UNIVERSITY of GUELPH

ENGG*4490 Sampled Data Control Design

01

Winter 2023
Section(s): C01

School of Engineering
Credit Weight: 0.75
Version 1.00 - December 23, 2022

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1 Course Details

1.1 Calendar Description

This course introduces the theory and techniques required to analyze, design, and implement sampled data controllers on real, continuous time systems. Topics include sampling, system identification and modeling, delay, state-space and frequency domain approaches to control, emulation methods, and direct z-domain methods. In the course project, students will apply the techniques discussed in class to design and implement a computer based controller for a real physical system, then compare the actual results obtained to the expected theoretical results and discuss sources of error and limitations of their approach.

Pre-Requisites:	ENGG*3390, ENGG*3410
Restrictions:	This is a Priority Access Course. Enrolment may be restricted to the ESC specialization in the BENG and BENG:C programs. See department for more information.

1.2 Course Description

Students are invited to explore the fundamentals of using computers and other discrete time tools to control real continuous time systems, and apply this knowledge to real control problems. The main goals of this course are to (1) train students in the tools used to to mathematically analyze and control 'hybrid systems' using a number of different methods, (2) to apply those concepts to real physical systems, and (3) to continue developing students' ability to write a well structured formal report.

2023 COVID-19 protocols: In the event of disruption to our in-person activities, the project will be moved to a high-fidelity simulation performed in Simulink and MATLAB and lectures will be moved online. Decisions about this will be communicated to the students throughout the term if the situation changes.

1.3 Timetable

Lectures:

Tues, Thur   01:00PM - 02:20PM - MCLN 107

Lab:

Mon   12:30PM - 02:20PM - RICH 2504
Wed   10:30AM - 12:20PM - RICH 2504

Note: Lab will start in the week of Jan 23th.

1.4 Final Exam

There is no final exam, rather there will be two term tests as discussed below. The term tests will take place in class, with options to write online if discussed with the professor.
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2 Instructional Support

2.1 Instructional Support Team

Instructor:	Robert Hunter
Email:	rhunte02@uoguelph.ca
Office:	TBA
Office Hours:	We will start with informal office hours, with flexibly scheduled online meetings on an as-needed basis. We may switch to regular scheduled office hours later in the semester if needed. The time and place will be communicated to students if this need arises.

2.2 Teaching Assistants

Teaching Assistant (GTA):	Nishith Bharatkumar Gajjar
Email:	gajjarn@uoguelph.ca
Office:	TBA
Teaching Assistant (GTA):	Victor Oliveira Santos
Email:	volive04@uoguelph.ca

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3 Learning Resources

Lecture Information: Lecture notes will be posted on Courselink after lectures.

Project Information: Information for the course project will be posted within the project section of the Courselink page.

Problem sets: Problem sets will 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 solution.

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:
1. Analyze a hybrid control system using a combination of Laplace transforms and z transforms.
2. Design a digital controller that achieves given specifications for a continuous time plant via both direct and emulation design techniques.
3. Analyze and design a digital controller in the context of process control.
4. Implement a digital controller using Matlab in a laboratory setting.
5. Compare and contrast different controllers in the context of performance, robustness, and stability.
6. Write a clear and comprehensive engineering report.
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5 Teaching and Learning Activities

Lectures in this course address material that students require in order to be able to do the project. Topics are fluid and are driven, at least in part, by student's project related needs. The following is a list of topics that will be covered in this course (in no particular order). The depth of coverage (and therefore the number of lectures devoted to those topics) will depend on student feedback.

Tentative lecture topics:

1. Review of systems, controls, and signals concepts

2. Modeling (linearization, using 'black box' data to generate a transfer function or state space representation)
3. Fundamentals of delay (in time and frequency domain, including Padé approximations)
4. Intro to sampled data systems D/A and A/D. Effects on stability, behavior, and control specifications.
5. First term test
6. Emulation and direct methods
7. Digital controller/filter implementation
8. Control architectures I (Bang-bang, PID, pole placement)
9. Control architectures II (cascade, feed-forward, internal model, possibly model predictive)
10. Multi-variable control, singular value decomposition, decoupling
11. Final term test
12. Final project demos

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6 Assessments

The coarse breakdown of assessments are presented below, and more detail can be found on Courselink. Both the final and mini projects will be done in groups of 3-4 established by the end of the first week of class.

6.1 Assessment Details

Mini Project (10%)
Due: Tue, Feb 7, 11:59 PM, Courselink

Term Test 1 (15%)
Date: Thu, Feb 16, 1:00 PM - 2:20 PM, in class

Term Test 2 (25%)
Date: Tue, Mar 28, 1:00 PM - 2:20 PM, in class

Final Project - Proposal (0%)
Due: Thu, Jan 19, 11:59 PM, Courselink
This assignment is pass/fail, however you must pass before you are allowed to demo or submit any project report.

Final Project - Modelling Report (5%)
Due: Tue, Feb 28, 11:59 PM, Courselink

Final Project - Control Report (5%)
Due: Thu, Mar 9, 11:59 PM, Courselink

Final Project - Informal Demo (0%)
Date: Mon, Mar 20 - Fri, Mar 24, in lab and some lecture
This assignment is pass/fail. Sign-up sheets will be provided in Courselink for students to

select specific days and times. Students who do not participate in the Informal Demo cannot participate in the Final Demo unless compassionate grounds and some alternative are established with the professor.

Final Project - Formal Demo (5%)
Date: Mon, Apr 3 - Fri, Apr 7, in lab and some lecture
Sign-up sheets will be provided in Courselink for students to select specific days and time

Final Project Report (35%)
Due: Wed, Apr 19, 11:59 PM, Courselink

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7 School of Engineering Statements

7.1 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.

7.2 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.

7.3 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.

8 University Statements

8.1 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.

8.2 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

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

8.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic 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

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.shtml

8.4 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.

8.5 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 make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

8.6 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

8.7 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.

8.8 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

8.9 Disclaimer

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, changes in classroom protocols, and academic schedules. Any such changes will be announced via CourseLink and/or class email.

This includes on-campus scheduling during the semester, mid-terms and final examination schedules. All University-wide decisions will be posted on the COVID-19 website (https://news.uoguelph.ca/2019-novel-coronavirus-information/) and circulated by email.

8.10 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).

8.11 Covid-19 Safety Protocols

For information on current safety protocols, follow these links:

- https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
- https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.

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