UNIVERSITY of HOUSTON | ECE

ECE 3337: Test #1

Fall 2024

Last name of student	Student ID number
First name of student	Email address

Do This First:

1. Make sure that you have all the pages of the exam.
2. Fill in the above information.
3. Turn off and put away all electronic gadgets (laptop, tablet, smartphone, calculator, smart watch, …)

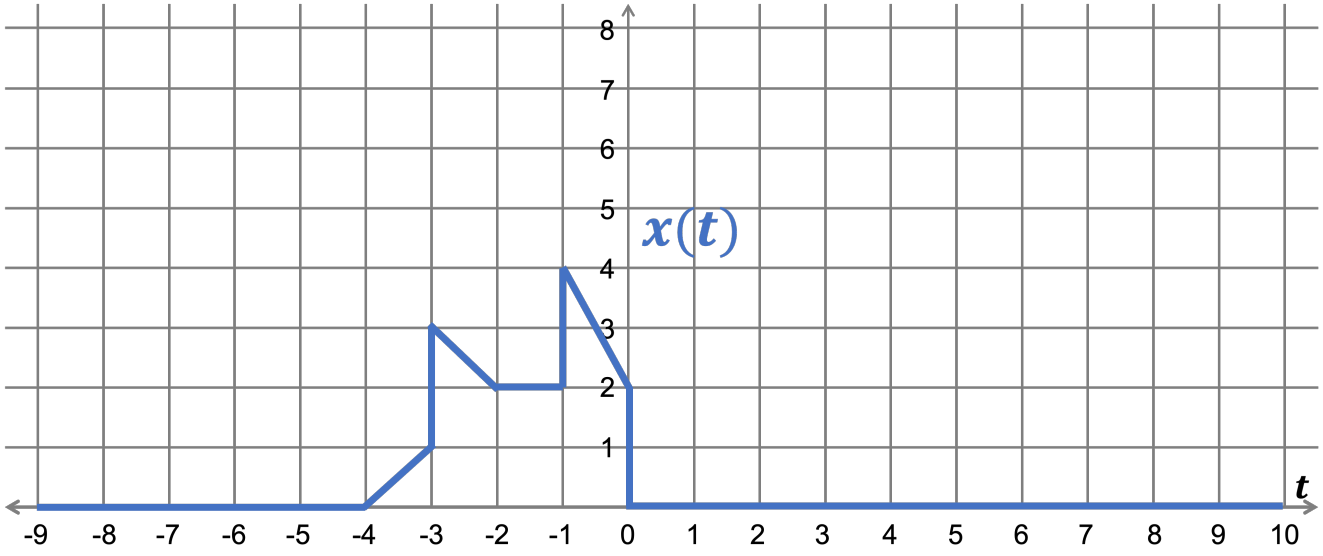
Exam Rules:

1. You are allowed to bring one 8.5” x 11” handwritten crib sheet (double sided).
2. Indicate your answers in the spaces provided. Use the back of the page to carry out calculations.

