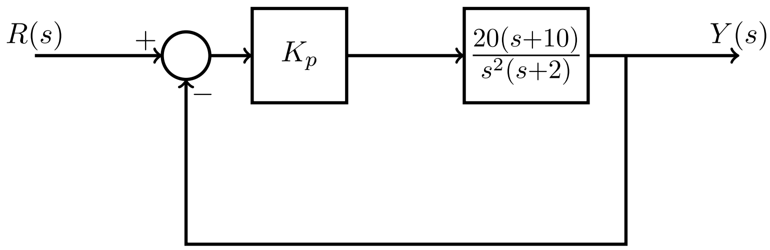
EEENG307: Intro to Feedback Control

Fall 2020

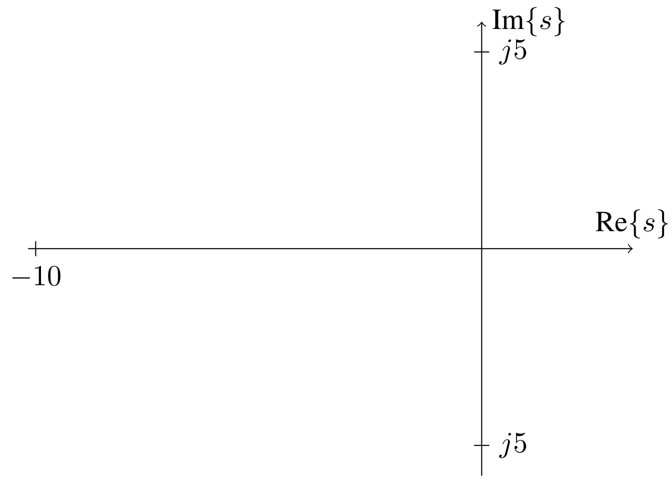
Homework Assignment #8

Due: Wednesday, Oct 28th, 11:59pm

1. You are considering implementing the proportional control system shown below. The desired specifications are a settling time of $t_s \leq 2$ s and a rise time of $t_r \leq 0.5$ s.

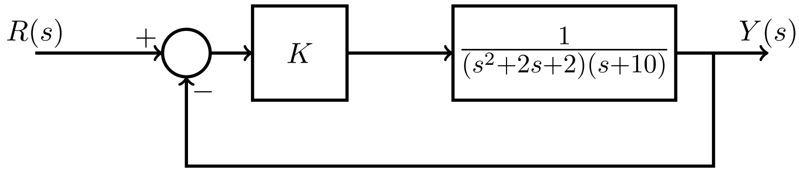


   (a) Sketch the appropriate region in the complex plane where the dominant closed loop poles should lie for all specifications to be met

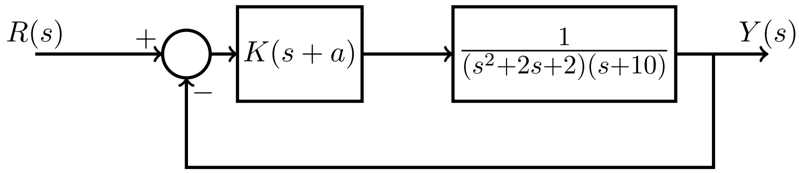


   (b) By sketching the root locus (also on the above axis) determine whether all closed loop poles can be placed in the region sketched in part (a) for some value of K_p.

2. (a) Sketch the root locus corresponding to the possible closed loop pole locations for the following feedback system

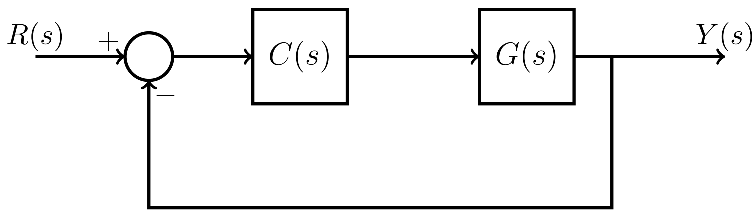


(b) Suppose the feedback control system is modified to be the following. Calculate the value of a such that two of the closed loop poles asymptotically approach a line with real part $\mathrm{Re}\{s\} = -2$ as $K \to \infty$.



