Name: _____

EE 105 Homework 6

Due 5pm, November 15 2019

(or when I return your midterm exams, whichever is later)

Problem 1: Damping ratio and phase margin

Consider the system

$$G(s) = \frac{\omega_n}{s\left(s + 2\zeta\omega_n\right)}$$

which under unity feedback produces an overall (familiar) TF of

$$H(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

a) Use MATLAB to draw Bode plots of $G(s)$ for $\zeta = 0.1, 0.5, 0.9$. It's best if you draw them all on one plot.

b) For each value of ζ, find the phase margin. Comment on the relationship between the phase margin and ζ.

Problem 2: Compensation

For each of the controllers below ($C(s) = ...$), do the following:

i Use MATLAB to make a Bode plot of $C(s)$.

ii Identify the relationship between the coefficients and the break point(s), and write this mathematically.

iii Describe what the controller does to the phase margin, assuming the poles/zeros are placed where they make a difference.

iv Determine how the controller responds at DC (i.e., what does it do with steady-state error)?

a) Proportional control ($C(s) = k_P$)

b) PD control ($C(s) = k_P + sk_D$)

c) PI control ($C(s) = k_P + k_I/s$)

d) Lead compensation: $\left(\frac{s+z}{s+p}\right)$ with $z < p$ or $\left(\frac{T_D s+1}{\alpha T_D s+1}\right)$, with $\alpha < 1$

e) Lag compensation: $\left(\frac{s+z}{s+p}\right)$ with $z > p$ or $\left(\alpha\frac{T_D s+1}{\alpha T_D s+1}\right)$, with $\alpha > 1$

Problem 3: Reflection

a) Approximately how long did you spend on this problem set?

b) What questions do you have about this problem set, or about the course material so far?