ECE 3510 Exam 3 given: Spring 13 (The space between problems has been removed.)

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

Your answers should be specific, clear, concise, and legible, or I'll assume you don't know.

1. (3 pts) You have a feedback system that doesn't work as well as you would like, but you don't know the open-loop transfer function. You've tried adjusting the gain, and have found the best balance of speed and overshoot that you can. Is it likely still possible to improve its performance? What would you use? What might you do?

2. (13 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

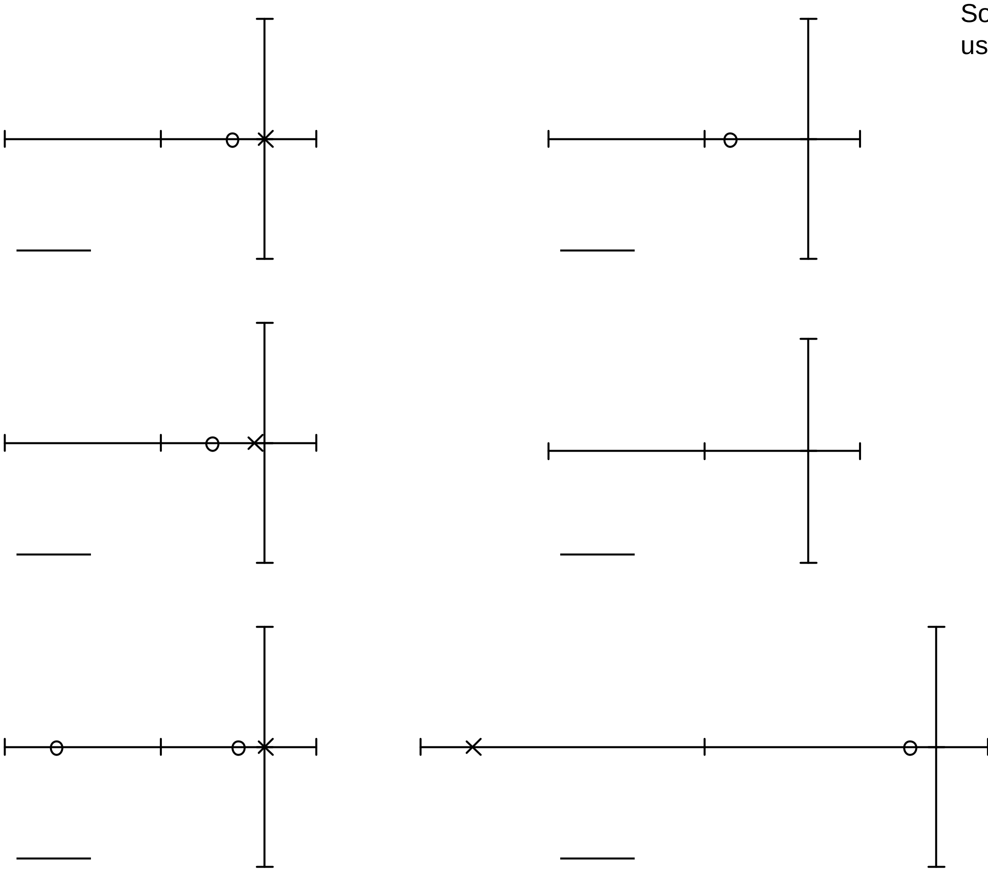
Lead

Zig

Zag

Over

Under



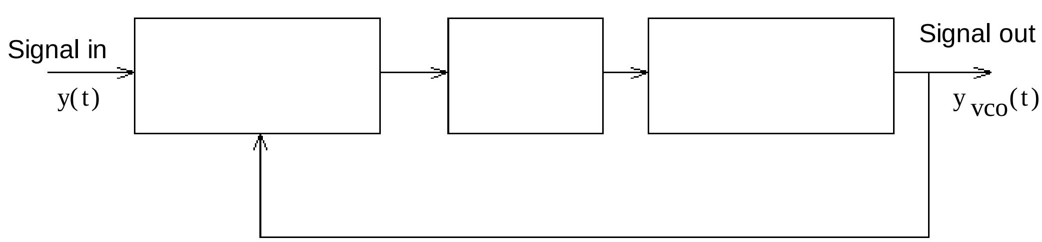
3. (7 pts) a) What is a PD compensator used for?

   b) What other compensator can be used for the same or similar purpose?

   c) What is a PI compensator used for?

