The University of Texas at Austin
Department of Aerospace Engineering and Engineering Mechanics

ASE 381P 2: Multivariable Control Systems
Spring 2022 Syllabus

Unique number: 14240
Instructor:

Dr. Takashi Tanaka (ASE 4.230).
Email: ttanaka@utexas.edu
Office hours: Wednesdays 10:00 am – Noon.

Time: T/Th 8:00 a.m. – 9:30 a.m.
Class format:
Considering the ongoing COVID-19 situation, President Hartzell instructed us to adopt an online lecture format until January 30, with a target date of January 31 to return to the originally assigned teaching modality. Therefore, we tentatively assume

- Until January 27: Online lecture format (two lectures per week, 75 minutes duration each)
- After February 1: Face-to-face lecture format (two lectures per week, 75 minutes duration each).

Location: Zoom for online lectures, ASE 1.124 for face-to-face lectures
Course webpage:

Canvas – http://canvas.utexas.edu

Main Textbook:

- Geir E. Dullerud and Fernando Paganini. *A Course in Robust Control Theory: A Convex Approach*. Springer Science & Business Media, 2000.

Additional References:

- Kemin Zhou, John C. Doyle, and Keith Glover. *Robust and optimal control*. Prentice hall, 1996.
- Jan M. Maciejowski, *Multivariable Feedback Design*, Addison-Wesley, 1989
- Stephen Boyd, Laurent El Ghaoui, Eric Feron, and Venkataramanan Balakrishnan. *Linear matrix inequalities in system and control theory*. Society for industrial and applied mathematics, 1994.

Course Objectives:

This course establishes mathematical foundations for multivariable control systems analysis through the development of robust control theory. Control design methods based on convex optimization are introduced. Topics to be covered include: finite dimensional vector spaces, convexity, state space systems theory, Linear Matrix Inequalities (LMIs), functional analysis and operator theory, model realization and reduction, Youla parametrization, H_2 (LQG) and H_∞ control, uncertain systems, μ-analysis, and Integral Quadratic Constraints (IQCs).

Prerequisites:

Undergraduate level linear algebra, matrix theory and complex analysis. Fundamentals of linear systems theory (ASE 330 or equivalent) and feedback control theory (ASE 370 or equivalent) will also be essential.

Grading:

The final grade will be calculated based on homework assignments (60 points), final project (25 points), and final examination (25 points). Grades will be based on the following rule: A (93-110), A- (90-92), B+ (87-89), B (83-86), B- (80-82), C+ (77-79), C (73-76), and C- (70-72). The extra 10% is granted to all students to accommodate unexpected events such as medical emergency.

Homework:

There will be weekly homework assignments during the semester. Each assignment and its due date will be posted on Canvas. No late homework will be accepted unless prior permission in exceptional circumstances has been granted. Collaboration is allowed. In case of collaboration, each student should return her/his work along with a statement that clearly indicates her/his collaborators and her/his role in the resulting work.

Final project:

Students are expected to either (1) read research papers on relevant topics in detail, or (2) develop original mini research project relevant to topics covered in class. Further details will be provided in the first lecture.

Final examination:

Time: Designated time and place during the final examination week (May 16, 2-5pm by default). Further details will be provided in the lecture.

Schedule:

(Tentative. See Canvas for updates.)

Week	Date	Topic
1	1/18, 1/20	Introduction
2	1/25, 1/27	Generalized plant, finite dimensional spaces, convexity,
3	2/1, 2/3	LMIs, controllability/observability, minimal realization
4	2/8, 2/10	Functional analysis and operator theory: L_2 norms, H_2 spaces
5	2/15, 2/17	H_∞ spaces, model realization
6	2/22, 2/24	Model reduction
7	3/1, 3/3	LMI-based control design, Youla parametrization
8	3/8, 3/10	LQG control, Riccati equations,
9	3/22, 3/24	H_2 optimal control
10	3/29, 3/31	H-infinity control, uncertain systems
11	4/5, 4/7	Small gain theorem, structured singular values
12	4/12, 4/14	Control of uncertain systems
13	4/19, 4/21	Robust control and IQCs
14	4/26, 4/28	Robust control and IQCs, Final project presentations
15	5/3, 5/5	Final project presentations

Computer usage:

Students are assumed to have an access to MATLAB and semidefinite programming solvers to complete homework assignments. Details will be discussed in the class.

Evaluation Plan:

The Measurement and Evaluation Center forms for the Cockrell School of Engineering will be used during the last week of class to evaluate the course and the instructor.

Accessible, Inclusive, and Compliant Statement:

The university is committed to creating an accessible and inclusive learning environment consistent with university policy and federal and state law. Please let me know if you experience any barriers to learning so I can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Services for Students with Disabilities (SSD). Please refer to SSD's website for contact and more information: http://diversity.utexas.edu/disability/. If you are already registered with SSD, please deliver your Accommodation Letter to me as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

COVID-19 Updates: Fall 2021 Semester

Classroom Safety and COVID-19

To help preserve our in person learning environment, the university recommends the following.

- Adhere to university mask guidance.
- Vaccinations are widely available, free and not billed to health insurance. The vaccine will help protect against the transmission of the virus to others and reduce serious symptoms in those who are vaccinated.
- Proactive Community Testing remains an important part of the university's efforts to protect our community. Tests are fast and free.
- Visit utexas.edu for more information.

Sharing of Course Materials is Prohibited:

No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings:

Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings. Guidance on public access to class recordings can be found here.

Prepared by: Takashi Tanaka Date: 1/18/2022