

Calendar Description

Introduction to control systems. Advantages of closed-loop feedback systems. The role of system mathematical model. Block diagrams and system flow graphs. The basic control system design problem, stability in control systems. Frequency response analysis techniques. Root-locus analysis. Elementary lead-lag compensation.

Instructor

Prof. Stephen L. Smith (EIT 3108, stephen.smith@uwaterloo.ca)

Note: Please put “ECE380” at the front of your subject line for all course related email.

Lab Instructor

Carmin Caradima (E2-3344A via E2-3348, ext. 33003, cmcaradi@ecemail.uwaterloo.ca)

TAs

Lab TAs:

- Amini, Amir-Reza (aamini@uwaterloo.ca)
- Azzouz, Maher Abdelkhalek (mazzouz@uwaterloo.ca)
- Farag, Hany Essa Zidan (hefarag@uwaterloo.ca)
- Faraji-Dana, Zahra (zfarajid@uwaterloo.ca)
- Liu, Yining (y354liu@uwaterloo.ca)
- Rajaei, Nazila (nrajaei@uwaterloo.ca)

Tutorial TA: Ebrahimzadeh Saffar, Hamidreza (h4ebrahi@uwaterloo.ca)

Schedule

Lectures:

- Tue/Wed/Thur: 10:30am-11:20am (RCH 211)
- Bonus lectures to replace midterm week are on the following Wednesday's at 11:30am-12:20pm (RCH 211): Jan 12, Jan 26, Feb 09, Mar 01, Mar 15, Mar 29 (**All bonus lectures may not be used.**)

Lectures will not be held on during reading week (Feb 20 - 24) and midterm week (Feb 27 - Mar 2).

Tutorials: Thurs 8:30-9:20 (RCH 211)

Instructor Office Hours: Thursdays, 5:00pm-6:00pm (EIT-3108), or as arranged otherwise.

Midterm: Saturday, March 3rd, 2012 13:00-14:20 (Rooms TBA)

Reference Material

Course Notes: The course notes for lectures are available for purchase at the EIT CopyCenter and for download at the course page on LEARN.

Optional Text: Norman S. Nise, *Control Systems Engineering*, 6th edition, Wiley, 2010. (There are copies on reserve in the library.)

Grading

Your final grade will be calculated according to the following:

$$\mathbf{Final\ Grade} = 0.2 \times \text{lab} + \max \{ 0.25 \times \text{midterm} + 0.55 \times \text{exam}, 0.8 \times \text{exam} \}.$$

If you miss the midterm for any reason, then you will receive zero on the midterm and your final exam will automatically be worth 80% of your final grade.

Course Outline

1. Motivation
Introduction to control engineering, the basic unity feedback structure, feedforward control, feedback control, typical design specifications.
2. Basic Signal and Systems Concepts
Complex variables, Laplace transforms, transfer functions, frequency response (Bode plots).
3. System Modeling
Differential equation models of physical systems, electromechanical examples, block diagram manipulation.
4. Step Responses of Linear Systems
First order systems, second order systems, standard forms, performance measures, effects of poles and zeros on step response, reduced order models.
5. Stability of Linear Time-Invariant Systems
BIBO stability, characterization of stability in terms of poles, pole-zero cancellations, stability of unity-feedback loop, tests for stability (sign test, Routh-Hurwitz test).
6. Basic Feedback Control
Disturbance rejection, sensitivity, tracking of reference signals, PID controller design.
7. Root Locus Design
Rules for drawing the root-locus, lead and lag dynamic compensator design.
8. Dynamic Compensator Design Using Bode Plots
Improving phase margin by lead compensation, improving low frequency behaviour by lag compensation, improving phase margin by lag compensation, lead-lag compensation.
9. Nyquist Plots
Construction of Nyquist plots, Nyquist stability test, quantifying stability robustness, using Nyquist plots for design.
10. Modern Control Theory
State-space representations of linear systems, nonlinear systems and linearization, linear state feedback.

Labs

Lab Room: E2-3341

Lab Webpage: <http://www.ece.uwaterloo.ca/~lab380>

Lab Manual (required): Each of the five lab modules has a manual, found under the course account on LEARN (D2L). More detail about labs, including lab-specific data assignment and lab FAQ can be found on the lab webpage.

Lab marks and mark adjustments if you miss a lab session or a deadline:

- There are 5 lab modules, which together constitute 20% of your final grade. Each of the labs is weighted as follows:
 - 2% for Lab 1 (Instrumentation and Measurement Techniques)
 - 4% for Lab 2 (Second-Order system Identification and Analysis)
 - 4% for Lab 3 (Motor Velocity and Position Control)
 - 5% for Lab 4 (PID Analysis)
 - 5% for Lab 5 (Lead and Lag Compensator Design)
- All submissions are to be done electronically, through the CourseBook system <https://ecewo32.uwaterloo.ca/cgi-bin/WebObjects/CourseBook>.
- Prelabs and lab reports are due as specified in the Lab Calendar posted on LEARN. Please verify that you have uploaded your submission on time, the document is complete, and it is under the group account of the correct course number.
- Prelabs will be graded, and the grades make up a part of the overall grade for each lab module. Late prelabs will incur a penalty of 20% in the first 24 hours, and 100% thereafter, unless prior arrangements are made or a valid reason presented. With a valid reason, prelabs can be handed in late, but no later than the date on which the actual lab sessions start.
- Late lab reports will incur a penalty of 20% in the first 24 hours, and 100% thereafter, unless prior arrangements are made or a valid reason presented within a week from the missed deadline. In no case will a lab report be accepted more than a week past the deadline; if a valid reason exists for being unable to hand in the lab within the week following the deadline, then the lab will be assigned a weight of zero and the remaining labs will be reweighted accordingly.
- Lab attendance is mandatory for each student. Missing a significant portion of a lab session without a valid reason will result in a reduction in the lab report grade (for that student only). The grade reduction will be proportional to the fraction of the lab session missed, where missing an entire lab session (without a valid reason) results in a 100% reduction in the lab report grade. In cases where a student misses part of a lab session, the lab instructor is the one who determines the mark reduction.

Rules about group work in labs:

- Students work in groups of two. Both partners must do all of the lab work, and attend all lab sessions (see above). Each group submits one prelab per lab, and one report per lab. See the Overview lab document for details about the report format.
- The instructor or lab instructor has the authority to split up or re-arrange groups for academic reasons, including the possibility of requiring certain students to work alone.

- Under no circumstances are students allowed to access, in any form, ECE/SE380 lab reports or answers or results from previous terms. Such access will be treated as an academic offence under Policy 71.
- You are allowed to talk with other students currently enrolled in the course about the lab content, but each group must write up their lab reports completely independently. Of course, students can also talk to the lab TAs, the lab instructor, or the course professor for help.

General University of Waterloo Guidelines

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. Check <http://www.uwaterloo.ca/academicintegrity/> for more information.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, <http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm>.

When in doubt please be certain to contact the departments administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity—check <http://www.uwaterloo.ca/academicintegrity/> to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, <http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm>.

For typical penalties check Guidelines for the Assessment of Penalties, <http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm>.

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) <http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm>.

Note for Students with Disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.