Sample Midterm #2

ELEE 4700/5700, Controls II

Professor Hill

University of Detroit Mercy, Fall 2011

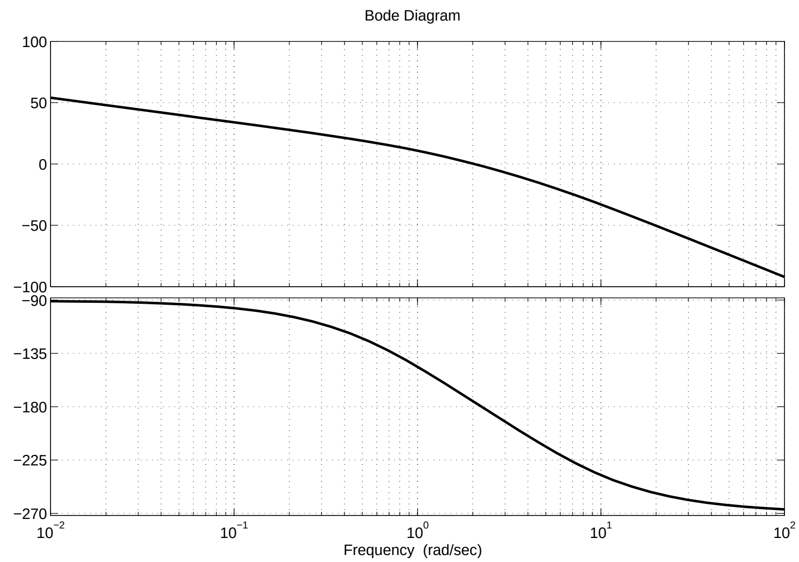
Name: ______________________________

Date: ______________________________

Scores:	Problem 1	________	35 points
	Problem 2	________	20 points
	Problem 3	________	45 points
	total	________	100 points

Please write your answers in the spaces provided on the exam. If you use the backs of the pages or extra sheets, provide a note and/or arrows to point out the location of your solution.

1. (35 points) Below is given the frequency response of an uncompensated plant.



(a) (6 points) Consider that it is desired to design a lead compensator with unity DC gain. Determine the ratio between the zero and pole of the compensator that will provide a maximum additional phase lead of 45°

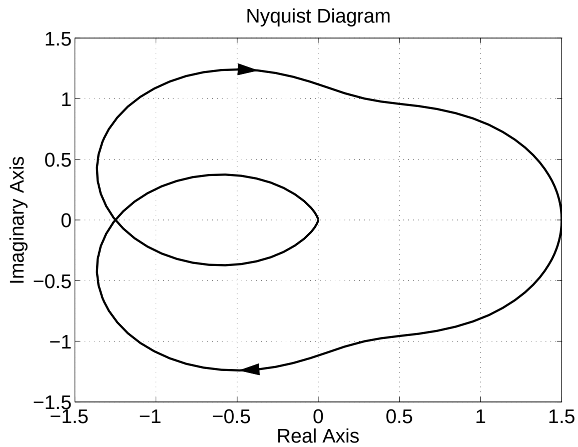
(b) (8 points) Determine the frequency where to center the pole and zero of the lead compensator to achieve the maximum increase in phase margin.

(12 points) Based on your answers to Part (a) and Part (b), what is your resulting lead compensator? What is the resulting phase margin when this compensator is put into a unity feedback architecture with the given plant?

(c) (3 points) For the design of the lead compensator performed in this problem, would you prefer to use a root locus approach or the approach you used? Explain.

(d) (6 points) State two other approaches to control you could use to achieve the same amount of phase margin provided by this lead compensator and discuss the associated tradeoffs.

2. (20 points) Consider the Nyquist diagram shown below.

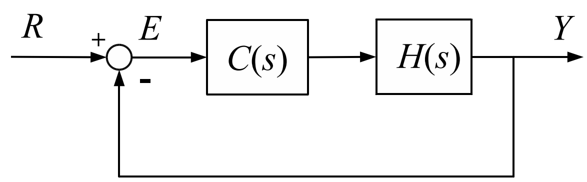


(a) (12 points) Choose the transfer function that corresponds to the diagram, and briefly explain your choice.

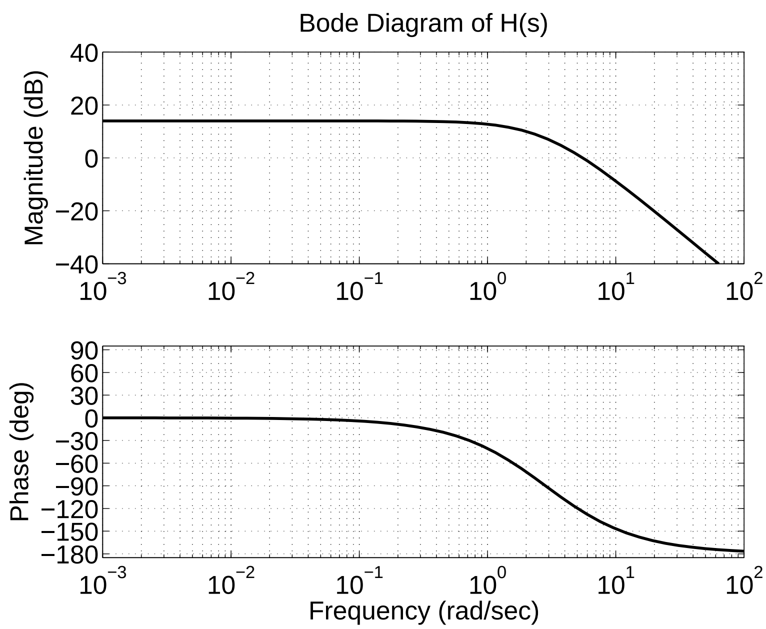
$$
\begin{aligned}
G_1(s) &= \frac{15}{s+10} \\
G_2(s) &= \frac{6}{(s+2)^2} \\
G_3(s) &= \frac{15}{s^2+s+10} \\
G_4(s) &= \frac{15}{(s+1)(s^2+s+10)} \\
G_5(s) &= \frac{30}{(s+1)(s+2)(s+3)}
\end{aligned}
$$

