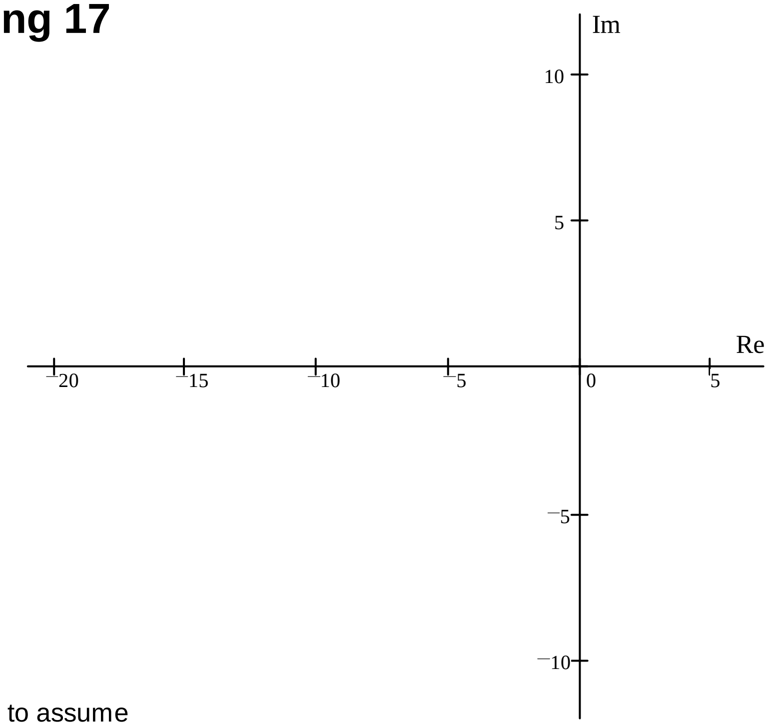
ECE 3510 Final given: Spring 17

1. (18 pts) a) Sketch the root locus for:

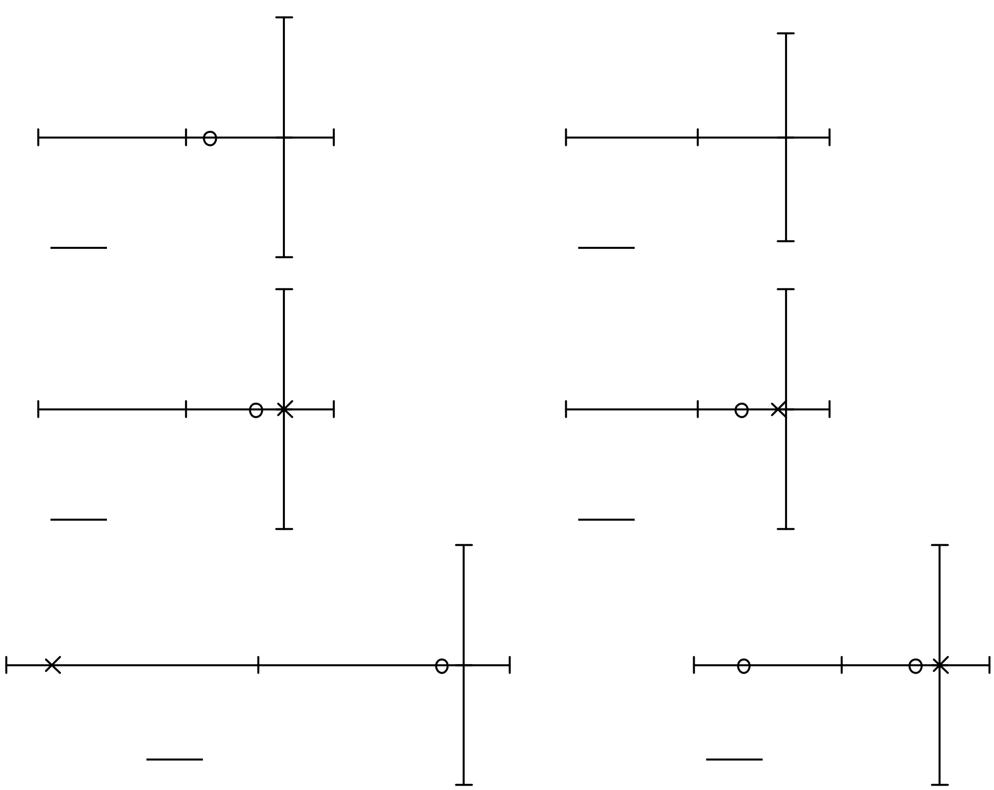
$$\mathbf{G}(s) = \frac{(s+8)\cdot(s+17.97)}{s^2 - 12\cdot s + 52}$$



b) Does the root locus cross the $j\omega$ axis at $9j$?
Be sure to show the work and method you used to decide.

c) Regardless of what you found in part a, continue to assume that the root-locus crosses the $j\omega$ axis at 9. Give the range of gain k for which the system is closed-loop stable.

2. (12 pts) Each of the pole-zero diagrams below represent a **controller** or **compensator**. Identify each of them with the possible answers listed.



Listed below are the possible answers. You may use some answers more than once. Some answers may not be used at all.

