills in **system dynamics modeling** using Vensim software.
- (3) Students will develop awareness in issues related to **global environmental and social change**.
- (4) Students will deploy system analysis skills in **business applications**.

Enrollment Qualifications

Graduate students are eligible for this course, with enrollment preference given to SEAS and Ross students. There are no pre-requisites for this course.

Course Format

This course has both lectures and labs within the 3-hour duration. Lectures are designed to introduce students with model concepts and simulation processes. Lecture slides or notes will be uploaded to Canvas. Labs are designed for modeling and simulation practices with software (Vensim PLE). Lab instructions will be distributed during the lab sessions.

Individual Homework

There are three individual homework assignments and eight lab assignments. **Each lab assignment is due by the beginning of the next class.** Homework assignments need to be submitted through Canvas under each assignment.

Textbook

Andrew Ford, **Modeling the Environment**, Second Edition (Island Press, 2010).

Recommended References

- John Sterman, **Business Dynamics: Systems Thinking and Modeling for a Complex World** (Irwin McGraw-Hill, 2000).
- Donella Meadows, **Thinking in Systems: A Primer** (Chelsea Green Publishing, 2008)
- Vensim online documentation, <https://vensim.com/docs/>

Grading

10% - Class participation

50% - Individual homework (3 individual assignments 5% each, 8 lab assignments 5% each excluding the assignment with the lowest score)

40% - Group project (interim deliverables 10%, report 20%, presentation 10%)

Class Policies

- Course materials will be made available on Canvas.
- For individual assignments, you may discuss problems and solution approaches with your peers, but work should ultimately be your own.
- Late assignments will be accepted up to 48 hours past this deadline at a penalty of 20%. Assignments will not be accepted more than 48 hours after they are due.
- All references must be appropriately cited.
- Challenges to grades must occur within one week of the return of the assignment. Challenges must be in writing and will result in a complete regrading of the assignment (i.e., scores may increase or decrease).
- Attendance is expected. If you have the need to miss a class, contact the GSI and the instructor prior to the class. One absence, with notification before the class starts, will be excused without penalty.
- If you need accommodation for any disability that affects your performance in this class, please contact me as soon as possible.
- Email policy: Questions about assignments should be directed to the GSI via email with [EAS550/STRAT566] in the subject, cc' the instructor. Questions and associated answers may be shared with the entire class.

Academic Honesty

Any violation of University of Michigan policy as described in the Rackham Academic and Professional Integrity Policy (<https://rackham.umich.edu/academic-policies/section8/>) and Ross Community Values (<https://www2.bus.umich.edu/MyiMpact/academics/ross-community-values>) will not be tolerated and may result in a failing grade. This course will be conducted in strict conformity with these academic honor codes. Claimed ignorance of these codes and related information appearing on the sites will be viewed as irrelevant should a violation take place. It is the responsibility of the student to be familiar with the terms of these academic honesty expectations.

Student Well-Being

Students may experience stressors that can impact both their academic experience and their personal well-being. These may include academic pressure and challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc.

If you are experiencing concerns, seeking help is a courageous thing to do for yourself and those who care about you. If the source of your stressors is academic, please contact me so that we can find solutions together. For personal concerns, U-M offers many resources, some of which are listed at [Resources for Student Well-being](#) on the Well-being for U-M Students website. You can also search for additional resources on that website.

Course Outline (subject to changes)

Week	Date	Topics	Readings
1	1/10	Introduction: Systems Thinking; Modeling Complex Systems; System Dynamics	Ch 1
	1/17	MLK Day, no class	
2	1/24	The Beer Game Group Project: Team Matching	handout
3	1/31	Stocks and Flows; Software Lab #1: Building stock and flow diagram with Vensim	Ch 2&3, Apx C
4	2/7	Accumulating the Flows; Modeling Nonlinearity Lab #2: The Mono Lake	Ch 4&5, Apx A&B
5	2/14	Feedback Loops; System Archetypes Due: Individual Assignment (Easter Island) Lab #3: Modeling S-shaped growth	Ch 6&7
6	2/21	Epidemic Dynamics Lab #4: Modeling epidemic dynamics	Ch 8
	2/28	Break, no class	
7	3/7	Causal Loop Diagram Due: Individual Assignment (System Archetypes) Lab #5: Causal loop diagram	Ch 9
8	3/14	Group Project: Progress Presentations Due: Individual Assignment (Fukushima)	
9	3/21	The Modeling Process; Key Vensim Functions Lab #6: iPhone sales Due: Group Project: Dynamic Hypothesis and CLD	Ch 13
10	3/28	Delays Lab #7: Modeling real estate construction Due: Group Project: Delays	Ch 14&18
11	4/4	Fishbanks Game Lab #8: Modeling the salmon population dynamics Due: Group Project: Nonlinearity	handout
12	4/11	Team Project Presentations	
	4/25	Due: Team Project Report and Model File (due at 8am)	

