ECE 3510 Final given: Spring 23 DO NOT use eraseable ink

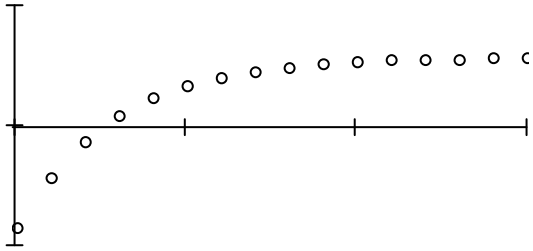
Show all work to receive credit. Circle answers, show units, and round off reasonably

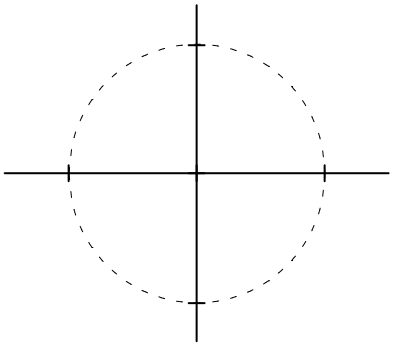
DO NOT use erasable ink

This part of the exam is Closed book, Closed notes (including colored sheets).

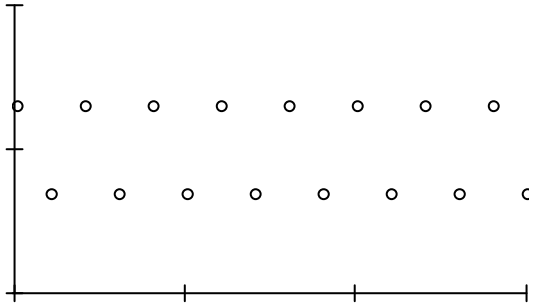
1. (18 pts) For each of the following discrete-time **signals**, draw the poles on the z-plane shown. A unit circle is shown on each z-plane as a dotted line.

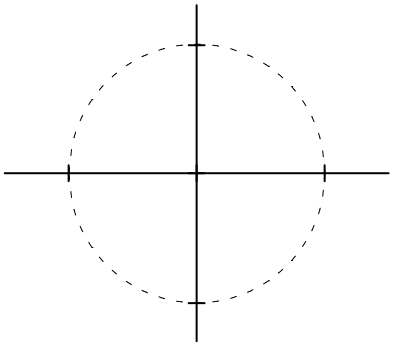
a)



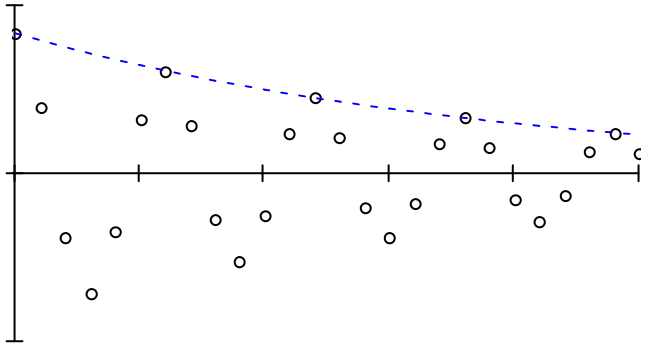


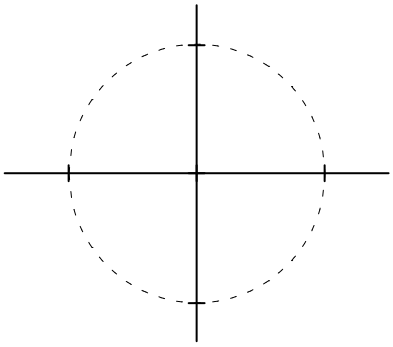
b)