P

PD

PI

I

D

PID

Lag

Lead

Zig

Zag

Over

Under

3. (14 pts) Below is a list of reasons to add a compensator to a feedback system. After each of the reasons, list all of the compensators that would be a good choice for the achieving the desired result without significant extra parts or negative side-effects. Select your answers from the list of possible answers above. Answers may be used more than once or not at all. Each blank may have more than one answer, list all reasonable answers.

   a) Increase the speed of the system response __________________

   b) Decrease overshoot __________________

   c) Decrease the settling time __________________

   d) Reduce the steady-state error __________________

   e) Eliminate the steady-state error for a DC input __________________

   f) Mostly reject constant disturbances __________________

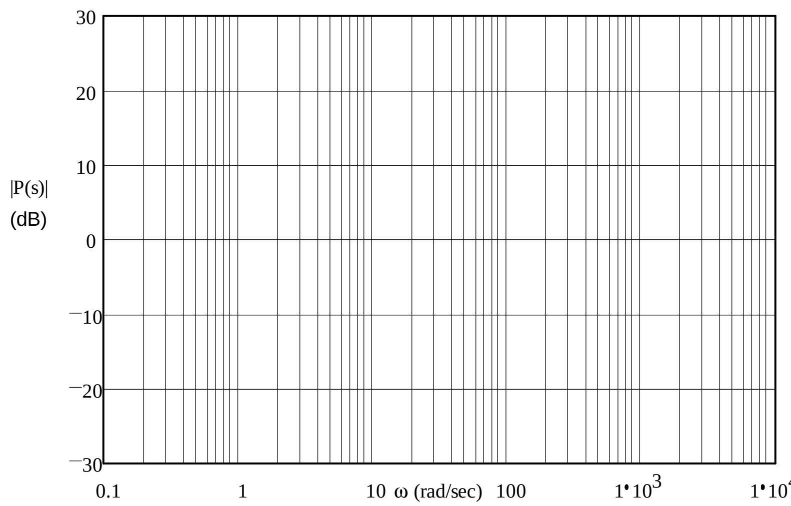
   g) Completely reject constant disturbances __________________

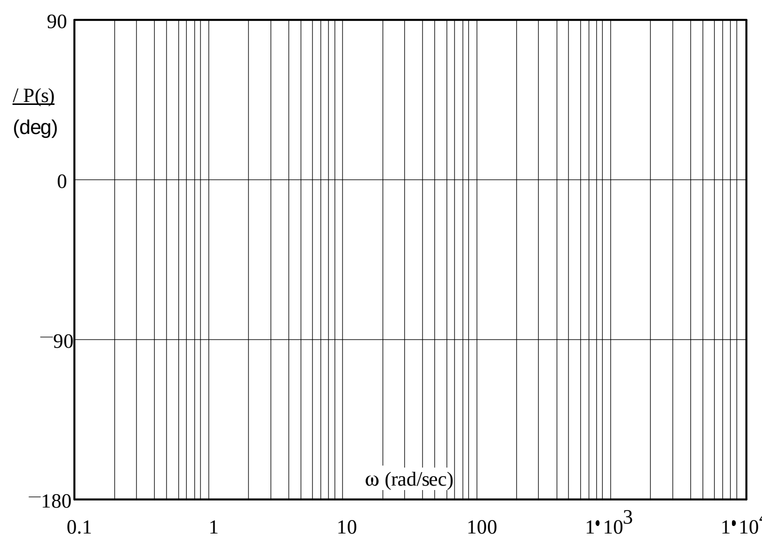
   h) All of the above __________________

Problem 5 is out of order

5. (13 pts) Sketch the Bode plot for the following transfer function. Make sure to label the graphs, and to give the slopes of the lines in the magnitude plot. Also draw the "smooth" lines.

$$P(s) = \frac{(s+4)\cdot(s+200)}{s\cdot(s+1000)}$$



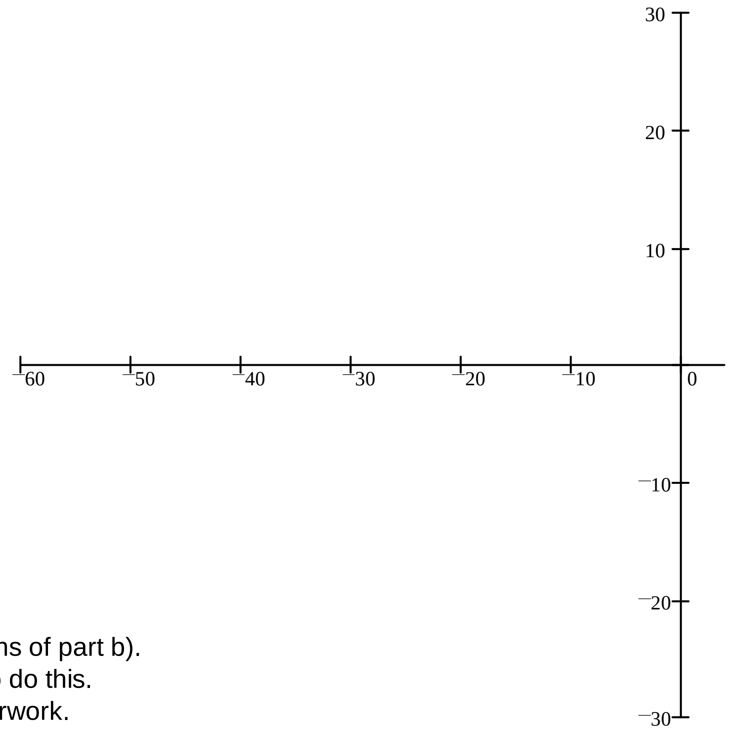


Do you want your grade and scores posted on the Internet?
If your answer is yes, then provide some sort of alias: ______________________________
otherwise, leave blank

The grades will be posted on line in pdf form in alphabetical order under the alias that you provide here.
I **will not** post grades under your real name or an alias that looks like a real name or u-number.
The pdf spreadsheet will show the homework, lab, and exam scores of everyone who answers here.

