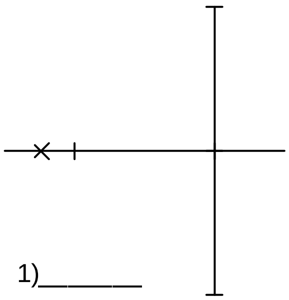
ECE 3510 Exam 1 given: Spring 09 (The space between problems has been removed.)

This part of the exam worth 40 points and is Closed book, Closed notes, No Calculator.

1. (40 pts) Each set of real and imaginary axes below show the poles of a **signal transform.**
   a) Find the best matching time-domain signal or answer on the next page.
   Answers may be used more than once or not at all.
   The axes below all have the same scaling. All time scales on the ANSWERS page are the same.
   Your answers should make sense relative to one another.
   dbl = double pole at that location



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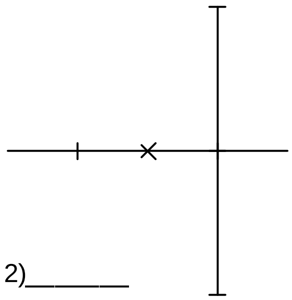

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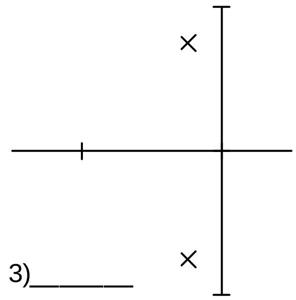

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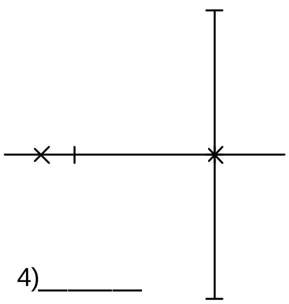

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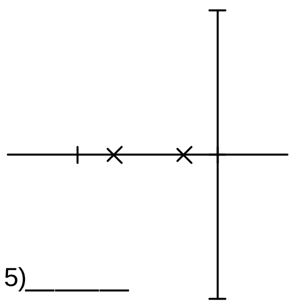

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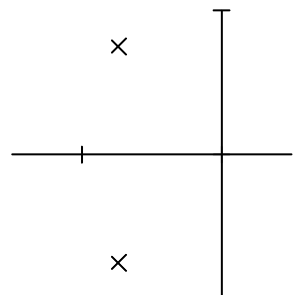

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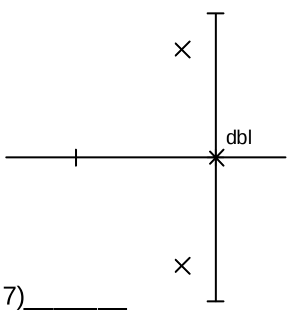

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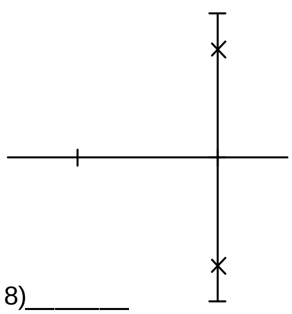

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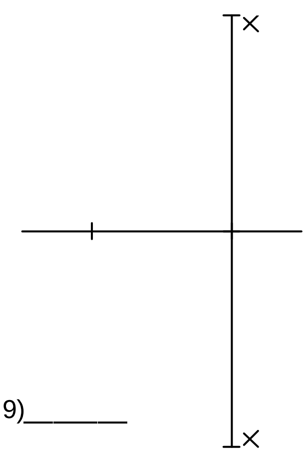

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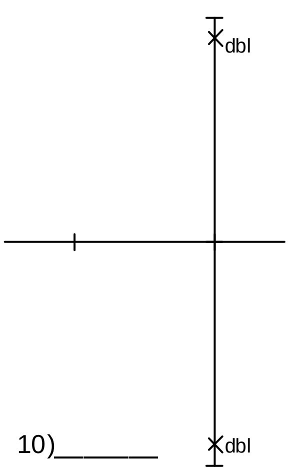

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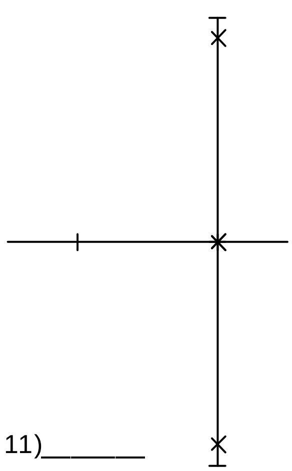


11)_______

b) List those numbers that are UNBOUNDED.

c) List those numbers on the other side and above that DO NOT converge

d) At maximum gain, the crude servo in lab 1 tried to produce which of the outputs on the ANSWERS page?

