EE361: Control Systems

Homework 4

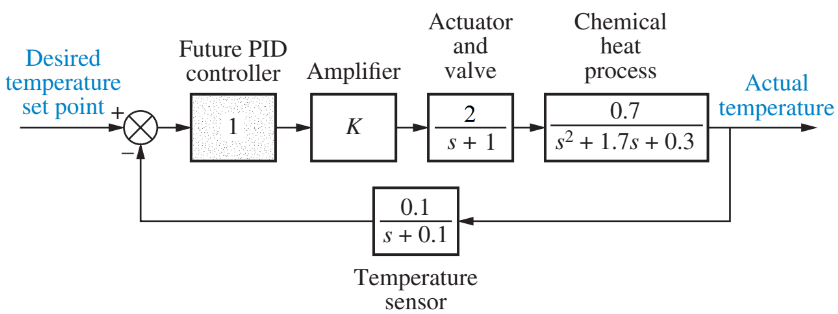
Due Mon Apr 15, 1:45 PM *Spring 2019*

Some tips to avoid plagiarism cases:

- Do not copy the solutions of your classmates.
- Your are encouraged to discuss the problems with your classmates in whatever way you like but make sure to REPRODUCE YOUR OWN SOLUTIONS in what you submit for grading.
- Cite all the online sources that you get help from.
- Keep your work in a secure place.

Problem 1

A common application of control systems is in regulating the temperature of a chemical process. The flow of a chemical reactant to a process is controlled by an actuator and valve. The reactant causes the temperature in the vat to change. This temperature is sensed and compared to a desired set-point temperature in a closed loop, where the flow of reactant is adjusted to yield the desired temperature. In class, we will soon learn how a PID controller is used to improve the performance of such process control systems. Figure shows the control system before the addition of the PID controller. The PID controller is replaced by the shaded box with a unity gain.



(a) Convert the system into an equivalent unity feedback configuration and find the open-loop transfer function $T_{\mathrm{OL}}(s)$ of the unity feedback system.

(b) What is the system type? Give a reason for your answer.

(c) In terms of K, find the steady-state error in the response of this system for a unit step input.

(d) In terms of K, find the steady-state error in the response of this system for a unit ramp input.

(e) Find the closed-loop transfer function $T(s)$ of this system.

(f) For this system, find the range of amplifier gain, K, to keep the system stable. (Hint: Routh-Hurwitz)

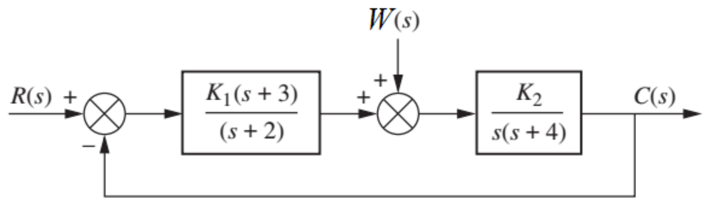
(g) Looking at the transfer functions in the figure and $T(s)$ that you found, what do you think is the effect of feedback on the stability of the system? With feedback is it more stable or less stable?

(h) Find the range of K to keep the steady-state error less than 25% for a step input. (Note: Steady-state error analysis only works for stable systems. So the range of K must fulfill the stability condition as well.)

(i) Is it possible to keep the steady-state error less than 8% for any value of K? Explain.

Problem 2

For the following system, where $W(s)$ is a disturbance signal affecting the system as shown,



(a) Design the values of K_1 and K_2 to meet both the following specifications

- Steady-state error component due to a unit step disturbance is -0.00012
- Steady-state error component due to a unit ramp input is 0.03

(b) Assuming a unit ramp input and a unit step disturbance, find the sensitivity of the disturbance steady-state error for changes in

  (i) K_1

  (ii) K_2

  Use the values of parameters and steady-state errors found in (a).