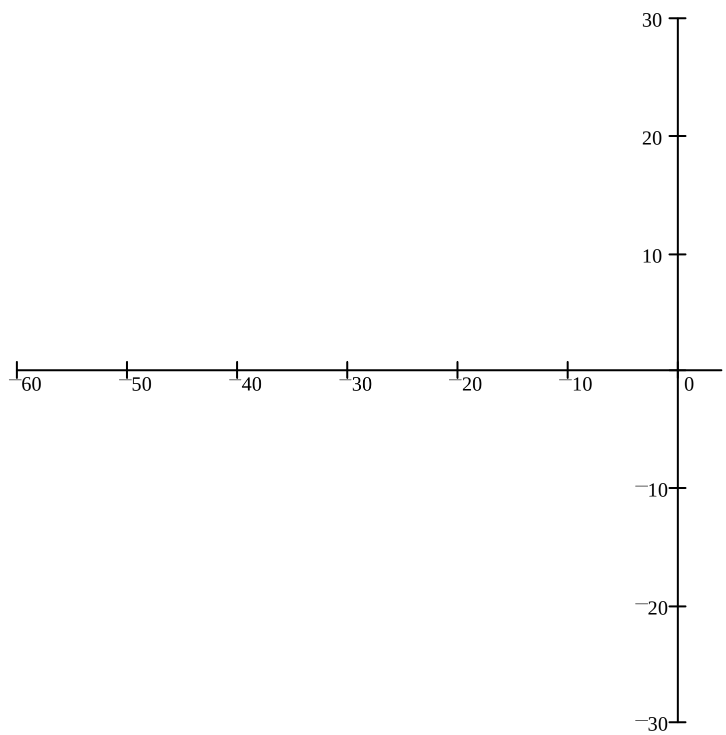
4. (22 pts) Consider this transfer function. $G(s) := \dfrac{100}{s(s+24)}$

a) Sketch the root-locus plot



b) Can the closed-loop poles be set to get ringing at 20 rad/sec and a settling time of 0.1sec?

c) You wish to add a compensator to get the conditions of part b).
Add a lead compensator so that you will be able to do this.
Set the lead compensator's pole at -60. Show yourwork.



d) With the compensator in place and a closed-loop pole at the location desired in part b)

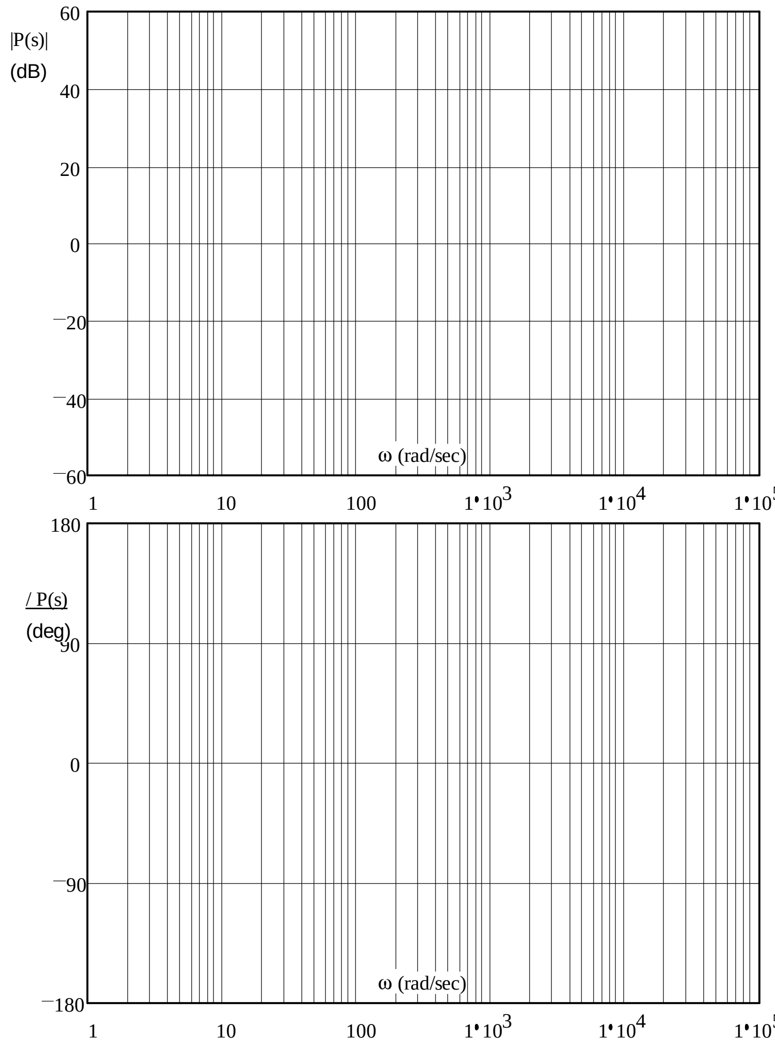
What is the gain?

e) What is the steady-state error to a unit-step input (closed-loop)? Express as %

f) Is it desirable to add another compensator to improve the steady-state error?
If yes, say what's needed.