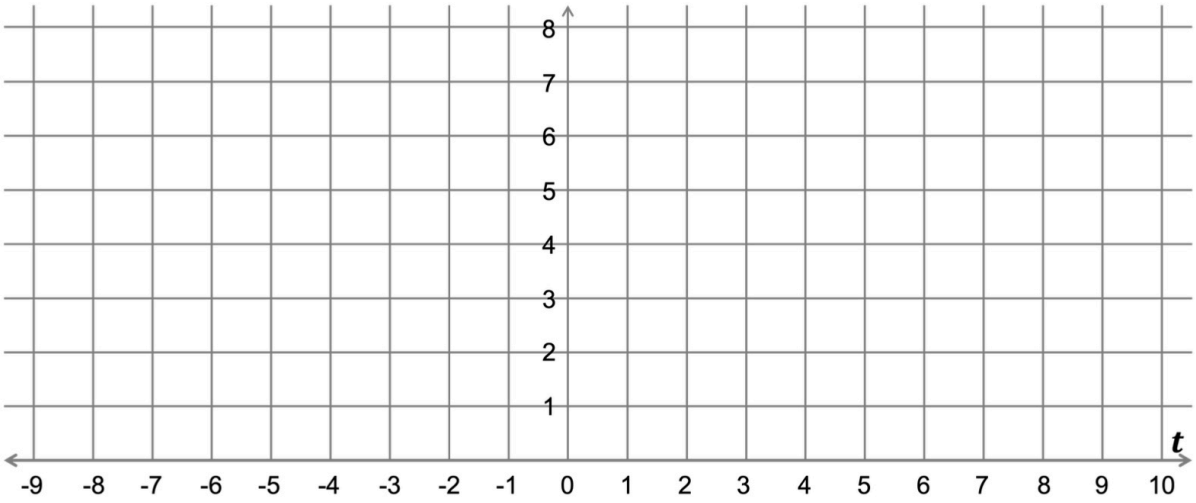
Q1	Q2	Q3	Q4	Q5	Q6	Total
15	20	15	15	15	20	100
Waveforms & Transformations	Signal Properties	System Properties	Convolution Integral	System Response	Frequency Response	

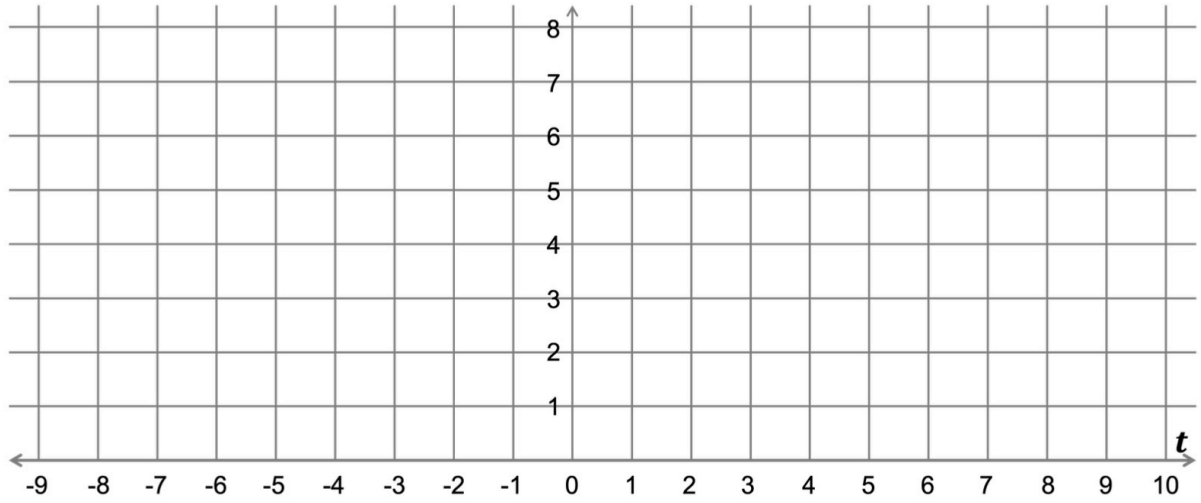
1. (15 points) Waveforms & Signal Transformations

a. (5 points) Write down a formula in terms of steps and ramps describing the signal sketched below.



b. (10 points) Plot $\frac{3}{2}x\left(\frac{-t-2}{2}\right)$ on the graph below. Your final answer should be sketched below. You may use the blank graphs at the end of the exam book for your work (they will not be graded).