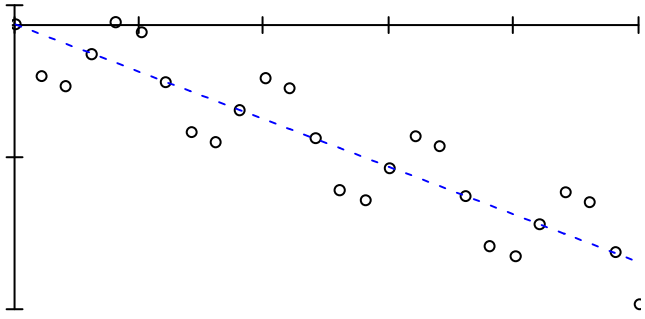


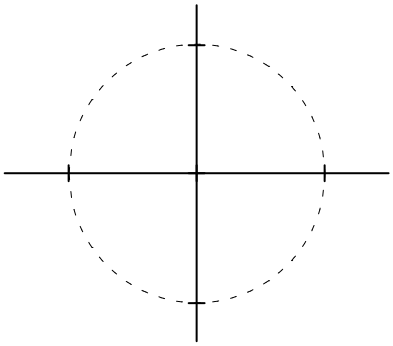
c)



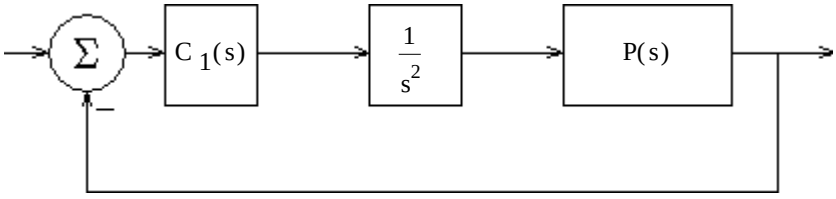


d)



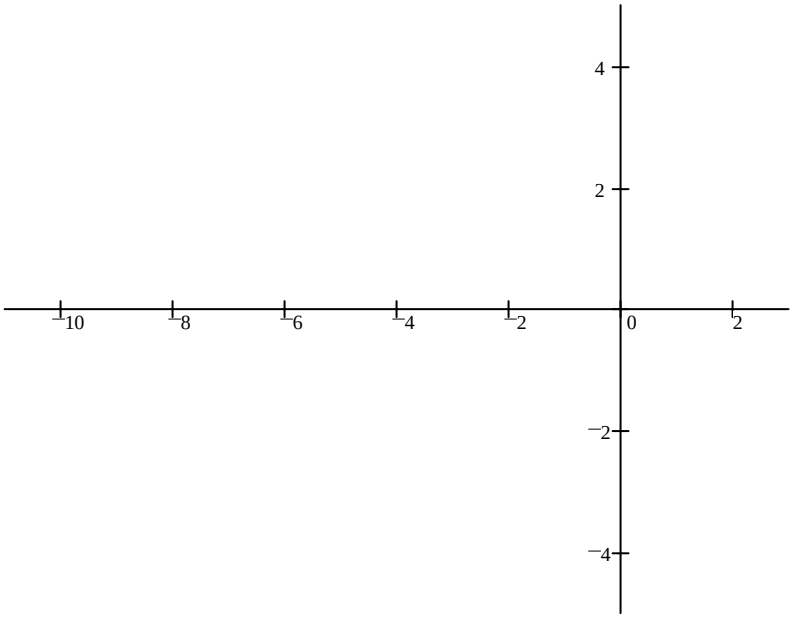


2. (6 pts) Consider the block diagram below. The double integrator is a big problem and is making the entire system difficult to control. What, if anything, can be done to change the pole locations of the double integrator? You may want to redraw the block diagram to show your change(s).



3. (9 pts) Sketch the root-locus plots for the following open-loop transfer function.
Use only the rules you were told to memorize, that is, you may estimate details like breakaway points and departure angles from complex poles. Show your work where needed. Draw things like the asymptote angles carefully.

$$\mathbf{G}(s) = \frac{1}{\left(s^2 + 2\cdot s + 10\right)\cdot(s+4)\cdot(s+6)}$$



4. (9 pts) When you represent a mechanical system of translational motion with an electrical circuit, what do the following mechanical quantities or parts translate to in the electrical circuit?

a) Force = Current (example answer)

b) Velocity =

c) Stationary reference of zero velocity =

d) Friction or damping =

e) Spring =

f) Mass =

g) Is the capacitor always hooked up in a certain way? If yes, say what.

