THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

ASE 330M Linear System Analysis
Spring 2022

SYLLABUS

Unique Number:	14085
Instructor:	David Fridovich-Keil ASE 3.232, dfk at utexas dot edu
Time:	Tu/Th, 8:00-9:30 am
Location:	Virtual location: until January 31 Link: here Meeting ID: 980 8940 4029 Passcode: 961455 Physical location: starting February 1 CPE 2.206 Class will be synchronous and all lectures will be recorded and posted on Canvas. Please watch for any updates on Canvas.
Teaching Assistant:	Martin Braquet (braquet at utexas dot edu, office hours TBA) Edward Jung (edward dot jung at austin dot utexas dot edu, office hours TBA)
Web Page:	Canvas, http://canvas.utexas.edu

Catalog Description:
Explore the fundamentals of signals and systems; mathematical modeling of mechanical systems; transfer function; impulse response; Laplace transforms; response of linear, time-invariant systems; frequency response methods; time-domain analysis; introductory concepts for feedback control systems; multivariate linear dynamical systems; eigenvalues and eigenvectors; matrix exponentials. An introduction to fundamental elements of the theory of systems and signals and exposure to necessary concepts and tools required to perform modeling and analysis of linear dynamical systems. Demonstrate the theory through several simulation examples relevant to applications of modern aerospace engineering systems.

May be counted toward the quantitative reasoning flag requirement.

Course Objectives:
Introduce students to the fundamental elements of the theory of systems and signals and teach them the necessary concepts and tools required to perform modeling and analysis of linear dynamical systems. The theory will be demonstrated through several examples relevant to applications of modern aerospace engineering systems.

Prerequisites:
Engineering Mechanics 311M and Mathematics 427J or 427K with a grade of at least C- in each; and credit with a grade of at least C- or registration for Computational Engineering 311K (or Aerospace Engineering 211K or Computational Engineering 211K).

Knowledge, Skills, and Abilities Students Should Have Before Entering This Course:
Good familiarity with linear algebra, the theory of ordinary differential equations, and the dynamics of mechanical systems is required. Some basic knowledge of either MATLAB or similar software (e.g., Python) will be helpful for the homework assignments.

Knowledge, Skills, and Abilities Students Gain from this Course (Learning Outcomes):
Students will understand the fundamental theory of systems and signals and its application to problems of modeling and analysis of mechanical and aerospace engineering systems.

Impact on Subsequent Courses in Curriculum:
This class is a pre-requisite to the course ASE 370C (Feedback Control Systems).

Relationship of Course to Program Outcomes:
This course contributes to the ABET Criterion 3 student outcomes that took effect with the Fall 2019 semester. For more information, see *Criteria for Accrediting Engineering Programs, 2020-2021* at https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2020-2021/

STUDENT OUTCOME	
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	√
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. an ability to communicate effectively with a range of audiences	
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

ABET Program Criteria Achieved:
Program criteria are unique to each degree program and are to be compiled from the program criteria given for each degree program and listed in table format below. The faculty should check which of the program criteria are achieved in the course.

Criterion	√	Criterion	√	Criterion	√
A. Aerodynamics		G. Orbital Mechanics		M. Preliminary/Conceptual Design	
B. Aerospace Materials		H. Space Environment		N. Other Design Content	
C. Structures		I. Attitude Determination and Control		O. Professionalism	
D. Propulsion		J. Telecommunications		P. Computer Usage	X
E. Flight Mechanics		K. Space Structures			
F. Stability and Control	X	L. Rocket Propulsion			

Topics:
List the major topics in the course and in parentheses the number of classes in which the topic is covered; assume 42 classes as in a MWF class on a long-session semester for this purpose. Give also in separate parentheses the Program Outcomes and Program Criteria addressed by each topic referenced by letter.

- Introduction to signals and systems, block diagrams (3), (F)
- Mathematical modeling of mechanical systems using ordinary differential equations, stability (16), (F, P)
- Linear approximation of systems (3), (F)
- Laplace transform, Fourier transform, impulse response, convolution (16) (F)
- Transfer function and input-output description of linear systems (6), (F)
- State-variable system models and relationships to input-output system models (3), (F)
- Computer-based analysis of linear systems (1), (P)

Professionalism Topics:
Discussion of ethics and teamwork based on instructor's professional experience will be given periodically throughout the semester.

Design Assignments:
There will be no design assignments.

Laboratory Assignments:
There will be no laboratory assignments.

Computer:
Students are strongly encouraged to use computers in order to become familiar with the computer-based techniques for modeling and analysis of linear systems using MATLAB or other similar software. Several homework assignments will require the use of such software for simulation and other analysis.

Text:
This class will draw from several different textbooks, though all essential material will be provided on Canvas and students are not required to purchase any specific book(s). The following texts are recommended, though not required:

- Aström, K. J. and Murray, R. M. *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, 2008.
- Oppenheim, A. V. and Willsky, A. S. *Signals and Systems*, Second Edition, Prentice Hall, 1996.
- Close, C. M., Frederick, D. H., Newell, J. C., *Modeling and Analysis of Dynamic Systems*, John Wiley & Sons, Inc., 3rd Edition, 2002.

Class Format:
Class will be virtual prior to January 31, 2022, and in-person thereafter. In-person lectures will be recorded and posted on Canvas. Please refer to the "Location" section above for further details, and watch for any updates on Canvas.

Classes designated as in-person are those for which there is at least some material critical for the class that cannot be acquired without in-person attendance. Most of these classes involve learning skills or using equipment that would not be available remotely. In-person classes may have some content presented online, but students who register for classes without coming to campus cannot take these classes.

