Name: ____________________

EE 105 Homework 6

Due 5pm, November 1 2019

Problem 1: Sketching root loci

For each of the following transfer functions, sketch the root locus by hand. You don't have to get the curly shapes exactly right, but you should have the basic shapes and start/end points correct. You're welcome to check your answers with MATLAB, so you have no excuse for getting these wrong!

a)

$$H_1(s) = \frac{1}{(s^2 - 2s + 2)(s + 3)(s + 1)}$$

b)

$$H_2(s) = \frac{s^2 + 4s + 8}{s^2 + 1}$$

c)

$$H_3(s) = \frac{s^2 + 4s + 8}{(s^2 + 1)(s^2 + 2s + 1)}$$

d)

$$H_4(s) = \frac{s + 10}{(s + 2)(s + 4)}$$

Problem 2: PID in root locus

Suppose we have the system

$$H(s) = \frac{1}{s^2}$$

a) Can this system be controlled using proportional feedback alone? Show a graph or equation to justify your answer.

b) Apply PD control to the system, using a ratio of $k_P/k_D = 0.1$. Plot the root locus (MATLAB is fine).

c) Apply PI control to the system, using a ratio of $k_P/k_I = 1$. Plot the root locus (MATLAB is fine).

d) Based on these plots and what you know about PID, explain briefly what happens to a feedback system as a result of applying derivative or integral gain. Can these change the stability of the system, and if so, how?

Problem 3: Stables gains

Suppose we apply proportional feedback control to the system

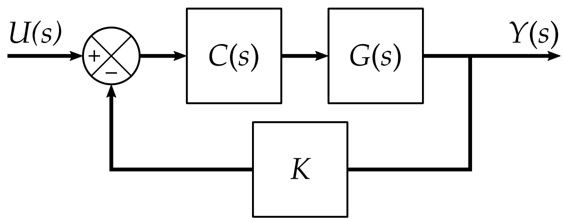
$$H(s) = \frac{(s + 10)}{(s + 3)(s + 5)(s - 1)}$$

For what range of K_p is the system stable? You should solve this analytically, but you can use MATLAB to check your answer.

Problem 4: Control with root locus

An obvious use of the root locus is to find a gain that achieves particular properties, but it can also be a helpful way of thinking about the effect of adding a controller which introduces poles or zeros into the overall transfer function.

For each of the following transfer functions, find a single-term controller (i.e., a single pole or zero in the form $s+\alpha$ or $\frac{1}{s+\beta}$) such that applying feedback achieves the stated objective for the smallest (closest to zero) possible integer α or β.



a) Makes the system stable for some gain K:

$$H(s) = \frac{1}{s(s-2)}$$

b) Makes the poles real and ≤ -10 for some gain K:

$$H(s) = \frac{1}{s^2+4s+20}$$

c) Makes the system unstable for some gain K:

$$H(s) = \frac{1}{(s+10)(s+2)}$$

Problem 5: 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?