What kept it from actually producing that output?

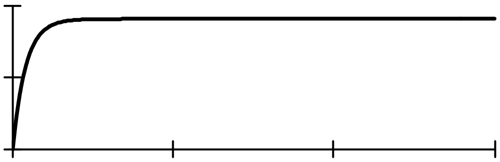
e) Which of the outputs on the ANSWERS page is the result of exciting a system at its resonant frequency?

ANSWERS

A No real time-domain answer could match these pole(s)

B None of these time-domain answers match these poles

C



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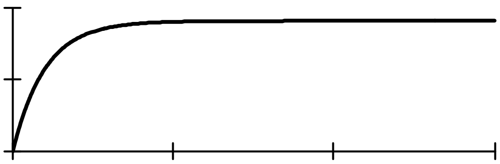

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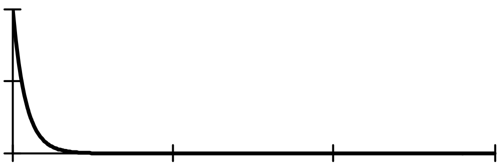

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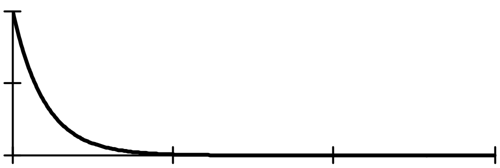

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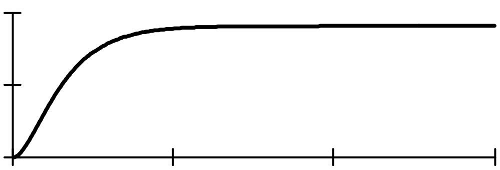

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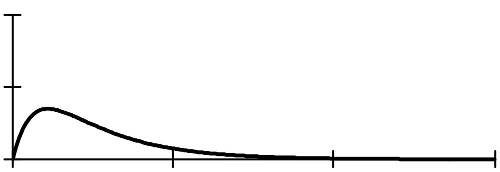

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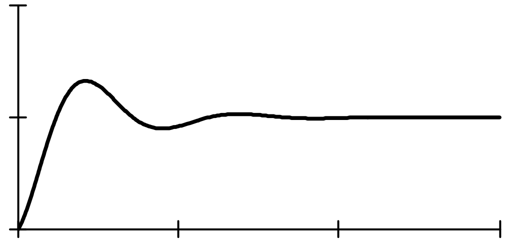

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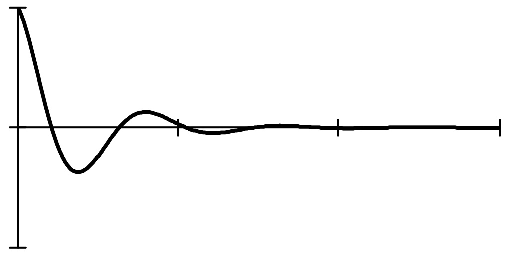

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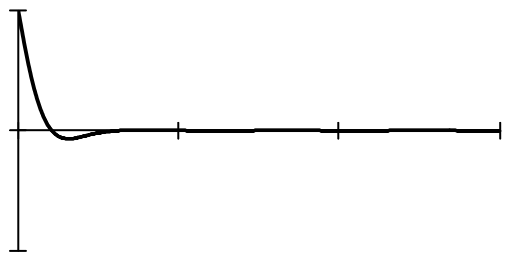

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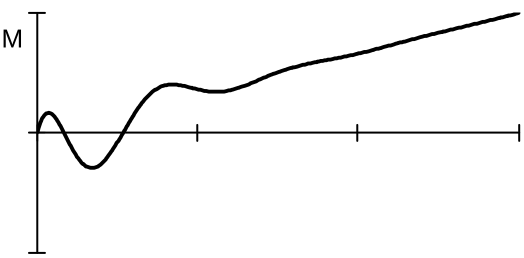

