ELEC 372
Fundamentals of Control Systems
Department of Electrical and Computer Engineering
Winter 2024

Course Instructor:
Amir Aghdam
amir.aghdam@concordia.ca
Room EV002.165

Office Hours:
Tuesdays 10:00-12:00, EV002.165

Tutorials:
Tutor for Section UA: Hesamoddin Mosalli – Mondays 11:45-12:35 (MB 2.255)
Tutor for Section UB: Hesamoddin Mosalli – Wednesdays 11:45-12:35 (MB S2.465)
Tutor for Section UC: Razieh Abdolahi – Mondays 11:45-12:35 (MB S2.465)
Online POD TA: Saba Sanami – Mondays 9:00-12:00 (the Zoom link provided on Moodle)

Labs:
The Lab Moodle website ELEC-372-X-Lab-2234 (https://moodle.concordia.ca/moodle/course/view.php?id=164481) is available to ELEC372 students now. Please find the following documents:

- ELEC372 Lab Guidelines
- ELEC372 Lab Schedule File
- ELEC372 Lab Manuals and Data

This term ELEC372 lab has six sections, and the TAs are assigned as below:

- UI-X, UJ-X: Sanami, Saba
- UK-X, UL-X: Rahimifard, Mahshid
- UM-X, UN-X: Asgari, Shadi

See also the Lab Details section.

Course Calendar Description:
Mathematical models of control systems. Characteristics, performance, and stability of linear feedback control systems. Root-locus methods. Frequency response methods. Stability in the frequency domain. Design and compensation of feedback control systems.

Prerequisites: ELEC 242 Continuous-Time Signals and Systems or 364 Signals and Systems II
Co-requisites: N/A

Specific Knowledge and Skills Needed for this Course:
Students taking this course are expected to have sufficient knowledge of the following topics. Should you have difficulties in any of these topics, you are strongly encouraged to review them before the DNE deadline.

Basic circuit theory; Complex numbers; Unilateral Laplace transform; Basics of MATLAB.

Course materials

Required Textbook: *Insert Name, Author(s), Publisher, Edition, Year*

R1 (the main textbook): Modern Control Systems by Richard C. Dorf and Robert H. Bishop, 14th Edition, Pearson Education Inc., 2022.
R2: Feedback Control of Dynamic Systems by Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, 6th Edition, Prentice Hall, 2010.
R3: Automatic Control Systems by Farid Golnaraghi and Benjamin C. Kuo, 9th Edition, John Wiley & Sons, Inc., 2010.
R4: Modern Control Engineering by Katsuhiko Ogata, 4th Edition, Prentice Hall, 2002.
R5: Feedback Control Systems by Charles L. Philips and Royce D. Harbor, Prentice Hall,
R6: Control Systems Engineering by Norman S. Nise, 6th Edition, John Wiley & Sons, Inc., 2011.
R7: Signals and Systems by Alan V. Oppenheim, Alan S. Willsky and S. Hamid Nawab, 2nd Edition, Prentice-Hall, 1997

Supplementary notes by Amir Aghdam will be posted on the course website
http://www.ece.concordia.ca/~aghdam/ELEC372/ELEC372_Winter2024.htm
a few days before lectures.

Grading Scheme

The final mark will be calculated as follows:
HW: 3%, Quiz: 12%, Lab: 15%, Midterm: 20%, Final: 50% OR
HW: 3%, Quiz: 12%, Lab: 15%, Final: 70% OR
HW: 3%, Best of 4 Quizzes: 9.6%, Lab: 15%, Midterm: 2.4%, Final: 70%
WHICHEVER IS BETTER.

Tentative Course Schedule

See the appendix

Lab Details

Lab coordinator: Mr. Dan Li (H851-03, dan.li@concordia.ca)
The labs will be held in H-863, with the first lab starting on January 29th. The lab consists of 5 compulsory experiments. All experiments will be conducted in person, and lab attendance is mandatory. The lab constitutes 15% of the total course grade. You must attend only the lab section you are registered in; transfers are not allowed. Repeating students are NOT exempted from the lab, even if they have obtained at least 50% of the lab marks.

There is a separate Moodle site for the ELEC372 lab (ELEC372 Lab 2234 - Winter 2024). You can find lab guides, schedules, and manuals on this site.