6. (16 pts) Sketch the Bode plot for the following transfer function. Make sure to label the graphs as necessary to show the magnitudes and slopes. Also accurately draw the "smooth" lines. Include dB values at important points

$$P(s) = \frac{(s+3000)\cdot 334\cdot s}{(s+5)\cdot\left(s^2+40\cdot s+10000\right)}$$



Problem 10 is out of order

10. (11 pts) a) Find the $H(z)$ corresponding to the difference equation below. Show your work.

$$y(k) \;=\; 2\cdot x(k)+\frac{1}{2}\cdot x(k-2)-\frac{1}{3}\cdot x(k-3)+\frac{1}{4}\cdot y(k-1)-\frac{1}{5}\cdot y(k-2)$$

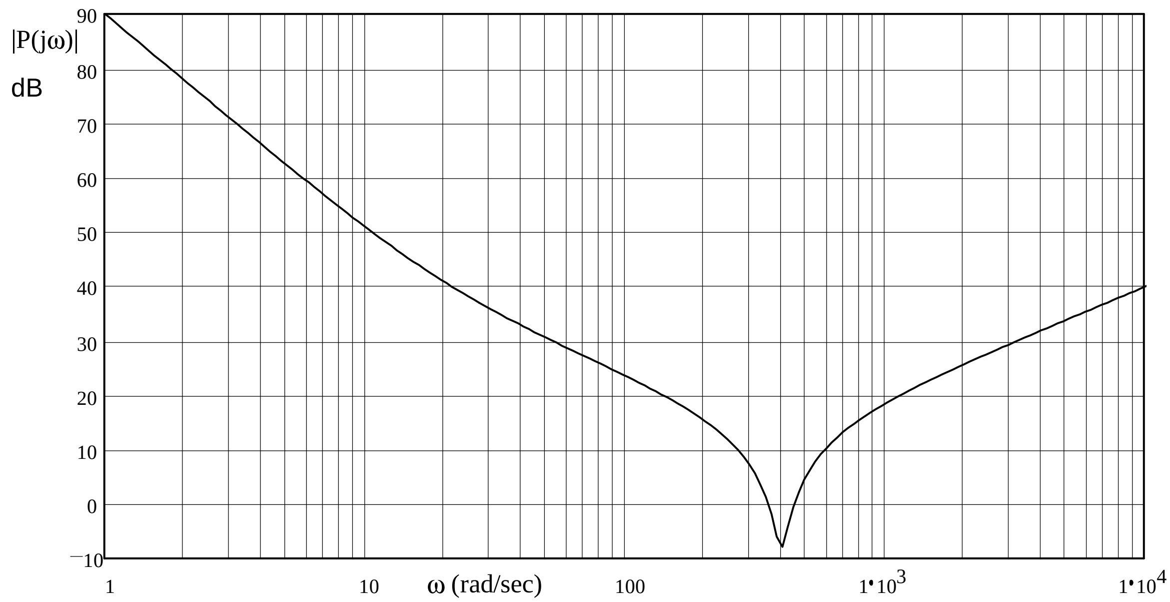
b) List the poles of $H(z)$. Indicate multiple poles if there are any.

c) Is this system BIBO stable? Yes No

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

EXTRA The following is not strictly part of this exam, but, if you can do it correctly, it can make up for up to 8 points missed elsewhere.
Draw a block diagram of an implementation of the difference equation above.

7. (18 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).



