ECE 3510 Exam 1 given: Spring 16 (The space between problems has been removed.)

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

1. (18 pts) This problem refers to the crude servo that you worked with in the first lab. It is essentially the same as the servo that I demonstrated in class the very first day.

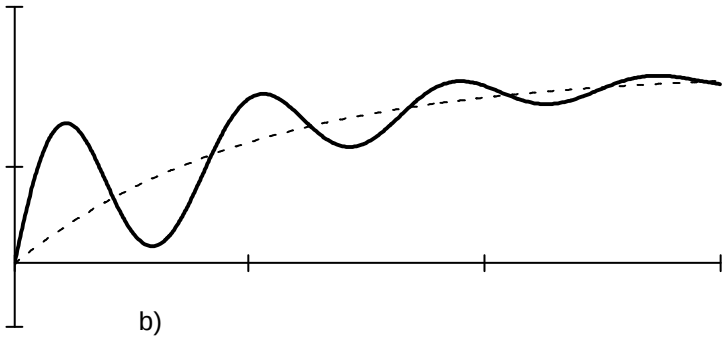
   a) Draw a system block diagram, identifying each of the parts in generic terms (controller, plant, feedback sensor, and possibly others) and in specific terms (Motor, amplifier, etc.). Don't try to remember the transfer functions.

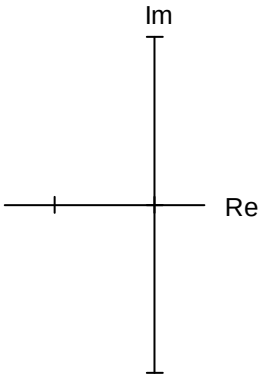
   b) Identify the input and output on the drawing. Show what the input and output are by giving me the units of each. (Don't worry if more than one answer is possible, just give one.)

   c) Identify all the other lines between all the blocks by the signal at that part of the block diagram. Include units.

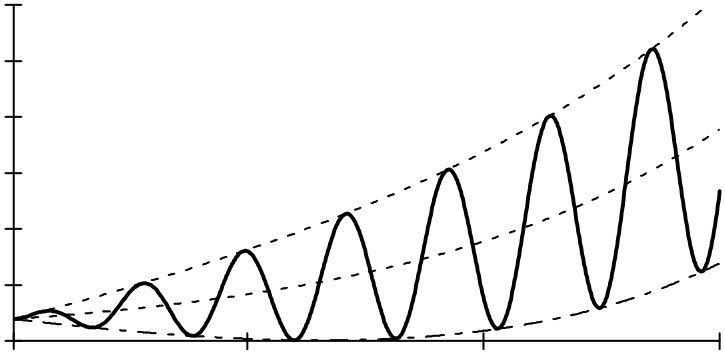
2. (12 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

a)

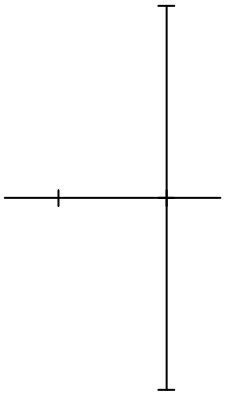




b)



sine wave amplitude grows linearly (not exponentially)



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

1. (12 pts) Find the inverse Laplace transform of the following function: $F(s) := \frac{s+10}{s\cdot(s+4)\cdot(s+6)}$

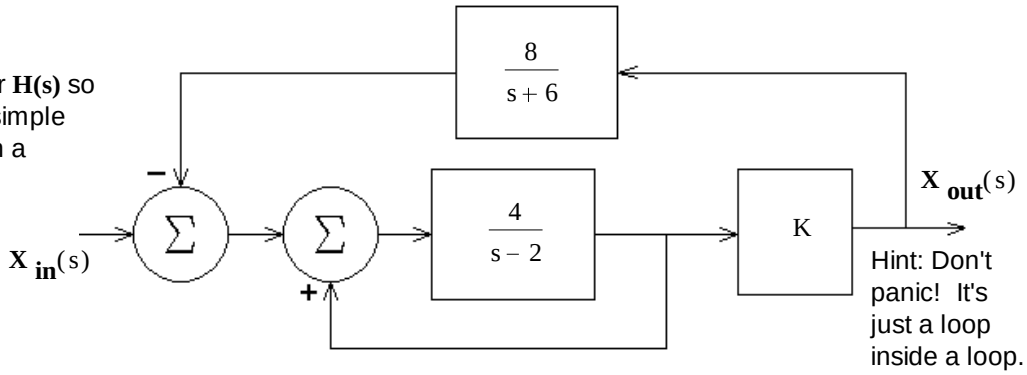
   Use partial fraction expansion and the tables. Show all your work to get credit.

