Systems and Control
(ELEC 341; 4 Credits)

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Course Description:

The course studies dynamic systems encountered in a variety of engineering systems. It will begin with a study of mathematical modeling of such systems which allows the response of these systems to various inputs to be predicted and their stability to be assessed. The effects of feedback on dynamic systems will be studied, leading to the development of a number of different design techniques for producing control systems. The topics that will be covered are: Continuous time system analysis by Laplace transforms; system modeling by transfer function and state space methods; feedback, stability and sensitivity; control design; frequency domain analysis.

Prerequisites:

One of ELEC 202 (Circuit Analysis II) or ELEC 221 (Signals and Systems).

Course Syllabus:

This course consists of the following main modules:

- Introduction to dynamic systems and control
- Laplace transform
- ODE solution via Laplace transform
- Modeling of electrical & mechanical systems, state-space modeling, and signal flow graph
- Modeling of DC motor, linearization, and time delay
- Stability: Routh-Hurwitz stability criterion
- Time-domain specifications and steady-state error
- Step responses of 1st and 2nd order systems
- Root locus: Introduction; Controller design; Lead-lag compensator design; PID controller design
- Frequency response
- Bode plot
- Nyquist stability criterion: Introduction; Relative stability
- Stability margin: Frequency domain specifications
- Frequency response shaping (Loop shaping)
- Lead-lag compensator design in frequency domain
- Frequency response shaping with Matlab (Simulink simulation)

Student Learning Outcomes:

On successful completion of this course students will be able to:

- Understand analogies between different dynamic systems and to model such systems mathematically.
- Understand the concept of feedback and how it influences the response of a system.
- Understand the response of a dynamic system to an input signal and to be able to predict the response of a particular system.
- Understand the state-space modeling.
- Understand the signal flow graph and its application.
- Analyze closed-loop control systems for stability and steady-state performance.
- Design a closed-loop control system to satisfy dynamic performance specifications using frequency response, root-locus, and steady state error specifications.
- Understand the operation and implementation of lead, lag and PID compensation and be able to design such compensators using root locus and frequency response techniques.
- Perform system identification and compensation of real-life feedback systems.
- Synthesize and demonstrate the efficacy of solutions to complex engineering problems, including formulating models from fundamental principles of engineering science.
- Implement and test dynamic system models and control designs in Matlab.
- Apply all concepts to various real-life engineering systems.

Textbook and Other Course Materials:

All the course materials will be posted online. They will be in the form of class lecture notes. Various textbooks and references can be used for this course, but the major reference for the course will be my course materials that will be posted on Canvas. All the assignments will be available on Canvas in a timely manner. A couple of optional useful textbooks for this course are:

1. Control Systems Engineering, 7th Edition; 2015; by Norman S. Nise; Publisher: Wiley.
2. Modern Control Systems, 13th Edition; 2016; by Richard C. Dorf and Robert H. Bishop; Publisher: Pearson.

Course Schedule:

From Jan 11, 2021 to Apr 14, 2021 (Web-Oriented Course). All class sessions will be presented live using Collaborate Ultra and during the regular class sessions, but they will also be recorded. The recorded sessions will be available at all times. Except for quizzes, midterm exam and final exam, attendance is not mandatory. That being said, I suggest that you attend all synchronous class sessions.

Activity	Days	Start Time	End Time	Classroom Location
Lecture	Mon; Wed	10:00 am	12:00 pm	Web-Oriented on Collaborate Ultra

Canvas Website:

The Canvas website (www.canvas.ubc.ca) can be used only by students enrolled in the course. Students will be able to access the course from both UBC and home. Instructions are given on the main Canvas page. **All the course materials (lectures, announcements, etc.) will be placed in the folder entitled "Files" on Canvas.**

Instructor's Office Hours:

My office hours will be held online using Collaborate Ultra on Canvas. They will be on Tuesdays and Thursdays from 1:00 pm to 2:30 pm. If you need to reach me, my email address is: **s.najarian@ubc.ca** (or **siamakn@ece.ubc.ca**).

Teaching Assistants' Contact Information:

- **Mr. Mohammad Najjarzadegan:** najjarzadegan@ece.ubc.ca
- **Mr. Andrew Yan:** andrew.yan@alumni.ubc.ca
- **Mr. Amirali Darbandsari:** amirali@ece.ubc.ca

Please note that Mr. Mohammad Najjarzadegan is the lead TA for this course. This means that Mohammad has the final say in any issues related to the marks of your works. That being said, you should directly contact the TA responsible for the work for any issues related to your marks (within the deadline that they announce). The TAs will also be holding online office hours which will be announced separately by them. They are available to mainly assist you with your assignments.

