ENGR4210 – ENGR6210
Linear Systems

Syllabus - M. Haidekker

1 Course Information

Mathematical description and modeling of mechanical and electrical systems through linear differential equations and in the frequency domain with the help of the Laplace and Fourier transforms.

Offered: Every Fall semester
Credits: 3 credit hours
Class: Lectures on Tuesday and Thursday
Prerequisites: ENGR 2170 (Electrical Circuits) or instructor's consent.

What is a system? In one book, a system was defined as an assemblage of things that performs some sepcified function. A system can be anything from a water tank to a car suspension to an aeroplane. In the context of this course, a system has a defined state (e.g., the water level of a tank, the compression of the spring in a car suspension, the attitude of an aeroplane). We interpret this state as the output of the system, and we stipulate that the output is quantifiable and measurable. In addition, the system must have an input. A control signal (for example, electrical or mechanical) applied to the input changes the output of the system in a predictable way.

A linear, time-invariant system is a system that has several defined properties. Strictly, linear systems do not exist. However, within limits, many electrical and mechanical systems can be adequately described with the linear system model.

In this course, we will examine systems and learn to describe them with mathematical *models*. With the help of a model, the behvior of the system can be predicted. By association, we will also examine signals, that is, the inputs and outputs of a system. We will learn how to measure and analyze signals to obtain meaningful information that allows us to describe a system. Specifically,

1. we will learn how to describe and characterize a linear system
2. we will learn how to measure and interpret signals
3. we will use time-domain methods (differential equations) and frequency-domain methods (Fourier analysis, Laplace transform) to effectively model linear systems and predict their dynamic and steady-state behavior
4. we will also use computer simulations to help us analyze a system and support the purely mathematical model.

This course provides you with the mathematical tools to analyze and describe systems. Notably, in the second class (Feedback Control Systems), we will then learn how to design a system, that is, modify a system that has a given, but undesirable behavior, into a system that meets specific design goals.

2 Instructor

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3 Syllabus – Topical Outline

Note: The course syllabus is a general plan for the course; deviations may be necessary and will be announced to the class by the instructor.

Lecture block	Topic
1	Signals and systems - the fundamentals
2	Mathematical description and manipulation of signals
3	Linear systems and their properties
4	Description of linear systems with differential equations
5	Input and output signals, system response, and the convolution
6	Transient and steady-state response
7	The Laplace transform
8	Description of linear systems in the Laplace domain
9	Transfer functions, characteristic equation, poles and zeros
10	State-variable description of linear systems
11	Predicting the system response in the Laplace domain
12	The Fourier transform
13	Frequency-domain analysis methods
14	Bode diagrams and Nyquist plots

4 Class Materials

- ENGINEERING SIGNALS AND SYSTEMS. By Fawwaz T. Ulaby and Andrew E. Yagle. National Technology and Science Press (2013). ISBN 978-1-934891-16-2.
- Supplemental reading: *Linear Feedback Controls – The Essentials*, by M.A. Haidekker. Elsevier 2013, ISBN 978-0-124-05875-0

A class web page exists at `http://photonics.engr.uga.edu/linear`, and course details, homework assignments and announcements can be found on that web page. Students are encouraged to visit that web page frequently.

5 Course Objectives and Expected Learning Outcomes

By the end of this course, students should have the ability to:

- Describe and characterize a system (block diagram, quantitative description)
- Measure and interpret signals
- Model a linear system (time-domain, Laplace transform)
- Simulate a linear system in software

6 Grading Policy

Grades will be assigned by a percentage of earned grade points. Grade points are awarded following the fill-the-bucket principle for:

- Homeworks (about 40% of the total score)
- Midterm exam (about 30% of the total score)
- Final exam (about 30% of the total score)

Grades are related to the percentage of earned grade points as follows:

Grade points (%)	Grade
95 or more	A
90 or more	A-
85 or more	B+
80 or more	B
75 or more	B-
70 or more	C+
65 or more	C
60 or more	C-
55 or more	D+
50 or more	D

The minimum passing score is 50% of the achievable score.

7 Reference to the University Honor Code and Academic Honesty Policy

As a University of Georgia student, you have agreed to abide by the University's academic honesty policy, A Culture of Honesty, and the Student Honor Code. All academic work must meet the standards described in A Culture of Honesty found at: `http://www.uga.edu/honesty`. Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation. Questions related to course assignments and the academic honesty policy should be directed to the instructor.

8 Additional ABET-Relevant Information

Overall, this course contributes to the Student Outcomes as follows:

a. An ability to apply knowledge of mathematics, science, and engineering: **Extensively**

b. An ability to design and conduct experiments, as well as to analyze and interpret data. **Moderately**

c. An ability to design a system, component, or process to meet desired needs. **Marginally**

d. An ability to function on multi-disciplinary teams. **Marginally**

e. An ability to identify, formulate, and solve engineering problems. **Moderately**

f. An understanding of professional and ethical responsibility. **Not at all**

g. An ability to communicate effectively. **Not at all**

h. The broad education necessary to understand the impact of engineering. **Not at all**

i. A recognition of the need for, and an ability to engage in life-long learning **Not at all**

j. A knowledge of contemporary issues. **Moderately**

k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. **Extensively**

The course learning outcomes (see Section 5) relate to the Student Outcomes as follows (3 indicates extensively; 2 indicates moderately; 1 indicates marginally):

Course Learning Objective	Relationship to Student Outcome						
	a	b	c	d	e	j	k
Describe & characterize a system (quantitative description, block diagram)	3	–	–	–	2	1	2
Measure and interpret signals	2	2	–	–	1	–	3
Model a linear system (time-domain, Laplace transform)	3	–	–	–	2	1	3
Simulate a linear system in software	3	2	1	1	3	2	3