Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Outline (W2022)

ELE639: Controls Systems

Instructor(s)	Dr. Gosha Zywno [Coordinator] Office: ENG463 Phone: (416) 979-5000 x 556105 Email: gzywno@ryerson.ca Office Hours: Mondays, 2-4 pm, Wednesdays, 1-2 pm, by email appointment only. Note: In Winter 2022, all communications will be through Email & Zoom.
Calendar Description	Introductory course in control theory: system modeling, simulation, analysis and controller design. Description of linear, time-invariant, continuous time systems, differential equations, transfer function representation, block diagrams and signal flows. System dynamic properties in time and frequency domains, performance specifications. Basic properties of feedback. Stability analysis: Routh-Hurwitz criterion, Root Locus method, Bode gain and phase margins, Nyquist criterion. Classical controller design in time and frequency domain: lead, lag, lead-lag compensation, rate feedback, PID controller. Laboratory work consists of experiments with a DSP-based, computer-controlled servomotor positioning system, and MATLAB and Simulink assignments, reinforcing analytical concepts and design procedures.
Prerequisites	ELE 532 and CEN 199
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	1. ELE639: Course Notes, Copyright 2000-2022, by M.S. Zywno, PhD. The lecture notes are available from the secure course website as PDF downloadable files. 2. MATLAB User Manual (including Control Systems Toolbox and Simulink) the Mathworks, Inc., Copyright 1995-2022, available for download on the Departmental Network as Matlab help files.
Reference Text(s):	1. Control Systems Engineering, Norman S. Nise, 8th edition 2019, Wiley Inc.
Learning Objectives (Indicators)	At the end of this course, the successful student will be able to: 1. Demonstrates competency in modeling and analysis of a SISO, continuous, LTI control system in a single feedback loop configuration, including specific tasks of defining a system analytical description, its stability and its dynamic response. Uses relevant computer simulation software, MATLAB and Simulink. Identifies and carries out steps required in performing system stability and dynamic response analysis. (**2b**) 2. Implements a PID controller on a real-time control system (servomotor), including obtaining experimental data. Applies the control theory learned to predict performance of the PID-controlled servomotor. (**3a**) 3. Describes the differences between theoretical (linear) model and the implemented design on a real-life system. Assesses accuracy of the results, verifying experimental data and explaining sources of possible discrepancies. (**3b**)

4. Identifies and carries out steps required in designing an in-the-loop controller (PID and Lead-Lag) for a low order LTI system in order to meet a set of specifications. (**4b**), (**4a**)
5. Evaluates the chosen controller design by verifying its performance against a set of criteria, is able to explain differences between expected and actual results. (**4c**)
6. Demonstrates proficiency in the use of high-performance engineering modeling and analysis software, including Matlab, Control Systems Toolbox and Simulink, for control system analysis and design, in this course and for subsequent engineering practice. (**5a**)
7. Accomplishes several tasks requiring efficiency in managing own time and tasks to achieve individual and team goals, including meeting various deadlines. (**6b**), (**6a**)
8. Produces a professionally prepared technical report using appropriate format, grammar, and citation styles, with figures and tables chosen to illustrate points made, with appropriate size, labels and references in the body of the report. Reports are graded on correctness, completeness, grammar, quality of graphics and layout. (**7a**)
9. Responds appropriately to verbal questions from instructors, formulating and expressing ideas, using appropriate technical terminology - assessed through comprehensive lab interviews. (**7b**)
10. Knows the role of the engineer in society, including responsibility for protecting the public interest (**8b**)

NOTE:*Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).*

Course Organization

3.0 hours of lecture per week for 13 weeks
1.5 hours of lab per week for 12 weeks
0.0 hours of tutorial per week for 12 weeks

Teaching Assistants

1. Ali Mehrkish (ali.mehrkish@ryerson.ca), Ph.D.
2. Shahab Ghorbani (shahab.ghorbani@ryerson.ca), Ph.D. Candidate

Course Evaluation

Theory	
Quizzes and Activities	13 %
Midterm Exam	22 %
Final Exam	40 %
Laboratory	
Lab Projects	25 %
TOTAL:	100 %

Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both **"Theory and Laboratory"** components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the **"Course Evaluation"** section above for details on the Theory and Laboratory components (if applicable).

Examinations

Midterm Exam will be scheduled in Week 7, online, as a take-home, open book exam. There will be multiple versions, covering problem-solving and theory (covers Weeks 1-6 of lecture notes).

