

AME 541 Syllabus - Fall 2015

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

Class Formal Name: Linear Control Systems II

Instructor Phone Number: 310-384-0123

Lecture Time: Thursdays, 6:40-9:20 PM

Lecture Location: OHE-100D

Discussion Time: Fridays, 12:00-12:50 PM

Discussion Location: OHE-100C

Instructor Office Hours: Mondays, 2:00-4:00 PM (OHE 430-I). DEN students can connect via Skype (2:00-4:00 PM, CA time).

Teaching Assistant: Joey Ge (zaoyuang@usc.edu)

TA Office Hours: Mondays, 3:00-5:00 PM and Wednesdays, 3:00-5:00 PM (VHE-202). DEN students can connect via Skype (Mondays, 3:00-5:00 PM and Wednesdays, 3:00-5:00 PM, CA time).

Formal Prerequisite: AME 451 (Linear Control Systems I)

Recommended Prerequisites: Linear Algebra; Differential Equations; Basic Probability Theory; Signals & Systems; Basic Real Analysis; Basic Programming using MATLAB[®] and SIMULINK[®].

Textbook: [1] Chi-Tsong Chen, *Linear System Theory and Design*, New York, NY and Oxford, UK: Oxford University Press, 2013 (4th Edition).

Other References (Not Officially Required):

- [2] João P. Hespanha, *Linear Systems Theory*, Princeton, NJ and Oxford, UK: Princeton University Press, 2009.
- [3] Geir E. Dullerud and Fernando Paganini, *A Course in Robust Control Theory*, New York, NY: Springer, 2000.
- [4] Thomas Kailath, *Linear Systems*, Englewood, NJ: Prentice-Hall, 1980.
- [5] Kemin Zhou and John C. Doyle, *Essentials of Robust Control*, Upper Saddle River, NJ: Prentice-Hall, 1998.
- [6] Gilbert Strang, *Introduction to Linear Algebra*, Wellesley, MA: Wellesley-Cambridge Press, 2009 (4th Edition).
- [7] Gilbert Strang, *Linear Algebra and Its Applications*, Brooks/Cole, 2006.
- [8] T. S. Blyth and E. F. Robertson, *Basic Linear Algebra*, London, UK: Springer, 1998.
- [9] T. S. Blyth and E. F. Robertson, *Further Linear Algebra*, London, UK: Springer, 2002.
- [10] Alan V. Oppenheim and Alan S. Willsky, *Signals and Systems*, Upper Saddle River, NJ: Prentice-Hall, 1997.

- [11] Alberto Leon-Garcia, *Probability and Random Processes for Electrical Engineering*, Reading, MA: Addison-Wesley, 1994.
- [12] Thomas Kailath, Ali H. Sayed and Babak Hassibi, *Linear Estimation*, Upper Saddle River, NJ: Prentice-Hall, 2000.
- [13] Harry Dym, *Linear Algebra in Action*, Providence, RI: American Mathematical Society, 2013.

Course Objectives:

This course discusses the fundamental topics in *linear systems theory* upon which *modern control theory*, *linear estimation (Kalman filtering)* and *linear robust control theory* have been developed. At the end of the semester, the students will be proficient in the most important topics in linear systems theory, including *system representation*, *stability*, *controllability*, *observability*, *realization theory*, *state estimation*, *state feedback control*, *LQR control*, basic concepts in *Kalman filtering*, *LQG control*, and *LTI system-order reduction*.

Grading:

5% Quiz #1 (September 10, 2015 at 6:40 PM in class)

5% Quiz #2 (October 22, 2015 at 6:40 PM in class)

10% Homework

15% Midterm Exam #1 (October 1, 2015 at 6:40 PM in class)

20% Midterm Exam #2 (November 12, 2015 at 6:40 PM in class)

5% Class Participation

40% Final Exam (December 10, 2015, 7:00-9:00 PM)

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 95% of your grade. Consistent with this policy, it also follows that if your final weighted average score is lower than your score in the Final Test, only your 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 11:59 PM, CA time, and due on Fridays of the following week at 11:59 PM, 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 5.**

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	Aug. 27	Modeling and mathematical description of linear systems	Slides; Ch2 in [1]; Ch1 in [2]; [10].	
2	Sep. 03	Linearity, time invariance, and causality; Review of mathematical concepts	Slides; Ch2 in [1]; Ch3 in [2]; [10]; Ch3 in [6]; Ch3 in [7]; Ch1 in [3].	HW #1 due next day (Friday)
3	Sep. 10	Review of fundamental mathematical concepts; Quiz #1	Slides; Ch3 in [1]; Ch3 in [6]; Ch3 in [7]; Ch1 in [3]; CH5 in [8].	HW #2 due next day (Friday)
4	Sep. 17	Solutions to LTI systems – Part 1	Slides; Ch4 in [1]; Ch6 in [2].	HW #3 due next day (Friday)
5	Sep. 24	Solutions to LTI systems – Part 2 (Jordan Form)	Slides; Ch4 in [1]; Ch7 in [2].	HW #4 due next day (Friday)

6	Oct. 01	Lyapunov stability; Midterm #1	Slides; Ch5 in [1]; Ch8 in [2]	HW #5 due next day (Friday)
7	Oct. 08	Input-output stability	Slides; Ch5 in [1]; Ch9 in [2].	HW #6 due next day (Friday)
8	Oct. 15	Controllability;	Slides; Ch6 in [1]; Ch11 & Ch12 in [2].	HW #7 due next day (Friday)
9	Oct. 22	Observability; Quiz #2	Slides; Ch6 in [1]; Ch15 & Ch16 in [2].	HW #8 due next day (Friday)
10	Oct. 29	Minimal Realizations and Coprime Fractions	Slides; Ch7 in [1].	HW #9 due next day (Friday)
11	Nov. 05	State Feedback	Slides; Ch7 in [1].	HW #10 due next day (Friday)
12	Nov. 12	LQR Controller design; Midterm #2	Slides; Ch8 in [1].	HW #11 due next day (Friday)
13	Nov. 19	State estimators and LQG controller design	Slides; Ch8 in [1].	HW #12 due next day (Friday)
14	Nov. 26	Thanksgiving		HW #13 due next day (Friday)
15	Dec. 03	System-order reduction and review for Final Exam	Slides; Ch4 in [3].	HW #14 due next day (Friday)

Document first uploaded: June 1, 2015.

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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.