ECE 3510 Exam 1 given: Spring 13

(The space between problems has been removed.)

This part of the exam is Closed book, Closed notes, No Calculator.

1. (14 pts) The poles and zeros referred to in this problem are of the Laplace transform or transfer function.

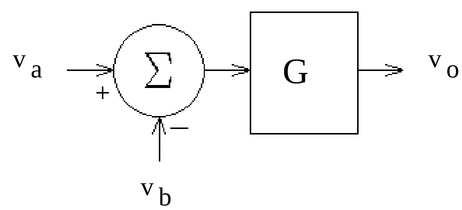
   a) A **system** integrates the input signal.
      i) What does that mean in terms of its poles and/or zeros?
      ii) What step response do you expect from this system?
      iii) Give me a real example of such a system also specifying the input and output.
      iv) Is this system BIBO stable? circle one: YES NO Can't tell

   b) A **system** step response dies out to zero.
      i) What does that mean in terms of its poles and/or zeros?
      ii) What mathematical operation does this system perform?
      iii) Is this system BIBO stable? circle one: YES NO Can't tell

   c) If a **signal** has a DC component, what does that mean in terms of its poles and/or zeros?

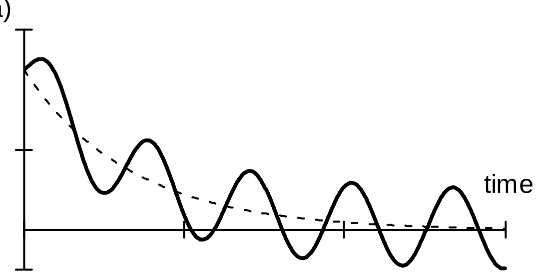
2. (4 pts) a) The little block diagram at right can represent a very common part that you have studied in previous classes and used in the labs of those classes. What is the part?

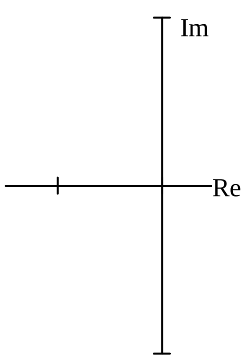
   b) Draw the schematic symbol of the part and label the inputs and outputs to match the drawing above.



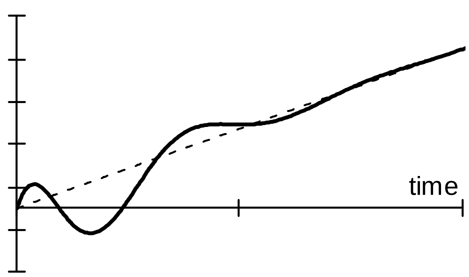
3. (15 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

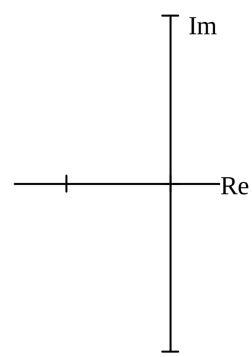
a)





b)