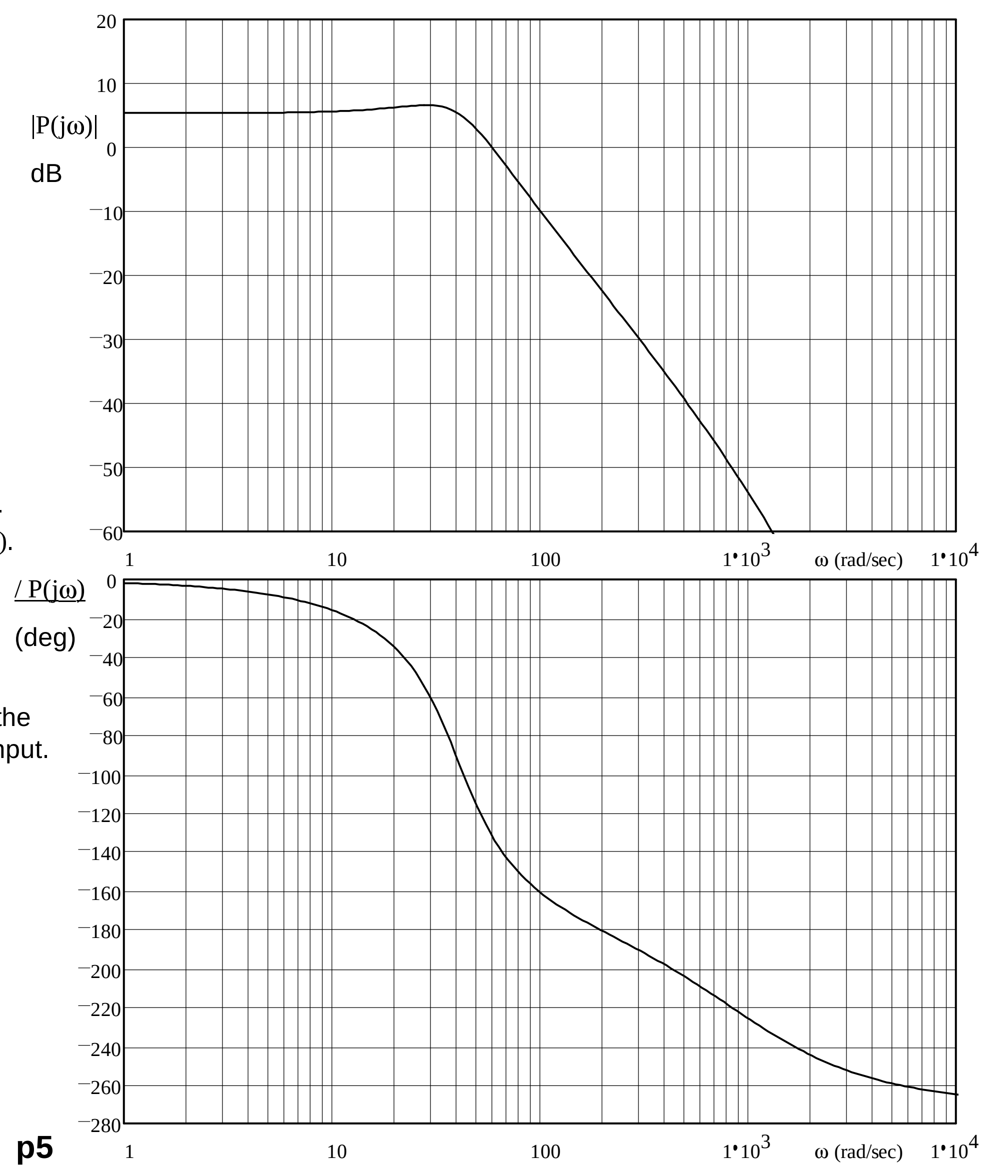
8. (20 pts) The open-loop Bode plots of a system are given at right.

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

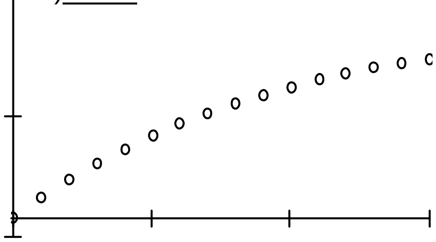
b) Find the delay margin.

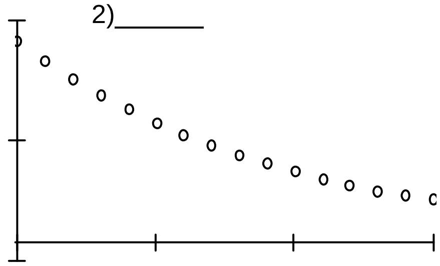
c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 4\sin(30t)$. express the answer in the time-domain. $y_{ss}(t)$ = ?

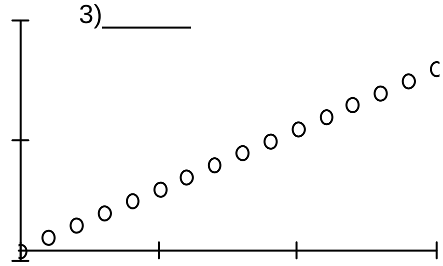
d) Give the steady-state response of the closed-loop system for the same input.

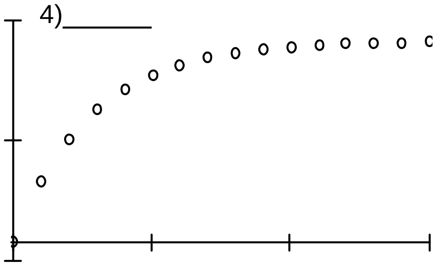


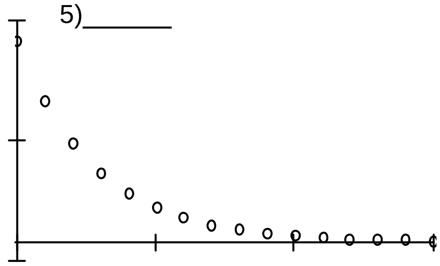
9. (36 pts) a) Match each of the following discrete-time **signals** to one of the answers on the next page. Find the single best match for each. Your answers should make sense relative to one another.

