**ME210: Linear Multivariable Control**

**Syllabus – Spring 2020**

**Catalog description:**

Modeling, analysis, and design of linear multi-input, multi-output control systems, including both state space and transfer matrix approach, with an emphasis on stability, controllability, stabilizability, observability and detectability are discussed. Both time-invariant and time-varying systems, and continuous-time and discrete-time systems are covered.

**Prerequisites:** ME141 Control Engineering, or equivalent.

**Course Title: “**Linear Multivariable Control**”**

**Course location:** tbd

**Instructor**: YangQuan Chen

**Office**: SE2-273

**Phone:** 209-228-4672 (Office)

**Email:** YangQuan.Chen@ucmerced.edu

**Class Time**: tbd

**TA:** TBD

**Help Session**: TBD

**Office Hours**: tbd. Other hours by prior appointment.

**Textbook:** Wilson Rugh. Linear Systems Theory (2nd edition). Prentice Hall; 2 edition (August 13, 1995) <http://www.amazon.com/Linear-System-Theory-Wilson-Rugh/dp/0134412052>

**References:**

* Kailath, T., Linear Systems, Prentice Hall, 1980.
* C.-T. Chen, Linear System Theory and Design, Oxford 1999.
* W. A. Wolovich, Linear Multivariable Systems, Springer-Verlag, 1974.

**Homework:** Homework assignments will be given approximately once a week.

**Tests**: One midterm and a final will be given.

**Final Exam:** tbd

**Course Outline**

1. State Models and Solution 5 Lectures

2. Internal Stability 5 Lectures

3. Controllability and Observability 5 Lectures

4. Realization 5 Lectures

5. State Feedback 4 Lectures

6. Output Feedback 4 Lectures

7. Emerging Research Topics 2 Lectures

8. Linear Algebra As needed

**Grading**

**The homework** (including programming) counts 50% of the grade.

**The midterm** counts 20%.

**The final** counts 30%.

**Grade Distribution**

 Grade Total Scores (%)

 A+ 99+

 A 95 - 99

 A- 90 - 94

 B+ 87 - 89

B 83 - 86

B- 80 - 82

C+ 77 - 79

C 73 - 76

C- 70 - 72

D+ 67 - 69

D 63 - 66

D- 60 - 62

F < 60

**Late submissions**

No late submission will be considered/counted.

**CATCOURSE:** We will be using CATCOURSE for posting the syllabus, lecture notes, assignments, announcements, and grades.

**Course Objectives:**

1. To enable the student to perform modeling, analysis, and design of linear multi-input, multi-output control systems, including both state space and transfer matrix approach, with an emphasis on stability, controllability, stabilizability, observability and detectability.
2. To be able to handle both time-invariant and time-varying systems, and continuous-time and discrete-time systems.
3. To develop hands-on experience in MIMO control system designs using Matlab/Simulink.

**Relationship to Program Learning Outcomes**

ME210 is aligned with the following Program Learning Outcomes for the M.S. and Ph.D. degrees in Mechanical Engineering:

1. PLO#1: Are able to identify significant research questions in mechanical engineering, and contextualize their research in the current literature of the field.
2. PLO#2: Are able to apply their knowledge of mathematics, science, and engineering to solve a problem, and to design and implement a suitable solution.
3. PLO#3: Are able to design and conduct experiments and/or simulations of mechanical systems, and to analyze and evaluate.
4. PLO#4: Have lifelong learning skills; are able to acquire and use new engineering techniques, skills, and tools for research and development in mechanical engineering, and to develop new methods and discover new knowledge.
5. PLO#5: Exhibit high professional standards in research, demonstrating objectivity, ethical conduct, and integrity.
6. PLO#6: Are able to communicate effectively through oral, visual, and written means, with a broad range of technical audiences.

**Course Learning Outcomes:**

The Course Learning Outcomes (CLOs) support student development of the Program Learning Outcomes (PLOs). The connections between the CLOs are made explicit through the indication of which PLOs are connected to each CLO below. Successful completion of the course assumes that a student is able to:

1. To perform basic analyses for LTI (linear time-invariant) and LTV (linear time-varying) multivariable systems; [PLO#1, PLO#2]
2. To perform basic synthesis for LTI (linear time-variant) multivariable feedback control systems using state feedback; [PLO#2, PLO#3]
3. To perform basic synthesis for LTI (linear time-variant) multivariable feedback control systems using output feedback; [PLO#2, PLO#3]
4. To have an updated knowledge of the emerging advanced control techniques that are built on top of this course. [PLO#4, PLO#5, PLO#6]

**Course Policies:** 1. NO CELL PHONES are allowed during lecture. 2. Be on time to class. Tardiness is discouraged. 3. No late assignments will be accepted. Medical or family emergency will be considered on case-by-case basis. 4. No make-up exams. If you miss the exam, a zero score will be assigned to the missed exam. No electronic devices other than a calculator will be allowed. 5. If you miss a class due to personal emergency or medical reasons, please be sure to inform the instructor by e-mail in advance. 6. Homework assignments are to be submitted by the due date/time. You should keep a record of your homework in HW notebooks or HW binder and be ready to present it upon request. You may discuss homework problems with your classmates, but you are responsible for your own work. 7. You are encouraged to read the sections in the textbooks related to the covered topics prior to the lecture as well as after. 8. After an assignment grade has been posted online, students must see the instructor within one week if they wish to discuss the assignment and their work. 9. University's rules on academic honesty concerning exams and individual assignments will be strictly enforced. See UC Conduct Standards:

<http://studentconduct.ucmerced.edu/sites/studentconduct.ucmerced.edu/files/page/documents/code_of_conduct_600_and_700.pdf>

**Academic DishonestyStatement:**a. Each student in this course is expected to abide by the University of California, Merced's Academic Honesty Policy. Any work submitted by a student in this course for academic credit will be the student's *own* work. b. You are encouraged to studytogether and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e mail, an e mail attachment file, a diskette, or a hard copy. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Policy can also be extended to include failure of the course and University disciplinary action. c. During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

<http://studentconduct.ucmerced.edu/sites/studentconduct.ucmerced.edu/files/page/documents/academic_honesty_-_800.pdf>

**Disability Statement:**

University of California, Merced is committed to creating learning environments that are accessible to all. If you anticipate or experience physical or academic barriers based on a disability, please feel welcome to contact me privately so we can discuss options. In addition, please contact Student Accessibility Services (SAS) at (209) 228-6996 or disabilityservices@ucmerced.edu as soon as possible to explore reasonable accommodations. All accommodations must have prior approval from Student Accessibility Services on the basis of appropriate documentation.

If you anticipate or experience barriers due to pregnancy, temporary medical condition, or injury, please feel welcome to contact me so we can discuss options. You are encouraged to contact the Dean of Students for support and resources at (209) 228-3633 or https://studentaffairs.ucmerced.edu/dean-students.