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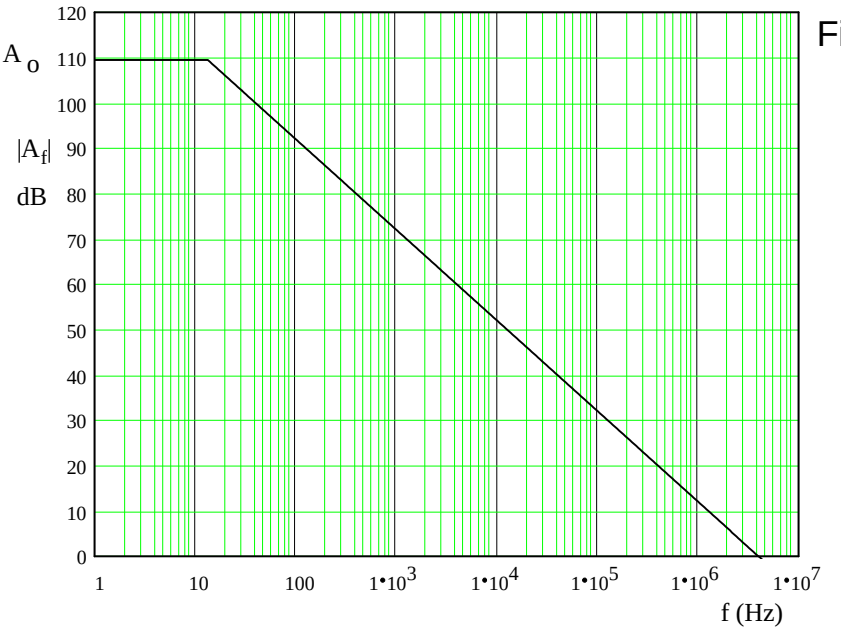
Open Note Sheets

1. (20 pts) The plot at right shows the frequency response of some device.



a) What type of device is it?

b) Find the gain-bandwidth product (GBW).

c) Find A_o in both dB and as a factor.

d) Find the open-loop roll-off point and the compensation pole location.

e) A voltage (series-shunt) feedback network is used to feed back 0.1% of the output back to the input in a negative manner. Find the closed-loop gain (as a factor and in dB) and the closed-loop roll-off point. Draw the closed-loop frequency response on the drawing above.

f) Now use two equal amplifier stages (two op amps) to achieve the same gain as part in d), Find the closed-loop roll-off point of a single stage. Draw the closed-loop frequency response of a single stage on the drawing above.

g) Would this also be the 3dB roll-off point of the entire two-stage amplifier? If not, why not?

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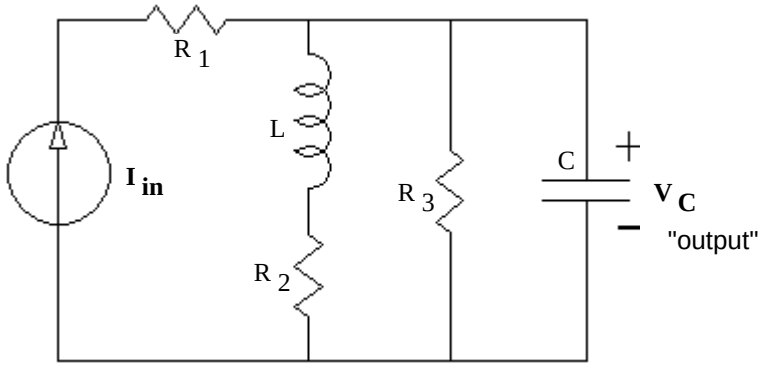
2. (24 pts) a) Find the s-type transfer function of the circuit shown. Consider $\mathbf{I_{in}}$ as the input and $\mathbf{V_C}$ as the "output".



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.

