

ENGG*3410
Systems and Control Theory
Winter 2016



(Revision 2: January 14, 2016)

1 INSTRUCTIONAL SUPPORT

1.1 Instructors

Instructor: Julie Vale, Ph.D., P.Eng.
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Instructor: Simon Yang, Ph.D.
Office: RICH 2513, ext. 52437
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Office hours: Tuesday 10:00-11:00 in THRN 2414 or by appointment

1.2 Lab Technician

Technician: Hong Ma
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1.3 Teaching Assistants

GTA	Primary Task	Email	Office Hours
Akul Bhatt	Tutorial	akul@mail.uoguelph.ca	TBA on Courselink
Aubrianna Bilyea	Tutorial	abilyea@uoguelph.ca	TBA on Courselink
Ahmed Elsaftawy	Lab 1	elsaftaa@uoguelph.ca	In lab
Abhishek Thota	Lab 2	athota@uoguelph.ca	In lab
Negin Lashkari	Lab 3	nlashkar@uoguelph.ca	In lab
Craig Duvall	Lab 4	cduvall@uoguelph.ca	In lab
Adarsh Tandiya	Lab 5	atandiya@uoguelph.ca	In lab
Mohamed Khalil	Lab support/Courselink	khalil@uoguelph.ca	In lab

2 LEARNING RESOURCES

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*3410 [Courselink](#) site. You are responsible for checking the site regularly.

2.2 Required Resources

1. W Bolton, *Control Engineering, 2nd ed.* Prentice Hall, 1998.

2.3 Additional Resources

Lecture Information: All of Dr. Vale's lecture notes will be posted on Courselink as they are finalized (prior to lectures). Dr. Yang's notes will be posted after class.

Quiz readings/videos: Links to reading and videos that must be used to prepare for quizzes will be posted in the 'quiz info' section of courselink. You are strongly encouraged to review this information before taking the quiz as these topics will not be covered in lectures. Videos will be predominantly drawn from YouTube, specifically [Brian Douglas](#).

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

Problem sets: Some problem sets are included in Dr. Vale's notes. Additional 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 GTA. Students are encouraged to post their attempts at solutions to the remaining questions in the discussion forums; GTA and the instructor will monitor these discussions and will provide support to help students arrive at the correct solutions.

Problem sets are not graded.

2.4 Communication and Email Policy

Please use lectures and lab help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. It is your responsibility to check the course website regularly. As per university regulations, all students are required to check their mail.uoguelph.ca e-mail account regularly: e-mail is the official route of communication between the University and its students.

Important: When writing email to course staff (instructors, TAs, or lab techs), please be professional in your communication. Unprofessional emails will not be responded to. This includes those using l33t, text messaging shorthand, a complete lack of punctuation or capitals, etc.

Furthermore, Miss., Mrs., Ms., and Mr. are inappropriate forms of address for any faculty member who has a PhD. When communicating with the course instructors, (verbally or via email), please use Julie, Dr. Vale, Dr. Yang, or Professor.

3 ASSESSMENT

3.1 Dates and Distribution

Note that reading week occurs between weeks 6 and 7. There are 12 weeks (and therefore 24 lectures) in the term. Due dates have been entered in your calendars on CourseLink; check there if you are confused.

Quizzes: (best 4 of 6)

- Lecture 2 (Jan 14): Matrix algebra
- Lecture 6 (Jan 28): Routh Hurwitz
- Lecture 11 (Feb 23): Bode Plot Sketching
- Lecture 16 (Mar 10): Nyquist Sketching
- Lecture 17 (Mar 15): Root Locus Sketching
- Lecture 21 (Mar 29): Bode Plot review

Labs: There is a safety quiz available online in CourseLink. This is a pass/fail quiz and does not contribute to your final course grade. You must pass (80% or higher) this quiz before you are allowed to enter the lab. If you do not pass this quiz, you will not be allowed to enter the lab and you will not be allowed to submit a lab report.

See section 5.3 below for information regarding in-lab dates and times. Lab reports are due at 4:30pm on the week indicated in Section 5.3 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).

Midterm Feb 11, in class

Final Exam: April 12, 19:00-21:00, location TBD.

The breakdown for grading the course is given below. It is based on the premise that you must pass the exams in order to pass the course while ensuring that there are no step discontinuities in the grades (e.g., getting a 50% on the final exam versus a 49% will not change your grade from 70% to 49%). Additionally, if you do better on the final exam than the midterm, the final will have a higher weighting.

