AME 451 Syllabus — Spring 2018

Instructor: Prof. Néstor O. Pérez-Arancibia (perezara@usc.edu)

Class Formal Name: Linear Control Systems I
Instructor Phone Number: 310-384-0123
Lecture Time: Mondays and Wednesdays, 11:00AM-12:20PM
Lecture Location: OHE-100D
Instructor Office Hours: Mondays, 3:30PM-5:30PM (OHE-430I). DEN students are welcomed to connect via Skype (Mondays, 3:30PM-5:30PM CA time)

Discussion Time: Thursdays, 12:30PM-1:20PM
Discussion Location: OHE-122
Teaching Assistant: Ke Xu (kexu@usc.edu)
TA Office Hours: Mondays, 4:00PM-6:00PM and Wednesdays, 4:00PM-6:00PM (VHE-202). DEN students are welcomed to connect via Skype (Mondays, 4:00PM-6:00PM and Wednesdays, 4:00PM-6:00PM, CA time)

Formal Prerequisite: AME 302 (Dynamic Systems); MATH 245 (Mathematics of Physics and Engineering)

Recommended Prerequisites: Linear Algebra; Differential Equations; Signals & Systems; Basic Programing using MATLAB® and SIMULINK®

Textbook: [1] Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, *Feedback Control of Dynamic Systems,* Upper Saddle River, NJ: Pearson, 2014 (7th Edition).

Other References (Not Officially Required):

- [2] William J. Palm III, *Systems Dynamics*, New York, NY: McGraw-Hill, 2014 (3rd Edition).
- [3] Richard C. Dorf and Robert H. Bishop, *Modern Control Systems*, Upper Saddle River, NJ: Prentice-Hall, 2010 (12th Edition).
- [4] Gilbert Strang, *Introduction to Linear Algebra*, Wellesley, MA: Wellesley-Cambridge Press, 2009 (4th Edition).
- [5] T. S. Blyth and E. F. Robertson, *Basic Linear Algebra*, London, UK: Springer, 1998.
- [6] Alan V. Oppenheim and Alan S. Willsky, *Signals and Systems*, Upper Saddle River, NJ: Prentice-Hall, 1997.

Course Objectives:
The course discusses the fundamental topics of *classical control engineering* upon which modern control theory has been developed, such as, plant modeling, classical SISO LTI controller design in the time and frequency domains, stability, stability robustness, performance robustness, and real-time control implementation.

Grading:
5% Quiz #1 (February 1, 2018 at 12:30PM during discussion)
5% Quiz #2 (April 19, 2018 at 12:30PM during discussion)
10% Homework
20% Midterm Exam #1 (February 21, 2018 at 11:00AM in class)
20% Midterm Exam #2 (March 29, 2018 at 11:00AM in class)
40% Final Exam (May 2, 2018, 11:00AM-1:00PM)

If for some reason you are not able to take one or more of the tests administrated previously to the Final Exam (i.e., Quiz #1, Quiz #2, Midterm #1, Midterm #2), the corresponding percentage is automatically added to the Final Exam's percentage. For example, if you miss Quiz #1, the weight of your Final Exam would be 45% instead of 40%. If you like (not recommended) you can take the final test only, which in that case would weigh 90% of your semester grade. Consistent with this policy, it also follows that if the score of a test administrated previously to the Final Exam (i.e., Quiz #1, Quiz #2, Midterm #1, Midterm #2) is lower than your score in the Final Test, the Final Test score will be used to compute your final grade. The pedagogical justification for this policy is that what really matters are your aggregated abilities and knowledge at the end of the semester. **Notice that this is a very favorable policy for conscientious, responsible students and extremely risky for students that leave everything for the last minute. So, use the rules wisely in your favor!**

Homework:
Homework is assigned weekly on Fridays by 11:59PM, CA time, and due on Fridays of the following week at 11:59PM, CA time. **Please check the DEN blackboard regularly for homework updates addressing questions and comments from students in the class.** Late submissions will not be graded and will receive a score of 0 (zero). While working on your homework you are allowed to talk to the teaching assistant (TA) and your classmates. Also, it is allowed to look at material on-line such as Wikipedia. However, you **must** write down your own solutions, using your own words. Therefore, copy-and-pasted solutions from other sources (classmates, books, on-line material, etc.) will be considered an academic integrity violation.