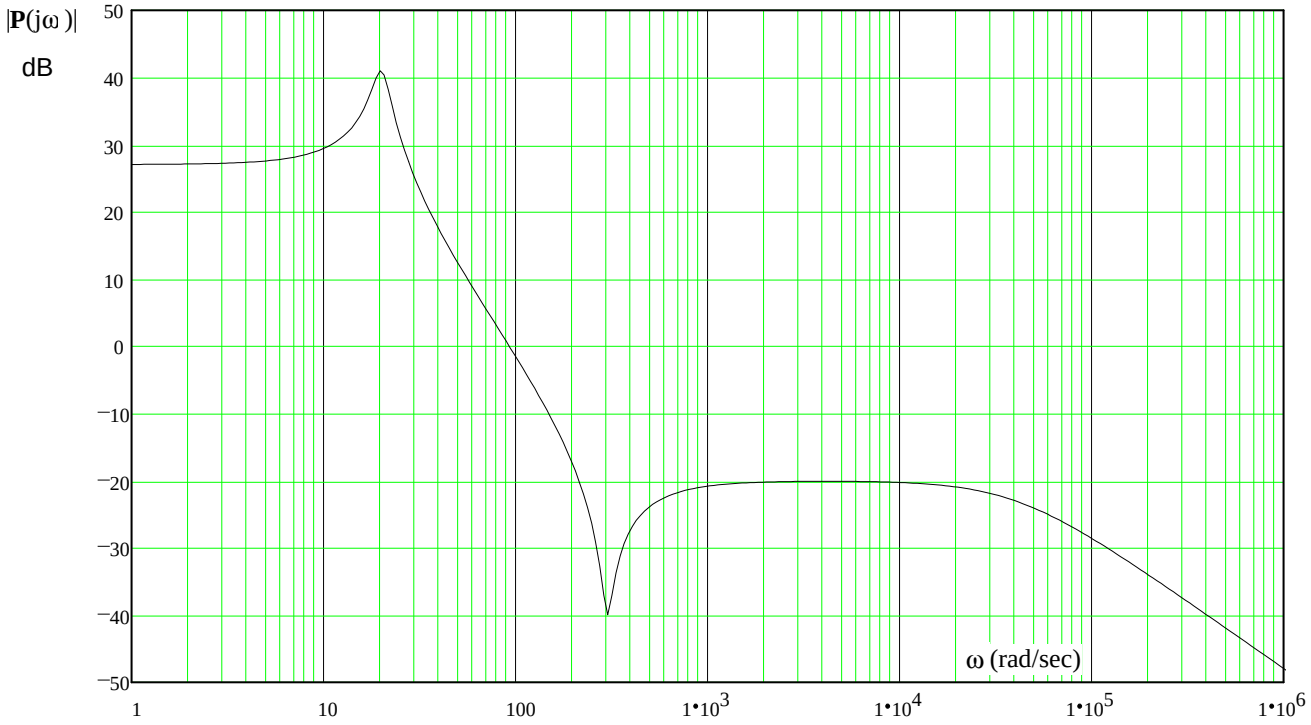
$\mathbf{H}(s)$ = ?

Work on next page

b) What load does this circuit place on the source of $\mathbf{I_{in}}$? In other words, what is the input impedance?
You do not need to simplify your impedance expression.

