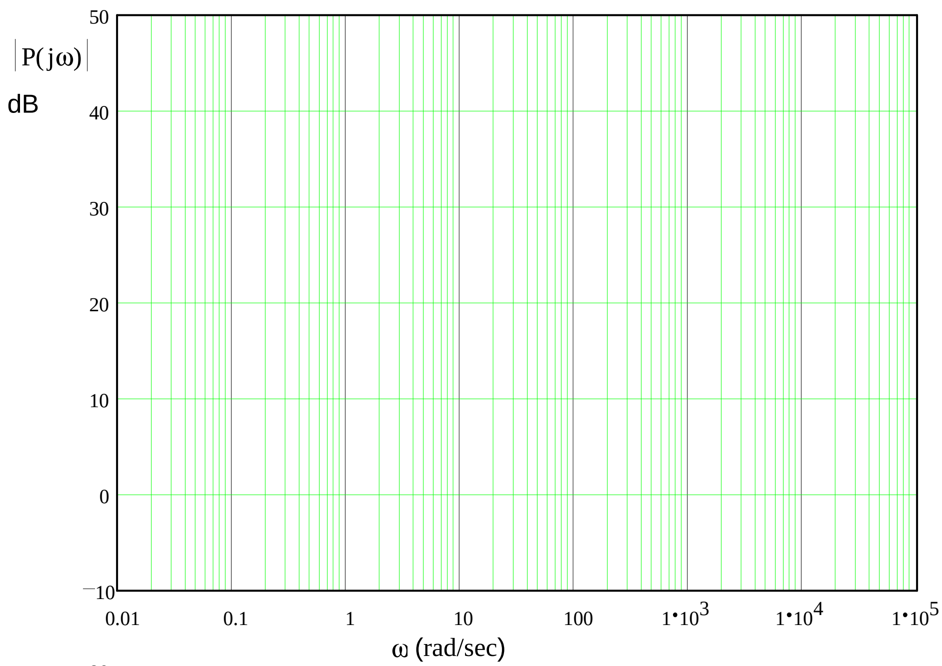
ECE 3510 Final given: Spring 20

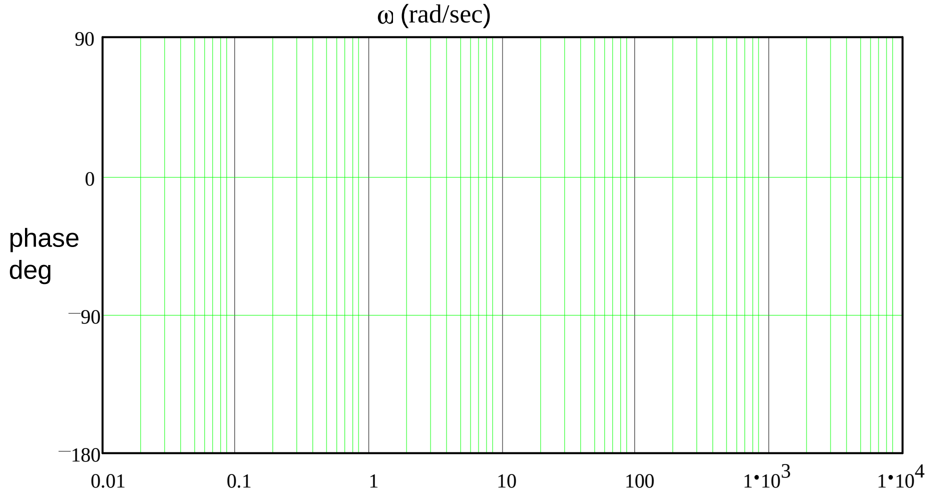
DO NOT use eraseable ink

Show all work to receive credit. Circle answers, show units, and round off reasonably

1. (32 pts) Sketch the Bode plot for the following transfer functions. Use the method I taught in class to find magnitudes, slopes and angles and to check yourself. Also accurately draw the "smooth" lines.