Group Project Grading Rubrics

The group project contributes to 40% of the final grade, including these three components:

1. Presentations (10%)

Each group presents their project to the class twice, including a project topic proposal presentation and final presentation. All members of the group are expected to present. The presentation should include the follows when applicable:

- Title and name
- Research question
- Motivation, importance, and how it relates to this course
- Methods and data
- Results and implications
- Conclusions

Grading criteria for the presentations:

	Exemplary	Competent	Developing
Organization (20%)	Presentation is clear, logical, and organized. Audience can follow line of reasoning.	Presentation is generally clear and organized. Some points may be confusing.	Organization is haphazard. Audience can follow only with effort. Logic is not clear.
Content (50%)	Presentation provides accurate and complete explanations of the research. Audience knows clearly what this case is intended to teach and how it will look like.	For the most part, explanations are accurate and complete. There are some components of the research are not clearly explained. Audience has a good idea of what this research is about.	Explanations are inaccurate and incomplete. Audience is not clear what the research is intended to do.
Presentation (20%)	Speakers give clear, engaging presentations of the poster. Speakers maintains good eye contact with the audience and is appropriately animated (gestures, moving around, etc.). Poster is clear and informative.	Speakers give generally clear presentations with eye contact with the audience. Poster is generally clear and informative.	Speakers do not seem to be familiar with the poster. Poster is unclear and hard to follow.
Question answering (10%)	Give direct, clear, accurate answers to questions.	Answers to questions are generally direct, clear and accurate.	Cannot provide direct, clear, and accurate answers to questions.

2. Interim deliverables (10%)

There will be three interim deliverables for the group project. Detailed instructions will be provided separately.

3. Project report (20%)

A template for your project report (no more than 10 pages) is attached below. The report should provide complete, accurate description of the research motivation, research question, methods, data, results, and discussions. Include only KEY figures and tables in the report; non-essential text, figures, and tables that are useful for readers to understand can be included in the appendix which does not count for the page limit.

Grading criteria for the project report:

	Exemplary	Competent	Developing
Research question (10%)	Research question is clearly defined with appropriate scope.	Research question is clear, but the scope might be too narrow or too broad.	Research question is not clear or ill-defined.
Research design and execution (40%)	Methods and data are appropriate for the research question. The execution is correctly done.	Methods and data are relevant to the research question. The execution is generally correct.	Methods and data are not appropriate for the research question. There are mistakes in the execution of the research.
Depth of discussion (20%)	In-depth discussion and elaboration on the research results. Clear elaboration on policy implications.	In-depth discussion and elaboration on some results.	Cursory discussion on the research results. No mention of policy implications.
Cohesiveness (10%)	Paper flows from one issue to the next smoothly. Writing demonstrates a good understanding of the topic, methods, and state-of-the-art.	For the most part paper flows smoothly. Writing demonstrates a general understanding of the topic, methods, and state-of-the-art.	Paper is written without clear logic, does not flow, and appears to be created from disparate issues. Writing demonstrates lack of understanding of the topic, methods, and state-of-the-art.
Spelling and grammar (10%)	No spelling and/or grammar mistakes.	Minimal spelling and/or grammar mistakes.	Noticeable spelling and/or grammar mistakes.
Citations (10%)	References are cited throughout the paper to	For the most part references are cited to	Inadequate references are cited to back

	<p>back authors' claims or provide sources of information, methods, or data. References are from reputable sources, largely from peer-reviewed journals. Citation style is used correctly and consistently.</p>	<p>back claims or provide sources of information, methods, and data. References are generally from reputable sources. Citation style is used almost correctly and consistently.</p>	<p>claims and provide sources. References are mostly from non-reputable sources such as websites, Wikipedia. Citation style is used incorrectly and inconsistently.</p>
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PLACE YOUR PAPER TITLE HERE (NO MORE THAN 10 PAGES TOTAL EXCL. APPENDIX)

Author1 Name (affiliation, email address), Author2 Name (affiliation, email address)...

