AOE 6744/ME 6544/ECE 6744: Linear Control Theory

Course Syllabus

Instructor: Dr. Kyriakos G. Vamvoudakis

226 Randolph Hall

Phone: 231-6707

E-mail: kyriakos@vt.edu

Web: http://www.dept.aoe.vt.edu/~kyriakos/

Time & Location: TR 3:30 PM to 4:45 PM

206A Randolph Hall

Office Hours: 11:00 AM - 12:30 PM Tuesdays & Thursdays or by appointment

Course Web Page: http://www.dept.aoe.vt.edu/~kyriakos/aoe6744.html , https://canvas.vt.edu/

Suggested Texts: Antsaklis, Panos J., and Anthony N. Michel. A linear systems primer. Vol. 1. Boston: Birkhäuser, 2007.

Hespanha, Joao P. Linear systems theory. Princeton university press, 2009.

Frank Lewis' online notes

Prerequisites: Undergraduate linear algebra, linear systems

Required Software: Student Edition of Matlab

Course Description and Topics: Advanced introduction to the theory of optimal control of time-varying and time-invariant linear systems; Solutions to the linear-quadratic regulator, optimal filtering, and linear-quadratic-gaussian problems; Robustness analysis and techniques to enhance robustness of controllers.

Course Topics:

I. Linear System Analysis

A. Review of matrix algebra
B. State variable systems
C. Linear state equations and linearization
D. Initial value problems
E. Computer simulations
F. Second-order systems
G. State transition matrices
H. Continuous-time state variable analysis

I. Structure analysis (Caley-Hamilton theorem, controllability, observability, duality)
J. State-space transformation and Jordan Normal Form

II. Analysis and Stability of Linear Systems

A. Input/output systems and stability
B. Discrete and continuous time systems
C. Lyapunov theory

III. System Design

A. State variable feedback
B. Reachability
C. Ackermann's formula
D. LQR, LQT in continuous and discrete time systems
E. Observers
F. Discretization
G. Deadbeat control
H. Separation principle
I. Output feedback
J. LQG and robust control
K. Dynamic programming and HJB

Tentative Grading Policy
Tentative Grading: Homework 25%-Midterm Exam 35%-Final Exam 40%

Homework Assignments:

- Due at the beginning of the class on the due date. Solutions to the homework will be posted on the web at the time that they are due. Therefore, NO LATE HOMEWORK will be accepted.
- Electronic submissions will be accepted before the class starts.
- Late homework will not be accepted without formal documentation of extenuating circumstances (e.g. a note from a Dean, a physician, etc.).

Course Policies: 1. NO CELL PHONES are allowed during lecture. 2. Be on time to class. Tardy is discouraged. 3. No make-up exams/quizzes. If you miss the exam, a zero score will be assigned to the missed exam/quiz. 4. If you miss a class due to personal emergency or medical reasons, please be sure to inform the instructor by e-mail. 5. Homework assignments are to be submitted by the due date. You may discuss homework problems with your classmates, but you are responsible for your own works. 6. 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.

Principles of Community: Students are expected to be polite and professional when interacting with one another and with the instructor. Abusive or insensitive behavior will not be tolerated. Virginia Tech's Principles of Community govern student conduct: http://www.diversity.vt.edu/principles-of-community/principles.html

Honor System: Graduates of Virginia Tech's engineering program have very high standards of personal and professional integrity. It is the responsibility of Virginia Tech's students and faculty to ensure that this legacy continues. The Undergraduate Honor Code pledge that each member of the university community agrees to abide by states:

> "As a Hokie, I will conduct myself with honor and integrity at all times. I will not lie, cheat, or steal, nor will I accept the actions of those who do."

Students enrolled in this course are responsible for abiding by the Honor Code. A student who has doubts about how the Honor Code applies to any assignment is responsible for obtaining specific guidance from the course instructor before submitting the assignment for evaluation. Ignorance of the rules does not exclude any member of the University community from the requirements and expectations of the Honor Code. For additional information visit: https://www.honorsystem.vt.edu/

Academic Support: The instructor will provide assistance through normal protocols, such as office hours, but cannot serve as a private tutor. Virginia Tech has numerous resources to support student achievement. For information about academic support services, please see: http://www.undergraduate.vt.edu/Subpages/aca-supp_index_SCMS.html

Special Accommodations: Special accommodations can be made for students with disabilities. Please bring any such issues to the instructor's attention *no later than the second week of class*. For information on the types of accommodations that are available, see http://www.ssd.vt.edu/

Emergency Preparedness: The Office of Emergency Preparedness has developed the following flyer outlining simple steps to follow when preparing for or responding to an emergency: http://www.emergency.vt.edu/help/resources-help/studentPreparedness.pdf

Tentative Roadmap			Spring 2018 (AOE 6744/ME 6544/ECE 6744)	
Number of Lecture	**date**	**day**	**Topic**	**Reading Assignments**
1	16-Jan	tue	Introduction to matrix algebra, models, differential equations	Chapter 1 and Appendix Antsaklis
2	18-Jan	thurs	Ordinary differential equations and state variable systems	Chapter 1 and Appendix Antsaklis
3	23-Jan	tue	Ordinary differential equations and state variable systems	Chapter 2 Antsaklis and Chapter 1 Hespanha
4	25-Jan	thurs	Linearization	Chapter 2 Hespanha
5	30-Jan	tue	Response of continuous and discrete-time systems	Chapter 3 Antsaklis and Chapter 5 Hespanha
6	1-Feb	thurs	Response of continuous and discrete-time systems	Chapter 3 Antsaklis and Chapter 5 Hespanha
7	6-Feb	tue	Response of continuous and discrete-time systems	Chapter 3 Antsaklis and Chapter 6 Hespanha
8	8-Feb	thurs	Response of continuous and discrete-time systems	Chapter 7 Hespanha
9	13-Feb	tue	Stability	Chapter 4 Antsaklis and Chapter 8 Hespanha
10	15-Feb	thurs	Stability	Chapter 4 Antsaklis and Chapter 9 Hespanha
11	20-Feb	tue	Lyapunov Theory	Chapter 4 Antsaklis
12	22-Feb	thurs	Controllability and observability	Chapter 5 Antsaklis and Chapter
13	27-Feb	tue	Controllability and observability	Chapter 5 Antsaklis and Chapter
14	1-Mar	thurs	Discretization of continuous-time systems	Mostly Notes
15	6-Mar	tue	Spring Break	
16	8-Mar	thurs	Spring Break	
17	13-Mar	tue	Canonical forms	-
18	15-Mar	thurs	Transformations	-
19	20-Mar	tue	Zeros, minimality	Chapter 19 Hespanha
20	22-Mar	thurs	State-variable feedback and Optimal Control	Chapter 10 Hespanha and Chapter 9 Antsaklis
21	27-Mar	tue	Continuous-time LQR	-
22	29-Mar	thurs	Discrete-time LQR	-
23	3-Apr	tue	Observers and duality	Chapter 9 Antsaklis
24	5-Apr	thurs	Observers and duality	Chapter 9 Antsaklis
25	10-Apr	tue	Output feedback	Chapter 23 Hespanha
26	12-Apr	thurs	Output feedback	Chapter 23 Hespanha
27	17-Apr	tue	Linear Tracking Regulator	Chapter 23 Hespanha
28	19-Apr	thurs	Dynamic Programming	-
29	24-Apr	tue	Hamilton-Jacobi-Bellman equation	-
30	26-Apr	thurs	Advanced Topics	-
30	1-May	tue	Advanced Topics	-
31	5-May	sat	Final Exam	-

These descriptions and timelines are subject to change at the discretion of the Instructor.