Class outline and schedule:
The course will be organized tentatively, as follows:

Week	Topic	Due
1	Administrivia, introduction to systems	
2	Deriving state space differential equations	
3	Linearity and time invariance	
4	Properties of linear operators	
5	Trajectories of state space linear systems	
6	Stability, controllability	
7	Modal decomposition	
8	Linearization	Midterm 1 (3/8)
9	Spring break	
10	Impulse response, convolution	
11	Eigenfunctions of LTI systems	
12	Fourier transform, frequency response	
13	Laplace transform	
14	Stability and eigenspaces, revisited	
15		Midterm 2 (4/26)
16	PID control design	

Final exam: Monday, May 16, 2:00 pm-5:00 pm

Grading:
Grades will be assigned according to the following proportions:
- Midterm 1: 20%
- Midterm 2: 20%
- Final exam: 45%
- Homework: 10%
- Participation/attendance: 5%

Note: This course will adopt the Plus/Minus Grading Policy. In particular, the passing grades will consist of the following ones: A, A-, B+, B, B-, C+, C, and C- . For more details, please refer to http://registrar.utexas.edu/students/grades.

Homework Policy:
There will be six homework assignments during the semester. Each assignment will be posted on http://canvas.utexas.edu (Canvas) and must be submitted in PDF format on Canvas as well. Homework assignments will be due approximately every two weeks, and posted at least seven days prior to their due date.

Students are encouraged to collaborate on homework assignments. However, to avoid plagiarism, students are required to acknowledge collaborators and write up solutions in their own words. Solutions should be written legibly and explained clearly; points may be deducted for sloppiness.

Late homework submissions will be accepted without a penalty in exceptional circumstances (e.g., a student is ill) only with the prior permission of the instructor. See also "A notice regarding accommodations for religious holidays." Otherwise, if homework is submitted late, it will be penalized 10% per day late, and will not be accepted after more than 5 days. For example, if a homework assignment is turned in between 1 minute and 24 hours late, its maximum score will be 90%.

Examinations:
There will be two mid-semester examinations (in-class exams). The first examination is scheduled for **Tuesday, March 8**, and the second one for **Tuesday, April 26**. The final exam will be administered in accordance with the University scheduled time as posted in the registrar website. The default final exam time for this course can be found in https://registrar.utexas.edu/schedules/222/finals (at present, it shows "**Monday, May 16, 2:00 pm - 5:00 pm**"). However, it is the student's responsibility to verify the exact date, time, and location of the final exam.

Attendance:
Note that regular attendance is expected. Both midterm exams will be held in class. Evidence for an excused absence from an exam day will be required (e.g., doctor's notice).

Office Hours:
Office hours will be organized as "problem sessions" in which students can collaborate on homework. Each problem session will be run by multiple course staff to answer both group and individual questions. Course staff will also run regular "homework post-mortem" sessions following each homework assignment to answer questions. Times and locations TBA.

To schedule other appointments, please reach out to the course staff by email. Put "ASE 330M" in the subject line, and suggest at least three time slots in which you could meet.

Important Dates:
Please refer to https://registrar.utexas.edu/calendars/21-22.

Policy on Academic Integrity
Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from the University. Since such dishonesty harms the individual, all students, and the integrity of the University, policies on academic dishonesty will be strictly enforced. For further information please visit the Student Judicial Services web site: http://deanofstudents.utexas.edu/sjs/.

A notice regarding accommodations for religious holidays
By UT Austin policy, a student must notify me of any pending absence at least fourteen days prior to the date of observance of a religious holy day. If the student must miss a class, an examination, a work assignment, or a project in order to observe a religious holy day, the student will be given an opportunity to complete the missed work within a reasonable time after the absence.

Special Notes:
The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the Cockrell School of Engineering Director of Students with Disabilities at 471-4321.

Evaluation:
Note that the Measurement and Evaluation Center forms for the Cockrell School of Engineering will be used during the last week of class to evaluate the course and the instructor. They will be conducted in an electronic format for Spring 2022. You may also want to note any other methods of evaluation you plan to employ.

COVID-19 Updates: Spring 2022 Semester
We will all need to make some adjustments in order to benefit from in-person classroom interactions in a safe and healthy manner. Our best protections against spreading COVID-19 on campus are masks (defined as cloth face coverings) and staying home if you are showing symptoms. Therefore, for the benefit of everyone:

- **Adhere to university mask guidance** (https://tinyurl.com/UTMaskGuidance). Masks are strongly recommended indoors regardless of vaccination status.
- **Vaccinations are widely available**, free and not billed to health insurance. The vaccine will help protect against the transmission of the virus to others and reduce serious symptoms in those who are vaccinated. Visit https://uthealthaustin.org/patient-resources/covid-19-updates/covid-19-vaccination for more information.
- **Proactive Community Testing** remains an important part of the university's efforts to protect our community. Tests are fast and free. Visit https://healthyhorns.utexas.edu/coronavirus_proactive_testing.html for more information.
- Information regarding safety protocols with and without symptoms can be found here.
- Visit **protect.utexas.edu** for updated information and announcements from the university.

To help keep everyone at UT and in our community safe, it is critical that students report COVID-19 symptoms and testing, regardless of test results, to University Health Services, and faculty and staff report to the HealthPoint Occupational Health Program (OHP) as soon as possible. Please see this link to understand what needs to be reported. In addition, to help understand what to do if a fellow student in the class (or the instructor or TA) tests positive for COVID, see this University Health Services link.

Sharing of Course Materials is Prohibited: No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings:
Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings. Guidance on public access to class recordings can be found here.