University of Vermont - Fall 2017
Syllabus
EE 301: Linear Systems Theory
TH 14:50-16:05, Room: TBD

Instructor: Professor Mads Almassalkhi
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Office Hours: TBD

Overview: This course is designed as a first-year graduate-level engineering course in systems theory and will apply fundamental linear algebra principles to linear models of electrical and mechanical systems. We will discuss the behavior of linear systems and mathematically prove the main results in linear system theory, including notions of controllability, observability, and stability. We will develop state-space transfer functions and design state feedback and state estimators. This is a fundamental course for graduate studies in systems engineering and emphasis will be focused on theoretical developments.

Web Site: We will use Blackboard.

Required Textbook(s): While I will not require a book, it is highly recommended that you have at least one good reference readily available during the course (see below). I will post full HW problems to Blackboard.

Recommended good references to have/be aware of*:

- *Linear Systems Theory and Design* by Chi-Tsong Chen, Oxford Univ. Press.
  Note: Most course contents will come from the 3rd/4th edition, but ANY edition will suffice.
- *State Variables for Engineers* by P.M. DeRusso et al., John Wiley & Sons, 2nd edition (1997)
  Note: This book is a well-written and classic reference.
- *Fundamentals of Linear State Space Systems* by John S. Bay, McGraw-Hill (1999)
  Note: This book is well-written and mathematically thorough.
- *Applied Linear Algebra* by B. Noble and J. W. Daniel, Prentice Hall, 3rd edition (1988)
- *Linear Algebra and Linear Operators in Engineering* by H.T. Davis & K.T. Thomson, Academic Press (2000)
- *An Introduction to Linear Control Systems* by T. Fortmann & K. Hitz, CRC Press (1977)

Pre-requisites: I will only assume that you have graduate engineering standing but it helps if you are comfortable with:

*These references should be on hold and available for 2-hour loans in the UVM main library.

- Laplace transforms, single-input single-out (SISO) systems, transfer functions, and feedback
- multiplying and inverting matrices and computing eigenvalues
- basic mathematical proof techniques (direct, contradiction, induction, etc.)

Officially, the prerequisites: MATH 230 or MATH 271, MATH 124, EE 171 or ME 111. While the course is fundamental and focuses on theoretical developments, having taken EE/ME 210 or taking EE 211 may be quite helpful to provide context for the concepts we cover in the course.

Approximate Course Schedule

Topics	
1	System modeling and representation (ca. 1 week)
2	Linear algebra fundamentals (ca. 3 weeks)
3	Solution of $\frac{d}{dt}x(t) = A(t)x(t)$ and exponential of matrix (ca. 2 weeks)
	- EXAM I -
4	Controllability and Observability for LTI systems (ca. 2 weeks)
5	Kalman Canonical Decomposition and minimal realizations (ca. 2 weeks)
	- EXAM II -
6	Stability á la Lyapunov (1 week)
7	Pole placement theorem and stabilizability (ca. 1 week)
8	Observers and dynamic output feedback (ca. 1 week)
9	Integral control, set points, and disturbance regulation (if time permits).

Homework Policy:

- Homework assignments highlight important topics from lecture and allows the student to understand the kind of problems they are expected to be able to solve. Homework is meant to be for practice and not worth as many points as exams.
- If you would like to submit your homework electronically, it should be neatly organized (e.g. use/learn LaTeX) and submitted as **a single pdf file** to me by e-mail with subject line: "EE 301: HW#".
- You may discuss homework with each other at a conceptual level, but not at a detailed level: e.g., you may discuss the procedural steps whereby you solve a problem, but do not share equations or Matlab code. If you do your work electronically, you should make sure that you did the final write-up independently (identical assignments will *both* get a 0 score). Please don't copy someone else's work — it rarely helps with the learning process.
- Late homework will **not** be accepted.

Grade Policy: Grades are based on performance on exams and HWs:

- Three exams: two midterms and one final (25% + 25% + 40%, respectively).
  - The final exam will be cumulative, but with a focus on material covered in the final third of the course.

  - I am leaning towards giving the midterms outside of scheduled class periods (e.g., 6-8PM on a weekday evening). This would offer you more time for problems and provide an extra week of lectures.

- Weekly homework assignments (10%).
  - Homework assignments will be assigned approximately weekly and are meant to provide you with practice and clarification of certain principles.
  - If the assignment requires MATLAB code, include your own commented code that comment each step of the logic.
  - I believe in feedback from HW grading, so for a random subset of assigned problems, I will proceed along the following:
    * THREE (3) points if the problem is perfectly correct or nearly so. Of course, "nearly so" is a subjective evaluation. I don't consider a numerical mistake to be important if it doesn't change the basic problem nor lead to greatly simplified reasoning. I am always concerned about conceptual errors. Please CIRCLE your final answer.
    * TWO (2) points if there are several minor errors or at least one major error, but it is clear that the person had a good idea of how to work the problem
    * ONE (1) point if the problem was attempted, but the reasoning is quite wrong, quite incomplete, or if the solution was unreadable (illegible writing, undefined notation, etc.)
    * ZERO (0) points only if the problem was not attempted.
  - Your lowest two HW scores will be dropped.

- Grades will be recorded on the course blackboard site (bb.uvm.edu) so check this. Letter grades will be assigned at the end of the course, based on the standard breakdown:

Score (%)	<60	60+	70	73+	77+	80+	83+	87+	90+	93+
Grade	F	D	C-	C	C+	B-	B	B+	A-	A

I reserve the right to adjust the score-to-grade mapping from the above scheme.

Academic Integrity: It is expected that everything that you submit with your name on is your own work. Anything that is not 100% your own work should be clearly labeled as such (credit your sources, group members, etc.). Students who submit others' work as their own will not pass the course and will be referred to the Center for Student Ethics and Standards for further discipline. The UVM policy on academic integrity is a useful guide:
https://www.uvm.edu/policies/student/acadintegrity.pdf.

University Attendance Policy: The lecture notes will form the bulk of materials, so attendance is important. Please refer to the most recent UVM Catalogue: *"Students are expected to attend all regularly scheduled classes. The instructor has the final authority to excuse absences."*

Student Learning Accommodations: In keeping with University policy, any student with a documented disability interested in utilizing accommodations should contact ACCESS, the office of

Disability Services on campus. ACCESS works with students to create reasonable and appropriate accommodations *via an accommodation letter to their professors as early as possible each semester.* Contact ACCESS: A170 Living/Learning Center - 802-656-7753 - access@uvm.edu.

Religious Holidays: Students have the right to practice the religion of their choice. If you need to miss class to observe a religious holiday, *please submit the dates of your absence to me in writing by the end of the second full week of classes.* You will be permitted to make up work within a mutually agreed-upon time.

Extra Help: Do not hesitate to come to my office during office hours or by appointment to discuss a homework problem or any aspect of the course. Blackboard discussion boards are also available if you want to ask questions to me or your peers.

ϟ I am looking forward to an eigenvaluable semester ϟ