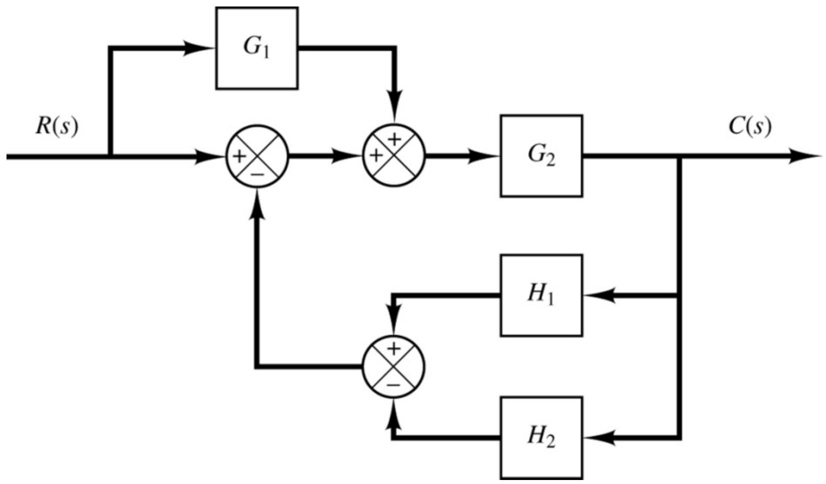
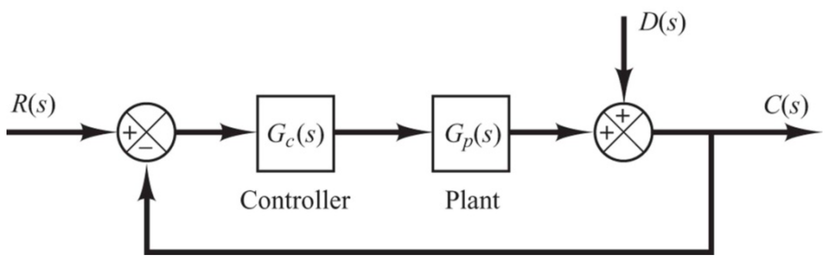
ESE 406/505 & MEAM 513 - SPRING 2013 - HOMEWORK #4
Block Diagrams & Time Response
DUE 6-Feb-2013 (Late Pass 11-Feb-2013)

1. (This is problem B-2-2 in Ogata.) Find the closed-loop transfer function, *C(s)/R(s)*, for the figure shown below.



Answer: $\dfrac{C(s)}{R(s)} = \dfrac{(1+G_1(s))G_2(s)}{1+G_2(s)H_1(s)-G_2(s)H_2(s)}$

2. (This is problem B-2-5 in Ogata). Find an expression for *C(s)* for the figure shown below.



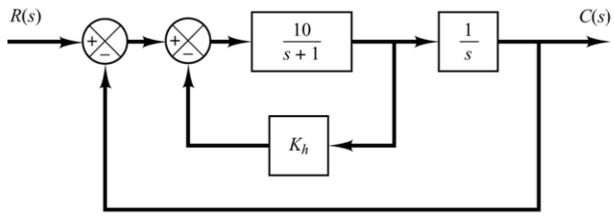
Answer: $C(s) = \dfrac{G_C(s)G_P(s)}{1+G_C(s)G_P(s)}R(s) + \dfrac{1}{1+G_C(s)G_P(s)}D(s)$

Notice that the denominators are the same. There is only one closed-loop denominator, which means only one set of closed-loop poles.

3. (This is problem B-5-1 in Ogata).
(a) A thermometer requires 1 minute to indicate 98% of the response to a step input. Assuming the thermometer is a first-order system, find the time constant.
(b) If the thermometer is placed in a bath, the temperature of which is changing linearly with time at a rate of 10 degrees per minute, how much error does the thermometer show?

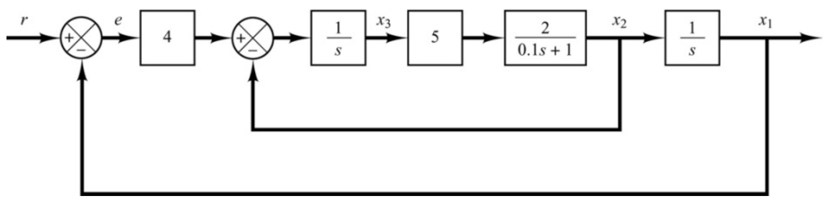
Answers: (a) 15 seconds; (b) 2.5 degrees

4. (This is a modified version of problem B-5-7 in Ogata). Determine the value of K_h in the figure below that will yield a closed-loop damping ratio of 0.5. Make a graph of the unit step response of the closed-loop system for the value of K_h you determined. On the same graph, add the unit step response of the system with $K_h=0$. Be sure to format the graph nicely and include a legend so it is easy to identify each curve. *Answer*: $K_h=0.216$.



5. Please download the files `HW04.m` & `HW04sim.mdl` from blackboard. Go through the `HW04.m` script and run it. You will need to understand how the commands in that script work in many future homework assignments. Use the internet, MATLAB's help system, or office hours if you need help.

   You can practice using many of these commands on the following system. All you have to submit is a nice graph of the closed-loop unit step response. That is, a graph of $x_1(t)$ for unit step $r(t)$.



6. Read Section 5.3 in Ogata, particularly the part about **Transient Response Specifications**, on pages 169 to 175. Assuming a second-order system, what time domain specifications are consistent with the pole location boundaries shown in the figure at right? (There are 3 specifications shown, corresponding to the inequalities on the figure. These correspond to 3 of the time-domain specifications in the figure below.)

   This figure is taken from Aeronautical Design Standard 33, a system requirements document for military helicopters. The boundaries are for the poles in the lateral-directional response of the helicopter in forward flight. Virtually all airplanes and helicopters have a lightly damped pole known as the "Dutch Roll Mode". It is stabilized, to meet requirements such as those shown here, using yaw rate feedback. We will consider this feedback on the 747 airplane in next week's homework.