Systems and Control
(ELEC 341; 4 Credits)

Siamak Najarian, Ph.D., P.Eng.
Professor of Biomedical Engineering (retired)
Department of Electrical and Computer Engineering
University of British Columbia

Course Description:

The course studies dynamic systems encountered in a variety of engineering systems. It will begin with a study of mathematical modelling 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:

May 06, 2019 to Jun 20, 2019

Activity	Days	Start Time	End Time	Classroom Location
Lecture	Mon Tue Wed Thu	10:00 am	12:00 pm	Building: **MacLeod** Room: **228**

Canvas Website:

The Canvas website (www.canvas.ubc.ca) can be used only by students enrolled in the course. The site is usually available during the first week of classes. Students will be able to access the course from both UBC and home. Instructions are given on the main Canvas page.

Instructor's Office Location and Office Hours:

My office is located at MacLeod Building, Room MCLD 451. My office hours are on Tuesdays and Thursdays from 1:00 pm to 2:30 pm. If you need to reach me, my email address is: **siamak.najarian@ubc.ca** (or **siamakn@ece.ubc.ca**). For contacting me, please do not use the email system inside Canvas. Instead, please just email me directly.

Teaching Assistants' Contact Information:

Mr. Su Wang; suwang@msl.ubc.ca
Mr. Mohammad Najjarzadegan; najjarzadegan@ece.ubc.ca

- For any assignment-related issues, please contact Mr. Su Wang and Mr. Mohammad Najjarzadegan.
- For assignments group formation (i.e., member names), please only contact Mr. Su Wang; suwang@msl.ubc.ca.

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.

Group Assignments:

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.

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 to your TA **(Mr. Su Wang; suwang@msl.ubc.ca)**. This should be done before the deadline of **May 13, 2019 (5:00 pm)**. If the list of group members is not sent to Mr. Wang 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 your TA in advance. Marking of the assignments will be done by both TAs (i.e., Mr. Su Wang; suwang@msl.ubc.ca and Mr. Mohammad Najarzadegan; najjarzadegan@ece.ubc.ca). **All issues related to the assignments (such as marking) 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. Normally, 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 tests are given only in extreme cases. Only one make up test is allowed. If a student has to miss a test, it is the student's responsibility to contact me as early as possible. If you are going to be absent on a day when a quiz or a test will be administered, you must contact me before that class time via email and excuse yourself, otherwise you will receive a zero for that quiz or test. **Quiz 1** is scheduled for Thursday, **May 30**, 2019 and **Quiz 2** for Thursday, **June 20**, 2019.

Midterm and Final Exams:

Both midterm and final exams are closed books/notes. No laptops or electronic devices are allowed. 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 bring your own hand-written crib/formula sheet. Please use an A4 size paper. You may use both sides of the paper. On the top of the page, you should write your name and student ID number. You cannot share crib/formula sheets. **Midterm exam** is scheduled for Monday, **June 10**, 2019.

Summary of Important Dates:

Event	Date
Deadline for submitting group members names	Monday, May 13, 2019
Quiz 1	Thursday, May 30, 2019
Midterm exam	Monday, June 10, 2019
Quiz 2	Thursday, June 20, 2019

Requirements:

The main requirements for this course are: attending lectures on a regular basis, 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.

Cell Phone Policy:

As a matter of courtesy, students are expected to turn off their cell phones during class. If extraordinary circumstances require an exception to this policy, the student is expected to discuss this with the instructor before class begins.

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.