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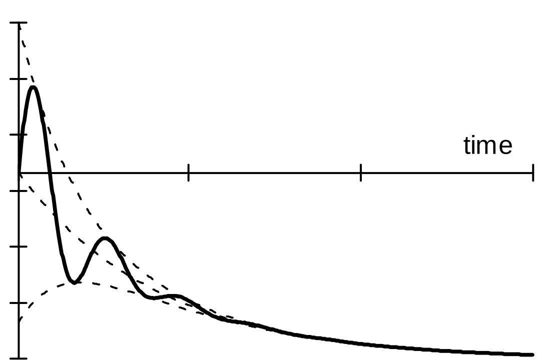
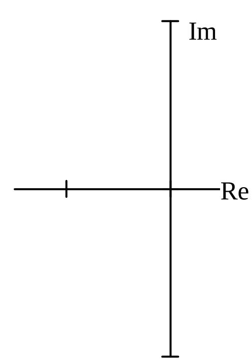
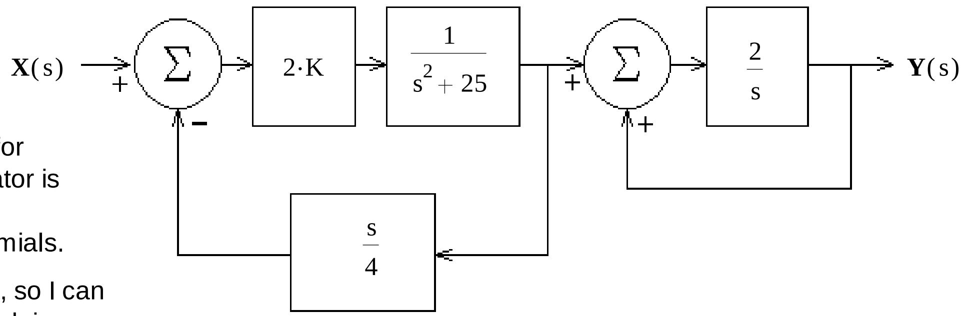




1. (18 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

$\mathbf{H}(s) = \dfrac{\mathbf{Y}(s)}{\mathbf{X}(s)}$ = ?



Simplify your expression for $\mathbf{H}(s)$ so that the denominator is a simple polynomial or a multiple of simple polynomials.

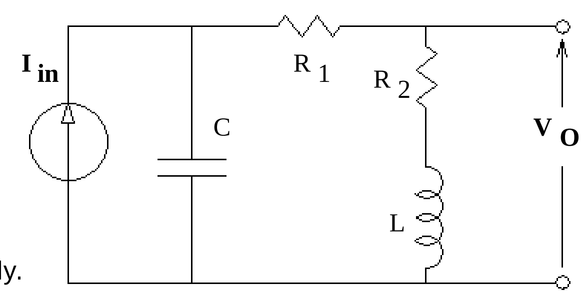
Be clear about your signs, so I can tell you know what you're doing.

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

c) If K is the value you found in part b), find **all** the poles of this system:

d) Does this system have a major problem? If yes, what is it?

2. (16 pts) a) Find the transfer function of the circuit shown. Consider $\mathbf{I_{in}}$ as the input and $\mathbf{V_O}$ as the output.



You MUST show work to get credit. Simplify your expression for $\mathbf{H}(s)$ so that the denominator is a simple polynomial with no coefficient before the highest-order s term in the denominator.

Hint: It's a two-step process, but it cleans up very easily.

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

b) How many zeroes does this transfer function have?
If it has 1 or more zeros, express them in terms of R_1, R_2, L and C).

c) How many poles does this transfer function have?

3. (15 pts) This system: $\mathbf{H}(s) = \dfrac{s+10}{s+4}$ Has this input: $x(t) = 2\cdot\sin(8\cdot t)\cdot u(t)$

a) Express the output, and separate into 3 partial fractions that you can find in the Laplace transform table without using complex numbers. Show what they are, but don't find the coefficients.

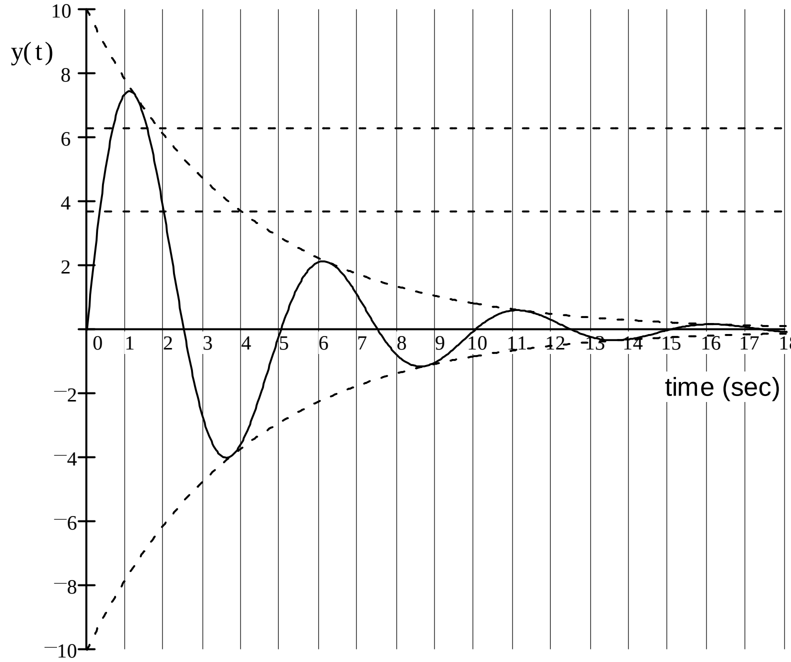
b) Continue with the partial fraction expansion just far enough to find the **transient** coefficient as a number.

