ELEC ENG 3CL4
Introduction to Control Systems

COURSE OUTLINE

Please refer to course website for updated information

CALENDAR/COURSE DESCRIPTION

Modelling of control systems in the continuous-time domain; state space representations; model linearization; performance of control systems in time and frequency; stability; control design.

PRE-REQUISITES AND ANTI-REQUISITES

Pre-requisite(s): Registration in any Computer Engineering or Electrical Engineering Program,
One of ELECENG 3TP3 or 3TP4
Anti-requisite(s): IBEHS 4AO3, MECHENG 4RO3, MECHTRON 3DX4, SFWRENG 3DX4

SCHEDULE AND MODE OF DELIVERY

The material for this course will be delivered through a mixture of textbook readings, classroom lessons, tutorials (for problem solving), and laboratories. Classroom lessons, tutorials, and laboratories will take place in-person unless otherwise notified. Classroom lessons and tutorials will not be recorded. Labs may have pre-lab videos that must be watched before the respective lab session.

Lectures: C01: Mondays, Wednesdays & Thursdays, 1:30 pm – 2:20 pm
C02: Mondays, Wednesdays & Fridays, 5:30 pm – 6:20 pm

Tutorials: T01: Wednesdays, 11:30 am – 12:20 pm
T02: Mondays, 6:30 pm – 7:20 pm

Labs: There will be five in-person lab sessions (every other week) as follows:

L01 Mondays	2:30 pm – 5:20 pm	(Jan 26, Feb 9, Mar 2, Mar 16, Mar 30)
L02 Mondays	2:30 pm – 5:20 pm	(Feb 2, Feb 23, Mar 9, Mar 23, Apr 6)
L03 Tuesdays	2:30 pm – 5:20 pm	(Jan 27, Feb 10, Mar 3, Mar 17, Mar 31)
L04 Tuesdays	2:30 pm – 5:20 pm	(Feb 3, Feb 24, Mar 10, Mar 24, Apr 7)
L05 Wednesdays	2:30 pm – 5:20 pm	(Jan 28, Feb 11, Mar 4, Mar 18, Apr 1)
L06 Wednesdays	2:30 pm – 5:20 pm	(Jan 21, Feb 4, Feb 25, Mar 11, Mar 25)
L07 Thursdays	2:30 pm – 5:20 pm	(Jan 29, Feb 12, Mar 5, Mar 19, Apr 2)
L08 Thursdays	2:30 pm – 5:20 pm	(Jan 22, Feb 5, Feb 26, Mar 12, Mar 26)
L09: Fridays	2:30 pm – 5:20 pm	(Jan 30, Feb 13, Mar 6, Mar 20, Apr 2*)
L10: Fridays	2:30 pm – 5:20 pm	(Jan 23, Feb 6, Feb 27, Mar 13, Mar 27)
L11: Tuesdays	6:30 pm – 9:20 pm	(Jan 27, Feb 10, Mar 3, Mar 17, Mar 31)

All laboratories must be completed to pass the course.
* Since there will be no classes or labs on April 3 due to Good Friday, Lab Section L09 will have their final lab on Thursday, April 2, 2026, from 6:30 pm to 9:20 pm.
Students should refer to their schedule on Mosaic to find the locations of classes, tutorials and labs.

INSTRUCTORS

Dr. Tim Davidson (Section C01)
E-mail: davidson@mcmaster.ca
Office: ITB A226
Phone: 905-525-9140 ext. 24818
Office Hours: See course website for details.

Dr. Shahrukh Athar (Section C02)
E-mail: athars3@mcmaster.ca
Office: ITB A317
Phone: 905-525-9140 ext. 26503
Office Hours: See course website for details.

When emailing your instructor, please ensure that your email subject starts with "EE3CL4:" and include in the body of the message your name, student number, lab section, and class section. Please include prior correspondence and endeavour to keep your emails concise. You must send emails from your @mcmaster.ca account.

