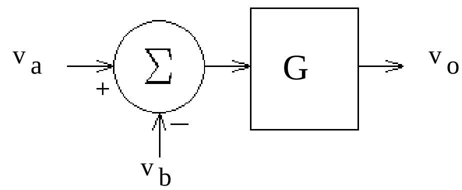
ECE 3510 Exam 1 given: Spring 19

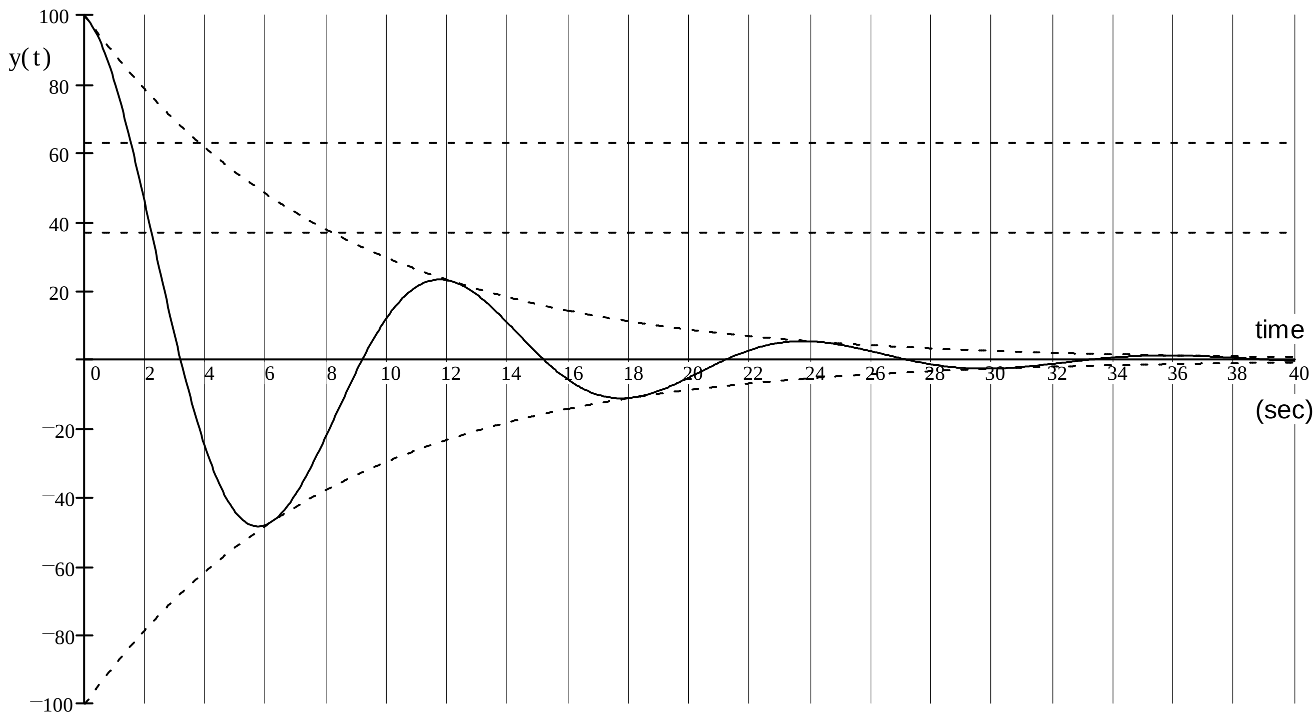
(Most of the space between problems has been removed.)

1. (12 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. (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 the 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.)

4. (20 pts) The input to a system is: $x(t) = 2\cdot e^{-4t}\cdot u(t)$

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

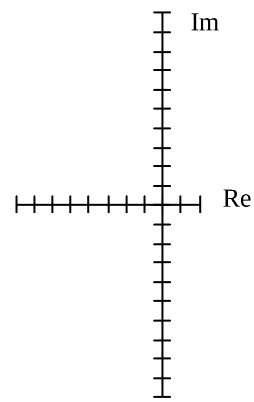
   a) Find system transfer function, $\mathbf{H}(s)$. Simplify into the standard form.

   b) Find the poles of $\mathbf{H}(s)$. NOTE: You can do this even if you can't find $\mathbf{H}(s)$.

   c) Is $\mathbf{H}(s)$ BIBO stable? circle one: YES NO Can't tell from information given
   Justify your answer (give the reason)

5. (20 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: $x(t) = \left(8 + 3\cdot e^{-6\cdot t}\right)\cdot u(t)$



The poles of the output **signal**, not the system.

   b) Show **all** the poles of the output **signal** on the axis provided.
   Make sure I can tell the values of the real & imaginary parts.

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

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

   e) If this **system** had a **step input** instead of the input above, what % overshoot would the output have?

6. (26 pts) This system: $\mathbf{H}(s) = \dfrac{8\cdot s}{s^2 + 4\cdot s + 40}$ Has this input: $x(t) = 2\cdot \sin(5\cdot t)\cdot u(t)$

   a) Find the resulting output, $\mathbf{Y}(s)$ and separate that into partial fractions that you can find in the Laplace transform table. Show what they are, but don't find the coefficients.

   Output: $\mathbf{Y}(s) =$

   b) Use steady-state AC analysis to find the phasor representation of the steady-state output in polar form.

   $\mathbf{Y}_{ss}(j\omega) = ?$

   c) Express the complete (both transient and steady-state) output as a function of time.
   Express the steady-state part as a cosine with a phase angle.
   Use the letters you used in part a) for the coeffieients of the transient parts $y(t) = ?$

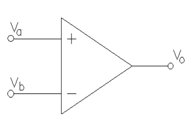
   d) What is the time constant of the transient part this expression? $\tau = ?$

Answers

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. An op-amp b)

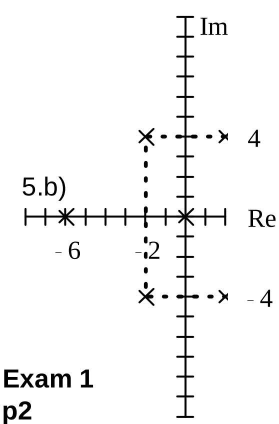


3. a) $\dfrac{100\cdot(s + 0.125)}{s^2 + 0.25\cdot s + 0.29}$ b) $\dfrac{100\cdot s\cdot(s + 0.125)}{s^2 + 0.25\cdot s + 0.299}$

4. a) $\dfrac{4.5\cdot s^2 + 16\cdot s + 8}{s\cdot(s + 2)}$ b) 0 2 c) $\mathbf{H}(s)$ has a pole at the origin

5. a) $18\cdot u(t)$ b) at right c) 4.47 d) 0.447 e) $20.8\cdot\%$

5.b)



6. a) $\dfrac{A\cdot(s + 2)}{s^2 + 4\cdot s + 40} + \dfrac{B\cdot 6}{s^2 + 4\cdot s + 40} + \dfrac{C\cdot s}{\left(s^2 + 25\right)} + \dfrac{D\cdot 5}{\left(s^2 + 25\right)}$ b) $3.2 \angle -53.13\cdot deg$

   c) $\left[e^{-2\cdot t}\cdot(A\cdot\cos(6\cdot t) + B\cdot\sin(6\cdot t)) + 3.2\cdot\cos(5\cdot t - 53.13\cdot deg)\right]\cdot u(t)$ d) $\dfrac{1}{2} = 0.5$