ECE 3510 Exam 1 given: Fall 22

(The space between problems has been removed.)

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

1. (22 pts) The poles and zeros referred to in this problem are of the Laplace transform or transfer function.
   a) If a **signal** eventually reaches a steady-state value of 5, what does that mean in terms of its poles and/or zeros?

   b) If a **signal** exponentially decays from an initial value of 11 to a value of 4.7 at 2 seconds and a final value of 1, what does that mean in terms of its poles and/or zeros? Be as specific as you can be.

   c) If the amplitude of sinusoidal **signal** is 4 and its frequency is 2 Hz, what does that mean in terms of its poles and/or zeros? Be as specific as you can be.

   d) If the **signal** of part c) is a cosine, can you say one more thing about its poles and/or zeros? Be as specific as you can be.

   e) i) If the output of a **system** ramps linearly to an unbounded value when the input is DC, what does that mean in terms of its poles and/or zeros?

   ii) What is this system doing to the signal in the time domain?

   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

   f) i) If the output of a **system** eventually decays to zero when the input is DC, what does that mean in terms of its poles and/or zeros?

   ii) What is this system doing to the signal in the time domain?

   iii) Is this system BIBO stable? circle one: YES NO Can't tell

   g) i) If the response of a **system** to a sinusoidal input of 1 Hz is a 1-Hz sinusoid that grows linearly with time to an unbounded value, what does that mean in terms of its poles and/or zeros?

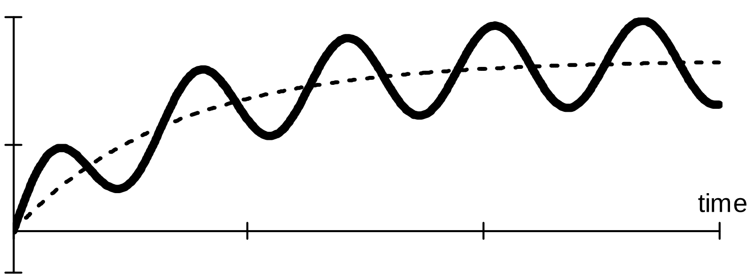
   ii) What is the more common description of what this system doing?

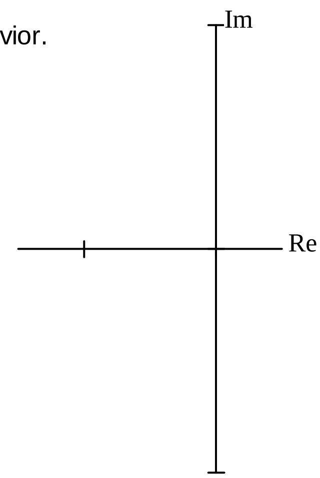
   iii) Is this system BIBO stable? circle one: YES NO Can't tell

   iv) Give me a real example of a system and input that approximates this type of behavior.

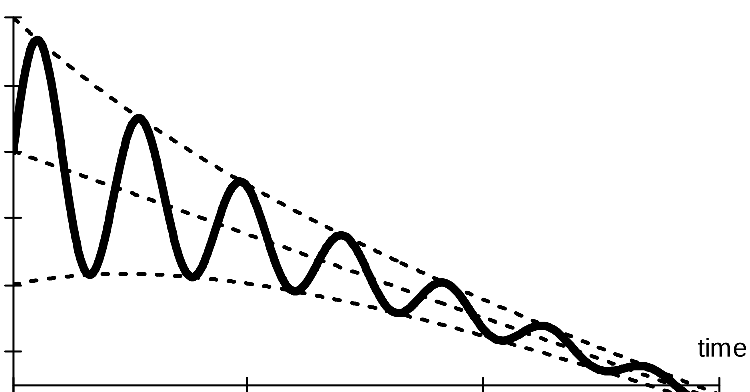
2. (12 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

