ECE 3510 Exam 1   given: Spring 22

(Most of the space between problems has been removed.)

This part of the exam is Closed book, Closed notes (including yellow sheet), Calculator OK.
This page (19 pts)

1. a) If a **signal** has a pole at origin, what does that mean?

   b) If a **system** has a pole at origin, what does that mean?

   c) If a **system** has a **zero** at origin, what does that mean?

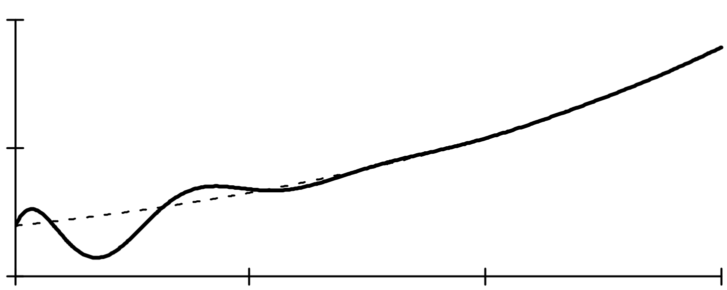
2. a) Give a second-order transfer function with no zeroes, poles at $-3 \pm 5j$ and a DC gain of 6.

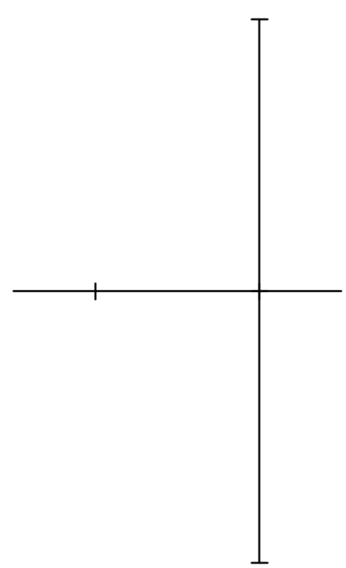
   b) What is the steady-state response ($y_{ss}(t)$) of this system to the input: $x(t) = \left(10 + 3 \cdot e^{-5 \cdot t}\right) \cdot u(t)$

3. List Three advantages of state space over classical frequency-domain techniques.

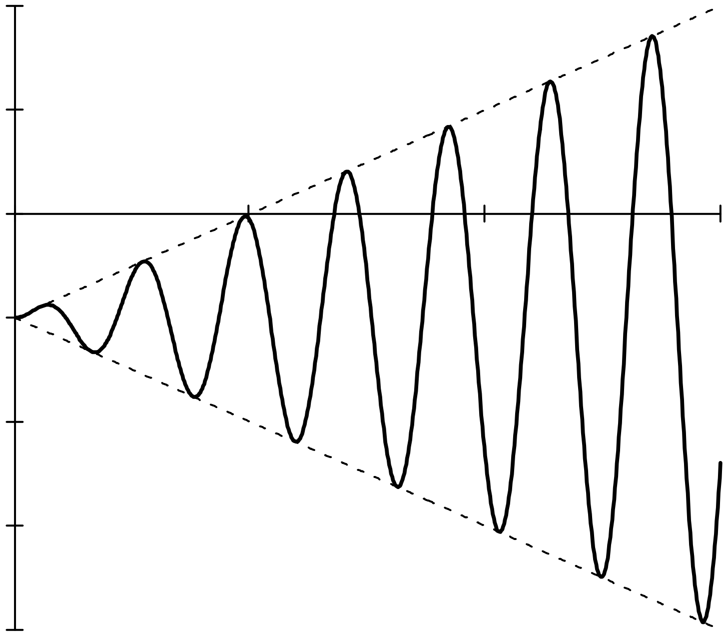
4. (15 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

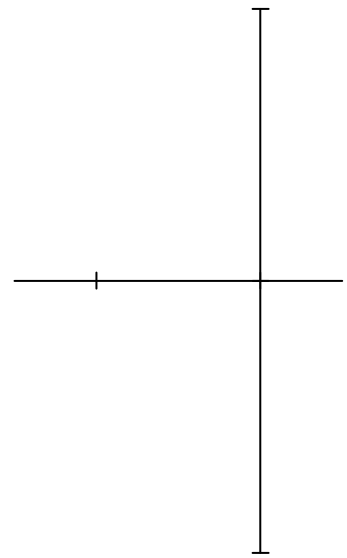
   a)



