ECSE 307: Linear systems and control

Fall 2023

1 General Description

Instructor: Borna Sayedana
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This course is for:

- Bachelor of Engineering (B.Eng.) - Computer Engineering

- Bachelor of Engineering (B.Eng.) - Electrical Engineering

- Bachelor of Engineering (B.Eng.) - Honours Electrical Engineering

Lectures: 04:35pm-05:55pm Tuesday, Thursday, WONG 1020

Tutorials: 09:35am-11:25am Friday, ENGTR 0100

Everyone **must** be registered for tutorials. Tutorials start from the first week of the classes.

Labs:

1. 01:35pm-03:25pm Monday, ENGTR 4090

2. 01:35pm-03:25pm Wednesday, ENGTR 4090

3. 03:35 pm-05:25pm Monday, ENGTR 4090

4. 01:35pm-03:25pm Tuesday, ENGTR 4090

5. 01:35 pm-03:25pm Friday, ENGTR 4090

Everyone **must** be registered for one of the lab sessions. Labs start from the second week of the classes (First lab session is on Tuesday September 5th).

Number of credits: 4

Learning objectives: Modelling and simulation of control systems, review of LTI systems, time response of first and second order systems, state space modeling, controllability, state feedback and pole placement, observability, observer design, and output feedback, PID controllers, Routh-Hurwitz stability criterion, system type and steady state errors, Bode plots, Nyquist plots, Nyquist stability criterion, gain and phase margins, lead-lag compensators. Lab work involving step response, frequency response, system identification, state feedback, output feedback, and lead-lag compensators.

2 Graduate Attributes and Learning Outcomes

KB-Knowledge Base for Engineering (I), PA-Problem Analysis (I), IN-Investigation (I)
Upon the successful completion of this course, the students will have demonstrated the ability to:

- Apply time- and frequency-domain tools to analyze linear time-invariant systems (KB,PA).

- Design controllers based on state-space methods, proportional controller, PID controllers, and lead-lag compensators to meet time-response specifications (KB,PA,IN).

- Use Matlab to analyze and synthesize controllers for linear time-invariant systems (PA,IN).

3 Course content

Week by week plan of the course:

Weeks	Materials
Week 1	Review of LTI Systems and Laplace Transforms
Week 2	Pole Zero Plot, Step response of first and second order systems, dominant pole approximation
Week 3	State space modeling, canonical forms, transfer functions of state space modes
Week 4	Matrix exponential and solution of matrix differential equations, time response of state space models
Week 5	Pole placement, controllability, and state feedback
Week 6	Luenberger observer, observability, output feedback, and separation principle
Week 7	Review and Mid-Term
Week 8	Routh-Hurwitz stability criterion. Proportional controller.
Week 9	Root locus diagram, and PID controller.
Week 10	System type, steady state error, disturbance rejection and sensitivity.
Week 11	Bode and Nyquist Plots.
Week 12	Nyquist stability criterion, gain and phase margins.
Week 13	Lead-Lag Compensators.

4 Logistics

Course Page: MyCourses

Teaching Assistants: Jingyu Liu, Jilan Samiuddin, Reihaneh Ghoroghchian

Office Hours:

1. After the lectures.

2. Posting your questions on the discussion board on MyCourses.

3. Mondays 12:30-1:30pm ENGTR 4103.

4. By appointments.

Text book:

- Control Systems Engineering, Norman Nise, 7th Ed, Wiley.

Other Reference Books:

- Gene F. Franklin, J. Da Powell, Abbas Emami-Naeini, Feedback Control of Dynamical Systems, 7th Ed, Pearson.

- Katsuhiko Ogata, Modern control engineering, 5th Ed, CRC Press.

Prerequisites/Co-requisites:

- ECSE 206 : Introduction to Signals and Systems
- ECSE 210 : Electric Circuits 2

5 Grading policy

Distribution of marks:

1. **Assignments (10%)**
2. **Laboratory (20%)**
3. **Midterm Exam (20%)**
4. **Final Exam (50 %)**

Grading policy

1. **Assignments (10%)**: Weekly homework assignments.

   - Submitting the assignments late causes 10% penalty per day for the maximum of 2 days. After 2 days or after the solution is posted on MyCourses, the assignment will not be accepted.
   - Due to paucity of grading hours, two or three **randomly** assignment questions will be graded each week.
   - The lowest two homework assignments will be dropped.

2. **Laboratory (20%)**: Weekly labs, to be conducted in groups of two.

   - We have a lab exam in the last week of labs (4%).
   - In order to receive the grade of each lab report you must:
     (a) participate in the lab **in person AND** (b) submit your lab report on time.
     You will receive a score of 0 if either criteria (a) or (b) is not fulfilled.
   - The lowest two **lab reports** will be dropped. (This rule doesn't apply to the lab exam).

3. **Midterm Exam (20%)**: 90 minutes exam held during regular class time on **October 19th**. Closed book. The exam material will be announced 1 week before the exam.

   - **There will be no make-up examination for students who miss the mid-term**. Student who miss the exam due to a valid reason (see `https://www.mcgill.ca/engineering/students/undergraduate /courses-registration/exams-assessment/midterms-and-class-tests/adjustments-missed-mid terms-and-class-tests`) should notify **the instructor within a week of the exam and provide necessary documentation**.
   - If, and only if, proper documentation for a missed exam is presented, the marks for the missed exam will be shifted to the final exam.
   - Students who miss the mid-term exam for any other reason (e.g., no medical note, going to the exam at the wrong time, or on the wrong day, etc.) will get zero marks on the exam.
   - Any request for reevaluation of a mid-term or an assignment must be made in **writing** within a **week** of its return. Note that requesting a re-grade will mean that your whole exam will be re-graded.

4. **Final Exam (50 %)** : 3 hours, during the exam period. Closed book. The final exam will cover **all** the material seen in the class during the term.

Attendance policy

1. **Attendance at lectures**: It is not mandatory but highly recommended.
2. **Attendance at tutorials**: It is not mandatory but highly recommended.
3. **Attendance at labs**: It **is mandatory**.

6   Course Delivery

Course Materials: The course is taught in a **"chalk and board"** style; there will be no power point presentations. All students are expected to **attend lectures and take notes**. Partial notes on some of the material will be provided, but are **not a substitute** for the material covered in class.

Copyright: ©Instructor-generated course materials (e.g., handouts, notes, summaries, exam questions) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.

7   McGill Policy

Right to submit in English or French written work that is to be graded: In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.

Academic Integrity: McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see `http://www.mcgill.ca/students/srr/honest/` for more information).

L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l'étudiant et des procédures disciplinaires (pour de plus amples renseignements, veuillez consulter le site `http://www.mcgill.ca/students/srr/honest/`.

Extraordinary circumstances: In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.

Learning experience: As the instructor of this course I endeavor to provide an inclusive learning environment. However, if you experience barriers to learning in this course, do not hesitate to discuss them with me and the Office for Student Accessibility and Achievement.

Course evaluation: End of the course evaluations are one of the ways that McGill works towards maintaining and improving the quality of courses and the student's learning experience. You will be notified by e-mail when the evaluations are available.

8   Acknowledgement

Acknowledgement: The instructor is grateful to **Prof. Aditya Mahajan** for sharing the lectures, assignments, laboratory assignments, and other supporting materials which are used for this course.