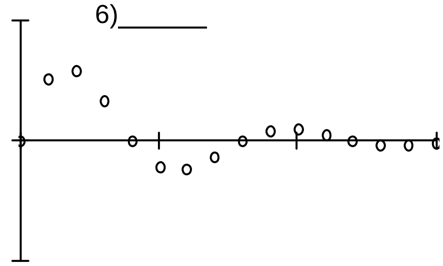
1)______


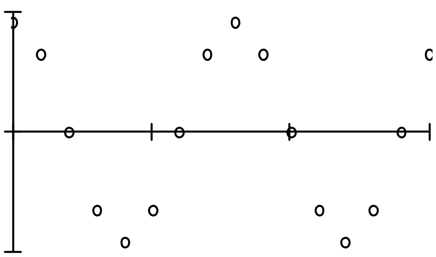
2)______


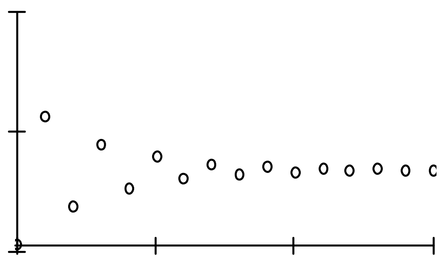
3)______


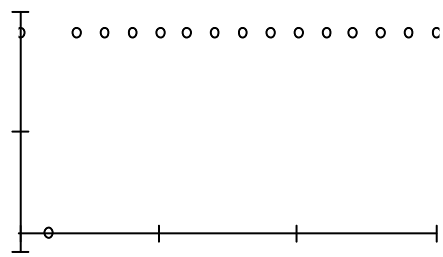
4)______


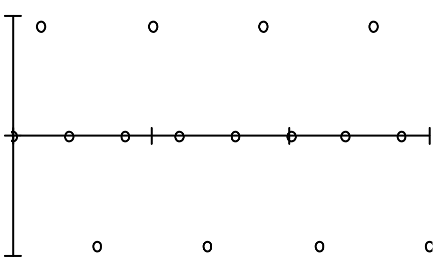
5)______


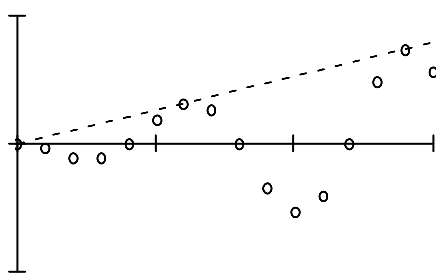
6)______


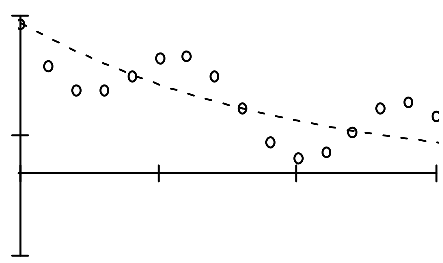

7)______


8)______


9)______


10)______


11)______


12)______

For parts b) and c), consider answers on the next page as poles of **transfer functions**.

b) List all that are BIBO stable.

c) Match each of the following transfer functions to one of the answers on the next page.

1) $H(z) = \dfrac{10 \cdot z}{z - 0.9}$ ______

2) $H(z) = \dfrac{6 \cdot z}{(z-1)\cdot(z+0.7)}$ ______

3) $H(z) = \dfrac{z}{10 \cdot \left(z^2 + 1\right)}$ ______

4) $H(z) = \dfrac{2 \cdot z}{z^2 - 1.414 \cdot z + 1}$ ______

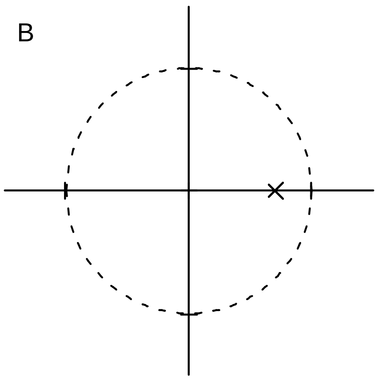
Each answer below is a z-plane showing the unit circle and usually some poles

Answers may be used more than once or not at all. dbl = double pole at that location.

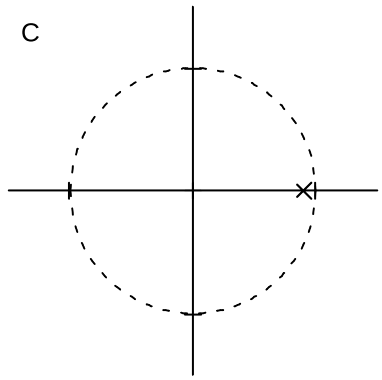
ANSWERS

A None of these answers match.