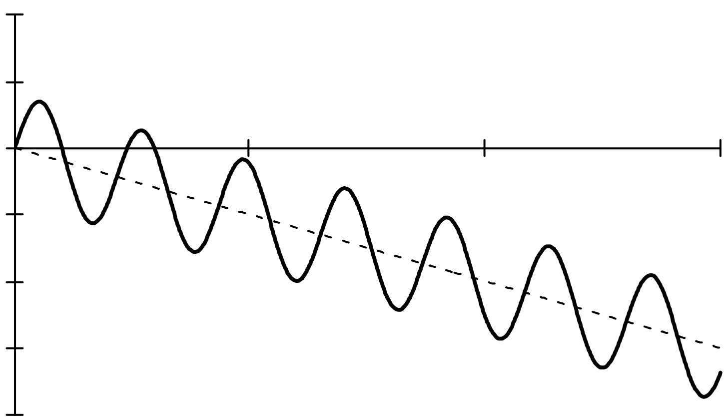


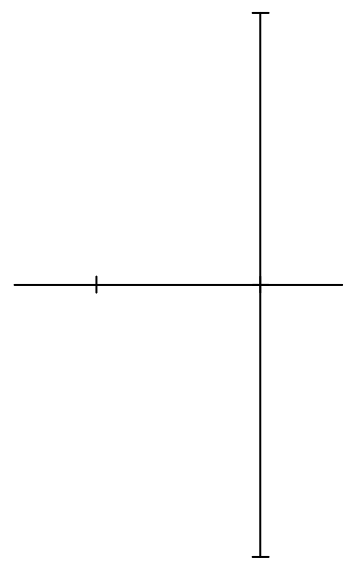
b)





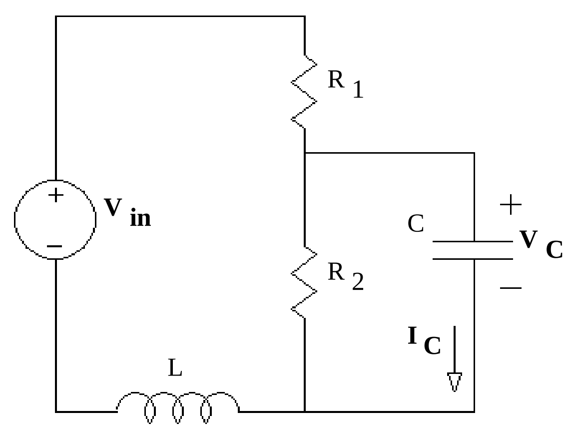
c)





1. (20 pts) a) Find the transfer function of the circuit shown. Consider the motor current ($\mathbf{V_C}$) as 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.

$$\mathbf{H}(s) = \frac{\mathbf{V_C}(s)}{\mathbf{V_{in}}(s)} = ?$$



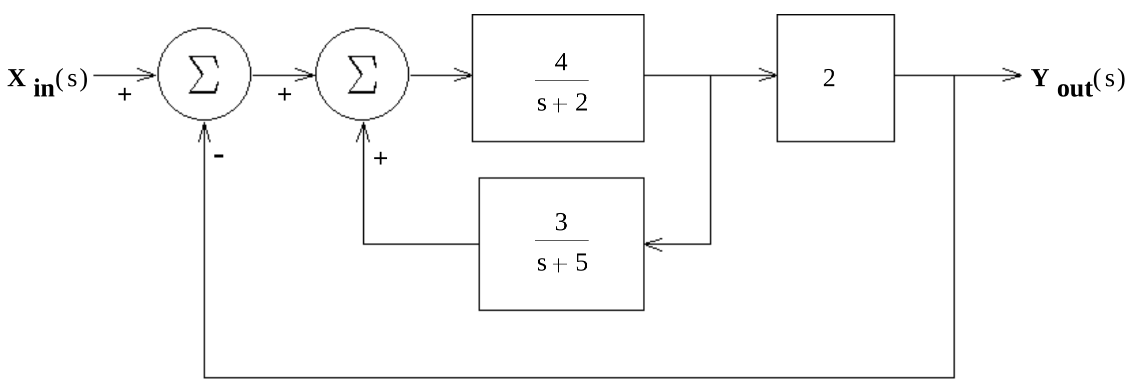
b) Modify the transfer function found in part a). Now consider I_C as the "output".