TEACHING ASSISTANTS

Names, contact information and office hours are provided on the course website.

COURSE WEBSITE

McMaster Avenue to Learn: https://avenue.mcmaster.ca/

COURSE OBJECTIVES

To engage students in the art of classical control system analysis and design for linear systems, with an emphasis on root locus, Nyquist diagram and frequency domain design techniques, and on the development of insight into the trade-offs in control system design. To achieve these goals, by the end of this course, students should be able to:

- Model physical systems by developing appropriate differential equations.
- Apply the Laplace transform to take a linear time-invariant system represented by differential equations in the time domain to the Laplace domain to facilitate control system analysis and design.
- Derive the transfer function of a DC servomotor and an effective second-order approximation of that transfer function.
- Employ various measurement techniques to identify the parameters of that second-order approximation for a physical servomotor.

- Analyze the step response of first- and second-order feedback control systems in terms of their transient behaviour and steady-state error performance.
- Utilize the Routh-Hurwitz condition to analyze the stability of linear feedback control systems.
- Sketch the root locus for a given linear feedback control system and use it to analyze the stability of the system.
- Design and analyze proportional, and phase lead, lag, and lead-lag compensators to fulfill given design objectives, using root locus principles.
- Assess the performance of the above design techniques on a physical servomotor.
- Plot the frequency response of linear control systems in terms of Bode plots and polar plots.
- Utilize the Nyquist criterion to analyze the stability of linear feedback control systems.
- Design and analyze phase lead, lag, and lead-lag compensators to fulfill given design objectives, using frequency domain techniques.

CEAB GRADUATE ATTRIBUTES (GAS)

Note: The CEAB Graduate Attributes (GAs) defined in this section are measured throughout the course and form part of the Department's continuous improvement process. They are a key component of the accreditation process for the program and will not be taken into consideration in determining a student's actual grade in the course. For more information on accreditation, please ask your instructor or visit: http://www.engineerscanada.ca

Attributes	Indicators		Measurement Method(s)
	Number	Description	
Knowledge Base for Engineering	1.1	Competence in Mathematics	Exams
Problem Analysis	2.1	Identifies and states reasonable assumptions and suitable engineering fundamentals, before proposing a solution path to a problem.	Exams
Problem Analysis	2.2	Proposes problem solutions supported by substantiated reasoning, recognizing the limitations of the solutions.	Exams
Investigation	3.2	Synthesizes the results of an investigation to reach valid conclusions.	Labs
Design	4.1	Defines the problem by identifying relevant context, constraints, and prior approaches before exploring potential design solutions.	Labs

ASSUMED KNOWLEDGE

- Basic understanding of dynamic systems (Phys 1D03)
- Basic understanding of electromagnetics (Phys 1E03)
- Understanding of electric circuit analysis (Elec Eng 2CI4/5, Elec Eng 2CJ4/Comp Eng 2CF3)
- Understanding of first and second order linear differential equations with constant coefficients (Math 2Z03, Elec Eng 2CI4/5, Elec Eng 2CJ4/Comp Eng 2CF3)
- Understanding of the Laplace Transform (Math 2Z03, Elec Eng 2CJ4/Comp Eng 2CF3)
- Understanding of Transfer functions (Elec Eng 2CJ4/Comp Eng 2CF3, Elec Eng 3TP3)
- Understanding of Bode diagrams (Elec Eng 2CJ4/Comp Eng 2CF3, Elec Eng 3EJ4)

COURSE MATERIALS

Recommended Texts:
Dorf and Bishop, *Modern Control Systems*, 14th edition, Pearson, 2022.
Available at the McMaster Campus Store (E-text)
Previous editions may also be used. However, they might differ a bit in the order of topics and end-of-chapter exercises.

Khalil, *Control Systems: An Introduction,* Michigan Publishing, 2023 (Free PDF version available at: https://control.eecs.umich.edu/).

Additional Text:
Nise, *Control Systems Engineering,* 8th edition, Wiley, 2019.

