UNIVERSITY OF THE PHILIPPINES
College of Engineering

EE 212
Linear System Theory

COURSE GUIDE

Course Description

Theory and application of discrete and continuous-time linear dynamical systems. Review of applied linear algebra; least-norm and least-squares methods. Autonomous linear dynamical systems; interpretations of eigenvalues, eigenvectors, matrix exponential, and invariant sets. Singular value decomposition with applications. Linear dynamical systems with inputs and outputs; transfer matrices. Observability and state estimation; controllability and state transfer. Examples and applications from digital filters, circuits, signal processing, and control systems.

Prerequisite: EEE 35 or equivalent and Math 114 or equivalent

Course Objectives

At the end of this course, the student should be able :
To analyze any general linear system. To compute solutions to state equations. To derive appropriate inputs to drive a linear system to convergence in a specified time. To observe the states of the system from the system output(s).

Course Outline

1. Class policies, class requirements / expectations
2. Overview
    - How do we classify systems
    - Concept of a state
    - Some examples
3. Linear functions
    - Examples and applications
    - Linearization
4. Lumped state-space models
    - Simple pendulum, RLC circuit, mechanical system
    - State-space models from ODEs
    - Canonical forms
5. Linear algebra review
    - Orthonormal vectors and QR factorization
    - Least-squares method
6. Autonomous linear systems
7. Quadratic forms and SVD
8. Controllability and state transfer
9. State-feedback
10. Observability and state estimation

Mode of Delivery

Course Site
This course will be delivered remotely. Most of the course resources can be found at http://202.92.132.69:8888/manuel under EE 212. Please go through the site so you would be familiar with the available materials. Especially important is the section on Academic Integrity. Other materials not found on the site will be emailed to you directly.

Communications Plan
Our main mode of communications is via email. I will be using your email address as registered under CRS. Please make sure you are able to access that particular email account.

What will be sent through email? Announcements, links to lecture videos, homeworks, and lab exercises will be sent through email. Email from me concerning this class will always contain the phrase "ee 212" in the subject line.   If you have questions, comments or will be submitting homeworks and lab exercises, please send it by using email reply to the original email. Refrain from creating new subject lines unless you want to bring up a matter that does not fall under previously sent headings.

I would be generally available via email and zoom during class hours. For questions related to the lecture material, please send them through email at this time.   If the question is simple enough, I will send the answer as an email reply. If the question needs some discussion that would be difficult to do via email, then I would send a zoom link so we can discuss the question online.

Teaching Strategy and Learning Activities
The main mode of teaching for this course is through lecture videos, and discussions during class hours via email or video call whichever is appropriate. A schedule of topics will be followed. This will try to closely match how the course is conducted during a regular semester. Links to lecture videos will be made available at least a week before the particular topic is to be scheduled to be taken up. *Since the videos were recorded in earlier semesters, please take note that dates mentioned in the videos (e.g. quiz dates, exam dates, lab schedule) may not apply. Please refer to the course guide and recent emails for the actual dates of activities and deadlines of deliverables.*

Additional learning activities for the course would be reading references and watching videos related to the topics in control. Students should keep an eye on the scheduled list of topics so that they can pace themselves appropriately and be ready for assessment activities. It is also expected that students would solve book problems to increase familiarity with the material being discussed.

The following lab exercises will be given throughout the semester to reinforce the concepts discussed in the lectures.

Lab experiment 1. Linear algebra applications
Lab experiment 2. Cayley-Hamilton, QR decomposition
Lab experiment 3. Least-squares

Assessment Strategy and Activities
The primary mode of assessment would be through two exams. Homeworks would also be used to assess student performance but is intended more to give the student an idea of how he/she is keeping pace with the material.

Exams will be held in person, during class hours (see schedule of activities). Please check the schedule of activities for any conflicts.

For homeworks, please see http://202.92.132.69:8888/manuel/captured_correctly.txt on how to prepare your online submissions.

Course Materials

The following are materials that will be provided for the course

- Course guide
- Lecture slides
- Lecture videos
- Reading assignments
- Links to relevant videos

Study Schedule

The table below shows the schedule of topics to be taken up and the dates for quizes and exams. The student must keep the schedule in mind to keep pace with the requirements.

Please note that according to the UP Academic Credit Transfer System (ACTS), 1 academic credit (unit) = 38-48 hrs of student workload (including 13-16 hours of academic instruction). Thus, 3 academic credits (units) = (a minimum of) 114 hours of student workload for the semester.

With EE 212 being equivalent to 3 academic units, this approximately translates to eight hours of student workload per week. The lecture videos are designed not to exceed three hours per week. Homework will take at most three hours of student work per week. This leaves about two hours of student work that the student should use to review material, read references, and solve practice problems.

Week	**Topics**	**Learning Outcomes**	**Assessment**
1	Introduction, Class Policies, Grading, References (lectures 00, 01) 20 January 2025	Taxonomy of linear systems. Why study linear systems. Examples.	
2	Linear equations and functions Engineering examples Linearization Broad categories of applications (lecture 02) 27 January 2025	Describe linear equations and linear functions. Familiarize with engineering examples Demonstrate ability to use linearization to simplify non linear systems	HW 01
3	State-space models Canonical forms Diagonal realizations (lecture 03) 03 February 2025	Determine state-space models from physics and from ODEs. Write different canonical forms. Determine the diagonal realization.	HW 02

4	Linear algebra review (lecture 04) 10 February 2025	Familiarize with vector spaces, independence, range and nullspace. Describe similarity transforms and norms. Determine eigenvectors and eigenvalues. Familiarize with Jordan canonical form and Cayley-Hamilton theorem.	HW 03
5	Lab 01 19 February 2025		
6	Orthonormal vectors QR factorization Orthogonal decomposition Least-squares solution (lecture 05) 24 February 2025	Define orthormal vectors. Determine QR factorization and orthogonal decomposition of matrices. Determine the least-squres solution to different applications.	
7	Lab 02 05 March 2025		
8	Multi-objective least-squares Regularized least-squares Nonlinear least-squares Minimum-norm solution (lecture 06) 10 March 2025	Familiarize with multi-objective least-squares and regularized least-squares. Solve nonlinear least-squares problems. Determine the minimum norm solution to underdetermined systems.	Exam 01 17 March 2025
9	Exam 01 17 March 2025		
10	Autonomous linear dynamical systems Higher-order systems Linearization near the equilibrium point Linearization along a trajectory (lecture 07) 24 March 2025	Familiarize with autonomous linear dynamical systems and higher-order systems. Determine the linearization at an equilibrium point. Familiarize with linearization along a trajectory.	
11	Lab 03 02 April 2025		
12	Laplace transform State transition matrix Matrix exponential (lecture 08) 07 April 2025	Define the Laplace transform of matrix-valued functions. Determine the state transition matrix. Determine the matrix exponential. Explain the qualitative behavior and stability of systems in terms of eigenvectors.	HW 04
13	General form of systems with inputs and outputs Transfer matrix Impulse and step response matrices	Define general form of systems with inputs and outputs. Determine the transfer matrix of a system. Determine the impulse and step matrices of a system.	Exam 02 05 May 2025

	(lecture 09) 28 April 2025		
14	Exam 02 05 May 2025		

Course Requirements
Exams – 50%
Lab exercises – 30%
Homeworks – 20%

Grading

92 - 100	1.0
88 - < 92	1.25
84 - < 88	1.5
80 - < 84	1.75
76 - < 80	2.0
72 - < 76	2.25
68 - < 72	2.5
64 - < 68	2.75
60 - < 64	3.0
< 60	5.0