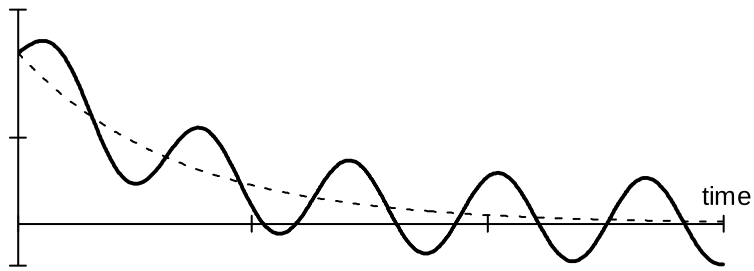
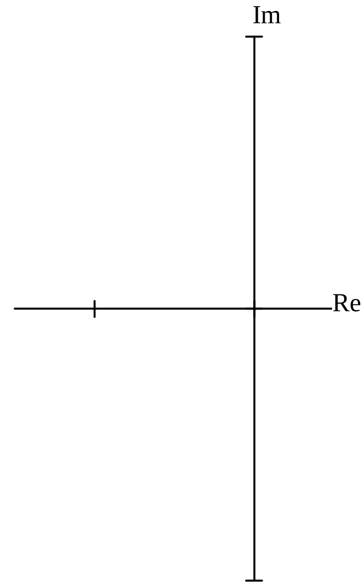
ECE 3510 Exam 1 given: Spring 23 (Some of the space between problems has been removed.)

This part of the exam is Closed book, Closed notes (including yellow sheet), Calculator OK.
DO NOT use erasable ink

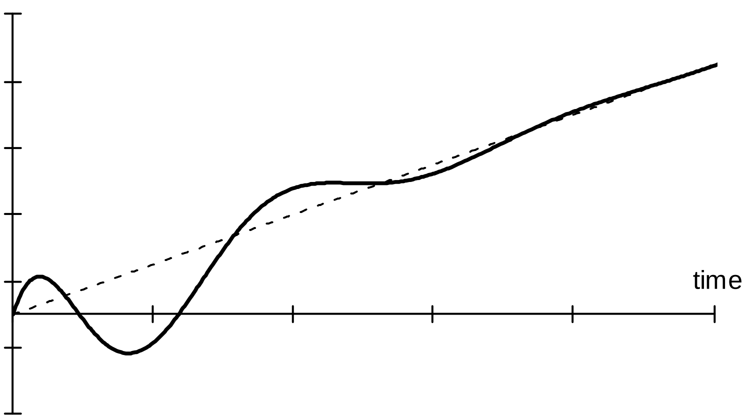
1. (15 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

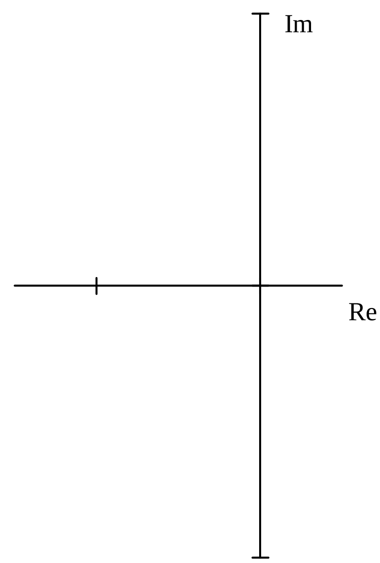
a)