Software (at no cost):
MATLAB and Simulink: https://www.mathworks.com/academia/tah-portal/mcmaster-university-31501097.html

Calculator:
Only the McMaster Standard Calculator will be permitted in tests and examinations. Please note that as of September 2017, the McMaster Standard Calculator is the Casio fx-991 MS or Casio fx-991 MS Plus. The Casio fx-991 is available with various letter configurations, however only the MS or MS Plus models are acceptable when the McMaster Standard Calculator has been designated for use. (See https://registrar.mcmaster.ca/exams/requirements/ for more information.)

Other Materials:
The slides/notes from lectures and tutorials will be posted on Avenue to Learn.

Additional material that may be helpful will be made available through Avenue to Learn.

COURSE OVERVIEW

Week	Topic
Week 1	Introduction
Weeks 2, 3	Mathematical modelling of dynamic systems
Weeks 4, 5	Feedback control systems (characteristics and performance)
Weeks 6, 7	Stability and Routh Hurwitz analysis
Weeks 7, 8	Root locus analysis
Weeks 8, 9	Root locus based control system design (proportional/lead/lag/lead-lag compensators)
Weeks 10, 11	Frequency domain techniques (Nyquist criterion)
Weeks 12-13	Frequency domain based control system design (lead/lag/lead-lag compensators)

A more detailed proposed timeline is available on the course website. If adjustments to the schedule are required, the instructors will notify all students in lectures and on the course website.

LABORATORY OVERVIEW

The course will have five in-person labs during the term. Labs are conducted in-person and are NOT held during the first two weeks of the term. Please see the schedule listed on Page 1 of this outline for your exact lab schedule.

Labs 2-5 will have up to three components: **1)** Pre-Lab report; **2)** In-lab control system analysis and design experiments (evaluated in-person by TAs); **3)** Final lab report. Lab 1 does not have a pre-lab nor a final report component. **Attendance is mandatory in ALL five labs.**

When attending labs, the student must attend the assigned room and section (see Page 1 of this outline). Attendance will be taken. All lab components are part of the academic assessment of the course and, as such, are subject to the terms laid out under the McMaster Academic Integrity Policy.

It is a mandatory requirement to complete ALL five labs to successfully complete the course.

An overview of lab topics is given in the table below.

Week	Topic
Weeks 3-5	Introduction
Weeks 5-7	System Identification
Weeks 7-9	Proportional Control and Velocity Feedback Control
Weeks 9-11	Lead Control using Root Locus techniques
Weeks 11-13	Lead-Lag Control using Root Locus techniques

LABORATORY OPERATION

- Each student in the course is required to pass the lab safety quiz prior to attempting any of the laboratories. The quiz will be available on Avenue to Learn.
- Access to all labs is restricted in the interest of security and safety. Information on using the lab can be found on the webpage: https://www.eng.mcmaster.ca/ece/resources/health-safety-labs/
- The laboratories will be performed in groups of two students.
- Labs 2-5 will involve a significant amount of pre-lab work. **The pre-lab report is due on the day of your lab at the beginning of your lab session**. **You should submit one pre-lab report per group. The format of the pre-lab report and the submission procedure will be specified in the lab manual**. Pre-lab reports submitted late will not be accepted (no exceptions) and thus no marks will be awarded for late submissions.
- **Each group is also required to submit a laboratory report electronically through the course website (Avenue Dropbox)**. **It is recommended that students complete the lab report and submit on Avenue Dropbox by the end of their designated lab time. However, the reports are due at 11:59 pm the day after the student's designated lab session.** For example, if your lab took place on February 2, 2026, then your lab report is due by 11:59 pm on February 3, 2026. No marks will be awarded to reports that are submitted more than 10-minutes late.
- The TAs and the instructors reserve the right to interview students to assess their understanding of the pre-lab material. Such interviews will be held at random, and we reserve the right to adjust the pre-lab mark based on the outcome of the interview.
- Your performance in the experiments described in the lab will also be assessed through an interview process with a TA during the lab. During the interview process students will demonstrate the outcome of the experiment. The TAs will ask questions that probe your understanding of the experiment and the outcome, and they will assess your work based on your responses. It is expected that both members of the group will be present to participate in the interview process.
- The laboratories will end after 2 hours and 50 minutes. If you are unable to complete an experiment by that time, you will not receive the marks for that component of the laboratory and there will be no make-up.
- The laboratories constitute an important component of the course, and, as such, the content of the labs is examinable in the midterm and final exams.
- **Note:** No food or drink is permitted in the lab. Please keep the lab clean.

