ENGG*3130 Modelling Complex Systems

Winter 2018
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2018

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1 Course Details

1.1 Calendar Description

This course explores the application of systems thinking to complex global issues. Key topics will include: systems theory, complex adaptive systems, systems tools, and systems approaches. The course will emphasize the role of computational modelling and simulation as a central tool for applying systems thinking to real-world settings.

Pre-Requisite(s): CIS*1500, ENGG*2400, STAT*2120

1.2 Course Description

This course aims to introduce the basic principles of systems thinking. We will see how complex patterns and behaviours can emerge from simple structures and rules. We will draw on these insights to develop a deeper understanding of the world around us.

Examples presented in class will be chosen to relate directly to students' experiences and focus on current issues. These may include globalization, climate change, conflict, democracy, cryptocurrency, artificial intelligence, health, and food security.

1.3 Timetable

Lectures:

Tuesday	10:00–11:20	ALEX 309
Thursday	10:00–11:20	ALEX 309

Laboratory:

Wednesday	11:30 - 13:20	THRN 1313

1.4 Final Exam

There is no final exam.

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2 Instructional Support

2.1 Instructor(s)

Graham Taylor Ph.D, P.Eng.
Email: gwtaylor@uoguelph.ca
Telephone: +1-519-824-4120 x53644
Office: RICH 3515
Office Hours: Tuesday 16:00–17:00

2.2 Instructional Support Team

Lab Technician: Matthew Kent
Email: mattkent@uoguelph.ca
Telephone: +1-519-824-4120 x54113
Office: THRN 2332

2.3 Teaching Assistant(s)

Teaching Assistant: Thor Jonsson
Email: tjonsson@uoguelph.ca
Office Hours: TBD

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3 Learning Resources

3.1 Required Resources(s)

Course Website (Website)
https://courselink.uoguelph.ca/
Course material, news, announcements, and grades will be regularly posted to the ENGG*3130 CourseLink site. You are responsible for checking the site regularly.

Think Complexity: Complexity Science and Computational Modeling (Textbook)
Allen B. Downey, 2nd edition, O'Reilly, 2017

Note that this book is available as a free PDF at http://greenteapress.com/complexity/. The second edition is still in development and not yet available in print.

Thinking in Systems: A Primer (Textbook)
Donella H. Meadows, 1st edition, Chelsea Green Publishing, 2008.

3.2 Additional Resources(s)

Lecture Information (Notes)
Notes to accompany lectures will be available at http://engg3130.github.io. Because these notes are a collaborative effort, they will be updated as the course progresses (usually at least

once per week). Every student is expected to contribute to the development and maintenance of these course notes. Information on how to contribute, as well as how to generate the notes in alternative formats (e.g. PDF) will be provided.

Lab Information (Notes)
The directives for all the lab sessions will be provided in the online course notes. Deliverables for the labs will be submitted electronically (via CourseLink Dropbox) and are due one week after the lab session. Attendance at labs is mandatory.

Miscellaneous Information (Other)
Other information related to Modelling Complex Systems will be posted on the course website.

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Synthesize his or her own definition of systems thinking.
2. Construct a system study, first identifying the system to be investigated and its important behaviours. Identify the purpose of the study, hierarchy, important processes and structures, elements and their interconnections, feedbacks, and environmental context.
3. Discuss real world systems that demonstrate nonlinear, emergent, self-organizing, and resilient behaviour.
4. Choose from a variety of systems tools given a context, justifying the choice.
5. Model and simulate a complex system in software.
6. Write code that demonstrates good software engineering practices: e.g. modularity, efficiency, use of appropriate data structures and algorithms, readability.
7. Communicate a systems approach to modelling both orally and in written form.