2. (4 pts) What is the time constant of this expression? $\frac{1}{3}\cdot e^{-5\cdot t}$ τ = ?

3. (18 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

SHOW YOUR WORK
Simplify your expression for **H(s)** so that the denominator is a simple polynomial, or better still, in a factored form.

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



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

b) Does the transfer function have any zeros? Answer no or find the s value(s) of the zero(s).

4. (20 pts) A system has the following transfer function: $\mathbf{H}(s) = \frac{K\cdot(s+9)}{s^2+6\cdot s+20\cdot K-15}$

a) If $K := 3$ what are the poles?

b) If $K := 3$ What is the damping factor (ζ) of this **system**?

c) If $K := 3$ What is the steady-state response ($y_{ss}(t)$) of this system to the input: $x(t) = \left(10+3\cdot e^{-5\cdot t}\right)\cdot u(t)$

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

e) Find the range of K to make the transfer function BIBO Stable.
Hint: Find the solutions of the characteristic equation and determine the range of K that keeps all the solutions negative.

5. (16 pts) The input to a system is: $x(t) = 3\cdot e^{-9t}\cdot u(t)$

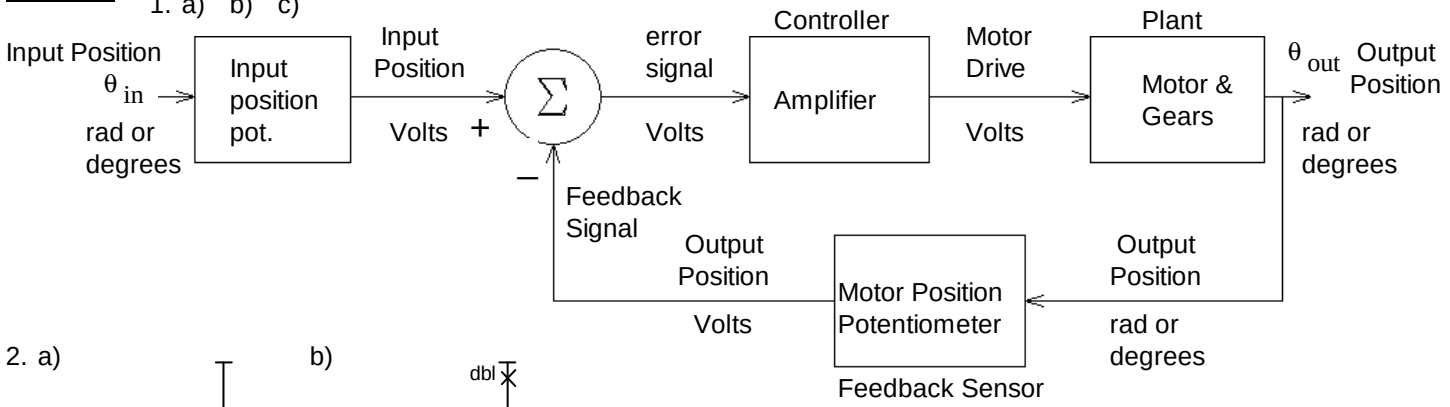
The output of this system is: $y(t) = \left(1+4\cdot e^{-6\cdot t}+e^{-9\cdot t}\right)\cdot u(t)$

a) Find system transfer function, **H**(s).

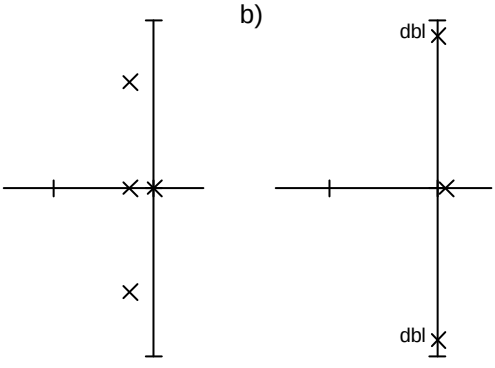
b) Find the poles of **H**(s). You can find this even If you can't find **H**(s). c) Is **H**(s) BIBO stable?

Answers

1. a) b) c)



2. a) b)



1. $\left(\frac{5}{12}-\frac{3}{4}\cdot e^{-4\cdot t}-\frac{1}{3}\cdot e^{-6\cdot t}\right)\cdot u(t)$ 2. $0.2\cdot sec$ 3. a) $\frac{4\cdot K\cdot(s+6)}{s^2-36+32\cdot K}$ b) -6

4. a) $-3+6\cdot j$ & $-3-6\cdot j$ b) 0.447
c) $6\cdot u(t)$ d) 1.2 e) 0.75

5. a) $\frac{2\cdot s^2+19\cdot s+18}{s\cdot(s+6)}$ b) origin & -6 c) NO