Name: ____________________ RIN: ____________________

Rensselaer Polytechnic Institute
Department of Electrical, Computer, and Systems Engineering
ECSE 2410: Signal and Systems, Fall 2020

Final Exam. Session 1
December 16, 2020, 3-5pm

Show all work for full credit.

- Open book, open notes. Calculators allowed.
- Computers, iPads, and similar devices for viewing notes only.
- No typing or writing on computers, iPads or similar devices.
- Cameras on, mic off. Announcements will be sent through Webex chat.
- If any doubt or question, send a PRIVATE message through Webex to the instructor or TAs.
- Because there are multiple versions of the exam, each of you only gets partial exam problems. To double check, your exam should contain the following problems. if not correct, please contact the instructor.

  Problems 1, 2, 3, 5, 6, 8, 10, 11
- When in doubt, show more work!

Please write down the following statement

"I have not witnessed any wrongdoing, nor have I personally violated any conditions of the Honor Code, while taking this examination."

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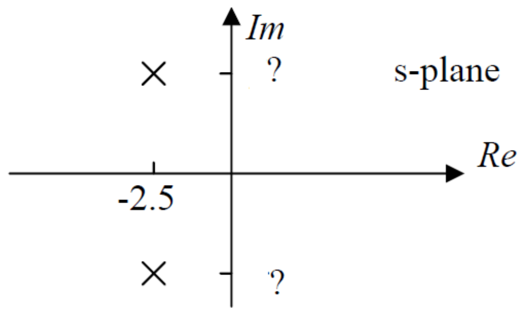
Signature: ____________________ Date: ____________________

1 (8 points.) The transfer function of a second-order system is given by

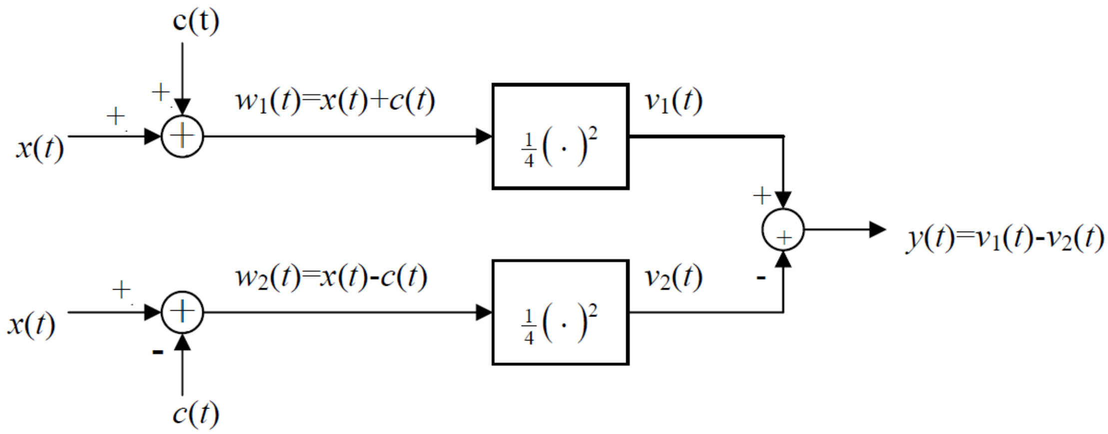
$$H(s) = \frac{25}{s^2 + \alpha s + 25},$$

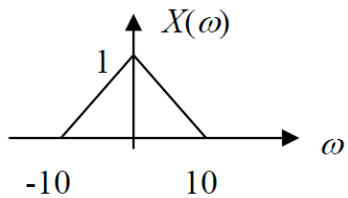
where α is unknown. However, $H(s)$ is known to have two complex poles whole real part is -2.5, and the imaginary parts are unknown, i.e.,



Find the damping factor and natural frequency for the system.

2 (10 points.) For the block diagram below (note negative signs), $c(t) = \cos(20t)$, $X(\omega)$ is as follows. Sketch $Y(\omega)$, and label the key values in the sketch.



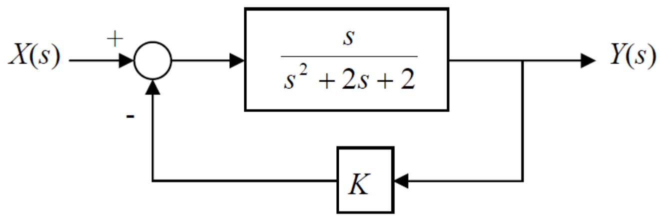


3 (10 points.) An LTI system has an impulse response, $h(t) = e^{-2t}u(t)$. Find the output $y(t)$ when the input is $x(t) = u(t) - u(t-2)$.

5 (15 points.) For the feedback system shown below, find the value of K that makes the closed-loop system stable.

(a) Find the poles of the system when there is no feedback, i.e., $K = 0$. Is the system stable or not? Why?

(b) Find the value of K that makes the closed-loop system stable.



6 (15 points.) Find the inverse Laplace transforms of the following three signals.

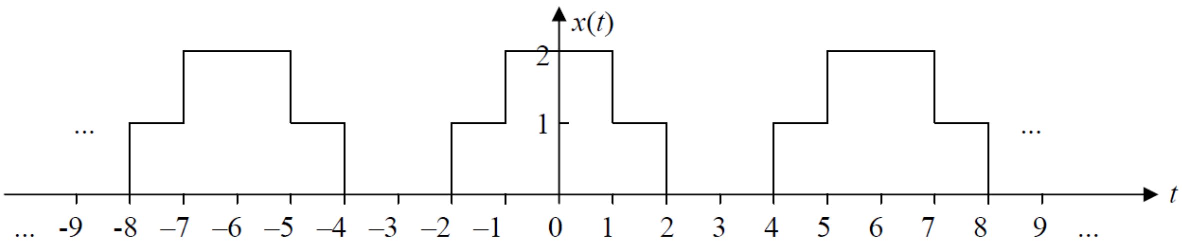
$$X(s) = \frac{s+3}{(s+1)(s^2+2s+5)}$$

$$Y(s) = \frac{(s+3)e^{-2s}}{s+2}$$

$$Z(s) = \frac{s+3}{(s+1)^2(s+2)}$$

8 (12 points.) Find the Laplace transform of $x(t) = e^{-2t}u(t-1) + e^{2t-4\pi}u(t) + e^{2t-8\pi}u(t-4\pi)$

10 (10 points.) Find the Fourier Series coefficients of the following periodic signal.



11 (20 points.) Consider the signal $x(t) = \text{sinc}(\frac{2t}{\pi}) + \cos(5t)$. ($\text{sinc}(x) = \frac{\sin(\pi x)}{\pi x}$)

(a) Sketch $X(\omega)$. Label the key values.

(b) What is the Nyquist rate of the signal?

(c) Suppose $y(t) = x(t) \cdot c(t)$, where

$$c(t) = \sum_{n=-\infty}^{\infty} \delta(t - \frac{\pi n}{4})$$

Sketch $Y(\omega)$. Label the key values.

(d) Suppose we filter $y(t)$ with an ideal low-pass filter with

$$H(\omega) = 2\pi, \text{ if } -4 \le \omega \le 4, \text{ and } H(\omega) = 0 \text{ otherwise.}$$

What is the explicit expression of the output signal $z(t)$ of the filter?

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