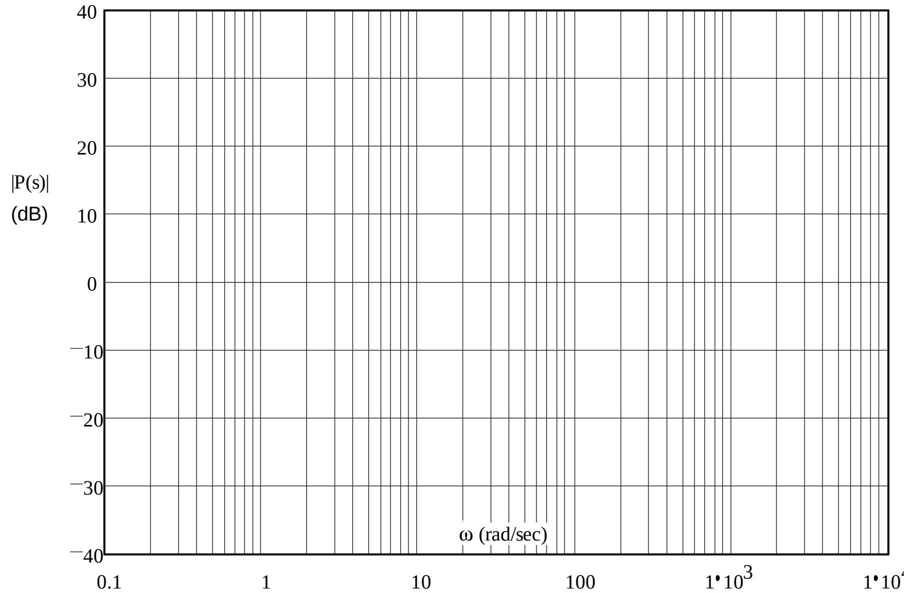
   d) What other compensator can be used for the same or similar purpose as the PI ?

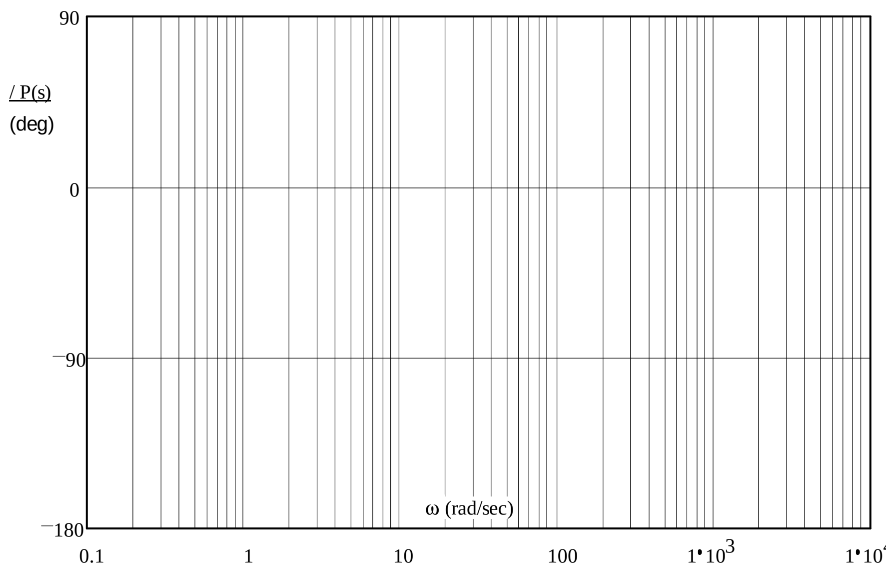
4. (5 pts) Identify the blocks (in words) in the phase-locked-loop shown below.



5. (12 pts) Sketch the Bode plot for the following transfer function. Accurately draw the magnitudes and slopes. Also accurately draw the "smooth" lines. Include dB values at important points