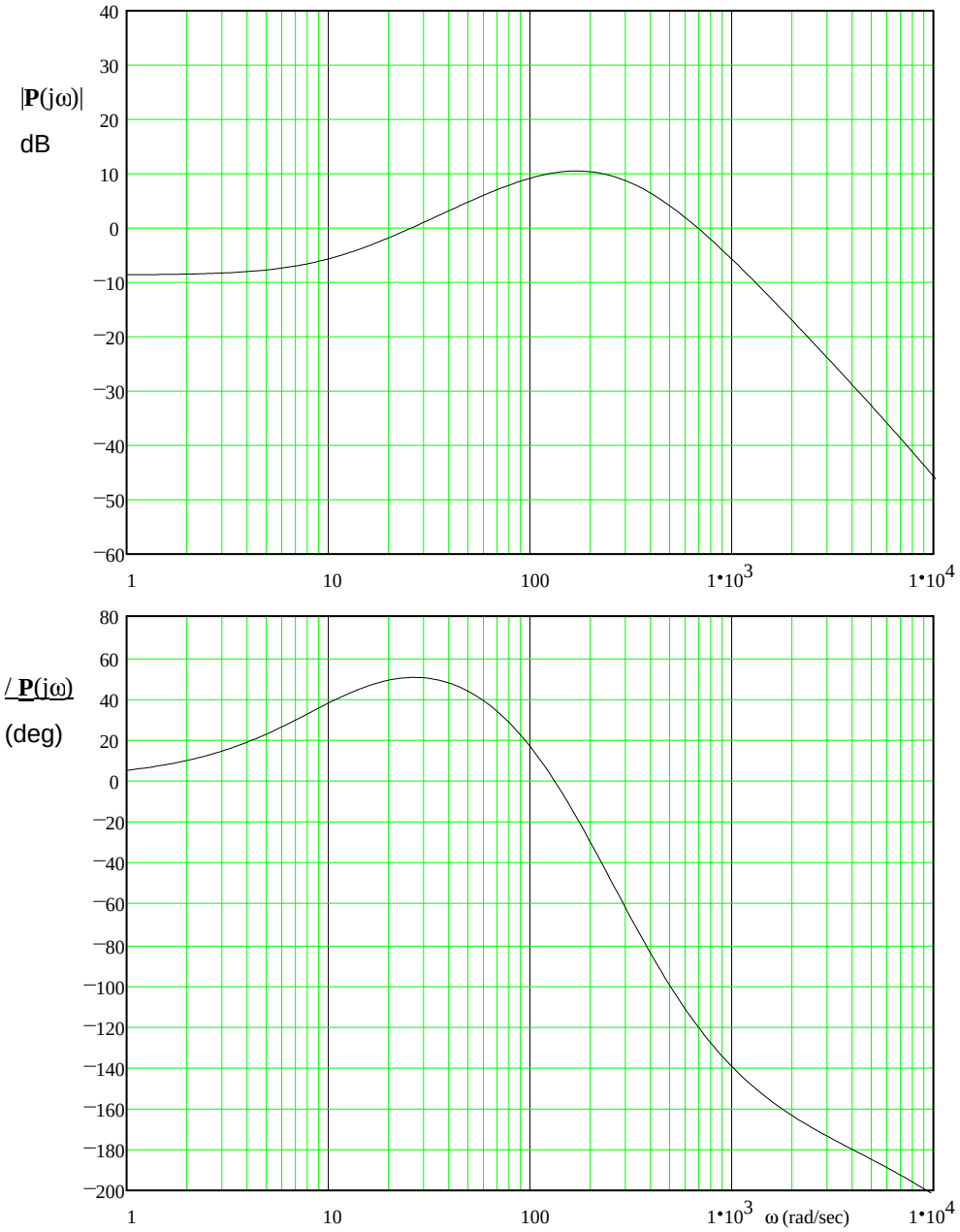
c) Find the output impedance of this circuit, assuming the current source is ideal.
You do not need to simplify your impedance expression.

3. (22 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).



4. (20 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 $x(t) = 4\sin(200t)$. express the answer in the time-domain. $y_{ss}(t)$ = ?

5. (34 pts) Use partial fraction expansion to find $x(k)$ for the following z-transforms:

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

b) $\mathbf{X}(z) = \dfrac{4 \cdot z}{(z - 0.8) \cdot \left(z^2 - 0.6 \cdot z + 0.9\right)}$

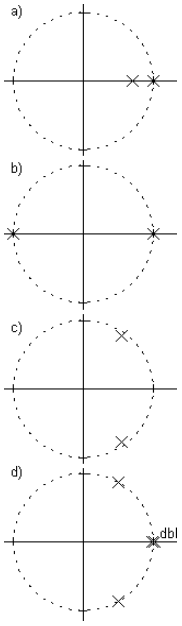
c) Is the signal represented by part b) bounded? How do you know?

Does it converge? If yes, to what value? _____ / 34 pts

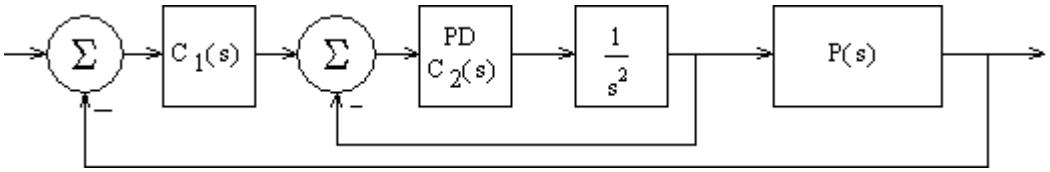
Last problem on next page ---->

Answers Closed Note Sheets

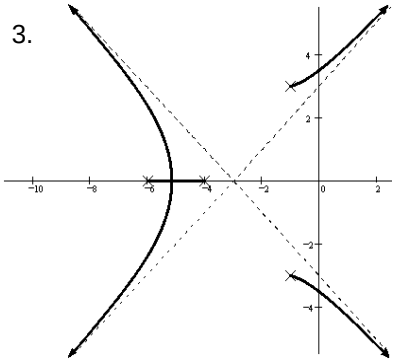
1.