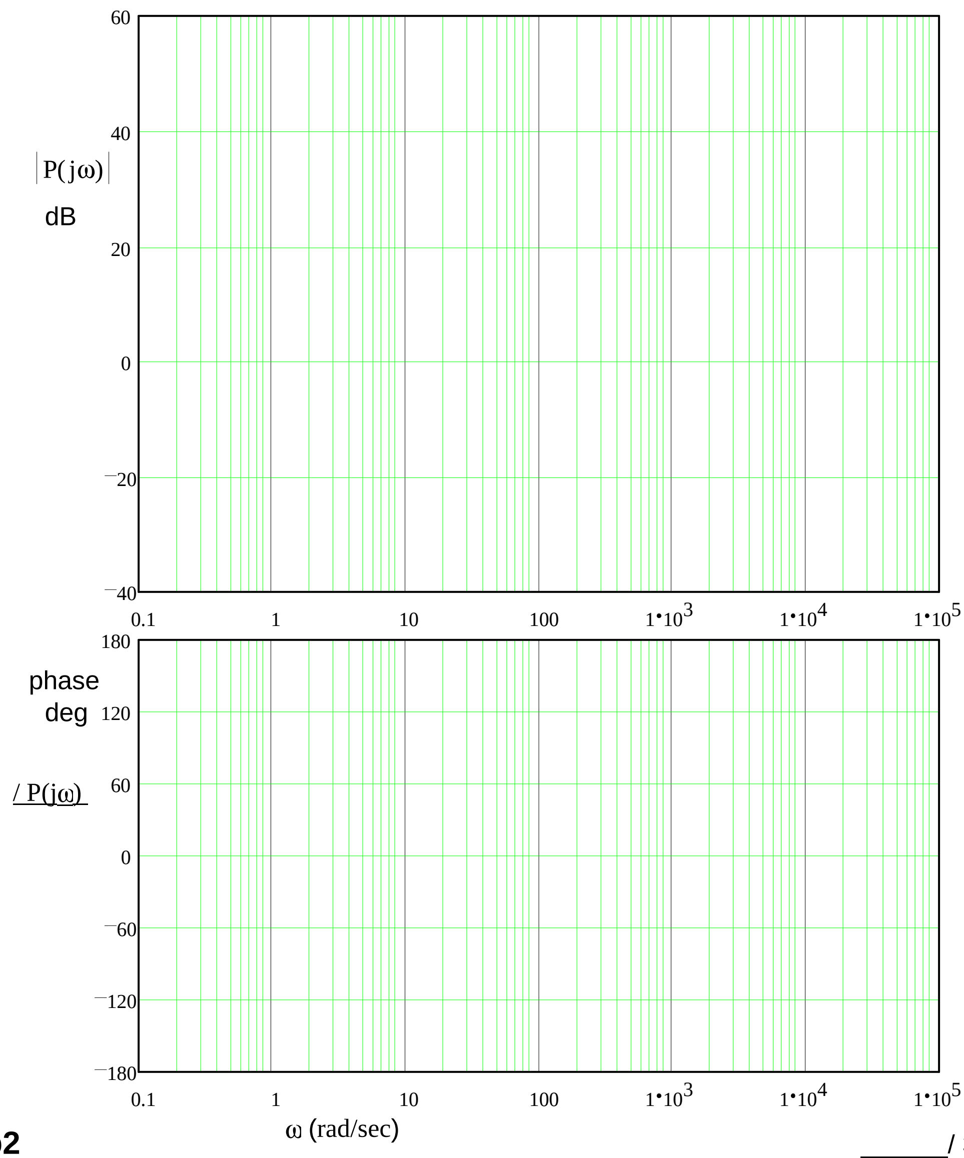
   a) $P(s) = \dfrac{20000\cdot(s+0.1)\cdot(s+80)}{(s+2)^2\cdot(s+5000)}$