Define: Final Grade := G , Final exam := F , Midterm := M , Laboratory reports := L , and Quizzes := Q (all in percent), then set

$$E := \frac{1}{0.7} \max\{0.5F + 0.20M, 0.6F + 0.10M\}$$

and

$$x := \frac{E - 40\%}{20\%}.$$

Your final grade is then given by

$$G := \begin{cases} 0.7E + 0.2L + 0.1Q, & E \geq 60\% \\ \min\{(1-x)E + x(0.7E + 0.2L + 0.1Q), \\ \quad 0.7E + 0.2L + 0.1Q\}, & 40\% \leq E \leq 60\% \\ \min\{E, 0.7E + 0.2L + 0.1Q\} & E \leq 40\%. \end{cases}$$

The ideal weighting (i.e., if you get over 60% on everything and do better on the final than the midterm) is

- midterm=10%
- final=60%
- labs=20%
- quizzes=10%.

Labs are not equally weighted: 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%).

A MATLAB grade calculator is available on courselink if you wish to experiment with different grade allocations.

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 **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.

Missed quizzes If you miss one or two quizzes, those quizzes will be given a grade of zero and will count towards the best 4 of 6 grade; no documentation or requests for accommodation are required. If you miss three or more quizzes and wish to request accommodation, you must have grounds for granting academic consideration or religious accommodation for **all** of the missed quizzes. In this case, each completed quiz will count for 2.5% towards the quiz grade and any remaining weight (of the 10% available for quizzes) 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.

Lab Work: A lab safety quiz is available on Courselink. You will not be allowed to enter the lab until you have successfully completed this quiz.

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: All labs except for lab 1 have a *mandatory* prelab. 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.

Bonus mark cap: There are bonus marks available in this course; however, no assessment grade can be greater than 100%.

4 AIMS, OBJECTIVES & GRADUATE ATTRIBUTES

4.1 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.

Prerequisite(s): ENGG*2400, Math*2270)

Corequisite(s): ENGG*2450)

4.2 Course Aims

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.

4.3 Learning Objectives

At the successful completion of this course, a student will 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

4.4 Graduate Attributes

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

Graduate Attribute	Learning Objectives	Assessment
1. Knowledge Base	1-5	All
2. Problem Analysis	1-5	Exams, labs
3. Investigation	5	Lab
4. Design	4	Labs, exam
5. Use of Engineering Tools	3-4	Labs
6. Communication	6	Lab reports
11. Environment, Society, Business, & Project Management	5	Safety quiz

4.5 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 Timetable

Lectures:

Tuesday		13:00 - 14:20	ROZH 101
Thursday		13:00 - 14:20	ROZH 101

Laboratory:

Monday	Sec 1x	15:30-17:30	RICH 1504
Tuesday	Sec 2x	14:30-16:30	RICH 1504
Wednesday	Sec 3x	15:30-17:30	RICH 1504
Thursday	Sec 4x	14:30-16:30	RICH 1504
Friday	Sec 5x	15:30-17:30	RICH 1504

Tutorial:

Monday	Sec x1	17:30-18:30	CRSC 116
Monday	Sec x2	19:00-20:00	CRSC 116
Wednesday	Sec x3	19:00-20:00	CRSC 117
Thursday	Sec x4	19:00-20:00	CRSC 116
Thursday	Sec x5	17:30-18:30	CRSC 116

5.2 Lecture Schedule

Please see the lecture notes on courselink for more information regarding what is contained in each chapter.

Lecture(s)	Topic
1-2	Topic 1 – Introduction to systems, Modeling and State space
3-6	Topic 2 – System characteristics: LTI, linearization, stability
7-8	Topic 3 – System responses: FVT, step, impulse, frequency
9	Review and selected problems
10	Midterm
11-12	Topic 3 pt 2 – System responses: FVT, step, impulse, frequency
13-16	Topic 4 – Introduction to Control: closed loop systems, block diagrams, closed loop stability (including Nyquist), system specifications
17-20	Topic 5 – PID control, includes root locus and state feedback
21-23	Topic 6 – More control (frequency domain): Lead and Lag
24	Review and selected problems

5.3 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.

Week	Lab	Due dates
1	Safety lab (online)	
2	Lab 1: On/Off lab (no pre-lab)	
3	Lab 2: MATLAB	Lab 1 Due
4		Lab 2 Due
5		
Reading week!		
6	Lab 3: Modeling	
7		Lab 3 Due
8	Lab 4: PID investigation	
9		Lab 4 due
10	Lab 5 (day 1): PID design	
11	Lab 5 (day 2): PID design	Lab 5 early submission - 10% bonus
12		Lab 5 Due

5.4 Other Important Dates

Monday, January 11 2016: First day of class

Monday, February 15 - Friday, February 21 2016: Winter Break

Friday, March 11 2016: drop date - 40th class

Friday, April 8 2016: 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.

A lab safety quiz is available on Courselink. You will not be allowed to enter the lab until you have successfully completed this quiz.

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>