During the semester, **14 (fourteen)** weekly homework assignments will be given. Each weekly assignment will have **at least 100 achievable points** so that at the end of the semester the aggregated amount of achievable points will be **at least 1400 (one thousand four hundred). A thousand (1000) points** are required for a 100% of the homework credit.

Midterm and Final Exams:
The Quizzes, Midterm Exams and Final Exam are **open-book/open-notes**. Talking on the phone, texting, emailing, communicating in any way with other people or similar activities are not allowed during the tests. You should bring your own exam booklet (or paper). The policy regarding the use of calculators, laptops and MATLAB® is contingent to the specific situation and will be announced in class.

Academic Integrity:
All cases of academic integrity violation will be referred by a written report to the Student Judicial Affairs and Community Standards (http://www.usc.edu/student-affairs/SJACS/). The

typical penalty recommended by SJACS is a grade of F for the course. **Also, see Appendix in page 6.**

Computer Software:
MATLAB® and SIMULINK®, which can be downloaded from the USC IT website. These are computer tools required for solving some of the homework questions and take-home exam questions.

Programmed Lectures

Week	Date	Topics	References	Comments
1	Mon. Jan. 8	**Lecture 1:** • The notion of feedback • Motivating examples	**Slides; Ch01 in [1].**	
1	Wed. Jan. 10	**Lecture 2:** • Dynamic models of systems — Part 1	**Slides; Ch02 in [1].**	HW #1 (A)
1	Thu. Jan. 11	**Discussion 1:** • Dynamic modeling examples		
2	Mon. Jan. 15	**MLK's Day**		**No Class Scheduled**
2	Wed. Jan. 17	• Dynamic models of systems — Part 2	**Slides; Ch02 in [1].**	HW #2 (A); HW #1 (D)
2	Thu. Jan. 18	**Discussion 2:** • More dynamic modeling examples		
3	Mon. Jan. 22	**Lecture 3:** • Laplace transform, transfer functions, time response • Laplace transform properties — Part 1	**Slides; Ch03 in [1].**	
3	Wed. Jan. 24	**Lecture 4:** • Laplace transform properties — Part 2	**Slides; Ch03 in [1].**	HW #3 (A); HW #2 (D)
3	Thu. Jan. 25	**Discussion 3:** • Laplace transform examples		
4	Mon. Jan. 29	**Lecture 5:** • Laplace transform properties — Part 3 • Introduction to state-space representation of systems	**Slides; Ch03 in [1].**	
4	Wed. Jan. 31	**Lecture 6:** • Effect of poles on the dynamic response • Effect of zeros on the dynamic response	**Slides; Ch03 in [1].**	HW #4 (A); HW #3 (D)
4	Thu. Feb. 1	**Quiz 1**		