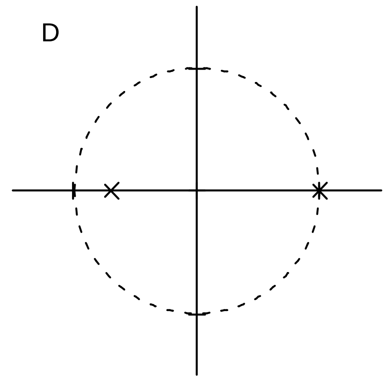
B



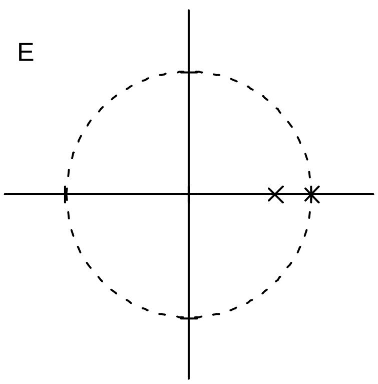
C



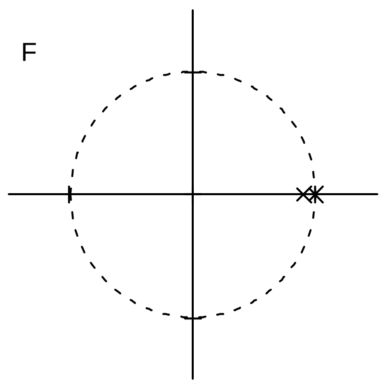
D



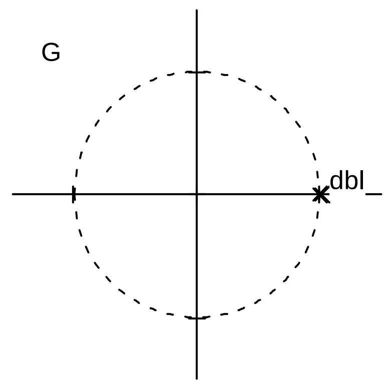
E



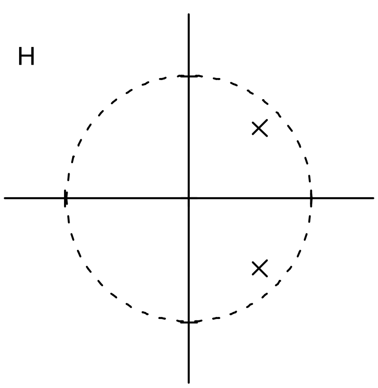
F



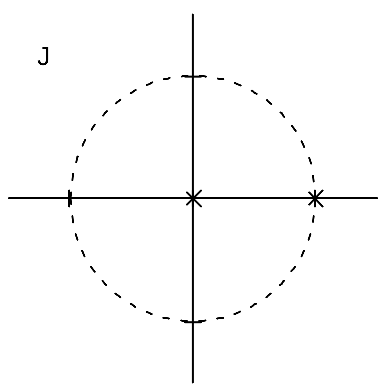
G



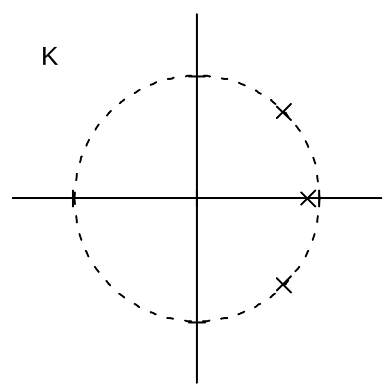
H



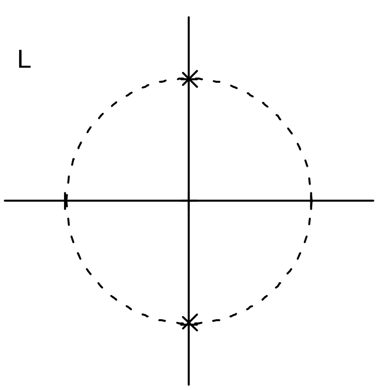
J



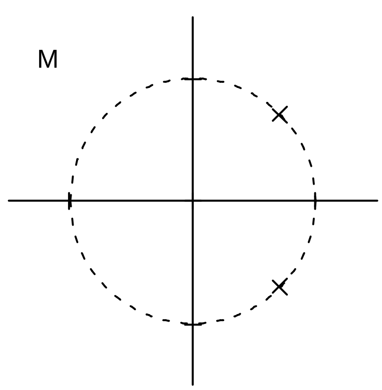
K



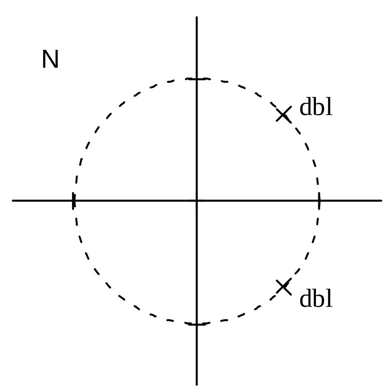
L



M

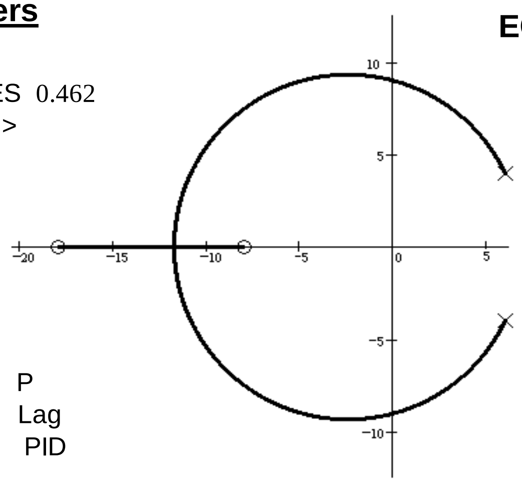


N



Answers

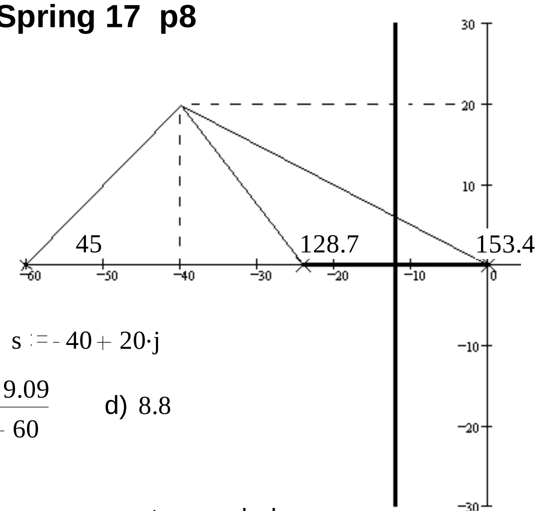
1. a)
   b) YES 0.462
   c) k >



2. PD P
   PI Lag
   Lead PID

3. a) PD & Lead b) PD & Lead c) PD & Lead
   d) PI & Lag e) PI f)Lag g) PI h) PID

