ENGG*3130 Modelling Complex Systems
Winter 2017

UNIVERSITY of GUELPH
School of Engineering

(Revision 0: January 4, 2017)

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1 Instructional Support

1.1 Instructor

Instructor:	Graham Taylor, Ph.D.
Office:	RICH 3515
Email:	gwtaylor@uoguelph.ca
Office hours:	Monday 16:00–17:00

1.2 Lab Co-ordinator

Technician:	Kyle Montgomery
Office:	RICH 1531
Email:	jbest@uoguelph.ca

1.3 Teaching Assistants

GTA	Email	Office Hours
Jane Doe	jdoe@uoguelph.ca	TBA on Courselink

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2 Learning Resources

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*3130 CourseLink site. You are responsible for checking the site regularly.

2.2 Required Resources

1. Allen B. Downey, *Think Complexity: Complexity Science and Computational Modeling*, 2nd edition, O'Reilly, 2016
   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.
2. Donella H. Meadows, *Thinking in Systems: A Primer*, 1st edition, Chelsea Green Publishing, 2008.

2.3 Additional Resources

Lecture Information: 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: 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 information related to Modelling Complex Systems will be posted on the course website.

2.4 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).

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3 Assessment

3.1 Dates and Distribution

Game Playing Exercises: (Teams of 2–3 students) 10%

- 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

Course Notes Development 10%

- 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, etc.)
  - Opening issues and participating in discussion where more clarification is needed
  - Responding to these issues
- Contributions must be submitted as a Github pull request

Lab Reports: 40%

- 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%

- 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%

- The project will focus on a case study of complex system modelling
- See the "Think Complexity" book (Section 2.2) 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

3.2 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.

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4 Aims, Objectives & Graduate Attributes

4.1 Calendar Description

This course explores the application of systems thinking to complex global issues. Key topics will include an introduction to: 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 solve problems.

4.2 Course Aims

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.

4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability 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.

4.4 Graduate Attributes

Successfully completing this course will contribute to the following CEAB Graduate Attributes:

Graduate Attribute	**Learning Objectives**	**Assessment**
1. Knowledge Base for Engineering	-	-
2. Problem Analysis	2	Labs, Final project
3. Investigation	3	Labs, Final project
4. Design	5	Labs, Final project
5. Use of Engineering Tools	4, 6	Labs, Final project, Course notes development
6. Communication	1, 7	Oral presentation, Game playing
7. Individual and Teamwork	2, 5	Labs (individual), Final project (team-based)
8. Professionalism	-	-
9. Impact of Engineering on Society and the Environment	2, 3	Oral presentation, Game playing
10. Ethics and Equity	-	-
11. Environment, Society, Business, & Project Management	-	-
12. Life-Long Learning	-	-

4.5 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. Lecture notes will be developed collaboratively and made available online but these are not intended to be stand-alone course notes. 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 assessments.

4.6 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and tutorials. 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.

4.7 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 Timetable

Lectures:		
Tuesday	16:00–17:20	ROZH 107
Thursday	16:00–17:20	ROZH 107
Laboratory:		
Monday	11:30–13:20	THRN 1313

5.2 Lecture Schedule

Lectures	Lecture Topics
1	Introduction
2	Systems Structure and Behaviour
3	Complexity Science
4	Graphs
5	Feedback Loops: One-Stock Systems
6	Analysis of Algorithms
7	Feedback Loops: Two-Stock Systems
8	Small World Graphs
9	Why Systems Work So Well
10	Scale-Free Networks
11	Why Systems Surprise Us
12	Cellular Automata
13	Systems Case Study (Guest Lecture)
14	Game of Life
15	System Traps and Opportunities
16	Physical Modelling
17	Leverage Points — Places to Intervene in a System
18	Self-Organized Criticality
19	Currency and Consensus (Guest Lecture)
20	Agent-Based Models
21	Artificial Intelligence and Machine Learning
22	Living in a World of Systems
23	Oral Presentations (1)
24	Oral Presentations (2)

5.3 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

6 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.

If the laboratory rules are not followed, consequences will include removing access to the lab. If this results in lab work not being completed, the student will receive a grade of 0.

7 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.

7.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/

Please also review the section on Academic Misconduct in your Engineering Program Guide.

The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

8 Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Centre for Students with Disabilities as soon as possible

For more information, contact CSD at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd/

9 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, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

10 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:
http://www.uoguelph.ca/registrar/calendars/index.cfm?index