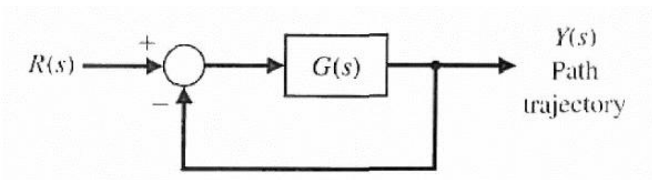
ME 5200/6200 Classical Controls **Fall 2020**

Homework 06 **Due Thurs, Oct. 22 at the beginning of class**

Do the following problems and show all your work for full credit. Note: not all problems will be graded, but you must complete all problems to get full credit.

Problem 1 [20 pts]

Consider the following closed-loop system:

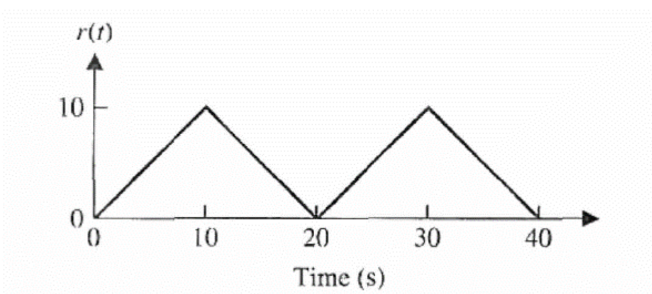


Let the transfer function for the system be:

$$G(s) = \frac{75(s+1)}{s(s+5)(s+25)}$$

(a) Find the steady state error when the input r(t) is a ramp.

(b) Now suppose the input is the following function:



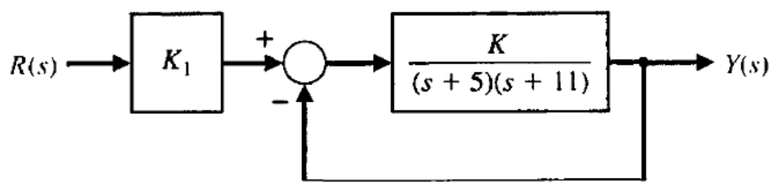
Using Matlab, simulate the response of the closed-loop system and show plots for the output vs. time and the error vs. time. Include your Matlab code. Describe the error behavior and how it relates to what you found in Part (a). In particular, does the analysis in Part (a) relate to the results you're seeing in the plots of the response and error?

Problem 2 [20 pts]

For the closed-loop system below,

(a) Determine the steady-state error for a unit step input in terms of K and K_1, where $E(s) = R(s) - Y(s)$.

(b) Select K_1 so that the steady-state error is zero.



Problem 3 [35 pts]

Consider a non-unity feedback control system where the controller and system transfer function and the feedback transfer function are given by:

$$G_c(s)G(s) = \frac{2}{s + 0.2K} \quad \text{and} \quad H(s) = \frac{2}{2s + \tau}.$$

(a) [5 pts] Draw the block diagram and label all signals and blocks.

(b) [5 pts] Find the transfer function from the input R(s) to the error E(s).

(c) [5 pts] Determine the expression for the steady-state for a given R(s).

(d) [10 pts] Suppose the input is unit step and τ=2.4, find the K value such that the steady-state error is zero

(e) [5 pts] For the chosen value of K in Part (d), determine the percent overshoot, settling time, and time to peak based on the equations that were given in class.

(f) [5 pts] Use Matlab to do the step response and show plot of output vs. time. From the plot, determine the percent overshoot, settling time, and time to peak. Compare these values with the ones from Part (e) and note the differences and explain.

Problem 4 [20 pts]

A unity feedback control system has the open-loop transfer function

$$G(s) = \frac{A}{s(s+a)}.$$

a) Compute the sensitivity of the closed-loop transfer function to changes in the parameter A.

b) Compute the sensitivity of the closed-loop transfer function to changes in the parameter a.

c) If the unity gain in the feedback changes to a value of $\beta \neq 1$, compute the sensitivity of the closed-loop transfer function with respect to β.

d) Assuming $A = 1$ and $a = 1$, plot the magnitude of each of the above sensitivity functions for $s = j\omega$ using the loglog or semilogx commands in MATLAB. Comment on the relative effect of parameter variations in A, a, and β at different frequencies ω, paying particular attention to DC (when $\omega = 0$).