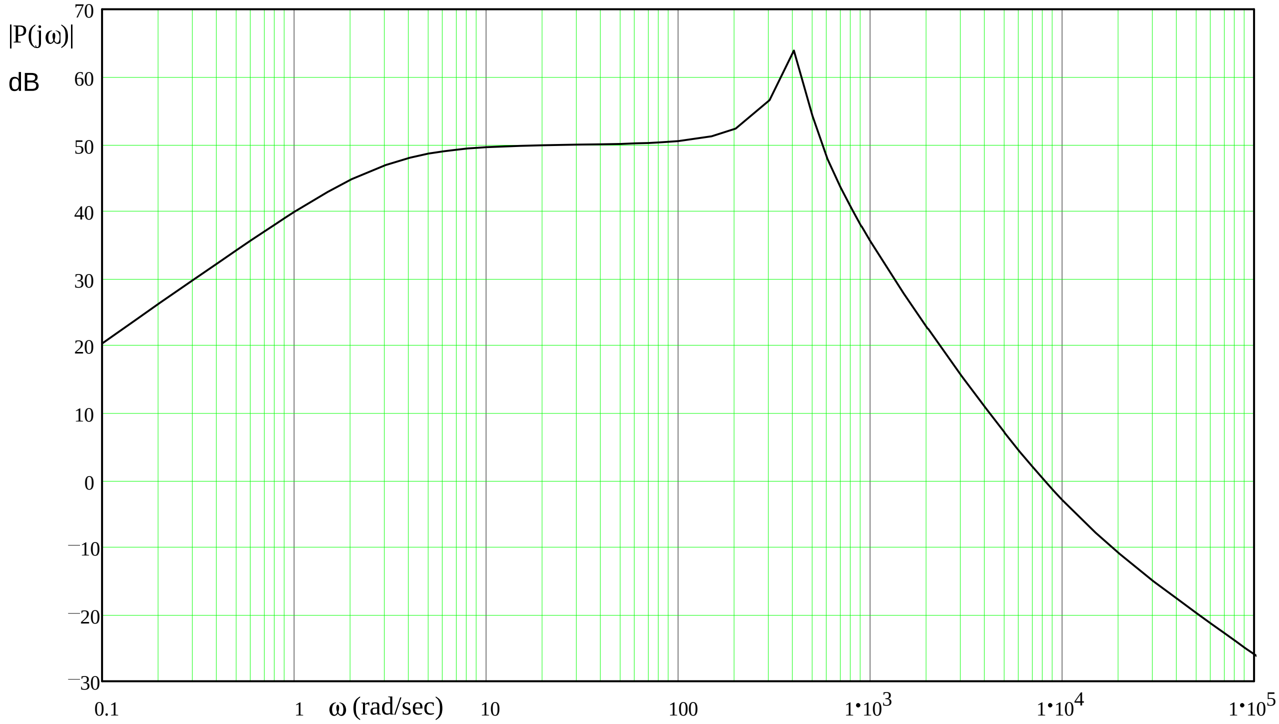


1, continued

b) $$P(s) = \frac{18000\cdot\left(s^2 + 0.3\cdot s + 9\right)}{\left[(s+20)^2 + 9600\right]\cdot(s+5000)}$$



2. (20 pts) Given the magnitude Bode plot of a system, estimate the transfer function of the system.
Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane).
Use a straight edge and show your work (how you made your estimate).



