Chapter 7 HW Assignment & Hints

Review Questions. 1, 3, 4, 5, 9. As usual, I think these are just a matter of text lookup.

Problem 2. (a) The steady-state error can be read right from the plot.

(b) Now the input is $r(t) = t$, you can ignore the $u(t)$ (it means a unit step starting at $t = 0$). Since the input in part (a) was a "steeper" ramp, the error in (b) should be less. For a linear system, if you decrease the input by some amount, all responses decrease by the same proportion. So with a "gentler" ramp, the error is less.

Problem 10. To do parts (a) and (b) you need to find the closed-loop TF and find ζ and ω_n. You've done this stuff before.

In parts (c), (d), and (e) you can again ignore the $u(t)$, the respective inputs are a step $r(t) = 5$, a ramp $r(t) = 5t$, and a parabola $r(t) = 5t^2$. I would suggest finding the appropriate error constants, and calculating the steady-state error using those.

Problem 15. The system **TYPE** is the number of "free" integrations in the forward path.

To find the type, first reduce the inner loop. The forward path for the overall system will just be the product of this inner loop TF with the $\frac{1000}{s}$. The number of free integrations in the resulting forward path TF will be the type.

Problem 38. Here I would like you to find the error **SEPARATELY** due to the unit step input, and the unit step disturbance. The total error will be the sum of these two errors, but I think it's instructive to first find them separately.

You can use the position error constant to find the error due to the reference input, but you have to use the **disturbance transfer function** $\frac{E(s)}{D(s)}$ to find the error due to the disturbance.

I found the error from the unit step disturbance to be much larger than the error from the unit step reference input.

Problem 40. Here you have to construct a Simulink model of the system, and use that to confirm your analysis. Parts (a), (c), and (e) are "hand" analysis, and parts (b), (d), and (f) are Simulink validations.

To "submit" the Simulink material, please capture a screenshot of your Simulink model, and also capture screenshots of the "scope" that displays the appropriate response for parts (b), (d), and (f).

BTW, the error $E(s)$ is not shown in Figure P7.16, but (as usual) it is the signal that leaves the left summing junction: $E(s) = R(s) - C(s)$.

Starr Problem. This is a problem I created that deals with **SENSITIVITY ANALYSIS.**

Consider a simple **angular velocity control system**, using an amplifier and a DC motor/load. It is possible to have both an **open-loop** angular velocity control system, and a **closed-loop** system.

Block diagrams of both open- and closed-loop systems of this type are shown on the next page.

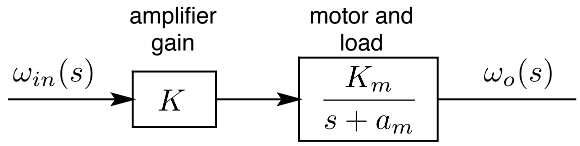

Figure 1: Open-loop angular velocity control system.

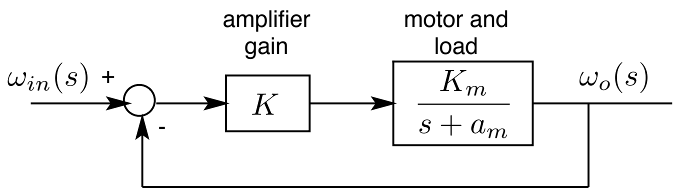

Figure 2: Closed-loop angular velocity control system.

Please do the following:

(a) Find the transfer function $\frac{\omega_o(s)}{\omega_{in}(s)}$ for the open-loop system.

(b) Find the transfer function $\frac{\omega_o(s)}{\omega_{in}(s)}$ for the closed-loop system.

(c) Find the **DC gain** of the transfer function $\frac{\omega_o(s)}{\omega_{in}(s)}$ for the open-loop system.

(d) Find the **DC gain** of the transfer function $\frac{\omega_o(s)}{\omega_{in}(s)}$ for the closed-loop system.

(e) Find the **sensitivity** of the DC gain of (c) to the parameter K.

(f) Find the **sensitivity** of the DC gain of (d) to the parameter K.

(g) Which system has the **least** sensitivity of DC gain to variations in amplifier gain K?