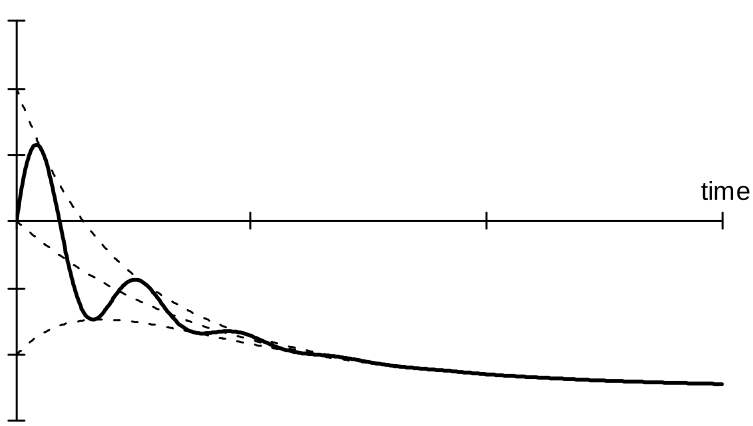


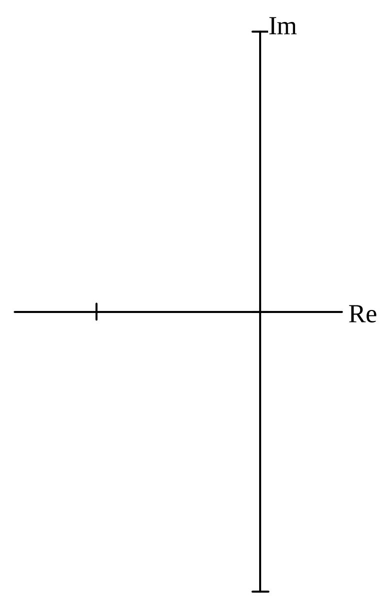
b)





c)

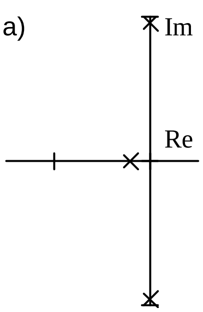




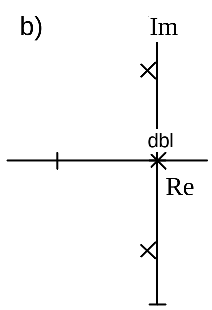
1. (13 pts) Find the inverse Laplace transform of the following function:
   Use partial fraction expansion and the tables.
   Show all your work to get credit.

$$\mathbf{F}(s) := \frac{s+3}{s\cdot(s+2)\cdot(s+4)}$$

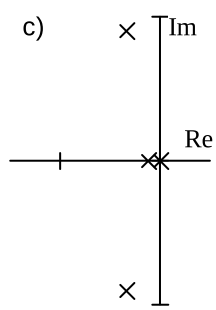
Answers Part 1: 1. a)



b)



c)



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Part2

1. $\left(\frac{3}{8} - \frac{1}{4}\cdot e^{-2\cdot t} - \frac{1}{8}\cdot e^{-4\cdot t}\right)\cdot u(t)$

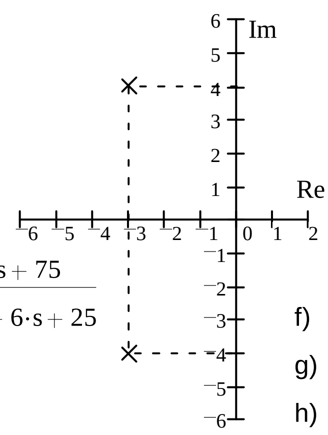
2. a) $$\frac{\frac{1}{L\cdot C}}{s^2 + \left(\frac{R_1}{L} + \frac{1}{R_2\cdot C}\right)\cdot s + \left(1 + \frac{R_1}{R_2}\right)\cdot\frac{1}{L\cdot C}}$$

   b) 2

   c) $0 = \left(\frac{R_1}{L} + \frac{1}{R_2\cdot C}\right)^2 - 4\cdot\left(1 + \frac{R_1}{R_2}\right)\cdot\frac{1}{L\cdot C}$

3. a) $\frac{8\cdot s + 40}{s^2 + 15\cdot s + 38}$ b) -3.228 and -11.772

4. a) 6 b) 1.8 c) C d) A e) $\frac{s+75}{s^2 + 6\cdot s + 25}$



f) 5

g) 0.6

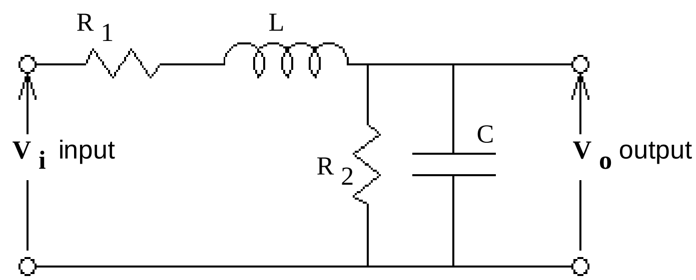
h) YES

5. $2\cdot\cos(8\cdot t - 13.1\cdot deg)$

6. a) $\frac{4\cdot s + 5}{s}$ b) NO

2. (15 pts) a) Find the transfer function of this circuit.