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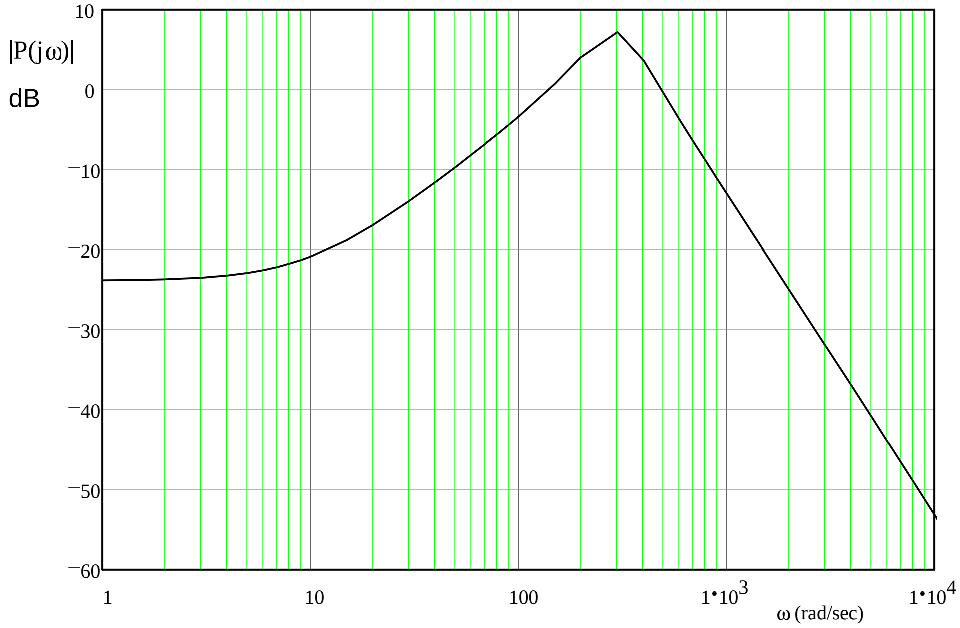
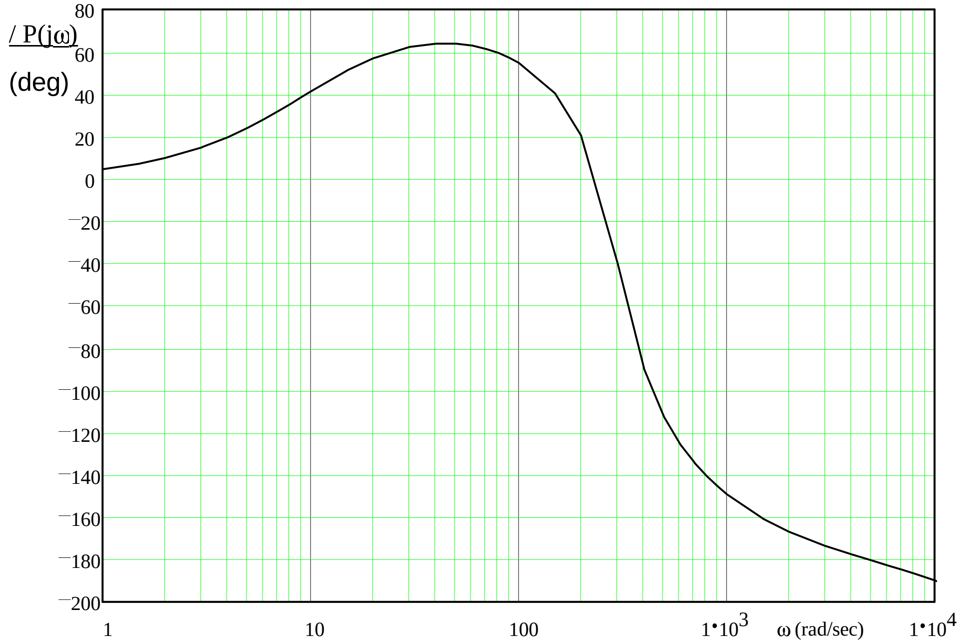
3. (18 pts) The open-loop Bode plots of a system are given at right.

a) Find the gain margin and phase margin of the closed-loop system. Show your work on the drawings.





b) Find the delay margin.

c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 7\cos(4t+30^o)$. express the answer in the time-domain. $y_{ss}(t)$ = ?