4. a)



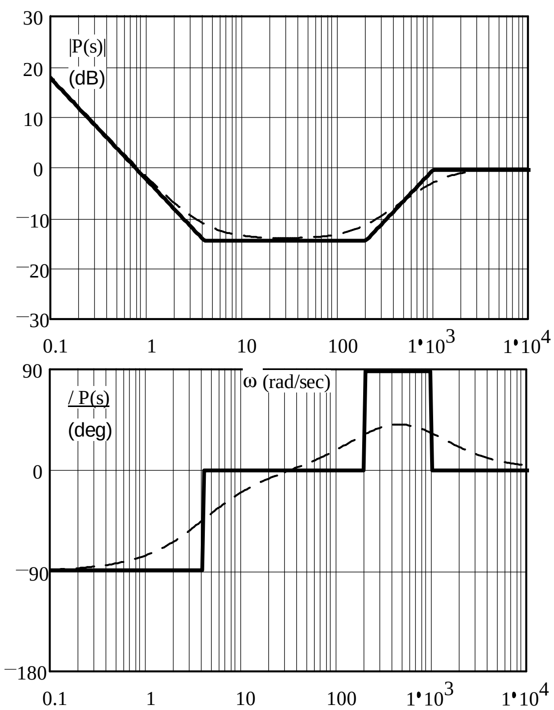
b) NO $s := -40 + 20 \cdot j$

c) $\dfrac{s + 9.09}{s + 60}$ d) 8.8

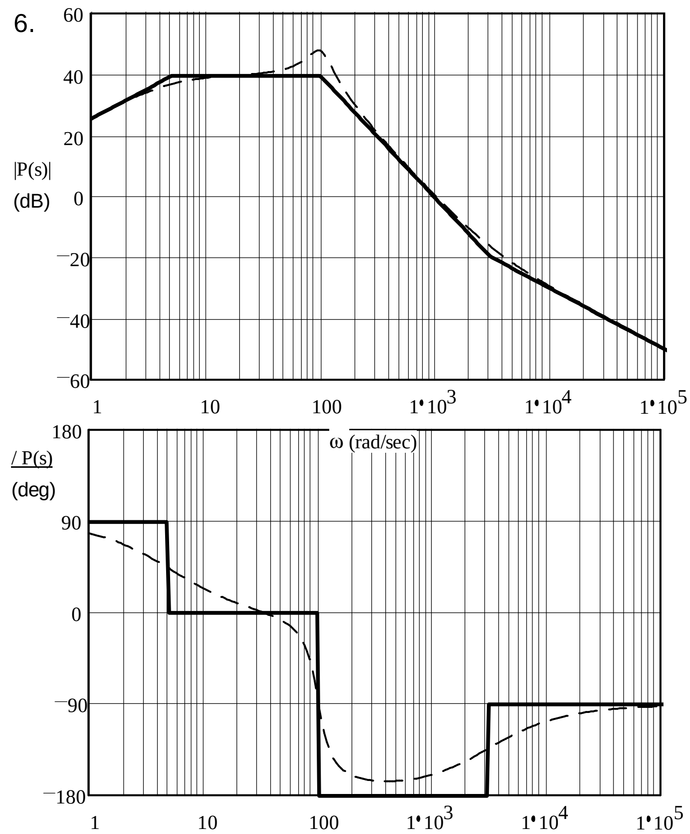
e) 0%

f) No, no compensator needed.

5.



6.



7. $0.01 \cdot \dfrac{(s+20)\cdot\left(s^2 + 40\cdot s + 160000\right)}{s^2}$

8. a) $22\text{dB} \quad 47\cdot\text{deg}$ b) $14\cdot\text{ms}$ c) $8.96\cdot\sin(30\cdot t - 60\cdot\text{deg})$ d) $3.12\cdot\sin(30\cdot t - 17.5\cdot\text{deg})$

9. a) 1) F 2) C or F 3) G b) B C H c) 1) C 2) D
   4) E 5) B 6) H 3) L 4) M
   7) M 8) D 9) J
   10) L 11) N 12) K

10. a) $\dfrac{2\cdot z^3 + \frac{1}{2}\cdot z - \frac{1}{3}}{z\cdot\left(z^2 - \frac{1}{4}\cdot z + \frac{1}{5}\right)}$ b) 0, $0.125 + 0.429\cdot j$, $0.125 - 0.429\cdot j$

c) Yes d) No $\frac{1}{4}\cdot y(k-1)$ & $\frac{1}{5}\cdot y(k-2)$

EXTRA