THE UNIVERSITY OF BRITISH COLUMBIA

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MECH 468: Modern Control Engineering (Term 2, 2019/20)
MECH522 Foundations in Control Engineering (Term 2, 2019/20)

University of British Columbia

Department of Mechanical Engineering

Course Instructor: Dr. Ryozo Nagamune

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Class Meeting Time and Location

Mondays, Wednesdays & Fridays 1-1:50pm, Location: CEME 1202

Course Structure

- Lectures with lecture slides
- Homework assignments
- Midterm and final exams
- Project only for MECH522

Learning Objectives

This course is an introductory course on linear control systems based on the state-space models. The main goal of the course is to provide students with basic tools in modeling, analysis and design for control and estimation. The analysis in this course includes stability, controllability, observability, realization and minimality of the state-space model, while the design methods are divided into pole placement for state feedback and observer design, and optimal methods such as linear quadratic regulator, Kalman filter and linear quadratic Gaussian control. Students will also learn how to apply the theory to engineering problems with MATLAB. The course will cover both continuous-time and discrete-time systems, as well as both time-invariant and time-varying systems. Simple examples from mechanical and electrical engineering will be used to show the applicability of the theory.

This course will give the basic knowledge for advanced control courses, such as nonlinear control, robust control, optimal control, adaptive control, digital control, sampled-data control, hybrid control, and system identification.

Course Schedule and Topics

Week	Topics	HW
1-2	Introduction, state space model, linearization, discretization	HW1
3	BIBO stability, internal stability, Lyapunov theorem	
4-5	Controllability, observability, Kalman decomposition	HW2
6-7	Realization, minimal realization, **Midterm exam**	HW3
8-9	State feedback control, observer, observer-based control	HW4
10-11	Linear quadratic regulator, Kalman filter	HW5
12-13	Project presentation, Course summary	

Learning Activities

Project: Only for students taking MECH 522. Each student is required to formulate a realistic control problem (preferably related to his/her own research, or otherwise we can help), to do analysis and design for the problem using the course material, to analyze the designed controller in simulation (and in implementation if possible), to give a seminar, and to submit a report. The project should show the usefulness and/or the limitation of linear control systems theory.

Course Requirements/Prerequisites: One of MECH 366, MECH 466.

Learning Materials: Required Textbooks: None. Optional textbooks are

- Linear Systems Theory (2nd Edition) Princeton University Press, 2018, Joao Hespanha
- Linear System Theory and Design (4th Edition) Oxford University Press, 2012, Chi-Tsong Chen
- Linear State-Space Control Systems Wiley, 2007, Robert L. Williams II and Douglas A. Lawrence
- A Linear Systems Primer Birkhauser, Boston, 2007, Panos J. Antsaklis and Anthony N. Michel
- Control System Design: An Introduction to State-Space Methods Dover Pub., 2005, Bernard Friedland
- Modern Control Theory Prentice Hall, 1991, William L. Brogan
- Optimal State Estimation John Wiley & Sons, 2006, Dan Simon
- Optimal Filtering Dover Publications, 2005, Brian D. O. Anderson and John B. Moore
- Optimal Control and Estimation Dover Publications, 1994, Robert F.Stengel

All materials (lecture slides, homework assignments etc.) are posted on Canvas.

Assessment, Evaluation, and Grading

Grading scheme:

MECH468 (3 credits): Homework 10%, Midterm 30%, Final 60%
MECH522 (4 credits): Homework 10%, Midterm 30%, Final 40%, Project 20%

Homework assignment: Assignments will be given out periodically. Your solutions should be handed in by the due date/time. Late assignments will be given a mark of zero. Assignments are to be done **individually**.

Copying another student's assignment is NOT allowed. Possible penalties for plagiarism include a mark of zero for all assignments.

Exam Policies: Closed-book. Calculators are not allowed. One page letter-size hand-written cheat-sheet (both sides) is allowed. Alternative exams can be arranged ONLY for medical reasons and with doctor's notes. For other reasons, discuss your case with the instructor before the exam dates.

In undergraduate MECH courses where at least 50% of the final grade is assigned to examinations, students may only pass the course if they achieve a weighted average examination grade of at least 50%. The "examination grade" includes scores from the final examination, midterms, and other tests done individually in a classroom setting.

Academic Misconduct

Academic honesty is a fundamental requirement of your studies. It is your obligation to inform yourself of the applicable standards. More information is available at *http://calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,0*.

Policies and Resources to Support Student Success

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious and cultural observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available at https://senate.ubc.ca/policies-resources-support-student-success. Mechanical Engineering also has a Student Services Office (students@mech.ubc.ca), located in CEME 2205, where there are staff who can provide support and refer students to the appropriate resources.

Inclusive Environment

The Department of Mechanical Engineering is committed to providing an inclusive learning experience, and affirms the UBC Statement on Respectful Environment (https://www.hr.ubc.ca/respectful-environment/files/UBC-Statement-on-Respectful-Environment-2014.pdf). You are encouraged to contact their instructor should situations arise that are not consistent with this expectation. You are also invited to advise the instructor if you wish to be addressed by or referred to with particular pronouns.

Laboratory Safety

UBC Mechanical Engineering considers safety first, and continuously, in its labs, research, and other activities. Students are expected to engage in safety discussions; to ask questions to ensure they understand safety information; to comply with policies and rules; to maintain a safe workspace; and to report all accidents, incidents, and near misses immediately to their supervisor and to https://cairs.ubc.ca. Students should work with their supervisors to ensure they understand (1) the risks associated with their work and (2) how those risks are controlled.