Engineering Tools

MATLAB is a software package for numerical computation and data visualization. It also offers programming features and graphical user interface tools, and comes with many useful toolboxes including Control System Toolbox. MATLAB is available on our computer network and you will

have to use it in some of the assignments, project and lab. You can learn the basics of MATLAB from Appendix A in the textbook. Furthermore, at the end of each chapter, the relevant features and functions of Control System Toolbox are covered. These topics will also be discussed in the tutorials. Details of the latest version of MATLAB can be found from the on-line help desk: http://www.mathworks.com/help/index.html

Details on assessment tools: N/A

Other information

The homework grade of 3% can be secured by solving and handing in all the homework assignments. Some homework problems will be solved in the tutorials; the complete solutions will be available at the copy center. The quiz questions will be exactly the same as or very similar to one of the supplementary problems. Therefore, it is to your benefit to do all the problems. There will be five quizzes, which will be taken during the first 15 minutes of the tutorials. For details, see the course schedule. Each homework will be assigned on Friday and collected the following Monday in the tutorial. No late homework will be accepted.

Verification of analytical solutions by scientific software such as MATLAB for some homework problems is recommended. Using such software tools, if learned early in the semester, will be very helpful.

Graduate Attributes:

The following is the list of graduate attributes (skills) that students use, learn and/or apply throughout the term.

- Problem analysis (PA):
  - o problem identification and formulation (advanced)
  - o modelling (advanced)
  - o problem solving (advanced)
  - o analysis (advanced).
- Investigation (INV):
  - o background and hypothesis formulation (advanced)
  - o designing experiments (advanced)
  - o conducting experiments and collection of data (advanced)
  - o analysis and interpretation of data (advanced).
- Use of engineering tools (UET):
  - o ability to use appropriate tools, techniques, and resources (advanced)
  - o demonstrate awareness of limitations of tools, create and extend tools as necessary(advanced).

Course Learning Outcomes (CLOs):

By the end of this semester, students are expected to master the following engineering concepts. The students that complete this course will be able to:

- Model feedback control systems (PA1, PA2)
- Determine the stability of linear time-invariant systems (using time-domain and frequency-domain
- techniques) (PA, INV, UET)
- Assess the transient response of linear time-invariant feedback control systems (using time-domain and frequency-domain techniques) (PA, INV, UET)

- Assess the steady-state response of linear time-invariant feedback control systems (using time-domain and frequency-domain techniques) (PA, INV, UET)
- Design compensator (controller) for linear time-invariant feedback control systems (using time-domain and frequency-domain techniques) (PA, INV, UET)

Health and Safety Guidelines

All health and safety rules specific to this course can be found in the lab manual. General health and safety instructions and available health and safety trainings can be found at: Safety Programs - Concordia University (https://www.concordia.ca/campus-life/safety/general-safety.html)

On Campus Resources

Please visit Student services at Concordia University for the services available Gina Cody School students.