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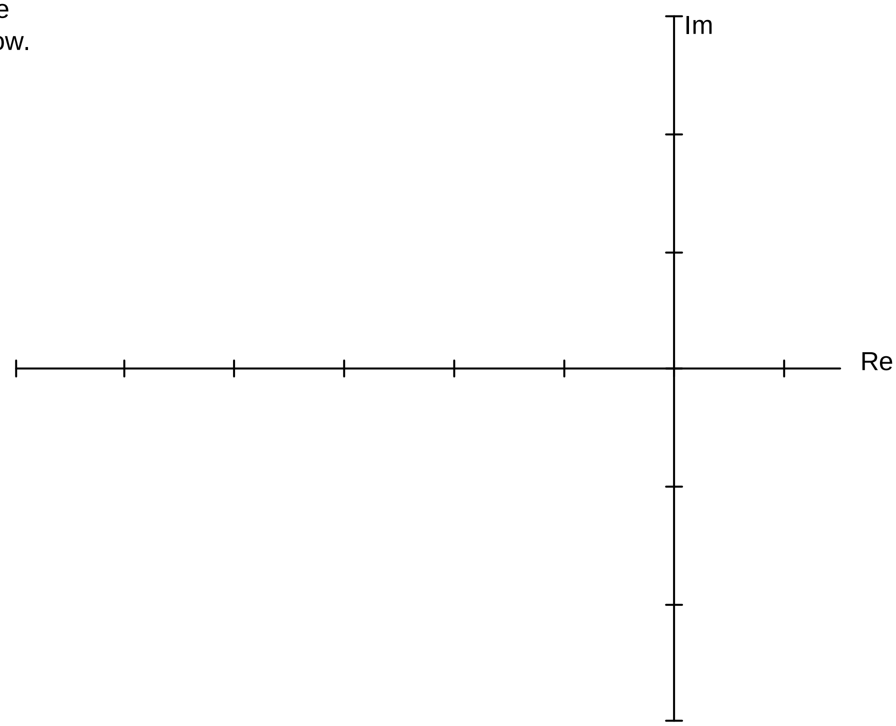
4. (26 pts) a) Lightly sketch (or use a dotted line) the root locus for the OL transfer function shown below.

$$G(s) = \frac{s+9}{(s+1)\cdot\left(s^2+4\cdot s+13\right)}$$



b) Find the departure angle from one of the complex poles.

c) Accurately draw the root locus using the departure angle you found.

d) Does the root locus cross the $j\omega$ axis at 5.91?
Be sure to show the work and method you used to decide.

c) Regardless of what you found in part c), continue to assume that the root-locus crosses the $j\omega$ axis at 5.91.
Give the range of gain k for which the system is closed-loop stable.

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5. (30 pts) Use partial fraction expansion to find $x(k)$ for the following z-transforms:

a) $X(z) = \dfrac{12 \cdot z \cdot (z - 0.7)}{(z - 1) \cdot (z + 0.8)}$

b) $X(z) = \dfrac{z \cdot (z + 0.5)}{(z + 0.9) \cdot \left(z^2 - z + 0.89\right)}$

c) Is the signal represented by part b) bounded?

Does it converge?

If yes, to what value?

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6. (23 pts) a) Draw the block diagram of a simple direct implementation of the difference equation.

$$y(k) = 3\cdot x(k) + 2\cdot x(k-1) - x(k-3) - \frac{1}{3}\cdot y(k-1) + \frac{1}{4}\cdot y(k-2)$$

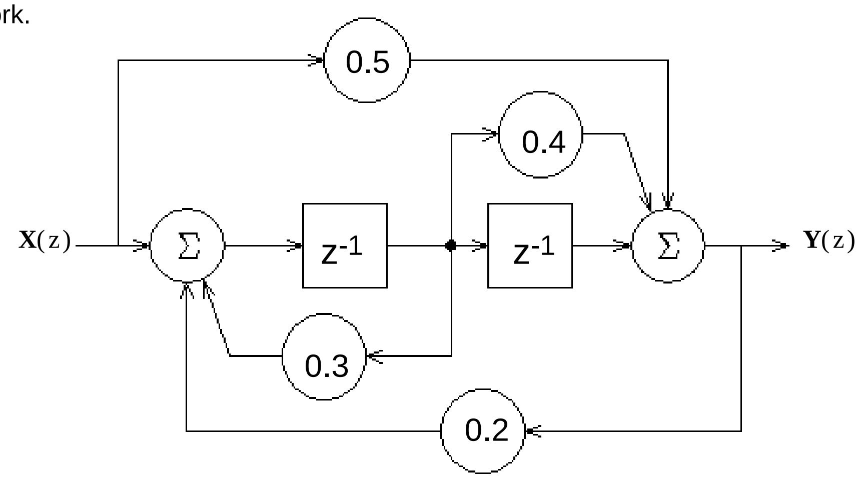
b) Find the $\mathbf{H}(z)$ corresponding to the difference equation above. Show your work.

c) List the poles of $\mathbf{H}(z)$. Indicate multiple poles if there are any.

d) Is this system BIBO stable? Yes No How do you know?

e) Is this an FIR system? Yes No
If not, which terms in the difference equation are to blame?