$$P(s) := \frac{10^6\cdot(s+0.4)}{s\cdot(s+200)\cdot(s+1000)}$$



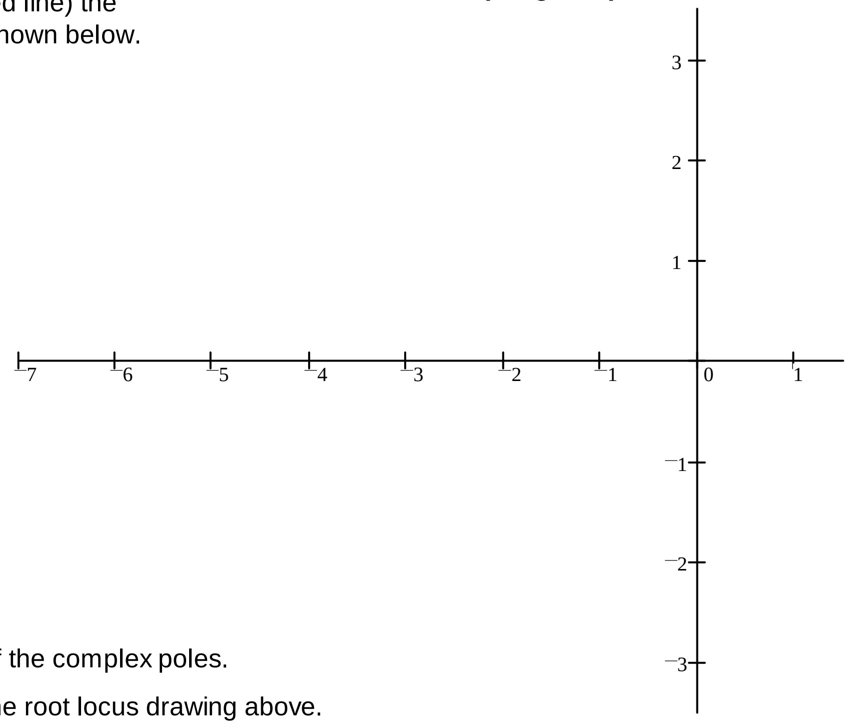


Note: $2 = 6\cdot dB$ $\quad \frac{1}{2} = -6\cdot dB$ $\quad \frac{1}{4} = -12\cdot dB$ $\quad 5 = 14\cdot dB$

$4 = 12\cdot dB$ $\quad$ Add dB to multiply numbers $\quad 10 = 20\cdot dB$ $\quad 20 = 26\cdot dB$

1. (18 pts) a) Lightly sketch (or use a dotted line) the root locus for the OL transfer function shown below.

$$\mathbf{G}(s) = \frac{(s+6)}{(s-1)\cdot\left(s^2+10\cdot s+29\right)}$$



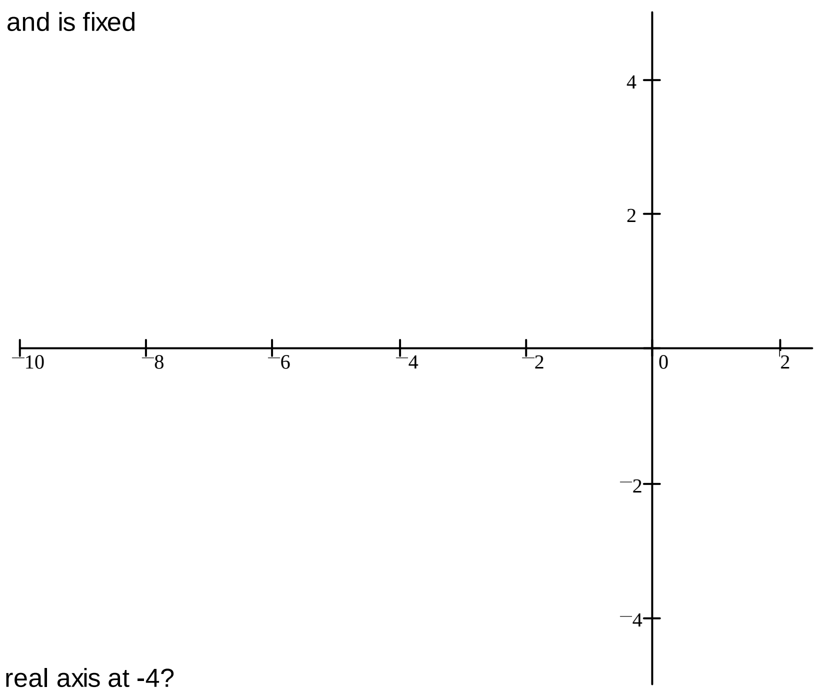
b) Find the departure angle from one of the complex poles.

c) Use the departure angle to finalize the root locus drawing above.

d) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$.

2. (18 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below. The root-locus should be plotted for an increasing x.

$$G(s) = \frac{k\cdot(5\cdot(s+2\cdot x)-6)}{s\cdot(x\cdot s+2\cdot(s+2\cdot x))} \qquad k = 2 \text{ and is fixed}$$



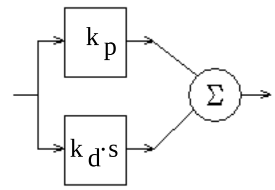
b) Can you place a closed-loop pole on the real axis at -4?
If yes, find the value of m needed to place the pole at this location.
If no, indicate what you think the best point on the real axis is and find the value of m needed to place the pole at that location.

3. (24 pts) Consider this transfer function. $G(s) := \dfrac{s+8}{s\cdot(s+5)\cdot(s+20)}$

   a) You wish to add a compensator to get closed-loop settling time to 1/3 sec and the ringing frequency to 12 rad/sec. (using the second-order approximation)

   b) With the compensator in place and a closed-loop pole at the location desired in part b), what is the gain?

   c) Find k_p and k_d of a standard PD controller.



   d) With this compensator in place, is there possibility for improvement (better speed and/or lower ringing)? If yes, what would be the simplest thing to do? Justify your answer.

