ECE 484: Digital Control Applications

Fall 2016

Department of Electrical and Computer Engineering
University of Waterloo

This course introduces the techniques required to analyze, design, and successfully implement dynamic controllers. Topics include: performance issues in digital control systems, sampling, and aliasing. Distinctions between continuous-time, discrete-time, and sampled-data control systems. Modeling of dynamic systems through differential/difference equations, state-space models, and transfer functions. Identification of system data from measurements. Nonlinear systems: inversion, equilibrium points, linearization-based control. Digital control system design: pole placement, internal model control, controller emulation methods, and direct z-domain methods. Examples are drawn from a variety of fields, including classical dynamics, electric power systems, aerospace, and instrumentation. In the course laboratory, students will apply the modelling and control design techniques from lectures to control a metallic ball rolling along a balance beam.

Instructor

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(*Please place "ECE 484" in the subject header of all e-mail correspondence.*)

Lab Instructor

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Teaching Assistants

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Course Website and Credit

Units: 0.5

Website: Hosted via UW Learn. For access issues please contact `learnhelp@uwaterloo.ca`.

(*Note: Course website will be available from the first day of class until the final exam is given.*)

Prerequisites

ECE 380 *or* MTE 360 *or* SYDE 352 *or* instructor permission

Antirequisite: ECE 481

Lecture, Tutorial, Office Hours, and Lab Schedule

Lectures:
- Monday: 10:30–11:20, RCH 112
- Wednesday: 09:30–10:20, MC 2066
- Friday: 11:30–12:20, RCH 112

Tutorials:
- Monday: 12:30–1:20, RCH 204
- Wednesday: 5:30–6:20, RCH 204

TA Office Hours:
- Tuesday: 1:30–2:30, EIT 3137
- Thursday: 3:30–4:30, EIT 3137

Laboratory:
- CPH-3682

Textbooks

There is no required text for this course.

Reference Material:
- C. Nielsen *Notes on Digital Control Systems*. Available through UW Learn.
- C. Phillips, H. Nagle, and A. Chakrabortty. *Digital Control System Analysis and Design*, 4th edition, Pearson Press, 2015.

Homework

Homework will be assigned periodically and posted on UW Learn, but will not be graded.

Evaluation

The final exam, the three labs, and the lab demo are mandatory. If you do not do all of them then you will obtain a grade of "Incomplete". If you do them all, then your grade is given by the formula

$$\textbf{Grade} = 0.25 \times \textbf{Lab} + \max\{0.25 \times \textbf{Midterm} + 0.5 \times \textbf{Final}, 0.75 \times \textbf{Final}\}.$$

If you miss the midterm for any reason, your midterm mark is zero.

The midterm will be held from 6:30pm to 8:00pm on October 25th, 2016 in RCH 211.

Please familiarize yourself with University of Waterloo's Assignment and Exam Regulations.

Tentative Laboratory Schedule

The below schedule can be treated as a rough timeline for lab progression. A detailed lab schedule indicating scheduled times when TA's can assist will be posted on UW Learn. Reserving time for your group in the lab will be done manually through a sign-up sheet inside the lab.

Week	Topic
1–2	Independent LabView Tutorial
3	GWiz Tutorial (sign up on LEARN) / Lab 1
4	Lab 1: Modeling and Validation of the Motor System
5	Lab 1 Due / Begin Lab 2
6	Lab 2: Design of the Inner Loop Controller and Modeling of the Ball and Beam
7	Midterm Week
8	Lab 2 Due
9–10	Lab 3: Design of the Outer Loop Controller
11	Lab 3 Due
12	Demonstrations (sign up on LEARN)

Laboratory Information

Lab-related postings (files or news notifications), lab group formation, lab signups, lab report submissions, and feedback will be carried out on UW Learn. Labs are performed in groups of two. Each group member is expected to actively participate in each part of the lab. We reserve the right to split up groups if one of the partners is neglecting their duties. Details for the lab reports expectations are in the lab manual. Doing all three labs and the demo is mandatory.

The penalty for handing in a lab report (together with related project code) is 10% for each day (or part thereof) late (modulo special circumstances); however, each lab report must be handed in no later than the "lab return date" so that the marking is not delayed.

The marking scheme for labs is
- Lab 1: 6%
- Lab 2: 7%
- Lab 3: 8%
- Controller demonstration: 4%

Tentative Lecture Schedule

Week	Lecture Topic
1	Introduction and examples, sampling in control systems, aliasing
2	Time-domain and frequency-domain continuous-time control system stability
3	Linear and nonlinear modeling, step-invariant transforms, state-space models
4	System identification
5	Pole placement, step tracking
6–7	Linear discrete-time systems: z-transforms, state-space models, stability
8	Discretization of continuous-time controllers
9–10	Sampled-data systems
11–12	Controller design in discrete-time

Academic Integrity, Discipline, Grievances, and Appeals

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. For an overview of academic integrity policies and sanctions, see here.

A student is expected to know what constitutes academic integrity 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. For typical penalties check Guidelines for the Assessment of Penalties.

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

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).

Disability Policy

AccessAbility Services, located in Needles Hall 1401, 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 AccessAbility Services at the beginning of each academic term.