ECE 3510 Exam 1 given: Spring 12 (The space between problems has been removed.)

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

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. Answer the following with the lettered answers given. More than one may apply, but list only the most restrictive (meaning if you said answered "no poles in bottom-half plane" don't also list "no double poles in the bottom-half plane".

   a) If a signal is bounded, its poles MAY NOT BE:

   b) If a signal converges to zero, its poles MAY NOT BE:

   c) If a signal converges to a non-zero value, its poles MAY NOT BE:

   d) If a signal has absolutely no ringing, its poles MAY NOT BE:

   e) If a **system** is BIBO stable, its poles MAY NOT BE:

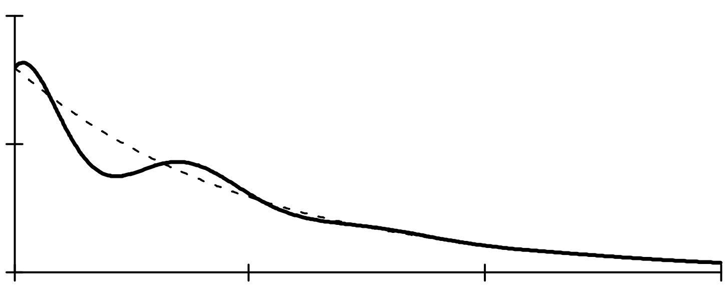
   A. In the right-half plane
   B. In the bottom-half plane
   C. On the $j\omega$ axis
   D. On the real axis
   E. On $j\omega$ axis, except for one at the origin
   F. Double poles on $j\omega$ axis
   G. Double poles on real axis
   H. Double poles in the left-half plane
   J. Double poles in the right-half plane
   K. At the origin
   L. Double poles at the origin
   M. Anywhere but the real axis

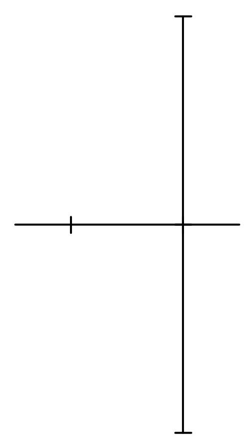
3. (6 pts) a) List Three advantages of state space over classical frequency-domain techniques.

   b) Give one advantage of the frequency domain method we are using in this class over the state-space method.

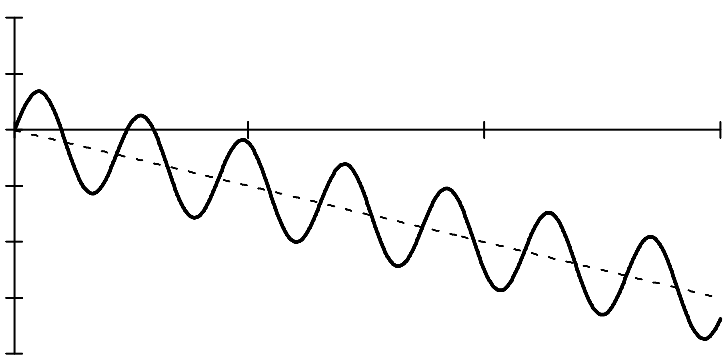
4. (12 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

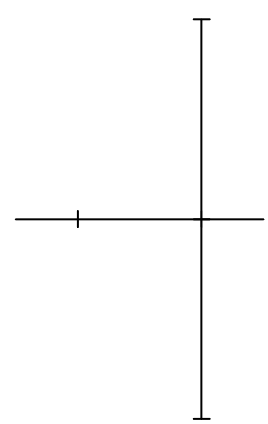
   a)