ABSTRACT. START THE FIRST LINE OF THE ABSTRACT ON THE SAME LINE AS THE HEADING “ABSTRACT” IN BOLD, FOLLOWED BY A PERIOD. YOU MAY USE EITHER ONE SPACE AFTER A PERIOD, OR TWO. ALL TEXT THROUGHOUT PAPER IS ARIAL SIZE 12. PLEASE LEFT-JUSTIFY (ALIGN TEXT LEFT) ALL PARAGRAPHS. ABSTRACT SHOULD BE ABOUT 300 WORDS AND PROVIDE A SYNOPSIS OF THE PAPER, INCLUDING MOST IMPORTANT RESULTS.

Introduction. Leave a blank line between paragraphs. Do not indent.

In the introduction, describe the problem statement, challenge, knowledge gap, or the motivation for the study.

References are cited within a sentence such as Last-Name (year) for single-author publications, Last-Name-1 and Last-Name-2 (year) for two-author publications, and Last-Name et al. (year) for publications with more than two authors. References can also be cited without being part of a sentence (Last-Name, year).

Subheader. Where subheaders are appropriate, use italics. Use existing literature to both establish the importance and novelty of the work. Minimizing number of subheaders you use.

Research Questions (or Hypothesis). Where appropriate, include a section for the hypothesis or research questions. If the paper is neither hypothesis- nor research question-driven, use headers of your own invention (such as ‘Goals’.)

Method. Describe the methods employed in the research, including materials (if appropriate), boundaries, data sources or scope.

Results and Discussion. Where ‘results’ are reported, include quantitative and/or qualitative data. Graphs and figures are preferable to data tables, and tables are preferable to reporting data as text in paragraphs.

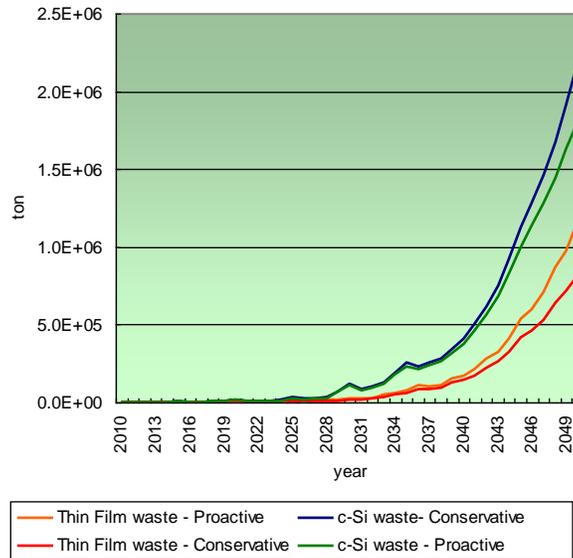


Figure 1: Example Figure. Center figures on the page, and center figure captions below the figure. All figures must have a caption. Use Arial Narrow 11pt. Begin the caption with ‘Figure #: Name of Figure.’ in bold and then write a brief description or interpretation.

Table 1. Please Put The Title Of Table Above Each Table and Use Bold Text, Arial Narrow 11

	Single pilot	Full pilot plant	Automated plant
Capacity	1876 module (~ 17ton)	185 ton/year	20,000 ton/year
Processing type	Manual separation	Manual Separation	Automated Separation
Throughput	Low	Low	High
Recovery rate	85%	85%	96%
Type of PV	mono-Si module	Crystalline Modules	Mixed modules

REFERENCES (DO NOT INCLUDE MORE THAN TEN REFERENCES)

Last Name of 1st Author and Initials of 1st Author, Last Name and Initials of Other Authors. Year of Publication. Title of Journal Paper. *Name of Journal*, Issue: pp. Digital Object Identifier or URL (where available or appropriate).

Last Name of 1st Author and Initials of 1st Author, Last Name and Initials of Other Authors. Year of Publication. *Title of Book or Report, Number of Report (i.e. EPA 2-3344)*, Name of Institution. Digital Object Identifier or URL (where available or appropriate).

Last Name of 1st Author and Initials of 1st Author, Last Name and Initials of Other Authors. Year of Publication. Title of book chapter or conference proceeding. In *Title of Book or Name, Date and Location of Conference*. Digital Object Identifier or URL (where available or appropriate).

APPENDIX (OPTIONAL, NOT WITHIN THE 10 PAGE LIMIT)