7. (20 pts) Find the transfer function $\mathbf{H}(z) = \mathbf{Y}(z)/\mathbf{X}(z)$. I suggest using a general interconnected system approach. Simplify your expression for $\mathbf{H}(z)$ so that the denominator is a simple polynomial or a multiple of simple polynomials. Show your work.



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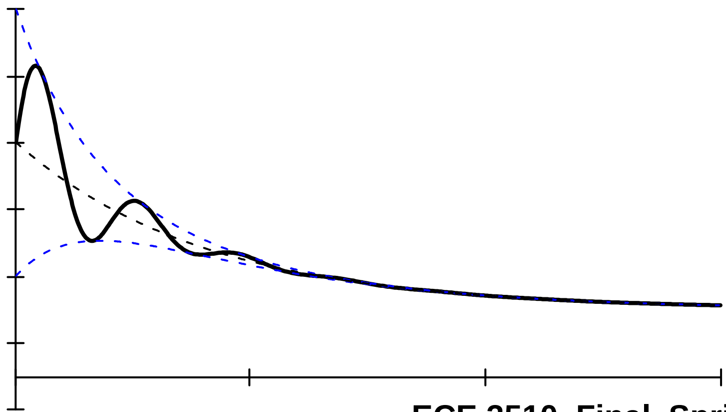
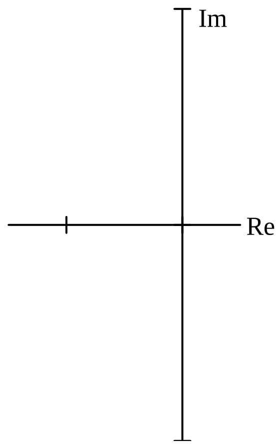
8. (4 pts) For the time-domain signal shown, draw the poles of the signal's Laplace transform on the axes provided. Clearly indicate double poles if there are any.





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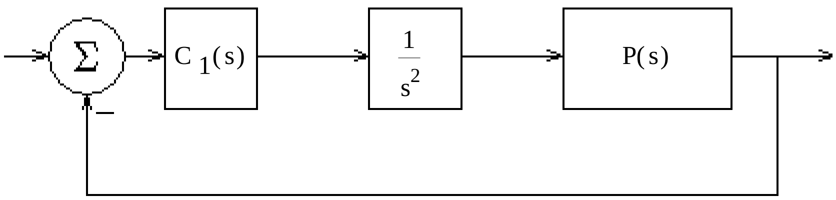
9. (7 pts) Consider the block diagram below. The double intergrator is a big problem and is making the entire system difficult to control. What, if anything, can be done to change the pole locations of the double integrator? You may want to redraw the block diagram to show your change(s).



