ENGG*4490 Sampled Data Control Design

01

Winter 2024
Section(s): C01

School of Engineering
Credit Weight: 0.75
Version 2.00 - January 26, 2024

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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. Non-BENG students may take a maximum of 4.00 ENGG credits.

1.2 Course Description

The objective of this course is to build upon introductory courses in automatic controls to cover advanced concepts in automatic control system analysis and design, with particular emphasis on “digital control” techniques.

1.3 Timetable

Lectures:

T, TH 04:00PM - 05:20 PM - MCLN 234

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.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Mohammad Al Janaideh
Email: maljanai@uoguelph.ca
Office: RICH 1505
Office Hours: T: 10:00-11:00 am

TH: 2:00-3:00 pm

2.2 Teaching Assistants

Teaching Assistant (GTA): Aneri Kanaiyabhai
Email: anerikan@uoguelph.ca
Office: TBA

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3 Learning Resources

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

Problem sets: Problem sets will be posted in the 'problem sets' section of Courselink. Solutions will be posted to the same section in Courselink by the instructor.

Textbook: Digital control system analysis and design, Phillips, Nagle, Chakrabortty, 4th edition.

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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 control system using 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 mechatronics
4. Implement a digital controller using Matlab.
5. Compare and contrast different controllers in the context of performance, robustness, and stability.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
1	Knowledge Base	1
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1
1.3	Recall, describe and apply fundamental engineering principles and concepts	1
1.4	Recall, describe and apply program-specific engineering principles and concepts	1
2	Problem Analysis	1
2.1	Formulate a problem statement in engineering and non-engineering terminology	1
2.4	Execute an engineering solution	1
3	Investigation	5
3.1	Propose a working hypothesis	5
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	5
3.3	Analyze and interpret experimental data	5
3.4	Assess validity of conclusions within limitations of data and methodologies	5
4	Design	2
4.1	Describe design process used to develop design solution	2
4.2	Construct design-specific problem statements including the definition of criteria and constraints	2

#	Outcome	Learning Outcome
4.3	Create a variety of engineering design solutions	2
4.4	Evaluate alternative design solutions based on problem definition	2
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	2
5	Use of Engineering Tools	2, 4
5.1	Select appropriate engineering tools from various alternatives	4
5.2	Demonstrate proficiency in the application of selected engineering tools	2, 4
5.3	Recognize limitations of selected engineering tools	2, 4
7	Communication Skills	2
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	2
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	2

5 Teaching and Learning Activities

The course will cover the following topics:

Tentative lecture topics:

•Introduction to Computer Controlled Systems

•Sampled Data Analysis

•The Z-Transform and the Difference Equations

•Discrete-Time System Representation

•Analysis of Discrete-Time Systems

•Design of Discrete Time Controller—Input/Output Approaches

•Design of Discrete Time Controller—Polynomial Approaches

•Design of Discrete Time Controller—State Space Approaches

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Test 1	20
Test 2	20
Project	60
Total	100

6.2 Assessment Details

Test 1 (20%)
Date: Thu, Feb 15, 4:00 PM - 5:00 PM, in class

Test 2 (20%)
Date: Tue, Mar 26, 4:00 PM - 5:00 PM, in class

Project (60%)
Due: Courselink

- Labs start the week of the 22nd with some safety orientation, training, and system description.
- In week 01, take an idea about the hardware and systems for the project.
- Lab managers and TA should be able to help with hardware issues.
- Two projects for this course, both of which provide interesting control challenges and reflect real-world applications:
  - Magnetic Levitation: Nonlinear, unstable system.
  - Four Tanks: Nonlinear, multi-input, multi-output coupled system.
- Each lab section should be split 50/50 between MagLev and Tank to make sure groups have sufficient access to the hardware. Please see the posted data sheets for the MagLev and Tank systems.
- Groups are 4 or 5 people.
- Report 01 (proposal) and presentation 01: Week 26th Feb [10%]
- Final Presentation 02: Week 1st April [20%]
- Final report: April 12 [courselink] [30%]

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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 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).