EE361: Control Systems

Homework 5

Due Fri May 3, 11:30 AM

Spring 2019

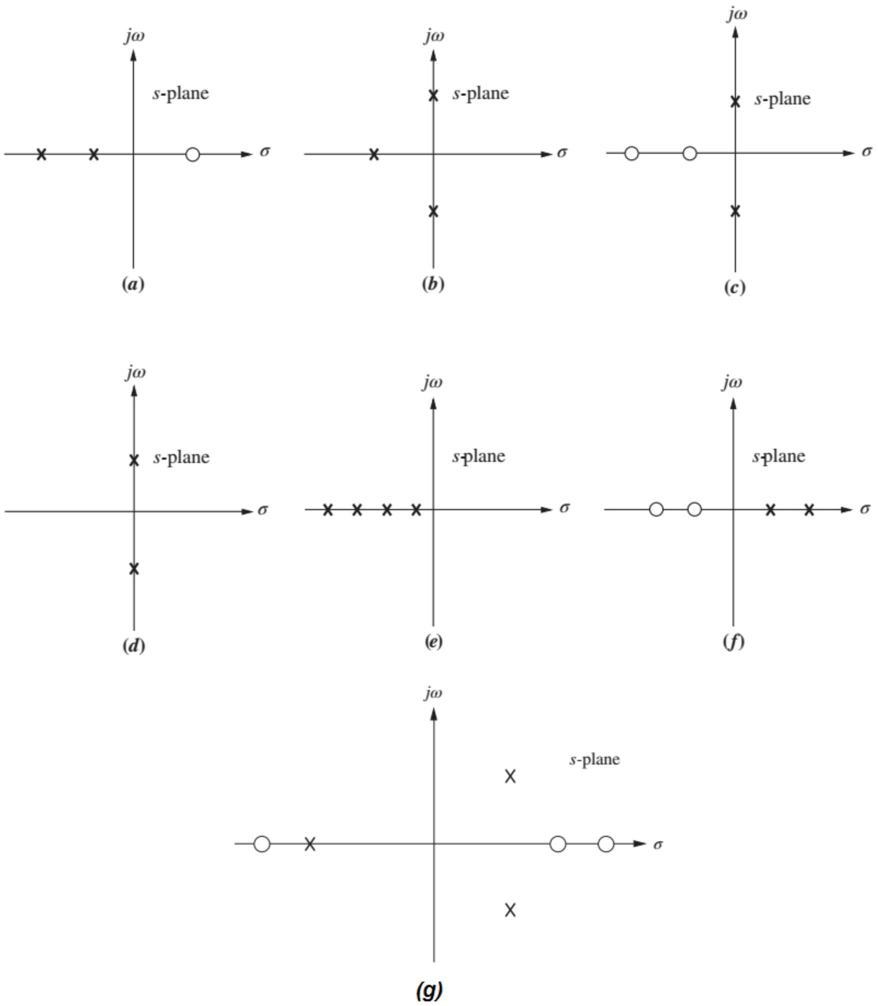
Some tips to avoid plagiarism cases:

- 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

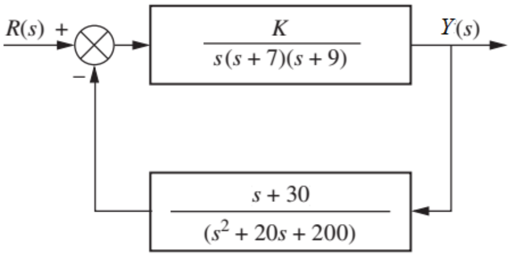
Each of the following plots shows poles and zeros of an open-loop transfer function $G(s)$ with unity feedback. Sketch the root locus of the closed-loop system for $0 < K < \infty$.

(If we vary K continuously from 0 to ∞, roots of the closed-loop characteristic equation $1 + KG(s) = 0$ change their location and move on a curve called root locus. These roots are actually the location of closed-loop poles of the unity feedback system.)



Problem 2

For the following closed-loop system,



(a) Find the range of values of K to yield stability. [Hint: Closed-loop characteristic equation]

(b) Is there a value of K for which the system's step response will be undamped? If yes, find that value.

(c) Sketch the root locus of the system.

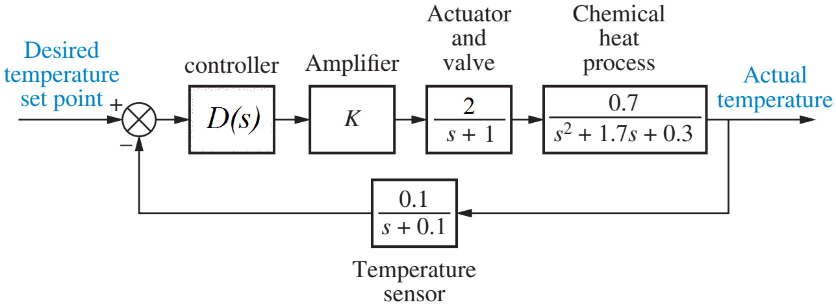
[Hint: Convert the closed-loop characteristic equation to the form $1 + KT_{\mathrm{OL}}(s) = 0$, where transfer function $T_{\mathrm{OL}}(s)$ is your equivalent open-loop transfer function with unity feedback.]

(d) Find the value of K that will yield an overshoot of 5% of the step response of the system's dominant poles. (You can solve this part using `rlocus()` plot on MATLAB but you must mathematically verify that at this value, the step response of the system's dominant poles have an overshoot of 5%.)

(e) Find the value of K that will yield closed-loop poles that give approximately critically damped response. (You can solve this part using `rlocus()` plot on MATLAB but you must mathematically verify that at this value, the system's dominant poles have a critically damped response.)

Problem 3

Consider the temperature control system for a chemical process. You have already analyzed this system in Homework 4.



The system without any compensation ($D(s) = 1$) is operating with a 20% overshoot and a peak time of 14 seconds. There is also a considerable steady-state error.

(a) Estimate the value of K at the uncompensated operating specifications given above.

(b) Design a PID controller so that the compensated system will have a peak time approximately 10 s and 5% overshoot to a unit step input. Attach the graphs of all your designed root locii and final step response. (Assume $K = 1$ for this part.)

(c) Now design a lag-lead compensator to meet the specifications in (b) and reduce the steady-state error to 10% of its original value. Attach the graphs of all your designed root locii and final step response.