c) Transfer functions have units based on the units of the output and the units of input.
What are the units of $\mathbf{H}(s)$ from part a)

d) What are the units of $\mathbf{H_2}(s)$ from part b)

2. (20 pts) For the feedback system shown below, find the transfer function of the whole system, with feedback.

Find $\mathbf{H}(s) = \dfrac{\mathbf{Y}_{\mathbf{out}}(s)}{\mathbf{X}_{\mathbf{in}}(s)}$ Simplify your expression for $\mathbf{H}(s)$ so that he numerator and denominator are both simple polynomials



3. (25 pts) This system: $\mathbf{H}(s) = \dfrac{s+12}{s+6}$ Has this input: $x(t) = 3\cdot\sin(10\cdot t)\cdot u(t)$

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 phasor representation of the steady-state output in polar form. $\mathbf{Y}_{ss}(\omega) = ?$

d) Express the complete (both transient and steady-state) output as a function of time. $y(t) = ?$

e) What is the time constant of the transient part this expression? $\tau = ?$

<u>Answers</u>

1. a) The signal has a DC component

   b) The system <u>integrates</u> the input signal OR The output signal will ramp to an unbounded value if the input has DC (pole at origin)

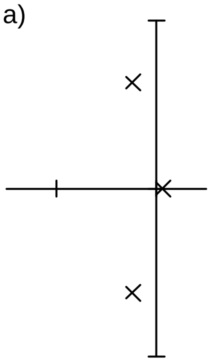
   c) The system <u>differentiates</u> the input signal OR The system <u>does not pass any DC</u> to the output

2. a) $\mathbf{H}(s) = \dfrac{6\cdot(9+25)}{s^2+6\cdot s+9+25} = \dfrac{204}{s^2+6\cdot s+34}$ b) $y_{ss}(t) = 6\cdot 10 = 60\ u(t)$

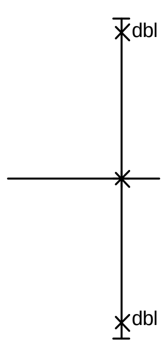
3. 1. Easily handles multiple inputs, multiple outputs and initial conditions
   2. Can be used with nonlinear systems
   3. Can be used with time-varying systems
   4. Reveals unstable systems that have stable transfer functions (pole-zero cancellations). You can determine:
      Controllability: State variables can all be affected by the input
      Observability: State variables are all "observeable" from the output
   5. Basis of Optimal control and adaptive control methods
   6. Good computer modeling packages

   3 of these

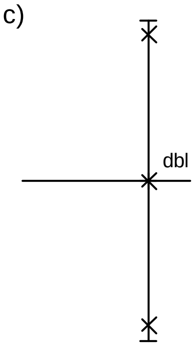
4. a)



b)



c)



Open Note Sheet

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

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

   c) none, unitless, or amp/amp

   d) amp/volt = 1/Ω

2. $\dfrac{8\cdot(s+5)}{s^2+15\cdot s+38}$

3. a) $\dfrac{A}{s+6} + \dfrac{B\cdot s}{\left(s^2+100\right)} + \dfrac{C\cdot 10}{\left(s^2+100\right)}$

   b) 1.324 c) $4.017\angle -109.2\cdot\text{deg}$ d) $\left(1.324\cdot e^{-6\cdot t}+4.017\cdot\cos(10\cdot t-109.2\cdot\text{deg})\right)\cdot u(t)$ e) $1/6$