UNIVERSITY OF CALIFORNIA, SAN DIEGO
Electrical & Computer Engineering Department
ECE 101 - Fall 2019
Linear Systems Fundamentals

MIDTERM EXAM

You are allowed two 2-sided sheet of notes.

No books, no other notes, no electronics.

PRINT YOUR NAME _____

Signature _____

Your signature confirms that you have completed this exam on your own and in accordance with the ECE 101 honor code.

Student ID Number _____

Problem	Weight	Score
1	20 pts	
2	30 pts	
3	20 pts	
4	30 pts	
Total	100 pts	

Please do not begin until told.
Show your work.
Use back of previous page and attached scratch sheets as needed.
Tables 3.1 and 3.2 from the textbook are attached to the exam.

Good luck!

Name/Student ID: _____

Problem 1 (20 pts)

(a) (8 pts)

Let $x(t) = 2^{-t}\,(u(t+1) - u(t-1))$. Define $y(t) = x((-2t)+1)$.

To obtain $y(t)$ from $x(t)$ you can

First shift $x(t)$ by _____

Then scale the result by _____

or

First scale $x(t)$ by _____

Then shift the result by _____

(b) (6 pts)

Let $x(t)$ and $y(t)$ be as in part (a) above.

Sketch precisely $y(t)$.

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Problem 1 (cont.)

(c) (6 pts)

Let $x(t)$ and $y(t)$ be as in part (a) above.

The signal $x(t)$ can be written as $x(t) = y(ct - d)$. Find c and d. Confirm mathematically that your answer is correct.

$c =$ _____

$d =$ _____

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Problem 2 (30 pts)

(a) (5 pts)

Consider the discrete-time system S_1 defined by

$$y[n] = \begin{cases} x[n-1], & n \geq 1 \\ 0, & n = 0 \\ x[n], & n \leq -1. \end{cases}$$

Determine and precisely sketch the impulse response $h[n]$.

(b) (5 pts)

Give the difference equation for the linear, time-invariant (LTI) system S_2 with the impulse response $h[n]$ you found in part (a).

Describe the action of the system S_2 in words.

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Problem 2 (cont.)

(c) (8 pts)

Is the system S_1 of part (a) an LTI system?

More specifically, is S_1 linear? Is S_1 time-invariant?

Indicate below whether the system satisfies each listed property.

Justify your answers with specific reference to the system S_1.

True	**False**	
☐	☐	LTI
☐	☐	Linear
☐	☐	Time-invariant

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Problem 2 (cont.)

(d) (12 pts)

Indicate below whether the system S_1 of part (a) satisfies each listed property.

Justify your answers with specific reference to the system S_1.

True	**False**	
☐	☐	Memoryless
☐	☐	Invertible (if so, give the inverse system)
☐	☐	Causal
☐	☐	Stable

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Problem 3 (20 pts)

(a) (6 pts)

Consider the continuous-time LTI system S defined by

$$y(t) = x(t) + \frac{1}{2}x(t-1).$$

Determine the impulse response $h(t)$ of the system.

(b) (6 pts)

Determine the system function and frequency response of the system in part (a). **Justify your answers.**

$H(s) =$ _____

$H(j\omega) =$ _____

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Problem 3 (cont.)

(c) (8 points)

Let $x(t) = \cos(\pi t)$ be the input to the system in part (a).

Determine the output $y(t)$. Express it in the form $y(t) = A\cos(\omega_0 t + \theta)$.

Justify your answer.

$A =$ _____

$\omega_0 =$ _____

$\theta =$ _____

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Problem 4 (30 pts)

(a) (16 points)

Let $x[n] = \cos(\frac{\pi}{2}n)\sin(\frac{\pi}{4}n)$. The signal has fundamental period $N = 8$.

Is $x[n]$ even, odd, or neither?

Determine the Fourier series of $x[n]$.

$x[n]$ is even _____ odd _____ neither _____

$a_0 =$ _____ $a_4 =$ _____

$a_1 =$ _____ $a_5 =$ _____

$a_2 =$ _____ $a_6 =$ _____

$a_3 =$ _____ $a_7 =$ _____

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Problem 4 (cont.)

(b) (7 points)

Let $x[n]$ be the signal of part (a). Determine $\sum_{n=0}^{7} x[n]$.

How does this sum relate to the Fourier series coefficient a_0?

(c) (7 points)

Let $y[n] = x[n-4]$, where $x[n]$ is the signal of part (a).

Is $y[n]$ even, odd, or neither?

Determine the relationship between the Fourier series b_k of $y[n]$ and the Fourier series a_k of $x[n]$.

$y[n]$ is even _____ odd _____ neither _____

$b_k =$ _____