2.



3.



4. a) Current b) Voltage
c) Ground d) Resistor
e) Inductor f) Capacitor
g) Yes, one side is always hooked to ground

Open Note Sheets

1. a) Op-amp b) $4\cdot MHz$ c) $110\cdot dB$
d) $12.65\cdot Hz$ pole: $\frac{1}{s+79.5}$ e) 1000 $3.162\cdot 10^5$ $60\cdot dB$ $4\cdot kHz$
f) $126.5\cdot kHz$
g) The 3dB roll-off point of the entire two-stage amplifier is a bit less than 126.5kHz because that would actually be a 6dB roll-off point.

2. a) $\frac{\frac{1}{C}\cdot s+\frac{R_2}{L\cdot C}}{s^2+\left(\frac{1}{R_3\cdot C}+\frac{R_2}{L}\right)\cdot s+\frac{1}{L\cdot C}\cdot\left(\frac{R_2}{R_3}+1\right)}$

b) $R_1+\frac{1}{\frac{1}{R_3}+\frac{1}{R_2+L\cdot s}+C\cdot s}$

c) $\frac{1}{\frac{1}{R_3}+\frac{1}{R_2+L\cdot s}+C\cdot s}$

3. $\frac{4000\cdot\left(s^2+30\cdot s+90000\right)}{\left(s^2+4\cdot s+400\right)\cdot(s+40000)}$

4. a) $29\cdot dB$ $58\cdot deg$ b) $1.45\cdot ms$
c) $12.65\cdot\sin(200\cdot t-30\cdot deg)$

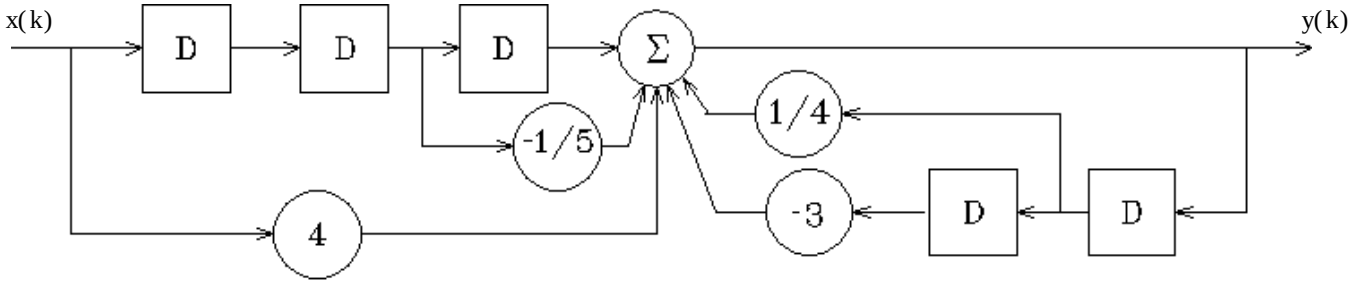
5. a) $\left[2+10\cdot(-0.8)^k\right]\cdot u(k)$ b) $\left[3.774\cdot(0.8)^k-(0.9)^{\frac{k}{2}}\cdot(3.774\cdot\cos(1.25\cdot k)+2.096\cdot\sin(1.25\cdot k))\right]\cdot u(k)$ c) All poles are inside unit circle Yes 0

6. a) $4\cdot x(k)-\frac{1}{5}\cdot x(k-2)+x(k-3)+\frac{1}{4}\cdot y(k-1)-3\cdot y(k-2)$

b) $\frac{4\cdot z^3-\frac{1}{5}\cdot z+1}{\left(z^2-\frac{1}{4}\cdot z+3\right)\cdot z}$ c) 0 $0.125+1.728\cdot j$ $0.125-1.728\cdot j$

d) NO, TWO poles are outside the unit circle

6. (18 pts) a) Find the difference equation that describes the following block diagram.



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

c) List the poles of $\mathbf{H}(z)$. Indicate multiple poles if there are any.
If you can't find the actual poles, show the equation you would have to solve in order to find them.

d) Is this system BIBO stable? Justify your answer. If you don't have the information you need, say how you would determine this.

_____ / 18 pts