4.2 Engineers Canada - Graduate Attributes

Successfully completing this course will contribute to the following:

#	Outcome Set Name	Course Learning Outcome
2	Problem analysis	2
2.1	Formulate a problem statement in engineering and nonengineering terminology	2
2.2	Construct a conceptual framework	2
2.3	Identify, organize and justify appropriate information	2
2.4	Execute an engineering solution	2
2.5	Critique and appraise results	2
3	Investigation	3

#	Outcome Set Name	Course Learning Outcome
3.1	Propose and test working hypotheses	3
3.2	Design and apply an investigation plan	3
3.3	Analyze and interpret experimental data	3
3.4	Assess validity of conclusions within limitations of data and methodologies	3
4	Design	5
4.1	Describe the design process	5
4.2	Construct design-specific problem statements	5
4.3	Create engineering design solutions	5
4.4	Develop engineering design solutions	5
4.5	Assess engineering design solutions	5
4.6	Implement engineering design solutions	5
5	Use of engineering tools	4, 6
5.1	Select appropriate engineering tools from various alternatives	4, 6
5.2	Apply selected engineering tools	4, 6
5.3	Recognize limitations of selected engineering tools	4, 6
6	Individual and team work	2, 5
6.1	Act as an individual team member to promote team success	2, 5
6.2	Demonstrate leadership through team building, providing feedback and positive attitude	2, 5
7	Communication skills	1, 7
7.1	Develop and deliver clear, key concepts using methods appropriate for the intended audience	1, 7
7.2	Critically evaluate received information	1, 7
7.3	Demonstrate active listening and follow instructions	1, 7
9	Impact of engineering on society and environment	2, 3
9.1	Analyze the social, environmental and legal aspects of engineering activity	2, 3
9.2	Summarize the common sources of uncertainty and risk in their engineering field	2, 3
9.3	Identify the impact of introducing innovative technologies to solve	2, 3

#	Outcome Set Name	Course Learning Outcome
	engineering problems	

4.3 Relationships with other Courses & Labs

Previous and/or Current Courses:

ENGG*1500: Solving systems of linear equations, matrix algebra, complex numbers

CIS*1500, CIS*2500, CIS*2430, CIS*2520: Object-oriented programming, data structures, analysis of algorithms

PHYS*1130: Analytic problem solving, physical systems

STAT*2120: Bayes' theorem, probability distributions, probability densities, descriptive statistics

ENGG*2400: Modelling and simulation of linear systems

Follow-on Courses:

ENGG*41x: Interdisciplinary design

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5 Teaching and Learning Activities

5.1 Lecture

Topic(s): Introduction

Topic(s): Systems Structure and Behaviour

Topic(s): Complexity Science

Topic(s): Graphs

Topic(s): Feedback Loops: One-Stock Systems

Topic(s): Analysis of Algorithms

Topic(s):	Feedback Loops: Two-Stock Systems
Topic(s):	Small World Graphs
Topic(s):	Why Systems Work So Well
Topic(s):	Scale-Free Networks
Topic(s):	Why Systems Surprise Us
Topic(s):	Cellular Automata
Topic(s):	System Traps and Opportunities
Topic(s):	Game of Life
Topic(s):	Physical Modelling
Topic(s):	Leverage Points — Places to Intervene in a System
Topic(s):	Systems Case Study (Guest Lecture)
Topic(s):	Self-Organized Criticality
Topic(s):	Currency and Consensus (Guest Lecture)
Topic(s):	Agent-Based Models
Topic(s):	Artificial Intelligence and Machine Learning
Topic(s):	Living in a World of Systems
Topic(s):	Oral Presentations (1)
Topic(s):	Oral Presentations (2)

5.2 Other Important Dates

Monday, January 9 2017: First day of class (No lab)
Monday, February 20 – Friday, February 24 2017: Winter Break
Friday, March 10 2017: drop date — 40th class
Friday, April 7 2017: last day of class

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Game Playing Exercises (Teams of 2–3 students)	10.00
Course Notes Development	10.00
Lab Reports	40.00
Oral Presentation	10.00
Final Project (Teams of 3–4 students)	30.00
Total	100.00

6.2 Assessment Details

Game Playing Exercises (Teams of 2–3 students) (10.00%)

- Each group of 2–3 students will have the opportunity to lead a game-playing exercise as well as a debriefing session during a lecture period
- The games will be selected from the *Systems Thinking Playbook* by the instructor, to reinforce topics in the course: http://www.chelseagreen.com/the-systems-thinking-playbook

Course Notes Development (10.00%)

