EE 489, Fall 2015, Take Home Design Problem.
Due December 8 in class.

This take-home design problem will test your understanding of the root-locus design technique. This is meant to be an individual effort. You may not ask for help from anyone else, or collaborate with your classmates or others. I ask that you please include a signed statement on your solutions that you have done your own work.

In this problem, you will consider the regulation of the plant \( G(s) = \frac{s+2+0.5q}{s(s^2+2s+2)} \), where \( q \) indicates the month you were born (January=1, February=2,...). The feedback control configuration is shown below:

![Control Configuration Diagram]

First, you will consider proportional control of the plant using the controller \( D(s) = K \), where \( K \geq 0 \) is a designable gain.

a. Please determine the system type for reference tracking.

b. The poles of the closed-loop system as \( K \) is varied from 0 to \( +\infty \) form a root locus. Please find the \( L(s) \) for this root locus.

c. Please sketch the root locus by hand. You should apply any of the six rules that are needed to sketch the locus accurately.

d. Please use Matlab to draw the root locus.

e. What is the best achievable settling time, and what gain \( K \) achieves this settling time? How about the best achievable rise time?

f. If we would like to limit the overshoot to 40%, what is the best achievable rise time?

g. If we would like to limit the steady-state tracking error to 0.02, what is the best achievable settling time?
Now consider PD control of the plant using a controller of the form $D(s) = K(s + 9)$, where $K \geq 0$ is a designable gain.

h. The poles of the closed-loop system as $K$ is varied from 0 to $\infty$ are again specified by a root locus. Please find $L(s)$ for this root locus, and use Matlab to draw the root locus.

i. Using Root Locus Rule 6, please exactly determine points on the root locus corresponding to repeated roots, if any.

j. What are the best achievable rise time and settling time in this case?

k. What is the best achievable rise time, if we want to limit the overshoot to 40%? What if we want to eliminate the overshoot entirely?

l. In general, what is the benefit of a PD controller compared to a proportional controller? Do we see this benefit for the particular plant considered here? Please explain.