Grading System:

Group Assignments	15%
Quizzes (2 × 5% each)	10%
Midterm Exam	35%
Final Exam	40%
Total	**100%**

All students are required to attend the final exam. Not attending the final exam leads to a mark of zero for this course. So even if some students reach a mark of 50 (out of a total of 100) before the final exam, they must still take the final exam in order to pass the course. In other words, the above grading scheme is only valid for those who attend the final exam. The format of the online exams/quizzes will be announced a couple of weeks before their due dates.

Group Assignments:

There will be 20 assignments on each lecture of the course. Each assignment usually consists of a couple of questions. The assignments will be provided to you in 2 separate sets (**Set 1** and **Set 2**). To encourage teamwork activities, group assignments will be given out periodically and form an important part of the course. Each group should consist of about **6 members** and the selection of the members will be decided by the students themselves. The electronic version of your group assignments solutions (one assignment solution per each group) should be submitted through Canvas before its due date. Late assignments will be given a mark of zero.

Mr. Amirali Darbandsari will be in charge of communications with the students on issues related to group formation. The names of the group members along with the name of the member in charge of correspondence with the TA (on behalf of your group) should be emailed directly to **Amirali**. You should contact Amirali before the deadline of **Monday, January 25, 2021 (5:00 pm)**. If the list of group members is not sent to him by the set deadline, he will set up the remaining group members himself and will let the students know the group arrangements a couple of days after the deadline is passed. Once a group is formed we encourage you not to change it. However, if for any reason you need to switch or change your group, you can do it **only once** by informing him in advance. You will not be asked about why you decided to change your team. Marking of the exams/assignments/quizzes will be done by your TAs. The TA who is responsible for marking your work will post an announcement on Canvas so that you would know to whom you should refer if you have any inquiries on that particular assignment. **All issues related to your marked works of any type should be directly discussed with the TAs.** Assignments are to be done by each group, so copying from other groups is not allowed. Possible penalties for plagiarism include a mark of zero for all assignments.

Quizzes:

There will be 2 quizzes that are done in class (using online format). No laptops or electronic devices are allowed (except for accessing Canvas for online quizzes). Quizzes are multiple-choice questions (closed notes/books, no crib/formula sheet). If there is a need for any formula, it will be provided. There will be no make-ups for missed quizzes. Make-up quizzes are given only in extreme cases. Even for extreme cases, only one make-up quiz is allowed. If a student has to miss a quiz, it is the student's responsibility to contact the TAs (and NOT the instructor) as early as possible. If you are going to be absent on a day when a quiz will be administered, you must contact your TAs before that class time via email and excuse yourself, otherwise you will receive a zero for that quiz. **Quiz 1** is scheduled for **Monday, February 22, 2021** and **Quiz 2** for **Wednesday, April 14, 2021**.

Midterm and Final Exams:

Both midterm and final exams are closed books/notes. No laptops or electronic devices are allowed (except for accessing Canvas for downloading exam file or uploading your solution file). There will be no make-ups for missed exams. Graphing calculators are not allowed and you are encouraged to obtain a regular scientific calculator for your exams and quizzes. For your midterm and final exams, please use your own hand-written crib/formula sheet. Please use a letter size sheet of paper. You may use both sides of the paper. On the top of the page, you should write your name and student ID number. This cheat sheet should be included in the exam submission file. You cannot share your crib/formula sheets. The **Midterm Exam** is scheduled for **Monday, March 1, 2021 (from 10:00 am to 12:30 pm)**.

Summary of Important Dates:

Event	Date
Deadline for submitting group members names	Monday, January 25, 2021 (5:00 pm)
Quiz 1	Monday, February 22, 2021 (during class session)
Midterm exam	Monday, March 1, 2021 (from 10:00 am to 12:30 pm)
Quiz 2	Wednesday, April 14, 2021 (during class session)

Requirements:

The main requirements for this course are: attending lectures on a regular basis (although not mandatory), participating in the in-class activities, completing assignments on time and delivering them before the deadlines, and successfully taking various exams and quizzes. **Students are expected to come to lectures regularly and to be always on time**.

Class Participation:

It should be noted that there is a strong correlation between attendance and grades. In order to understand the posted material better, you will need to be present in class. Regular attendance is necessary in order to be most successful. Please note that arriving late to a class is considered unprofessional.

Acknowledgments:

Many resources and references have been used in the preparation of the materials for this course. However, special thanks should go to Prof. R. Nagamune for sharing some of the materials for this course with me.