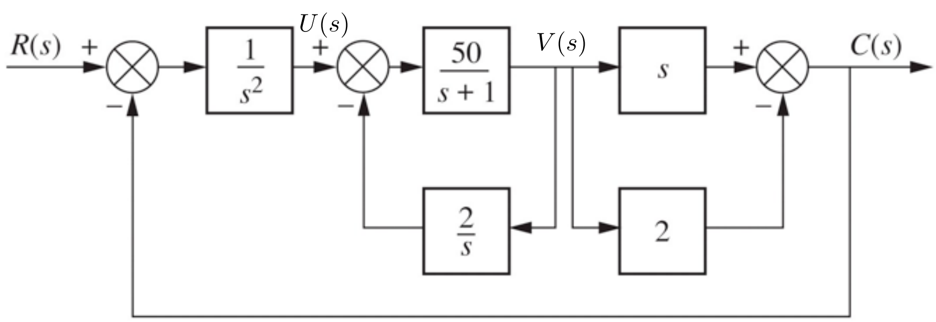
Chapter 5 HW Assignment & Hints

Review Questions. 1, 6. As usual, I think these are just a matter of text lookup.

Problem 1(a). I modified text Figure P5.1 to give "names" to two of the internal variables in the block diagram:



Starting from the "inside out"...first reduce the inner forward path $V(s)/U(s)$, then the inner parallel blocks $C(s)/V(s)$, then the outer feedback loop.

I got the denominator of $T(s) = s^3 + s^2 + 150s - 100$.

(b) Using MATLAB, follow basically the same procedure. I wrote a script and got the same result.

NOTE: MATLAB may not cancel the "s" in the final numerator and denominator of the result. **UPDATE:** MATLAB function `minreal()` does any needed cancellation. Thanks to all the students who told me about this function.

Problem 11. Reduce the single feedback loop and the rest is similar to what you've done in Chapter 4.

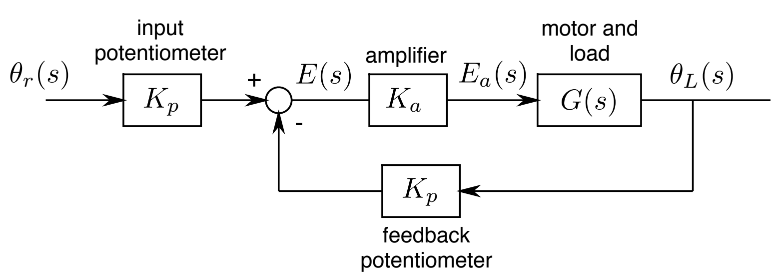
I obtained the 2% settling time $T_s = 0.53$ sec.

Problem 15. Reduce the single feedback loop, and again the problem is like the Chapter 4 stuff.

Starr DC Motor Problem. Consider the **DC Motor and Load** that I assigned for Chapters 3 and 4. This motor will be driven by an amplifier with voltage gain K_a.

The position of the load will be measured by the potentiometer described in Chapter 1 HW Problem 1: a 10-turn potentiometer with ±50V across it. We found the "transfer function" (it's just a constant gain) back in the Chapter 1 HW. Also consider that the reference input is the desired angle of another of the same potentiometers.

A block diagram of the system is shown below:



Let the transfer function of the "motor and load" be the $G(s)$ of the Chapter 4 HW problem, with load position θ_L in rad, and motor voltage e_a in V. Both the "input potentiometer" and "feedback potentiometer" are identical, and have transfer function (gain) of K_p V/rad in accordance with Chapter 1 Problem 1.

(a) Find the closed-loop transfer function $\dfrac{\theta_L(s)}{\theta_r(s)}$.

(b) Find the value of amplifier gain K_a to yield critical damping.

(c) What is the DC gain of the closed-loop system?

(d) Plot the step response of the system to a 1-turn step input.

(e) Plot motor voltage e_a in response to the input of (d). You will have to re-draw the block diagram showing motor voltage as the output. The "motor and load" will now be in the feedback path, and you will have to find the transfer function $E_a(s)/\theta_{r(s)}$. It should have the same denominator as in (a), but the numerator will be different.