The final exam will be scheduled during the exam period, on campus, in person: multiple versions,

	three hours duration, problem-solving type, closed book with a standard formula sheet. The exam is comprehensive, but with emphasis on the design aspects of the course.
Other Evaluation Information	Please note that the three labs are of different weights: 7%, 9% and 9%, respectively. Also note that in Winter 2022, due to COVID-19 considerations to mitigate the in-person contact within the lab, in-person Lab Interviews will be replaced with short D2L Lab Quizzes, and the requirement to check the pre-lab with the TA is being suspended. The D2L Lab Quizzes are scheduled for January 30, March 6, and April 3, 2022. Course evaluation includes both individual effort (midterm, final exam, D2L quizzes) and group work (lab reports, homework).
Teaching Methods	In Winter 2022, all lectures and counseling hours are virtual for the whole semester, using Zoom sessions. Live lectures will be recorded on Zoom and later posted on D2L. Live Q & A segments of lectures and counseling hours will not be recorded. Midterm Test will be conducted online, as a take-home test, with multiple versions, both problem-solving and theory questions, to be uploaded to D2L using Assignments feature. The final exam is scheduled to take place in person, on campus during the exam period. Course Activities will be in form of D2L Quizzes and Homework. All labs are scheduled to be conducted in person, in ENG413, under the supervision of TAs. Please note that as per Ryerson announcement, the return to campus is postponed till January 30, 2022. This means the labs will start in virtual mode, and switch to on-campus mode after January 30. All Lab Reports will also have to be uploaded to D2L using Assignments feature. Please see the note above re. temporary lab changes for Winter 2022.
Other Information	1. All students shall adhere to the rules of Academic Integrity, and shall acquaint themselves with the Student Code of Academic Conduct and all other relevant policies all relevant university policies found on Ryerson Senate website: http://ryerson.ca/senate/course-outline-policies. Any suspected breach of Academic Integrity such as cheating or plagiarism will be investigated with the participation of the Academic Integrity Officer. Please check the course D2L website for more information on current policies, including COVID-19 considerations. 2. In accordance with the Policy on Ryerson Student E-mail Accounts (Policy 157), Ryerson requires that any electronic communication by students to Ryerson faculty or staff be sent from their official Ryerson email account. 3. In the lab, there are two computer simulation-based (MATLAB and Simulink) and one real-time DSP-based control system experiment to be completed. The first two lab projects (simulations) focus on the stability and performance analysis on the PID Controller and the third project is the feedback control design of the DC servo motor system in the Control Systems Lab (ENG413). In simulation projects students will work with non-repeating data sets that are frequently modified, to be completed in pairs. For the real-time experiment, students will work in groups of three. All partners shall contribute equally to the lab reports. When submitting a lab report, students will be interviewed by lab instructors with questions relevant to the completed project. As well, partners will be asked to describe their contributions. Any student found not to have adequately contributed to the project, will be asked to re-do the project on their own. Please see the note above re. temporary lab changes for Winter 2022. 4. Please note that the lab report marks may be adjusted at the end of the course to equalize differences between sections and different Teaching Assistants' marking styles. 5. All students registered in ELE639 are expected to participate throughout the course in Course Activities that will support their understanding of the course material. They will include completing quizzes on D2L and home assignments, for which they will be earning Course Activity Points. Course

	Activities are worth 13% of the final grade. Activities will take place every week. These are low stakes, frequent activities, and there are no make-up arrangements for the missed ones.

Course Content

Week	Hours	Chapters / Section	Topic, description
Week 1	3	Chapter 1	Goals for the course and course logistics. Review of terminology, objectives, and control system analysis/design procedures. General concepts of feedback and control - open vs. closed loop systems. Introduction to Matlab & Simulink. Models: transfer functions & block diagrams. Laplace Transform review (ELE532).
Week 2	3	Chapter 2	System stability, Routh Array, Routh-Hurwitz Criterion.
Week 3	3	Chapter 3	Models: block diagrams vs. signal flow graphs. Mason's Gain.
Week 4	3	Chapter 4	Step response specifications. Time domain analysis. Steady state errors.
Week 5	3	Chapters 5	Time domain analysis - transient response of 1st and 2nd order systems. Standard second order model. Higher order dynamics, dominant poles, reduced order models.
Week 6	3	Chapters 6	System control in time domain - classical three mode controller - characteristics of P, PD, PI and PID control. PID Controller tuning. Top-down design of a simple controller (PD, PI, lead).
Week 7	3	Review	Midterm Test. Review of course materials after the midterm.
Week 8	3		Root locus method of system analysis, Proportional Control design from Root Locus plot - choosing gain.
Week 9	3	Chapter 7	Root locus method of system analysis continued. PID Controller design from Root Locus plot - choosing gain and time constants.

