



# ENGG\*3410 Systems and Control Theory

Winter 2019

Section(s): C01, C02

School of Engineering

Credit Weight: 0.50

Version 2.00 - January 06, 2019

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## 1 Course Details

### 1.1 Calendar Description

Modeling, performance analysis and control with potential application to engineering, physical and biological systems. Topics include modeling in time, Laplace and frequency domains. Performance and stability by methods of Hurwitz, Routh, Bode, and Nyquist. Control by ON/OFF and PID Controllers.

**Pre-Requisite(s):** ENGG\*2400, MATH\*2270

**Co-Requisite(s):** ENGG\*2450

### 1.2 Course Description

This course explores the fundamentals of systems and control. The course has two primary focuses:

(1) understanding and predicting system behaviour and (2) design and analysis of closed loop control systems.

### 1.3 Timetable

#### Section 1

Lecture	Time	Location
Tuesday	11:30 AM - 12:50 PM	ALEX 100
Thursday	11:30 AM - 12:50 PM	ALEX 100

#### Section 2

<b>Lecture</b>	<b>Time</b>	<b>Location</b>
Tuesday	05:30PM - 06:50PM,	ROZH 103
Thursday	05:30AM - 06:50PM,	ROZH 103

### **Section 1 & Section 2**

<b>Lab</b>	<b>Time</b>	<b>Location</b>
Monday	10:30 AM - 12:20 PM	RICH, Room 1504B
Monday	02:30PM - 04:20PM	RICH, Room 1504B
Tuesday	8:30 AM - 10:20 AM	RICH, Room 1504B
Wednesday	8:30 AM - 10:20 AM	RICH, Room 1504B
Wednesday	10:30 AM - 12:20 PM	RICH, Room 1504B

### **Section 1 & Section 2**

<b>Tutorial</b>	<b>Time</b>	<b>Location</b>
Monday	07:00PM - 07:50PM	MCKN, 115

Tuesday 07:00PM - 07:50PM RICH, 2529

Tuesday 07:00PM - 07:50PM ANNU 156

Wednesday 07:00PM - 07:50PM MCKN 121

Thursday 07:00PM - 07:50PM MCKN 031

## 1.4 Final Exam

April 13, 08:30AM - 10:30PM, location TBD on Webadvisor

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## 2 Instructional Support

### 2.1 Instructional Support Team

**Instructor:** Mohammad Biglarbegian PhD., P.Eng.  
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**Lab Technician:** Hong Ma  
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### 2.2 Teaching Assistant(s)

**Teaching Assistant:** Abolfazl Rahimnejad  
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## 3 Learning Resources

### 3.1 Required Resource(s)

#### Textbook (Textbook)

Control Systems Engineering - Norman S. *7th edition* Wiley, 2013

Any information about the course, news, announcements, etc., and grades will be regularly posted to the ENGG\*3410 Courselink site. You are responsible for checking the site regularly.

### 3.2 Recommended Resource(s)

#### Control Systems Engineering (Textbook)

Richard C. Dorf, Robert H. Bishop, "Modern Control Systems", Pearson, 13th Edition.

### 3.3 Additional Resource(s)

#### Lab Information (Lab Manual)

The lab manuals and rubrics will be posted in the lab section of the Courselink page.

#### Problem sets (Notes)

Additional homework problems may be posted in the 'problem sets' section of courselink. Solutions to selected questions will be posted to the same section in Courselink by the instructor and the GTAs. **Homework problems will not be graded.**

## 4 Learning Outcomes

### 4.1 Course Learning Outcomes

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

1. apply systems theory to complex real world problems in order to obtain models that are expressed using differential equations, transfer functions, and state space equations
2. predict system behaviour based on the mathematical model of that system where the model may be expressed in time or frequency domain
3. analyze the behaviour of closed loop systems using tools such as root locus, Routh Hurwitz, Bode, Nyquist, and Matlab
4. design controllers using classical PID methods, root locus methods, and frequency domain methods
5. devise a safe and effective method of investigating a system identification problem in the lab
6. write a report that effectively communicates the results of an experiment or design