(b) (8 points) Is the system stable in closed-loop with unity feedback? Explain why or why not using the provided Nyquist diagram.

3. (45 points) You are to design a controller $C(s)$ for the plant $H(s)$ as shown in the following unity feedback configuration.



In order to perform your design, you have also been given the following frequency response information for the uncompensated plant $H(s)$.



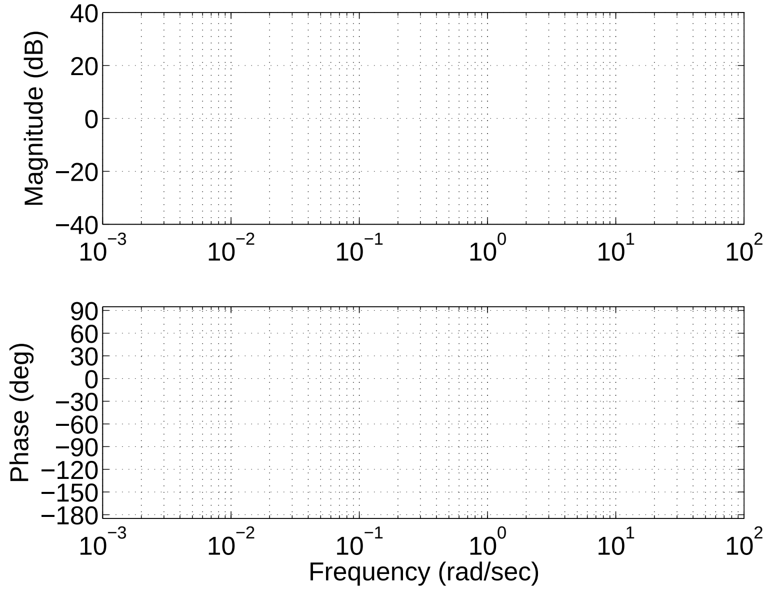
(a) (5 points) What range of gain K can be added to the original system $H(s)$ such that the system in unity feedback remains stable? Justify your answer.

(b) (8 points) Now consider that the pure time delay e^{-Ts} has been put in series with the original plant $H(s)$. What range of delay T results in the system being stable when in unity feedback?

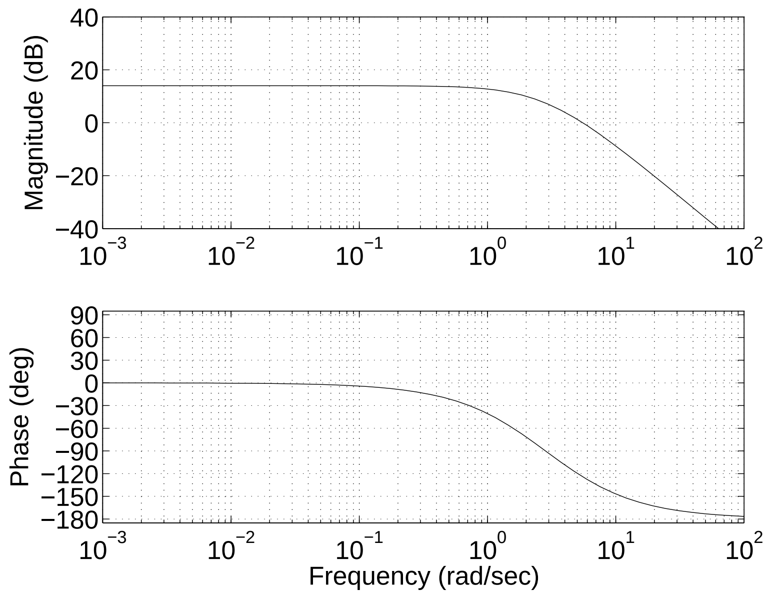
(c) (15 points) It is ultimately desired that the resulting closed-loop system have a steady state error less than 0.2 for a constant step reference input. For the system $H(s)$ with a proportional controller, $C(s) = K$, what value of K will meet this control goal? What is the predicted overshoot with this value of K?

(d) (12 points) Consider a lag compensator: $C_{\text{lag}}(s)\dfrac{s+0.1}{s+0.01}$. On the given graphs, first sketch the Bode plot of $C_{\text{lag}}(s)$. Then sketch the Bode plot of $C_{\text{lag}}(s)H(s)$ (the plot of $H(s)$ is given for your reference again here).

Bode plot of $C_{\text{lag}}(s)$



Bode plot of $C_{\text{lag}}(s)H(s)$



(e) (5 points) How will the response of the system change with the addition of the lag compensator? Justify your answer.