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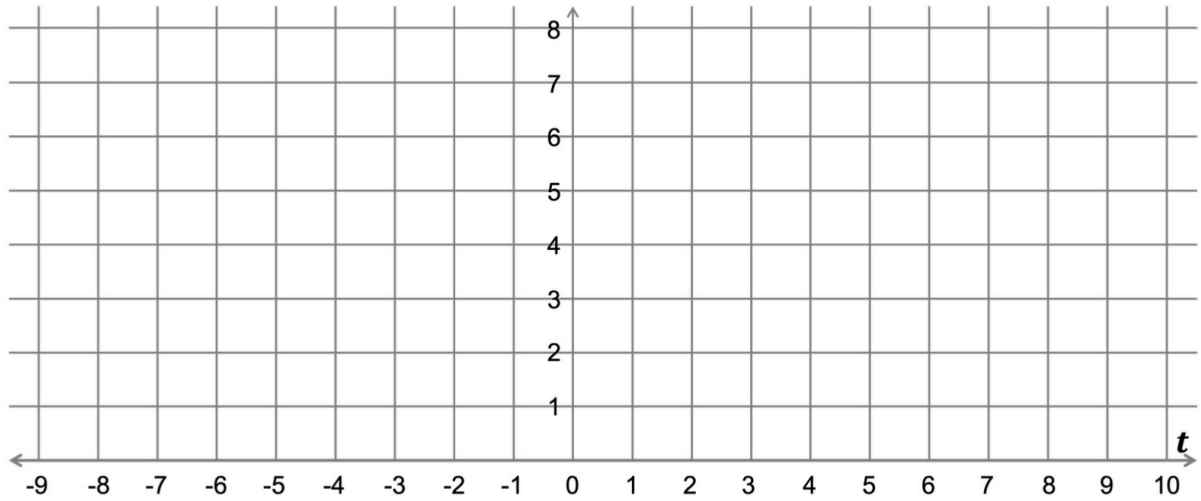
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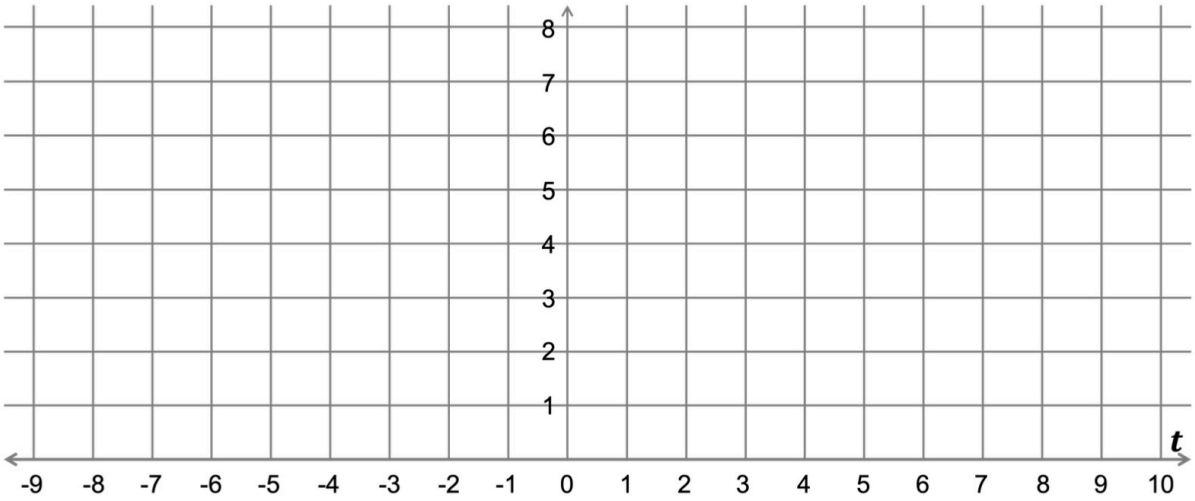
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-9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10

2. (20 points) Signal Properties

a. (4 points) Determine the time period of the signal $x_1(t) = |\, 2\cos(2\pi t)\,|$, where | | represents absolute value.

b. (6 points) Calculate the results of sampling the signal $x_2(t) = u(t) + 2r(t)$ with $s(t) = \delta\left(\frac{t}{3} - 1\right)$

c. (5 points) If the odd and even components of the signal $x(t)$ are $x_o(t)$ and $x_e(t)$, respectively, then prove that the signal $y(t) = x_e(t)\, x_o(t)$ is odd symmetric.

d. (5 points) If the average power of a signal $x(t)$ is P, what is the average power of the signal $\frac{1}{2}x(4t-2)$?

