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 lectures, tutorials (for problem solving), and laboratories. Classroom lectures, tutorials, and laboratories will take place in-person unless otherwise notified.

Lectures: C01: Mondays, 12:30 pm - 2:20 pm; Wednesdays, 12:30 pm - 1:20 pm.
C02: Tuesdays, Thursdays, and Fridays, 8:30 am - 9:20 am.

Tutorials: T01: Fridays, 10:30 am – 11:20 am.
T02: Mondays, 11:30 am – 12:20 pm

Labs: There will be five in-person lab sessions (every other week).
L01 Mondays 2:30 pm – 5:20 pm
L02 Mondays 2:30 pm – 5:20 pm
L03 Tuesdays 2:30 pm – 5:20 pm
L04 Tuesdays 2:30 pm – 5:20 pm
L05 Wednesdays 2:30 pm – 5:20 pm
L06 Wednesdays 2:30 pm – 5:20 pm
L07 Thursdays 2:30 pm – 5:20 pm
L08 Thursdays 2:30 pm – 5:20 pm
L09: Fridays 2:30 pm – 5:20 pm
L10: Fridays 2:30 pm – 5:20 pm
L11: Tuesdays 6:30 pm – 9:20 pm

All the laboratories must be completed to pass the course.

INSTRUCTORS

Dr. Shahrukh Athar (Section C01)
E-mail: athars3@mcmaster.ca (Please include "[EE3CL4]" in the subject line)
Office: ITB A317
Phone: 905-525-9140 ext. 26503
Office Hours: TBA

Dr. Ayman Negm (Section C02)
E-mail: negma1@mcmaster.ca Please include "[EE3CL4]" in the subject line
Office: ITB A201
Phone: 905-525-9140 ext. 24971
Office Hours: TBA

TEACHING ASSISTANTS

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

COURSE WEBSITE

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.

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)
- Understanding of first and second order linear differential equations with constant coefficients (Math 2Z03, Elec Eng 2CI4/5, Elec Eng 2CJ4)
- Understanding of the Laplace Transform (Math 2Z03, Elec Eng 2CJ4)
- Transfer functions (Elec Eng 2CJ4, Elec Eng 3TP3)
- Understanding of Bode diagrams (Elec Eng 2CJ4, Elec Eng 3EJ4)

COURSE MATERIALS

Required Text:
Dorf and Bishop, *Modern Control Systems*, 14th edition, Pearson, 2022.
Available at the McMaster Campus Store (Options: Permanent access or 6-month access)
Previous editions may also be used. However, they might differ a bit in the order of topics and end-of-chapter exercises.

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	Readings (Sections in textbook)
Week 1	Introduction	1.1, 1.3, 1.5, 1.8, 1.9, 1.10
Week 2, 3	Mathematical modelling of dynamic systems	2.1, 2.2, 2.3, 2.4, 2.5, 2.6
Weeks 3, 4	Feedback control systems (characteristics and performance)	4.2-4.4, 4.6, 4.7, 5.2, 5.3, 5.5, 5.6
Weeks 5, 6	Stability and Routh Hurwitz analysis	6.1, 6.2, 6.3, 6.7
Weeks 6-9	Root locus analysis and design	7.2, 7.3, 7.6 10.3, 10.5, 10.7
Week 9	PID	7.6
Week 10	Frequency response	8.1-8.3, 10.3
Weeks 10-13	Nyquist diagram analysis and frequency-domain design	9.2-9.5, 10.4, 10.8

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

LABORATORY OVERVIEW

Date/Week	Topic
Weeks 2-4	Introduction
Weeks 4-6	System Identification
Weeks 6-8	Proportional control
Weeks 8-10	Lead control using Root Locus techniques
Weeks 10-12	Lead-Lag control using Root Locus techniques

LABORATORY OPERATION

- The laboratories will be performed in groups of two students.
- Labs 2-5 will involve a significant amount of pre-lab work. You should submit one pre-lab report per group, electronically through the course web site. The pre-lab report is due by 12:01 pm on the day of your lab. Pre-labs submitted after 12:01pm but before 2:30pm will be subject to a penalty of 50%. No marks will be awarded to pre-labs submitted after 2:30pm.
- Each group is also required to submit a laboratory report electronically through the course web site. The reports are due one week from the day of the lab at 11:59pm. Reports that are late up to 24 hours will receive a penalty of 50%. No marks will be awarded to reports that are more than 24 hours 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 of the experiments described in the lab will also be assessed through an interview process with a TA. 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 3 hours. If you are unable to complete an experiment by that time, you will not receive the marks for that component of the laboratory.
- The laboratories constitute an important component of the course, and, as such, the content of the labs is examinable in the midterm test(s) and the final exam.

ASSESSMENT

Component	Weight
Laboratory Work	30% (5 Labs: Lab handouts have exact weights)
Mid-term Test	30%
Final Exam	40%
Total	100%

Grading Policies:

- In order to be eligible for a final grade, each student must personally complete all laboratories and contribute to the writing of pre-lab and laboratory reports.
- 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.

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
https://secretariat.mcmaster.ca/app/uploads/Academic-Integrity-Policy-1-1.pdf

The following illustrates only three 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.
• improper collaboration in group work.
• copying or using unauthorized aids in tests and examinations.

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., Avenue-to-Learn, 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 ensures 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 www.mcmaster.ca/academicintegrity.

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 to Learn, 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 accommodation 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".

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: https://hr.mcmaster.ca/app/uploads/2019/07/2019-McMaster-Lab-Manual.pdf

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. https://bit.ly/3fOE71E
10. Current University health and safety issues, and protocols should be known. https://hr.mcmaster.ca/resources/covid19/workplace-health-and-safety-guidance-during-covid-19/

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, 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	Mohamed Bakr- ITB A111	mbakr@mcmaster.ca
ECE Administrator	Shelby Gaudrault- ITB A111/B	gaudraus@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	