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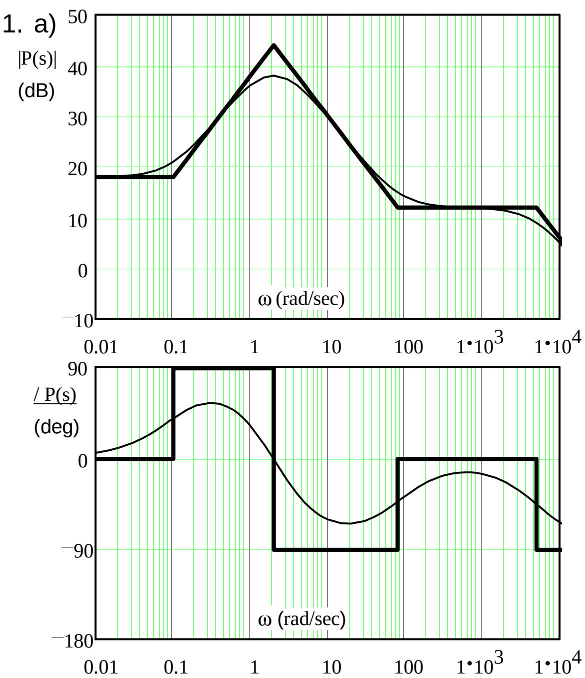
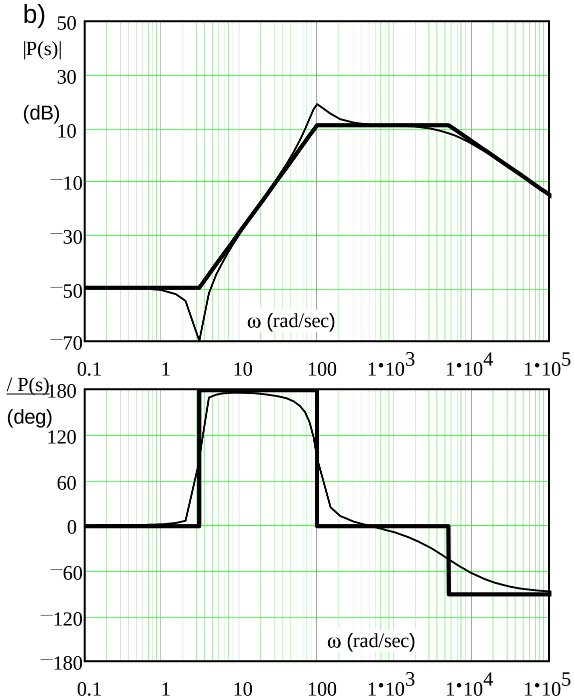
Answers

1. a)



b)

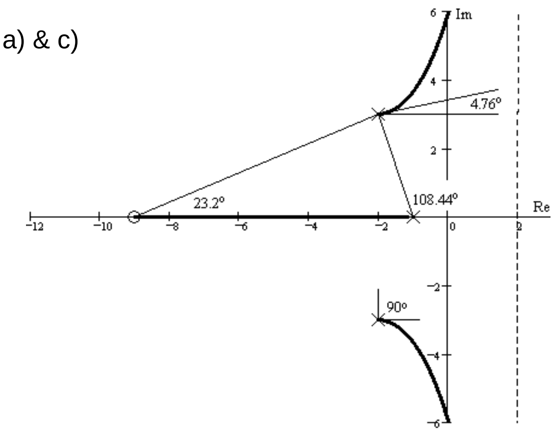


2. $\dfrac{5000\cdot(s+10000)\cdot s}{(s+3)\cdot\left(s^2+80\cdot s+160000\right)}$

3. a) $41\cdot dB$ $68\cdot deg$ / 1 b) $2.4\cdot ms$

c) $0.5\cdot\cos(4\cdot t+50\cdot deg)$

4. a) & c)



b) $4.76\cdot deg$

d) YES

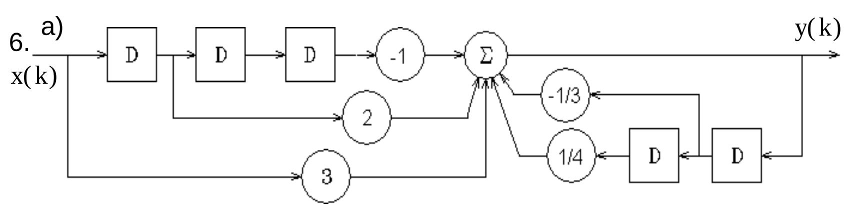
c) $k<17.95$

5. a) $\left[2+10\cdot(-08)^k\right]\cdot u(k)$

b) $\left[-0.154\cdot(-0.9)^k+(0.89)^{\frac{k}{2}}\cdot(0.154\cdot\cos(1.012\cdot k)+0.981\cdot\sin(1.012\cdot k))\right]\cdot u(k)$

c) Yes Yes 0

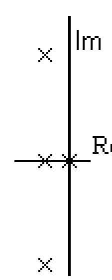
6. a)



b) $\dfrac{3\cdot z^3+2\cdot z-1}{z\cdot\left(z^2+\frac{1}{3}\cdot z-\frac{1}{4}\right)}$

7. $\dfrac{0.5\cdot z^2+0.25\cdot z+1}{z^2-0.38\cdot z-0.2}$

8.



9.