3. (15 points) System Properties

a. (5 points) Is the system $y(t) = 2x(t)\mathrm{e}^{-j2t}$ linear? Explain your reasons.

b. (5 points) Is the system defined by $y(t) = x\left(\frac{t+1}{2}\right)$ causal? Explain your reasons.

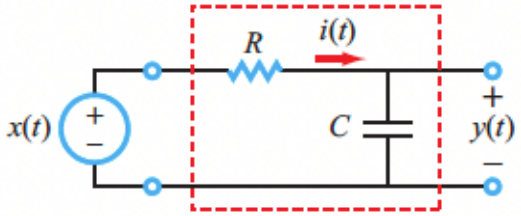
c. (5 points Is the system $y(t) = \frac{x(t-1)}{1-e^{-t}}$ BIBO stable? Explain your reasoning.

4. (15 points) Convolution Integral

a. (5 points) Calculate the output $y(t)$ of an LTI system whose impulse response is $h(t)$ when it is provided the input $x(t)$, where:

$$x(t) = u(t)$$
$$h(t) = [t + \cos(t)]u(t)$$

b. (5 points) Calculate the response of the following circuit with $RC = 1$ for the input $x(t) = e^{j3t}u(t)$.



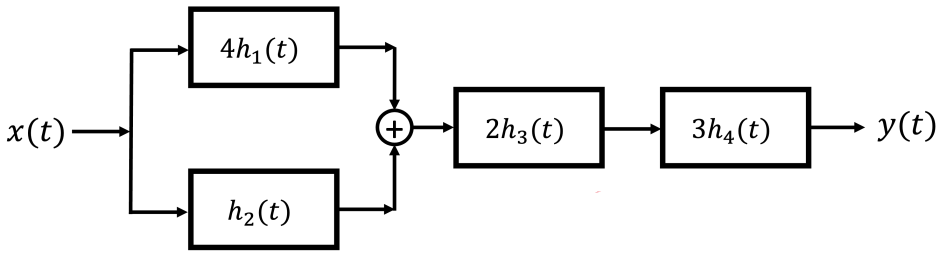
The impulse response is given by $h(t) = \frac{1}{RC}e^{-\frac{t}{RC}}u(t)$, and the initial conditions are zero.

c. (5 points) Compute the convolution $y(t) = u(t-2) * \{u(t-3) + 3r(t+1) + 4\delta(t-1)\}$ without computing any integrals. You can utilize the following results: $u(t) * u(t) = r(t)$ and $u(t) * r(t) = \frac{t^2}{2}u(t)$

5. (15 points) System Response

a. (10 points) Find the ramp response $y_{ramp}(t)$ of the system given by the differential equation $\frac{dy(t)}{dt} + 3y(t) = \frac{d^2x(t)}{dt^2} + 2\frac{dx(t)}{dt}$. Assume zero initial conditions.

b. (5 points) Find the overall impulse response of the following system if each of the individual systems $h_1(t) \ldots h_4(t)$ are LTI.



6. (20 points) System Frequency Response

a. (10 points) Find the frequencies at which the LTI system described by the following linear constant coefficient differential equation introduces a zero phase change to an input signal $x(t) = \cos \omega t$. In other words find all values of ω_0 for which, $\angle \widehat{\mathbf{H}}(\omega_0) = 0$.

$$\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 4y(t) = \frac{dx(t)}{dt}$$

b. A system is defined by the following differential equation:

$$\frac{d^2y(t)}{dt^2} + B\frac{dy(t)}{dt} + 9y(t) = 2\frac{dx(t)}{dt} + 3\frac{d^2x(t)}{dt^2}$$

i. (4 points) Determine the value of B that will make the following system critically damped:

ii. (3 points) For $B = 7$, find the roots of the characteristic equation.

iii. (3 points) For $B = 5$, is the system BIBO stable? Why or Why not?

USE THESE FOR YOUR WORK IF NEEDED.

ONLY YOUR FINAL ANSWER ON PAGE 2 WILL BE GRADED.