Answers

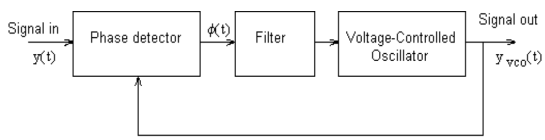
1. Use a PID controller. Use PID tuning techniques.

2.

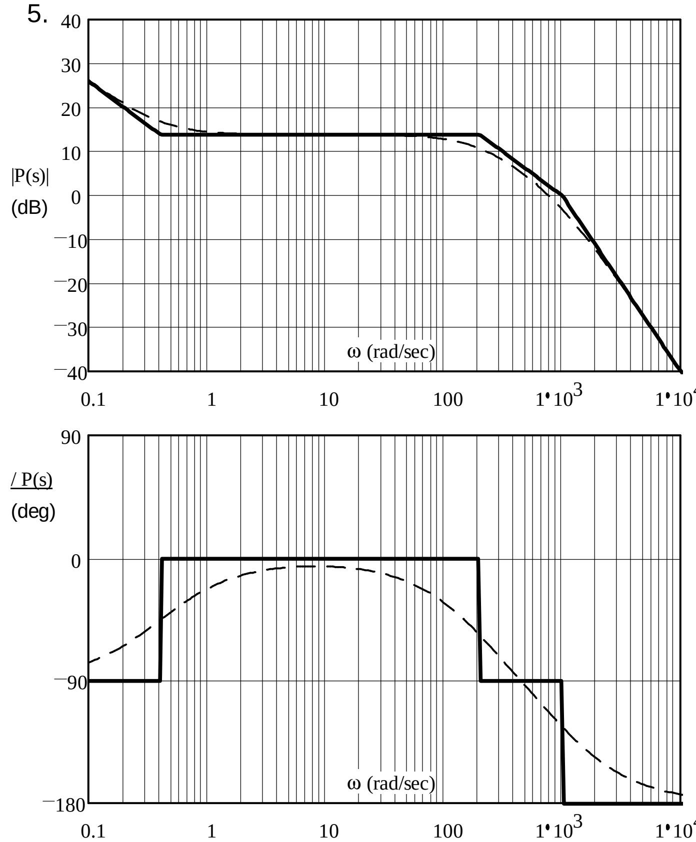
PI	PD
Lag	P
PID	Lead

3. a) To increase speed and/or decrease overshoot. b) Lead
   c) To eliminate steady-state error and reject disturbances d) Lag

4.

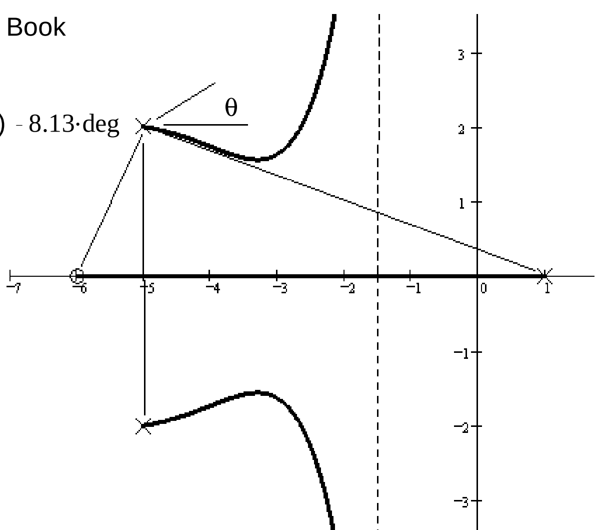


5.



Open Book

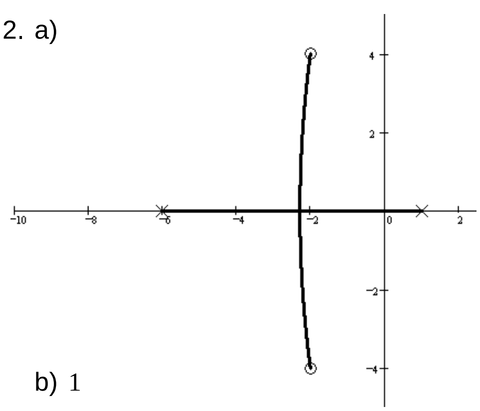
1. a)



   b) $-8.13\cdot\text{deg}$

   d) $k > 4.833$

2. a)



   b) 1

3. a) $(s+40.1)$ b) 8.8
   c) $k_d := 8.8$ $k_p := 353$
   d) Increasing the gain would improve the system.