### 4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome(s)
1	Knowledge Base	1, 2
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2
2	Problem Analysis	2, 3
2.1	Formulate a problem statement in engineering and non-engineering terminology	2, 3
2.2	Identify, organize and justify appropriate information, including assumptions	3
2.3	Construct a conceptual framework and select an appropriate solution approach	3
2.4	Execute an engineering solution	3
3	Investigation	5
3.1	Propose a working hypothesis	5
3.2	Design and apply an experimental plan/investigative approach (for	5

#	Outcome	Learning Outcome(s)
	example, to characterize, test or troubleshoot a system)	
3.3	Analyze and interpret experimental data	5
3.4	Assess validity of conclusions within limitations of data and methodologies	5
4	Design	4
4.1	Describe design process used to develop design solution	4
4.2	Construct design-specific problem statements including the definition of criteria and constraints	4
4.3	Create a variety of engineering design solutions	4
4.4	Evaluate alternative design solutions based on problem definition	4
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	4
6	Individual & Teamwork	5
6.1	Describe principles of team dynamics and leadership	5
6.2	Understand all members' roles and responsibilities within a team	5
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	5
6.4	Apply strategies to mitigate and/or resolve conflicts	5
6.5	Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel	5
7	Communication Skills	6
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	6
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	6
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	6

#	Outcome	Learning Outcome(s)
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	6
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	6

### 4.3 Relationships with other Courses & Labs

**Previous Courses:**

ENGG\*2400: System fundamentals, linear equations, responses, solving differential equations

MATH\*2270: Linear differential equations, responses, solving differential equations, Laplace transform

ENGG\*2450: Foundations of systems analysis, frequency response, RLC circuit analysis, ideal operational amplifiers

**Follow-on Courses:**

ENGG\*3490: Foundations of systems and control, system responses, stability, PID

ENGG\*4280: Everything

ENGG\*4430: Foundations of systems and control, closed loop control

## 5 Teaching and Learning Activities

### 5.1 Lecture

Topic(s): Lecture	Tentative Schedule Topic
1-2	Topic 1 – Introduction to systems, Math review (Laplace, partial fractions, etc.)
3-4	Topic 1,2 – Transfer functions: FVT
5-9	Topic 3 – Modeling in time domain: linearization, state-space
10-11	Topic 4 – Time response (transient characteristics)
12-14	Topic 5 – Stability, steady-state errors

15-16	Topic 6 – Introduction to Control: closed loop systems, block diagrams
17-20	Topic 7 – Root locus, PID control
20-23	Topic 8 – Frequency design: Bode, Nyquist
24	Topic 9 – More control design: lead-lag

## 5.2 Lab

### Topic(s): Lab Schedule

- All of the lab sections are all full. This means that you will not be allowed to attend a lab section that you are not scheduled for. Please go to the laboratory time and date that corresponds to the section that you selected in webadvisor.
- Lab reports are due at 4:30pm on the week indicated below on the day of the week corresponding to your lab section (i.e., if your lab is on a Monday, then your submission is due on a Monday at 4:30pm in the week indicated below). You must submit your lab using Courselink. The final writup for lab 5 must be submitted in softcopy on courselink **and** in hardcopy in the SOE submission boxes (box number 18).

Week	Lab	Due Date
1		
2	Lab 1: On/Off Lab, Safety Lab	
3	Lab 2: MATLAB	Lab 1 Due
4		Lab 2 Due
5	Lab 3: Modeling	
6		Lab 3 Due
7	Reading Week	
8	Lab 4:PID Investigation	
9		Lab 4 Due
10	Lab 5 (day 1): PID Design	
11	Lab 5 (day 2): PID Design	
12		Lab 5 Due



### 5.3 Note: Week 1 is the week of January 8.

### 5.4 Other Important Dates

Monday, January 7, 2019: First day of class  
 Monday, February 18, 2019: Winter study week  
 Friday, March 8, 2019: drop date – 40th class  
 Friday, April 5, 2019: last day of classes

### 5.5 Lab Schedule

All of the lab sections are all full. This means that you will not be allowed to attend a lab section that you are not scheduled for. Please go to the laboratory time and date that corresponds to the section that you selected in webadvisor.