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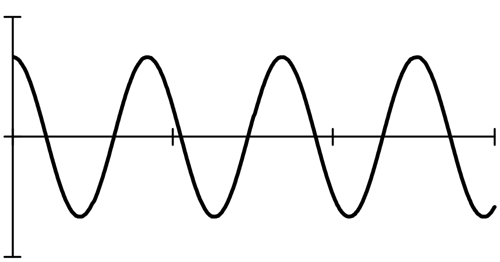

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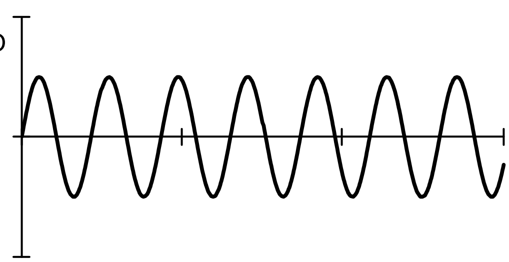

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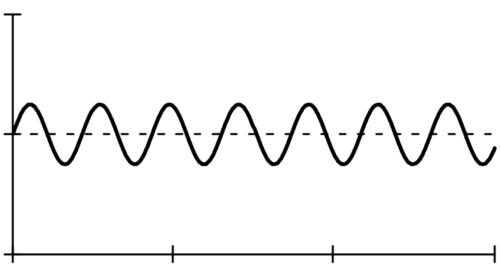

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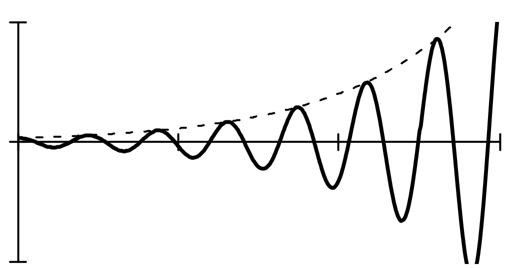
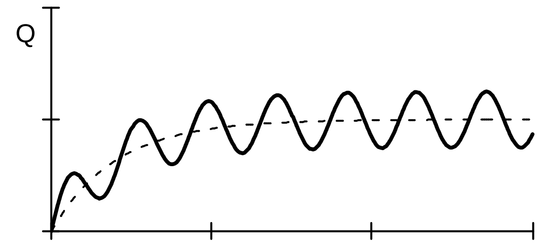
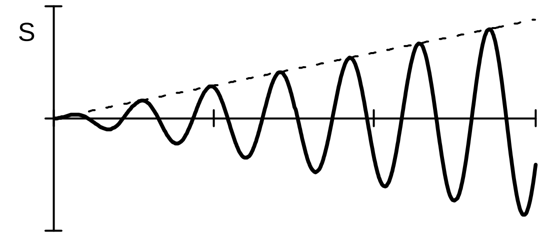
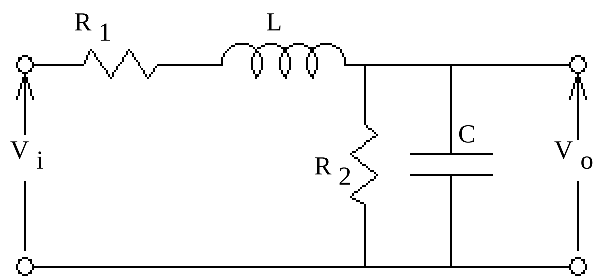






This part of the exam is Open book, Open notes, Calculator OK.

2. (13 pts) a) Find the transfer function of the circuit shown.
   V_i is the input and V_O is the output.
   You <u>MUST</u> show work to get credit.
   Simplify your expression for $H(s)$ so that the denominator is a simple polynomial.



   $\mathbf{H}(s) = ?$

   b) Find the characteristic equation of the circuit shown.

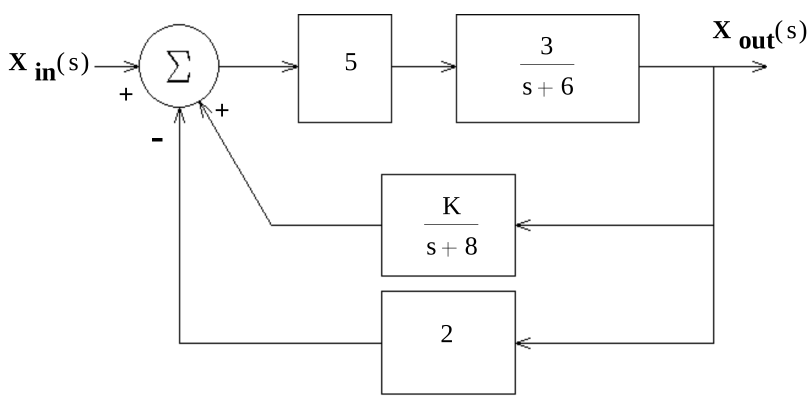
   c) The solutions to the characteristic equation are called the _______ of the transfer function.

   d) Does the transfer function have one or more zeros? If yes, express it (them) in terms of R_1, R_2, C, & L.