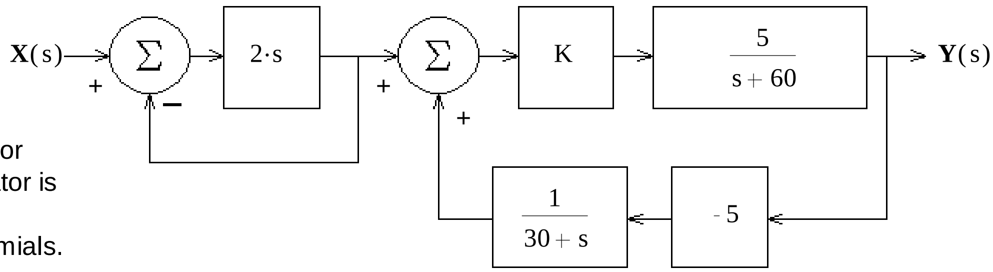
   b)





1. (20 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 H(s) so that the denominator is a simple polynomial or a multiple of simple polynomials.

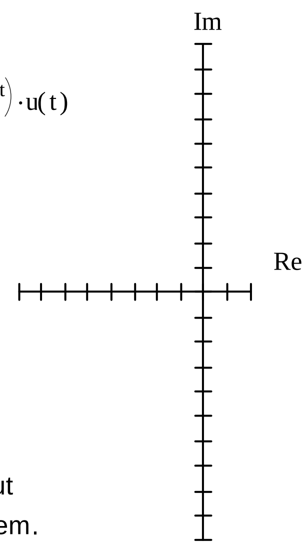
Be clear about your signs, so I can tell you know what you're doing.

b) Find the value of K to make the transfer function (or part of it) critically damped.

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

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

2. (20 pts) A system has this transfer function: $\mathbf{H}(s) = \dfrac{8\cdot s + 5}{s^2 + 6\cdot s + 45}$



a) What is the steady-state response ($y_{ss}(t)$) of this system to the input: $x(t) = \left(18 + 5\cdot e^{-4\cdot t}\right)\cdot u(t)$

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?

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

3. (27 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.

$\mathbf{Y}(s) =$

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.

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

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? $\tau = ?$

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) A F b) A C c) A E d) M e) A C

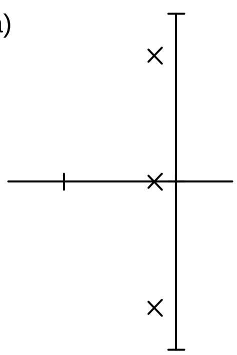
3. a) 1. Easily handles multiple inputs, multiple outputs and initial conditions
   2. Can be used with nonlinear systems
   3. Can be used with time-varying systems
   4. Reveals unstable systems that have stable transfer functions (pole-zero cancellations). You can determine:
      Controllability: 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

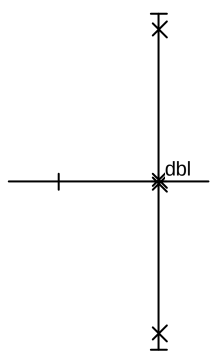
   b) Easy to set up analysis and find transfer functions
   Transfer functions and poles provide lots of information without a complete analysis
   Rapid, easy and intuitive design

   1 of these

4. a)



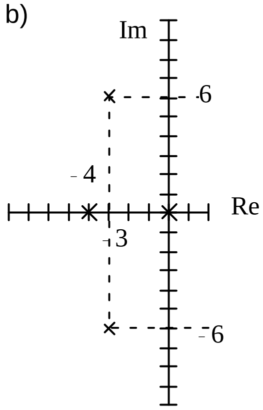
b)



Open Book Part

1. a) $\dfrac{10\cdot K\cdot s\cdot(s+30)}{(1+2\cdot s)\cdot\left(s^2+90\cdot s+1800+25\cdot K\right)}$ b) 9 c) $-\dfrac{1}{2}$, -45 , -45 d) $s = 0$ $s = -30$

2. a) $2\cdot u(t)$ b)



c) $\sqrt{45} = 6.708$

d) 0.447

e) $20.8\cdot\%$

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) $4.017 \angle -109.2\cdot deg$

d) $\left(1.324\cdot e^{-6\cdot t} - 1.324\cdot\cos(10\cdot t) + 3.794\cdot\sin(10\cdot t)\right)\cdot u(t)$

e) $\dfrac{1}{6}$