Week 10	3	Chapter 8	Stability in frequency domain: gain and phase margins. Polar plots and Nyquist criterion. Frequency response of a closed loop system. Closed loop second order model in frequency domain. Phase margin of a second order system.
Week 11	3	Chapter 9	Correlation between frequency response and time domain response as a basis of frequency response design. Controller design in frequency domain: lead controllers.
Week 12	3	Chapter 10	Controller design in frequency domain: lag and lead-lag controllers.
Week 13	3	Review Examples	Review of course materials for final exam, Questions and answers regarding the final exam.

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2-3	Lab 1	Lab Project 1: Stability of Control Systems under Proportional, PI, PD and PID Control. Two (2) sessions + extra time outside the lab time as required. Simulations to analyze system stability under P, PI and PD Control. Individual data sets assigned to lab partners. Note that there is an individual Pre-Lab for this project that will be checked by the TA. Failure to present the Pre-lab will result in a 20 point deduction on the lab report. Lab 1 Report due in Week 04. Interviews for Lab 1 also scheduled in Week 04.
4-7	Lab 2	Lab Project 2: Performance of Control Systems under P, PI, PD, and PID Control. Four (4) sessions + extra time outside the lab time as required. Part1: Proportional Control – Performance Analysis Part2: PI Control – Performance Analysis Part3: PD Control – Performance Analysis Part4: PID Control – Performance Analysis Individual data sets assigned to lab partners. Note that there is an individual Pre-Lab for this project that will be checked by the TA. Failure to present the Pre-lab will result in a 20 point deduction on the lab report. Lab 2 Report due date and lab interviews are scheduled for Week 8.
8-11	Lab 3	Lab Project 3: Feedback Control of a Real-time DSP-based DC Servo Motor. Four (4) sessions, only in Control Systems Lab (ENG413).

		Part1: Uncompensated Servo Motor Response Part2: Compensated Servo Motor Response Part3: PID Controller Operation Outside the Nominal Range Note that there is an individual Pre-Lab for this project that will be checked by the TA. Failure to present the Pre-lab will result in a 20 point deduction on the lab report. Lab 3 Report due date and lab interviews are scheduled for Week 12.

Policies & Important Information:

Students must be reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the following URL: http://ryerson.ca/senate/course-outline-policies

1. Students are required to obtain and maintain a Ryerson e-mail account for timely communications between the instructor and the students;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Ryerson senate policy 157 requires that any electronic communication by students to Ryerson faculty or staff be sent from their official Ryerson email account.
5. Familiarize yourself with the tools you will need to use for remote learning. The Continuity of Learning Guide for students includes guides to completing quizzes or exams in D2L or Respondus, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.
6. The University has issued a minimum technology requirement for remote learning. Details can be found at: https://www.ryerson.ca/covid-19/students/minimum-technology-requirements-remote-learning. Please ensure you meet the minimum technology requirements as specified in the above link.
7. Ryerson COVID-19 Information and Updates (available https://www.ryerson.ca/covid-19/students) for Students summarizes the variety of resources available to students during the pandemic.
8. Refer to our **Departmental FAQ** page for information on common questions and issues at the following link: https://www.ee.ryerson.ca/guides/Student.Academic.FAQ.html.

Missed Classes and/or Evaluations

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. **Academic Consideration Requests for missed work** (e.g. missing tests, labs, etc) - According to Ryerson Senate Policy 134, sections 1.2.3, if you miss any exams, quizzes, tests, labs, and/or assignments for helth or compassionate reasons you need to inform your instructor(s) (via email whenever possible) in advance when you will be missing an exam, test or assignment deadline. When circumstances do not permit this, you must inform the instructor(s) as soon as reasonably possible "*In the case of illness, a Ryerson Student Health Certificate, or a letter on letterhead from an appropriate regulated health professional with the student declaration portion of the Student Health Certificate attached. For reasons other than illness, proper documentation is also required (e.g. death certificate, police report, TTC report).* ***ALL supporting documentation for illness or compassionate grounds MUST be submitted within three (3) working days of the missed work.***" **NOTE: You are required to submit all of your pertinent documentation through Ryerson's online Academic Consideration Request system at the following link:** prod.apps.ccs.ryerson.ca/senateapps/acadconsform.
2. ***Religious, Aboriginal and Spiritual observance*** - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at

www.ryerson.ca/senate/forms/relobservforminstr.pdf. **If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;**

3. ***Academic Accommodation Support*** - Before the first graded work is due, students registered with the Academic Accommodation Support office (AAS - www.ryerson.ca/studentlearningsupport/academic-accommodation-support) should provide their instructors with an Academic Accommodation letter that describes their academic accommodation plan.