- Each student should make individual contributions to the course notes
- Students will be assessed on the **quantity and quality** of the contributions, which may include:
  - Being the primary note taker for one lecture session (we will schedule this so that everyone has an opportunity to collaborate)
  - Correcting errors or making additions to existing notes (or labs,)
  - Opening issues and participating in discussion where more clarification is needed https://guides.github.com/features/issues/
  - Responding to these issues
- Contributions must be submitted as a Github pull request https:/help.github.com/articles/about-pull-requests/

Lab Reports (40.00%)

- Lab reports will be submitted as Jupyter notebooks. They are due (by CourseLink Dropbox) exactly one week from the start of the lab
- There will be 10 labs
- Lab reports will be marked according to a terniary scheme:
  - High pass (more than average effort, essentially complete)
  - Pass (reasonable effort, may be missing some components)
  - Fail (less than average effort, mostly incomplete)
- The two lab reports with the lowest grade will be dropped. However, **reports that are not submitted will not be dropped**

Collaboration Policy

I expect you to try solving each lab on your own. However, when you are stuck on a problem, I encourage you to collaborate with other students in the class, subject to the following rules:

1. You may discuss a problem with any student in this class, and work together on solving it. This can involve brainstorming and verbally discussing the problem, going together through possible solutions, but should not involve one student telling another a complete solution.
2. Once you solve the problem, you must write up your report on your own, without looking at other people's reports or giving your report to others.
3. In your solution for each problem, you must write down the names of any person with

whom you discussed it. This will not affect your grade.
4. Do not consult solution manuals or other people's solutions from similar courses. However, you are encouraged to make use of open source tools and libraries unless otherwise instructed. Don't reinvent the wheel — just give proper attribution. If unsure, ask the instructor.

Oral Presentation (10.00%)

- Each student will research and present a 5 minute talk on a prominent systems thinker
- The talks will be distributed throughout the term (details about signing up will be posted on CourseLink)

Final Project (Teams of 3–4 students) (30.00%)

- The project will focus on a case study of complex system modelling
- See the "Think Complexity" book (version 1) for examples of case studies written by students
- Details on formatting and deliverables will be provided before reading week
- Deliverables (report and associated code) are due April 13 at 23:59 via CourseLink Dropbox

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments

If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations

If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Consideration of Religious Obligations: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade

The passing grade is 50%.

Missed labs

If you miss a lab due to grounds for granting academic consideration or religious accommodation, you are expected to complete the necessary work on your own time and still submit a report. There will be no makeup labs.

Questions concerning grades

If you have questions about the grade you received, please ask your TA within one week of the document being returned. However, all requests for re-marking must be made to the instructor. Any item that is re-marked will be re-marked entirely. Therefore it is strongly suggested that you thoroughly review your entire document **before** making a re-marking request. Pencil-written works will not be re-marked. Re-marking requests will not be honoured more than one week after the document has been returned.

7.2 Communication and Email Policy

Please use lectures and tutorials as your main opportunity to ask questions about the course. Major announcements and/or changes will be posted to the course website. **It is your responsibility to check the course website regularly.**

Electronic communication should be limited to the course forum, however topics of a personal and confidential nature (e.g. marks) should be emailed to the instructor: gwtaylor@uoguelph.ca. Please note that **all email communication must be made through your University of Guelph email account** (i.e. username@mail.uoguelph.ca).

7.3 Turnitin

In this course, your instructor will be using Turnitin, integrated with the CourseLink Dropbox tool, to detect possible plagiarism, unauthorized collaboration or copying as part of the ongoing efforts to maintain academic integrity at the University of Guelph.

All submitted lab reports and projects will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the Usage Policy posted on the Turnitin.com site.

A major benefit of using Turnitin is that students will be able to educate and empower themselves in preventing academic misconduct. In this course, you may screen your own assignments through Turnitin as many times as you wish before the due date. You will be able to see and print reports that show you exactly where you have properly and improperly referenced the outside sources and materials in your assignment.

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8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink

but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

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9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The regulations and procedures for Academic Consideration are detailed in the Undergraduate Calendar.

9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for Dropping Courses are available in the Undergraduate Calendar.

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is

required, however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance, and not later than the 40th Class Day.

More information: www.uoguelph.ca/sas

9.6 Academic Misconduct

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community – faculty, staff, and students – to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

The Academic Misconduct Policy is detailed in the Undergraduate Calendar.

9.7 Recording of Materials

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

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