ASSESSMENT

Component	Weight
Laboratory Work	25% (5 Labs: Each lab has 5% of course weight) *
Mid-term Test (1)	25%
Final Exam (1)	50%
Total	100%

* All labs must be attended, and all pre-lab and laboratory reports must be completed, in order to pass the course; Passing the *Lab Safety Quiz* in Lab 1 is mandatory to receive marks in subsequent labs.

Students are expected to attend all classes and tutorials, as well as their assigned laboratory section. Students will be responsible for all material covered in these venues.

Grading and Evaluation Policies:

- To be eligible for a final grade, each student must personally complete ALL laboratories and contribute to the writing of pre-lab and final laboratory reports.
- Use of books, notes, other copied materials, computers or cell phones is not allowed during exams, unless otherwise notified.
- The final exam must be written else a final grade of F will be awarded with the notation DNW (Did Not Write) regardless of the student's course aggregate achieved without the final exam.
- **To pass the course a student must obtain a mark of at least 30% on the final examination.**
- Make-up midterm tests will not normally be granted. Weight of a missed midterm test will be transferred to the final exam only after an approved MSAF is received.
- For a student who writes both the midterm and final exams, the weight of the midterm test will be transferred to the final exam if that improves the student's overall grade.
- Percentages will be converted to letter grades using the Registrar's recommended procedure.
- Statistical adjustments (such as "bell curving") will not normally be used.
- When a test or examination is formally deferred, the instructor reserves the right to conduct that test or examination orally.

See Avenue to Learn for dates, times, and instructions for the Midterm Exam and Final Exam.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g., the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at this link.

The following illustrates only a few forms of academic dishonesty:

- Plagiarism, e.g., the submission of work that is not one's own or for which other credit has been obtained.
- In case a course is being repeated, submitting work done earlier by the student may constitute self-plagiarism. Students should discuss with the instructor for clarity.
- Improper collaboration in group work.
- Copying or using unauthorized aids in tests and examinations.
- Using generative AI tools to do work that is to be submitted for credit if the instructor has prohibited such use.

Note: The use of generative AI tools (such as ChatGPT) is prohibited in this course unless explicitly allowed by the instructor. Any violation in this regard will constitute academic dishonesty.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g., A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to this link.

COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g., e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, usernames for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online. It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g., use of Avenue 2 Learn, Microsoft Teams, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATIONS

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's Academic Accommodation of Students with Disabilities policy.

Students requiring academic accommodations based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations.

Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work". The applicable policy is located at this link.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory and online at this link.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following whether conducting lab work at school or at home:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.

8. Proper waste disposal procedures should be followed.
9. Personal ergonomics should be practiced when conducting lab work. Please see this link.
10. Current University health and safety issues, and protocols should be known. Please see this link.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
Main Lobby of ITB or dial "88" after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.

Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.

University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.

See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs.

Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.

ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (On Campus Dial 88)

When calling to report a fire, give name, exact location, and building.
1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any

other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people.

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other non-flammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In power labs, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol For Safe Laboratory Practice

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer - ITB 147	spencers@mcmaster.ca
ECE Chair	Dr. Shahram Shirani - ITB A111	shirani@mcmaster.ca
ECE Administrator	Shelby Gaudrault - ITB A111	gaudraus@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	