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## 6 Assessments

### 6.1 Assessment Details

#### Labs (25%)

**Learning Outcome(s):** 3,4,5,6

All of the lab sections are all full. This means that you will not be allowed to attend a lab section that you are not scheduled for. Please go to the laboratory time and date that corresponds to the section that you selected in webadvisor.

Labs are worth 25% (5% Prelabs and 20% Labs) **The Prelabs and labs are not equally weighted.**

Prelab 2 is 1%, Prelab 3 is 2%, Prelab 5 is 2%, (for a total of 5%).

Lab 1 is 2%, Lab 2 is 3%, Lab 3 is 4%, Lab 4 is 5% and lab 5 is 6% (for a total of 20%).

#### Midterm (35%)

**Date:** Sat, Mar 2, 10:00 AM - , 12:00 PM, TBA

**Learning Outcome(s):** 1,2,3

#### Final Exam (40%)

**Date:** Sat, Apr 13, 8:30 AM - , 10:30 AM, location TBD on Webadvisor

**Learning Outcome(s):** 1,2,3,4

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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 both course instructors. 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 both course instructors 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>

**Missed midterms:** If you miss the midterm due to grounds for granting academic consideration or religious accommodation, the weight of any missed test will be added to the final exam weight. There will be no makeup tests. No extra time will be given to students who arrive late.

**Midterm and Final exams:** For both exams you will be supplied with one aid sheet A4 size that will have the needed formulas.

**Lab Work:** You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab.

**Attendance** will be taken in the lab. All students are required to demo their lab during their lab session; this demo is graded. If you are not present for your lab and your demo, you will not be allowed to submit a lab report and you will get a zero on that lab. If you miss more than 25% of a lab period due to lateness or by leaving before you have finished the lab, you will be considered absent. Some labs are scheduled to take place over two weeks; if you complete your lab in the first week, you do not need to attend the second week.

**Pre-lab:** Some labs have a *mandatory* prelab. Prelabs will be posted on the Courselink. Your group must submit your prelab 24 hours prior to arriving to your scheduled lab section. Your prelab will be graded by the TA before you enter the lab. You should arrive at the lab already having looked at the feedback from your prelab. You will not be allowed to enter the lab if your prelab is incomplete or missing. Since all lab sections are full, we can not allow you to attend a later lab if you miss your scheduled time due to a missing prelab; therefore, if your prelab is incomplete, then you will get an automatic zero on that lab.

**Late Lab Reports:** Late submissions of lab reports will be penalized at a rate of 10% per hour.

All labs and prelabs are submitted via courselink. It is your responsibility to ensure that your lab has been properly submitted, not your lab partner's. Double check that the correct file has been uploaded to the drop box. If you upload the incorrect file or fail to upload properly and do not fix the problem before the due date, you will be penalized according to the late submission rules: there will be NO exceptions. If you are having trouble submitting to courselink, email a copy of your report to the TA or submit a hard-copy before the deadline to provide proof that you completed the lab on time. A date stamp on a soft copy file DOES NOT constitute proof of timely completion.

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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 grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml>

Graduate Calendar - Grounds for Academic Consideration

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

### **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 course registration are available in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Dropping Courses

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml>

Graduate Calendar - Registration Changes

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml>

### **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 can be found on the SAS website

<https://www.uoguelph.ca/sas>

## 9.6 Academic Integrity

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 encourages academic integrity. 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.

Undergraduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml>

Graduate Calendar - Academic Misconduct

<https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml>

## 9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, 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 that apply to undergraduate, graduate, and diploma programs.

Academic Calendars

<https://www.uoguelph.ca/academics/calendars>

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