   H(s) = ?



b) How many poles does this transfer function have?

c) Write an equation that would have to be true if this system were critically damped (probably in terms of R_1, R_2, L and C).

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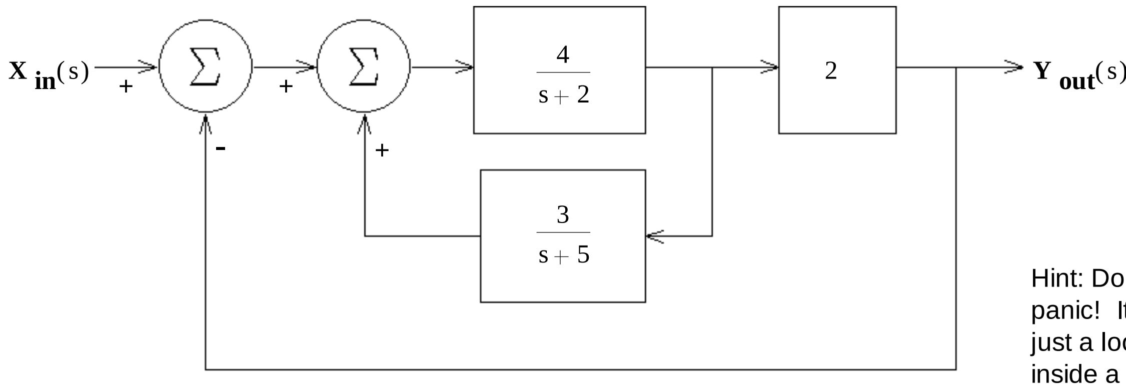
3. (19 pts) For the feedback system shown below, find the transfer function of the whole system, with feedback.

Find $H(s) = \dfrac{\mathbf{Y}_{\mathbf{out}}(s)}{\mathbf{X}_{\mathbf{in}}(s)}$

Simplify your expression for **H(s)** so that he numerator and denominator are both simple polynomials



Hint: Don't panic! It's just a loop inside a loop.

b) Find the pole(s) of the transfer function.

4. (18 pts) Consider the **step response** of a system that has the following transfer function:

$$\mathbf{H}(s) = \frac{s + 15 \cdot k}{s^2 + 6 \cdot s + 5 \cdot k}$$

Step input: $x(t) = 2 \cdot u(t)$

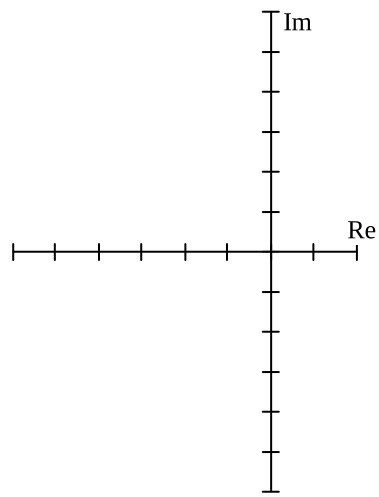
a) What is the final value of the output (steady-state value)?

b) What value of k will make the output critically damped?

c) $k = 1$, the output is: A) underdamped B) critically damped C) overdamped (Circle one)

d) $k = 6$, the output is: A) underdamped B) critically damped C) overdamped (Circle one)

e) For $k := 5$ Express $\mathbf{H}(s)$ in a normal form, and draw the poles of the system.



f)What is the natural frequency (ω_n) of this **system**?

g) What is the damping factor (ζ) of this **system**?

h) Is $\mathbf{H}(s)$ BIBO stable?

5. (10 pts) This system: $\mathbf{H}(s) = \frac{4}{s+6}$ Has this Cosine input: $x(t) = 5\cdot\cos(8\cdot t + 40\cdot deg)\cdot u(t)$

Use steady-state AC analysis to find the steady-state response ($y_{ss}(t)$) of the system.

Prob 5 ______/ 10

6. (10 pts) The input to a system is: $x(t) = 2\cdot e^{-5t}\cdot u(t)$

The output of this system is: $y(t) = \left(2 + 6\cdot e^{-5\cdot t}\right)\cdot u(t)$

a) Find system transfer function, $\mathbf{H}(s)$.

If you can't find $\mathbf{H}(s)$, at least find the poles of $\mathbf{H}(s)$.

b) Is $\mathbf{H}(s)$ BIBO stable?

Prob 6 ______/ 10

Part 1 ______ / 15 Total ___________ / 100