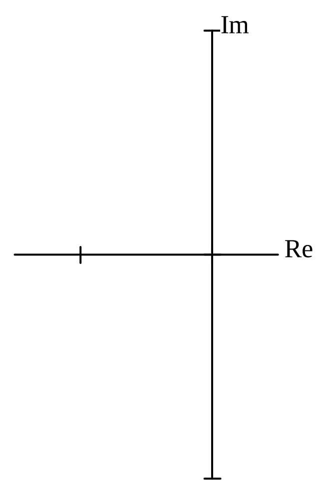
   a)



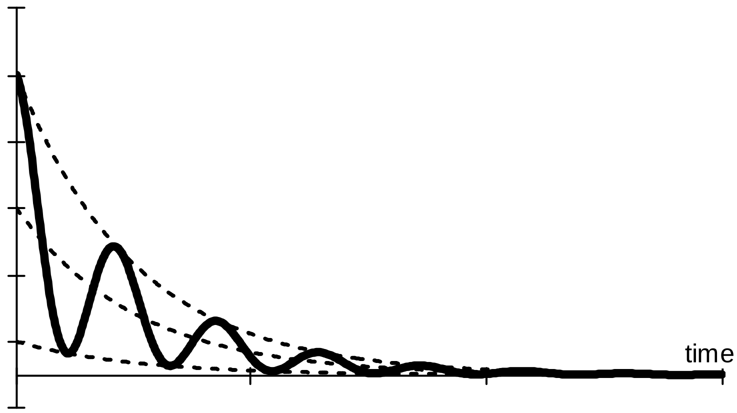


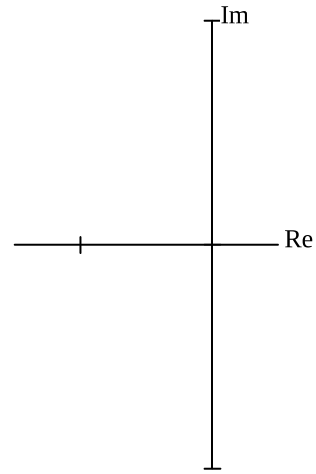
   b)





3. (6 pts) The time-domain signal shown below is the **step response** of a **SYSTEM**, draw the poles and/or zeros of the **system's** transfer function on the axes provided.



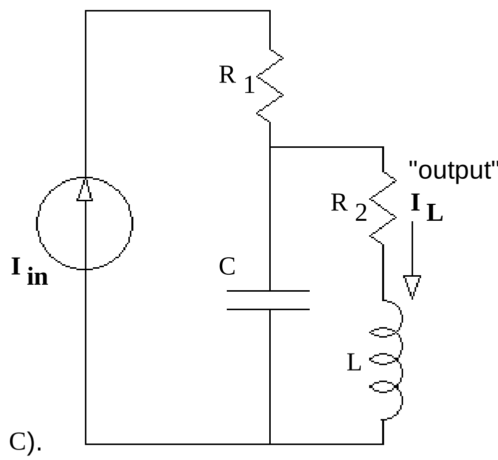


This part of the exam is Open book, Open notes, Calculator OK.

1. (14 pts) a) Find the transfer function of the circuit shown. Consider $\mathbf{I_L}$ as the "output".

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

   $$\mathbf{H}(s) = \frac{\mathbf{I_L}(s)}{\mathbf{I_{in}}(s)} = ?$$



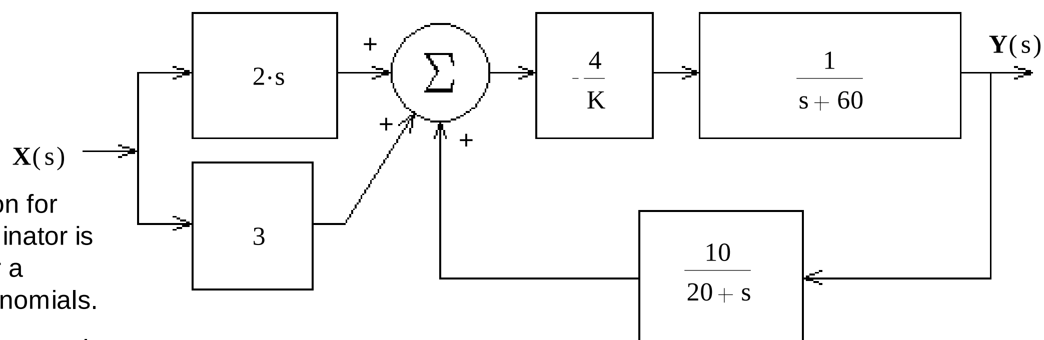
   b) How many zeroes does this transfer function have?

   c) How many poles does this transfer function have?

