EE6620: LINEAR SYSTEMS THEORY AND DESIGN

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Linear Systems Theory and Design

Subject Code
EE - Electrical Engineering
Course Number
6620

Academic Unit
Electrical Engineering (EE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
MA2170 Linear Algebra and Multi-variable Calculus, or EE3210 Signals and Systems, or EE3118 Linear Systems and Signal Analysis

Equivalent Courses
Nil

Exclusive Courses
EE5411 Linear Systems Theory and Design

Part II Course Details

Abstract

This course aims to introduce to students fundamental concepts, techniques, and tools in linear system analysis and design, required for a broad range of engineering disciplines including systems and control, signal processing, and communications.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Recognise and determine system characteristics.		x	x	
2	Describe and apply state-space modelling.		x	x	
3	Implement the solution/response of linear dynamical systems.		x	x	
4	Describe and apply controllability and observability to linear systems.		x	x	
5	Apply state feedback and state estimator to engineering design.		x	x	x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will gain knowledge of fundamental concepts, essential criteria, and key techniques.	1, 2, 3, 4, 5	2 hrs/wk
2	Tutorials	Students will participate in tutorials to strengthen understanding on key concepts and techniques by working on closely related problems.	1, 2, 3, 4, 5	1 hr/wk
3	Written assignments	Students will develop skills and strengthen understanding by problem solving	1, 2, 3, 4, 5	

4	Case studies	Students will conduct mini-projects to be kept abreast of contemporary research and practical problems	2, 5	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Tests (2)	1, 2, 3, 4, 5	25	None	No
2	Assignments (6)	1, 2, 3, 4, 5	15	None	No
3	Case study and term paper	2, 5	10	None	Yes

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

30

Minimum Examination Passing Requirement (%)

30

Additional Information for ATs

Remark: To pass the course, students are required to achieve at least 30% in course work and 30% in the examination. # may include homework, tutorial exercise, project/mini-project, presentation

Assessment Rubrics (AR)

Assessment Task

Examination (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Achievements in CILOs

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal level

Assessment Task
Coursework (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion
Achievements in CILOs

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal level

Assessment Task
Examination (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Achievements in CILOs

Excellent
(A+, A, A-) High

Good
(B+, B) Medium

Marginal
(B-, C+, C) Low

Failure
(F) Not even reaching marginal level

Assessment Task
Coursework (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion
Achievements in CILOs

Excellent
(A+, A, A-) High

Good

(B+, B) Medium

Marginal

(B-, C+, C) Low

Failure

(F) Not even reaching marginal level

Additional Information for AR

Constructive Alignment with Programme Outcomes

PILO 1, 2 The course will provide fundamental concepts and techniques required in the modeling, analysis, and design of modern engineering systems in broad fields such as control technology, communication systems, and signal processing algorithms.

PILO 3, 4 Student will be able to analyze and design state feedback and state observers, and consequently to analyze and design feedback systems using numerically efficient state-space methods.

PILO 5 The lectures will provide the necessary tools for students to access contemporary research developments. The case studies will expose students to new research frontiers.

PILO 6,7 The case studies and presentation will provide students with the opportunity to work as a team and to develop their communication skills.

Part III Other Information

Keyword Syllabus

Mathematical Systems Descriptions
Review of basic concepts, causality, stability, linearity, time-invariance, input-output description, state-space description, LTI systems, linearization.
Basic Mathematical Background
Linear space, vector norms, linear equations, linear transformation, eigenvalues and eigenvectors, canonical forms, matrix function, positive definite matrices, matrix induced norms.
Linear Dynamical Equations
Solution space, fundamental matrix, transition matrix, adjoint systems, equivalent systems.
Controllability and Observability
Controllability Gramian, rank test, PBH test, output controllability, observability Gramian, observability test, PBH test, duality, canonical forms, canonical decomposition, minimal realizations.
State Feedback and Observer
State feedback, pole placement, performance index, full-state observer, reduced state observer, separation principle, tracking and regulation.
Stability Analysis
Input-output stability, system induced norms, internal stability, Lyapunov stability, Lyapunov equation.

Reading List

Compulsory Readings

	Title
1	C.T. Chen, Linear System theory and Design, 3rd Ed., Oxford Univ. Press, 1999

Additional Readings

	Title
1	T. Kailath, Linear Systems, Prentice Hall, 1980
2	P. Antsaklis and A.N. Michel, Linear Systems, Springer, 2006.