5	Mon. Feb. 5	**Lecture 7:** • Performance specifications for 1st and 2nd order systems	**Slides; Ch03 in [1].**	
5	Wed. Feb. 7	**Lecture 8:** • Block diagrams	**Slides; Ch04 in [1].**	HW #5 (A); HW #4 (D)
5	Thu. Feb. 8	**Discussion 4:** • Performance specifications examples		
6	Mon. Feb. 12	**Lecture 9:** • Feedback structures and the effect of feedback	**Slides; Ch04 in [1].**	
6	Wed. Feb. 14	**Lecture 10:** • Stability	**Slides; Ch04 in [1].**	HW #6 (A); HW #5 (D)
6	Thu. Feb. 15	**Discussion 5:** • Effect of feedback examples • Stability examples		
7	Mon. Feb. 19	**Presidents' Day**		**No Class Scheduled**
7	Wed. Feb. 21	**Midterm 1**		HW #7 (A); HW #6 (D)
7	Thu. Feb. 22	**Discussion 6:** • Midterm #1 solutions		
8	Mon. Feb. 26	**Lecture 11:** • Unit feedback system type • Proportional Integral Derivative (PID) control — Part 1	**Slides; Ch04 in [1].**	
8	Wed. Feb. 28	**Lecture 12:** • Proportional Integral Derivative (PID) control — Part 2 • Rate feedback control	**Slides; Ch04 in [1].**	HW #8 (A); HW #7 (D)
8	Thu. Mar. 1	**Discussion 7:** • PID examples		
9	Mon. Mar. 5	**Lecture 13:** • Root-locus/rules — Part 1	**Slides; Ch05 in [1].**	
9	Wed. Mar. 7	**Lecture 14:** • Root-locus/rules — Part 2	**Slides; Ch05 in [1].**	HW #9 (A); HW #8 (D)
9	Thu. Mar. 8	**Discussion 8:** • Root-locus/rules examples		
10	Mon. Mar. 12	**Spring Break**		**No Class Scheduled**
10	Wed. Mar. 14	**Spring Break**		**No Class Scheduled**
10	Thu. Mar. 15	**Spring Break**		**No Discussion Scheduled**
11	Mon. Mar. 19	**Lecture 15:** • Lead and lag compensator design	**Slides.**	
11	Wed. Mar. 21	**Lecture 16:** • Frequency response and frequency response methods • Bode plots — Part 1	**Slides; Ch06 in [1].**	HW #10 (A); HW #9 (D)
11	Thu. Mar. 22	**Discussion 9:** • Bode plot examples		

12	Mon. Mar. 26	**Lecture 17:** • Bode plots — Part 2	**Slides; Ch06 in [1].**	
12	Wed. Mar. 28	**Midterm 2**		HW #11 (A); HW #10 (D)
12	Thu. Mar. 29	**Discussion 10:** • Bode plot examples		
13	Mon. Apr. 2	**Lecture 18:** • Nyquist stability criterion — Part 1	**Slides; Ch06 in [1].**	
13	Wed. Apr. 4	**Lecture 19:** • Nyquist stability criterion — Part 2	**Slides; Ch06 in [1].**	HW #12 (A); HW #11 (D)
13	Thu. Apr. 5	**Discussion 11:** • Nyquist stability examples		
14	Mon. Apr. 9	**Lecture 20:** • Stability margins • Stability robustness	**Slides; Ch06 in [1].**	
14	Wed. Apr. 11	**Lecture 21:** • Sensitivity functions • Loop shaping — Part 1	**Slides.**	HW #13 (A); HW #12 (D)
14	Thu. Apr. 12	**Discussion 12:** • Stability margins examples		
15	Mon. Apr. 16	**Lecture 22:** • Loop shaping — Part 2	**Slides.**	
15	Wed. Apr. 18	**Lecture 23:** • Frequency-response method design examples — Part 1	**Slides; Ch06 in [1].**	HW #14 (A); HW #13 (D)
15	Thu. Apr. 19	**Quiz 2**		
16	Mon. Apr. 23	**Lecture 24:** • Frequency-response method design examples — Part 2	**Slides; Ch06 in [1].**	
16	Wed. Apr. 25	**Lecture 25:** • Review for final exam	**Slides.**	HW #14 (D)
16	Thu. Apr. 26	**Discussion 13:** • Design examples		

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The contents of this syllabus are subject to change. Weekly information will be updated without notice. Change in policies, important dates, and homework content will be announced in class.

Prof. Néstor O. Pérez-Arancibia

APPENDIX: Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu or to the *Department of Public Safety* http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* *http://emergency.usc.edu* will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.