   If it has 1 or more, express them (probably in terms of R_1, R_2, L and C).

2. (22 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system.

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



   Simplify your expression for **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 critically damped.

   c) If K is **greater** than this value the system will be: underdamped or overdamped Circle one

   d) Does the transfer function have a zero? Answer no or find the s value(s) of the zero(s).

3. (9 pts) A system has this transfer function: $\mathbf{H}(s) = \dfrac{3 \cdot s + 45}{s^2 + 4 \cdot s + 20}$

   a) What is the steady-state response ($y_{ss}(t)$) of this system to the input: $x(t) = \left(8 + 3 \cdot e^{-6 \cdot t}\right) \cdot u(t)$

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

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

4. (15 pts) The input to a system is: $x(t) = 2\cdot e^{-4t}\cdot u(t)$

The output of this system is: $y(t) = \left(2 + 3\cdot e^{-2\cdot t} + 4\cdot e^{-4t}\right)\cdot u(t)$

a) Find system transfer function, $\mathbf{H}(s)$. Simplify $\mathbf{H}(s)$ to the standard form (like you did for problems 1 & 2)

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

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

<u>Answers</u>

1. a) It has a pole at the origin b) It has one pole at the origin and another at -0.5

c) It has poles at ± 4πj on the imaginary axis d) It has a zero at the origin

e) i) It has a pole at the origin ii) The system <u>integrates</u> the input signal

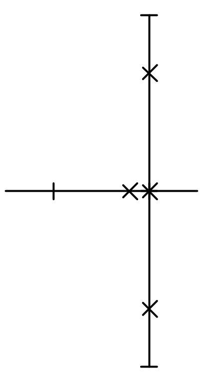
iii) A DC motor with voltage as input and position as output. iv) **<u>NO</u>**

f) i) It has a zero at the origin ii) The system <u>differentiates</u> the input signal iii) **<u>YES</u>**

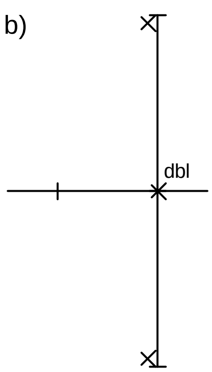
g) i) It has poles at ± 2πj on the imaginary axis ii) The system is resonating at 1 Hz iii) **<u>NO</u>**

iv) Pushing a child on a swing in time with the swings. The Tacoma narrows bridge

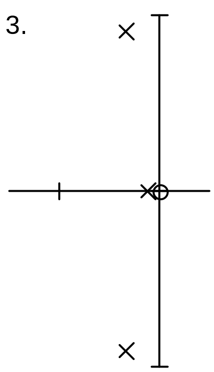
2. a)



b)



3.



Open Book Part

1. a) $\dfrac{\frac{1}{L\cdot C}}{s^2 + \frac{R_2}{L}\cdot s + \frac{1}{L\cdot C}}$ b) 0 none c) 2 $\dfrac{-\frac{R_2}{L} \pm \sqrt{\left(\frac{R_2}{L}\right)^2 - \frac{4}{L\cdot C}}}{2}$

2. a) $(2\cdot s + 3)\cdot\dfrac{\frac{-4}{K}\cdot(s+20)}{s^2 + 80\cdot s + 1200 + \frac{40}{K}}$ b) 0.1 c) overdamped d) -20 $-\left(\frac{3}{2}\right)$

3. a) $18\cdot u(t)$ b) 4.472 c) 0.447 4. a) $\dfrac{4.5\cdot s^2 + 16\cdot s + 8}{s\cdot(s+2)}$ poles: origin -2 b) NO