3. (17 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

$$\mathbf{H}(s) = \frac{\mathbf{X_{out}}(s)}{\mathbf{X_{in}}(s)} = ?$$

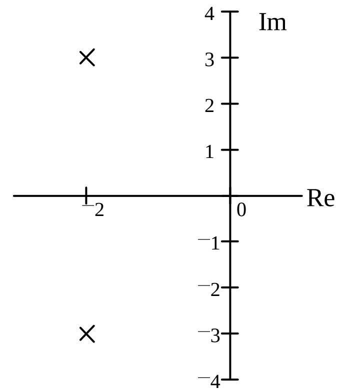
   Simplify your expression for H(s) so that the denominator is a simple polynomial.



   b) Find the value of K to make the transfer function critically damped.

4. (6 pts) A system has this transfer function: $\mathbf{H}(s) = \dfrac{2\cdot s + 20}{s^2 + 5\cdot s + 4}$

   What is the steady-state response ($y_{ss}(t)$) of this system to the input $x(t) = \left(2 + 3\cdot e^{-4\cdot t}\right)\cdot u(t)$



5. (10 pts) A system has the following poles:

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

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

   c) If this system had a step input, what % overshoot would the output have?

6. (14 pts) This system: $\mathbf{H}(s) = \dfrac{2\cdot s + 3}{s^2 + 6\cdot s + 8}$

   Has this input: Cosine input: $x(t) = \cos(3\cdot t)\cdot u(t)$ $\mathbf{X}(s) = \dfrac{s}{\left(s^2 + 3^2\right)}$

   Resulting in this output: $\mathbf{Y}(s) = \dfrac{2\cdot s + 3}{s^2 + 6\cdot s + 8}\cdot\dfrac{s}{\left(s^2 + 9\right)}$

   a) This separates into 4 partial fractions that you can find in the Laplace transform table.
   Show what they are, but don't find the coefficients.

   $$\mathbf{Y}(s) = \frac{2\cdot s + 3}{s^2 + 6\cdot s + 8}\cdot\frac{s}{\left(s^2 + 9\right)} =$$

   b) Continue with the partial fraction expansion just far enough to find ONE **transient** coefficient as a number or fraction.

   c) Express the part you just found as a function of time.

<u>Answers</u>

1. a) 1) E 2) F 3) K 4) C 5) H 6) L 7) M 8) N 9) R 10) S 11) P b) 7 9 10 c) 7 8 9 10 11

   d) R Nonlinearities, especially, limits of the power supply and amplifier e) S

2. a) $\dfrac{\dfrac{1}{L\cdot C}}{s^2 + \left(\dfrac{R_1}{L} + \dfrac{1}{R_2\cdot C}\right)\cdot s + \left(1 + \dfrac{R_1}{R_2}\right)\cdot\dfrac{1}{L\cdot C}}$ b) $0 = s^2 + \left(\dfrac{R_1}{L} + \dfrac{1}{R_2\cdot C}\right)\cdot s + \left(1 + \dfrac{R_1}{R_2}\right)\cdot\dfrac{1}{L\cdot C}$ c) poles d) No

3. a) $\dfrac{15\cdot(s + 8)}{s^2 + 44\cdot s + 288 - 15\cdot K}$ b) -13.067 4. $10\cdot u(t)$ 5. a) 3.606 b) 0.555 c) $12.3\cdot\%$

6. a) $\dfrac{A}{s+2} + \dfrac{B}{s+4} + \dfrac{C\cdot s}{\left(s^2+9\right)} + \dfrac{D\cdot 3}{\left(s^2+9\right)}$ b) $\dfrac{1}{13} = 0.0769$ OR $-\dfrac{2}{5} = -0.4$ c) $\dfrac{1}{13}\cdot e^{-2\cdot t}$ OR $-\dfrac{2}{5}\cdot e^{-4\cdot t}$