c) Use steady-state AC analysis to find the time-domain representation of the steady-state output.

4. (18 pts) The unit-step response of a system is shown below as a function of time.
   Note: unit-step means $x_m := 1$

   a) Find to Laplace transform of the unit-step response, $\mathbf{Y}(s)$.

   Express $\mathbf{Y}(s)$ as precisely as you can, finding as many numbers as you can. If there is anything that you know must be a part of $\mathbf{Y}(s)$, but you cannot find as a number, express it as a letter constant (a or b or c etc.)



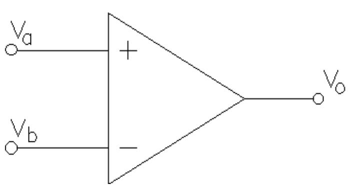
b) Find system transfer function, $\mathbf{H}(s)$.

Express $\mathbf{H}(s)$ as precisely as you can, finding as many numbers as you can. If there is anything that you know must be a part of $\mathbf{H}(s)$, but you cannot find as a number, express it as a letter constant (a or b or c etc.)

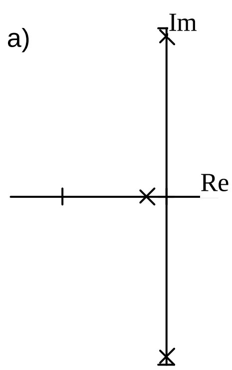
<u>Answers</u>

1. a) i) It has a pole at origin ii) The output signal will ramp to an unbounded value.
   iii) A DC motor with voltage as input and position as output. iv) NO
   b) i) It has a zero at origin ii) It differentiates the input iii) YES c) It has a pole at origin

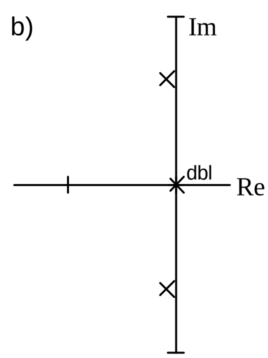
2. a) An op-amp
   b)



3. a)



b)



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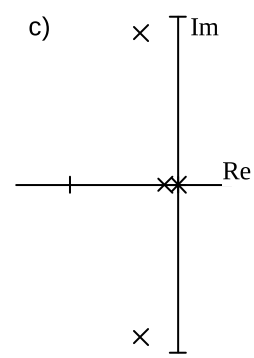

Open Book Part

1. a) $\dfrac{4\cdot K}{\left(s^2+\dfrac{K}{2}\cdot s+25\right)\cdot(s-2)}$ b) 20 c) -5 , -5 , 2 d) A pole in the right-half plane!

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

3. a) $\dfrac{A}{s+4} + \dfrac{B\cdot s}{\left(s^2+64\right)} + \dfrac{C\cdot 8}{\left(s^2+64\right)}$
   b) 1.2 c) $2.86\cdot\cos(8\cdot t-115\cdot deg)\cdot u(t)$

4. a) $\dfrac{12.566}{s^2+0.5\cdot s+1.642}$ b) $\dfrac{12.566\cdot s}{s^2+0.5\cdot s+1.642}$