Appendix – Tentative Course Schedule

i) Based on 8th, 9th or 10th editions of the main textbook R_1

DATE	TOPIC	Assignments
Lecture Notes #1 Week of Jan. 15	Introduction to Control Systems and Mathematical Foundation R_1: Ch. 1, R_7: 1.6.3-1.6.6, R_1: 2.4	**HW 1 (Due: Jan. 22)**
Lecture Notes #2 Week of Jan. 22	Linearization and Block Diagrams R_1: 2.6, R_2: 3.2.1 (and lecture notes)	**HW 2 (Due: Jan. 29)** **Quiz 1 on Jan. 29, 31**
Lecture Notes #3 Week of Jan. 29	Mathematical Modeling of Systems R_1: 2.2, 2.5 **NOTE: DNE Deadline Jan. 29**	**HW 3 (Due: Feb. 5)**
Lecture Notes #4 Week of Feb. 5	Time Domain Analysis: 1st Order Systems R_4: 5.2	**HW 4 (Due: Feb. 12)** **Quiz 2 on Feb. 12, 14**
Lecture Notes #5 Week of Feb. 12	Time Domain Analysis: 2nd Order Systems and Model Reduction R_1: 5.3 (and lecture notes)	**HW 5 (Due: Feb. 19)**
Week of Feb. 19	**Review on Tuesday, Feb. 20** **Midterm on Thursday, Feb. 22 (during the lecture time)**	**No Homework**
Week of Feb. 26	**Reading Week**	
Lecture Notes #6 Week of Mar. 4	Steady-State Error; Routh-Hurwitz Criterion R_1: 5.7, 12.11, 5.8, 5.9, R_1: 6.2, 6.3, R_5: 6.1 (and lecture notes)	**HW 6 (Due: Mar. 11)** **Quiz 3 on Mar. 11, 13**
Lecture Notes #7 Week of Mar. 11	Root Locus Technique R_1: 7.1-7.3	**HW 7 (Due: Mar. 18)**
Lecture Notes #8 Week of Mar. 18	Root Locus Technique R_1: 7.5, 10.5	**No Homework** **Quiz 4 on Mar. 25, 27**
Lecture Notes #9 Week of Mar. 25	Root Locus Technique; Frequency Domain Representation R_1: 10.7, 8.2-8.5	**HW 8 (Due: Apr. 3)**
Lecture Notes #10 Week of Apr. 1	Frequency Domain Analysis: Nyquist Criterion R_1: 9.2-9.4	**HW 9 (Due: Apr. 8)**
Lecture Notes #11 Week of Apr. 8	Design of Control Systems in Frequency Domain R_1: 10.3, 10.4, 10.6, 10.8	**HW 10 (Due: Apr. 15)** **Quiz 5 on Apr. 8, 10**
Week of Apr. 15	**NOTE: DISC Deadline Apr. 17**	
Final Exam		

ii) Based on 11th, 12th, 13th or 14th editions of the main textbook R_1

DATE	TOPIC	Assignments
Lecture Notes #1 Week of Jan. 15	Introduction to Control Systems and Mathematical Foundation R_1: Ch. 1, R_7: 1.6.3-1.6.6, R_1: 2.4	**HW 1 (Due: Jan. 22)**
Lecture Notes #2 Week of Jan. 22	Linearization and Block Diagrams R_1: 2.6, R_2: 3.2.1 (and lecture notes)	**HW 2 (Due: Jan. 29)** **Quiz 1 on Jan. 29, 31**
Lecture Notes #3 Week of Jan. 29	Mathematical Modeling of Systems R_1: 2.2, 2.5 **NOTE: DNE Deadline Jan. 29**	**HW 3 (Due: Feb. 5)**
Lecture Notes #4 Week of Feb. 5	Time Domain Analysis: 1st Order Systems R_4: 5.2	**HW 4 (Due: Feb. 12)** **Quiz 2 on Feb. 12, 14**
Lecture Notes #5 Week of Feb. 12	Time Domain Analysis: 2nd Order Systems and Model Reduction R_1: 5.3 (and lecture notes)	**HW 5 (Due: Feb. 19)**
Week of Feb. 19	**Review on Tuesday, Feb. 20** **Midterm on Thursday, Feb. 22 (during the lecture time)**	**No Homework**
Week of Feb. 26	**Reading Week**	
Lecture Notes #6 Week of Mar. 4	Steady-State Error; Routh-Hurwitz Criterion R_1: 5.6, 12.7, 5.7, R_1: 6.2, 6.3, R_5: 6.1 (and lecture notes)	**HW 6 (Due: Mar. 11)** **Quiz 3 on Mar. 11, 13**
Lecture Notes #7 Week of Mar. 11	Root Locus Technique R_1: 7.1-7.3	**HW 7 (Due: Mar. 18)**
Lecture Notes #8 Week of Mar. 18	Root Locus Technique R_1: 7.4, 10.5	**No Homework** **Quiz 4 on Mar. 25, 27**
Lecture Notes #9 Week of Mar. 25	Root Locus Technique; Frequency Domain Representation R_1: 10.7, 8.2-8.4	**HW 8 (Due: Apr. 3)**
Lecture Notes #10 Week of Apr. 1	Frequency Domain Analysis: Nyquist Criterion R_1: 9.2-9.4	**HW 9 (Due: Apr. 8)**
Lecture Notes #11 Week of Apr. 8	Design of Control Systems in Frequency Domain R_1: 10.3, 10.4, 10.6, 10.8	**HW 10 (Due: Apr. 11)** **Quiz 5 on Apr. 8, 10**
Week of Apr. 15	**NOTE: DISC Deadline Apr. 17**	
Final Exam		