Virtual Proctoring Information (if used in this course)

Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of any such virtually proctored exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to ensure academic integrity is maintained and then will be deleted.

Access to a computer that can support remote recording is your responsibility as a student. The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a typical high-speed internet connection. Please note that you will be required to show your Ryerson OneCard prior to beginning to write the exam. In cases where you do not have a Ryerson OneCard, government issued ID is permitted.

Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam, please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

Turnitin (if used in this course)

Turnitin.com is a plagiarism prevention and detection service to which Ryerson subscribes. It is a tool to assist instructors in determining the similarity between students' work and the work of other students who have submitted papers to the site (at any university), internet sources, and a wide range of books, journals and other publications. While it does not contain all possible sources, it gives instructors some assurance that students' work is their own. No decisions are made by the service; it generates an "originality report," which instructors must evaluate to judge if something is plagiarized.

Students agree by taking this course that their written work will be subject to submission for textual similarity review to Turnitin.com. Instructors can opt to have student's papers included in the Turnitin.com database or not. Use of the Turnitin.com service is subject to the terms-of-use agreement posted on the Turnitin.com website. Students who do not want their work submitted to this plagiarism detection service must, by the end of the second week of class, consult with their instructor to make alternate arrangements.

Even when an instructor has not indicated that a plagiarism detection service will be used, or when a student has opted out of the plagiarism detection service, if the instructor has reason to suspect that an individual piece of work has been plagiarized, the instructor is permitted to submit that work in a non-identifying way to any plagiarism detection service.

Academic Integrity

Ryerson's Policy 60 (the Academic Integrity policy) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspicions of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to an including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams

For more detailed information on these issues, please refer to the Academic Integrity policy(https://www.ryerson.ca/senate/policies/pol60.pdf) and to the Academic Integrity Office website (https://www.ryerson.ca/academicintegrity/).

Academic Accommodation Support

Ryerson University acknowledges that students have diverse learning styles and a variety of academic needs. If you have a diagnosed disability that impacts your academic experience, connect with Academic Accommodation Support (AAS). Visit the AAS website or contact aasadmin@ryerson.ca for more information.

Note: All communication with AAS is voluntary and confidential, and will not appear on your transcript.

Important Resources Available at Ryerson

1. The Library (https://library.ryerson.ca/) provides research workshops and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or go to https://library.ryerson.ca/workshops

2. Student Learning Support (https://www.ryerson.ca/student-life-and-learning/learning-support/) offers group-based and individual help with writing, math, study skills and transition support, as well as resources and checklists to support students as online learners (https://www.ryerson.ca/student-life-and-learning/learning-support/).

3. You can submit an Academic Consideration Request (https://prod.apps.ccs.ryerson.ca/senateapps/acadconsform) when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill and academic requirement. You may always visit the Senate website (https://www.ryerson.ca/senate/) and select the blue radial button on the top right hand side entitled: Academic Consideration Request (ACR) to submit the request.

   Policy 167: Academic Concideration due to COVID-19: Students that miss an assessment due to cold or flu-like symptoms, or due to self isolation, are currently not required to provide a health certificate. Other absences must follow Policy 167: Academic Consideration.

   Also NOTE: Outside of COVID-19 symptoms, the new Policy 167: Academic Consideration does allow for a once per term academic consideration request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. In the absence is more than 3 days in duration and/or is for a final exam/final assessment, documentation is required. For more information please see Senate Policy 167: Academic Consideration.

4. Ryerson COVID-19 Information and Updates for Students (https://www.ryerson.ca/covid-19/students/) summarizes the variety of resources available to students during the pandemic.

5. Familiarize yourself with the tools you will need to use for remote learning. The Continuity of Learning Guide (https://www.ryerson.ca/centre-for-excellence-in-learning-and-teaching/learning-guide/) for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.

6. Information on Copyright for Faculty (https://library.ryerson.ca/copyright/faculty/copyright-faqs/my-teaching-materials-have-been-posted-online/ and students (https://library.ryerson.ca/copyright/home/copyright-for-students-2/students-course-sharing-websites-and-file-sharing/).

7. At Ryerson, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis. Below are resources we encourage all Ryerson community members to access to ensure support is reachable. https://www.ryerson.ca/mental-health-wellbeing.

   If support is needed immediately, you can access these outside resources at anytime:
   - **Distress Line** - 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
   - **Good2Talk** - 24/7 hour line for postsecondary students (phone: 1-866-925-5454)