3. You want to design an orientation controller for a satellite system whose thrusters provide a torque τ to modify the angular position θ with transfer function

$$G(s) = \frac{\theta(s)}{\tau(s)} = \frac{0.1}{s^2}.$$



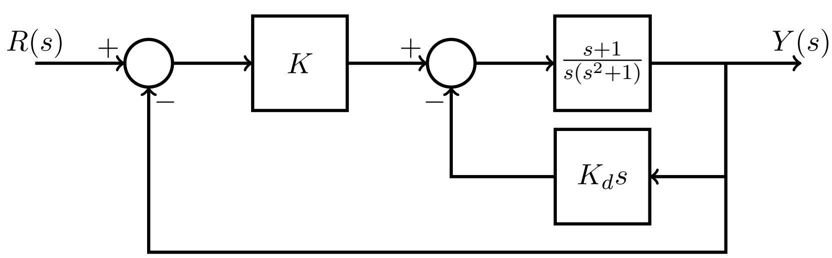
You want to add damping to the system to minimize any oscillations (%OS < 5%) but still maintain a 1% settling time of less than 60 s to a unit step input.

(a) Sketch the allowable pole locations in the complex plane to meet the %OS and settling time requirements.

(b) Which type of controller is more likely to improve the damping: PI or PD? Why?

(c) Import your plant transfer function $G(s)$ into Matlab's sisotool and insert a real zero at an arbitrary value (if you answered PD) or a real pole at 0 and a real zero at an arbitrary value (if you answered PI). Move your arbitrary zero and change your closed-loop gain until you have achieved the required specifications. Submit your root locus, your final $C(s)$, and your step response from sisotool (showing the specifications have been met) as part of your homework.

4. Consider the following system.

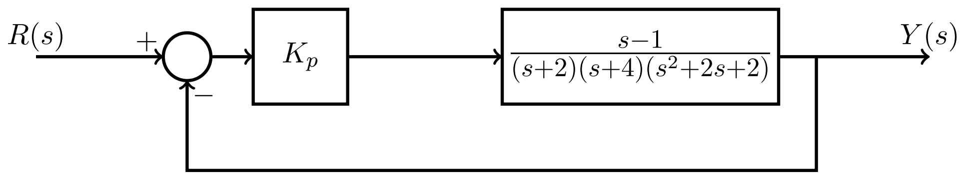


(a) Sketch the root locus (of closed loop poles as K varies) if $K_d = 0$

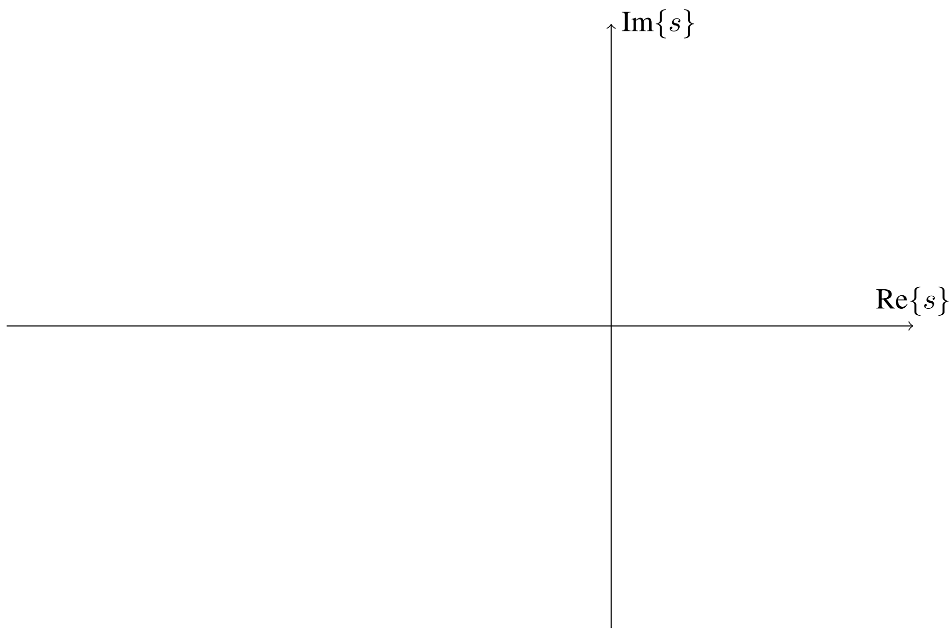
(b) Sketch the root locus (of closed loop poles as K varies) if $K_d = 2$

(c) In which cases, if any, does there exist a K such that the closed loop system is stable?

5. You are considering implementing the proportional control system shown below. The desired specifications are a settling time of $t_s \leq 2.3$ s and a rise time of $t_r \leq 2.2$ s.

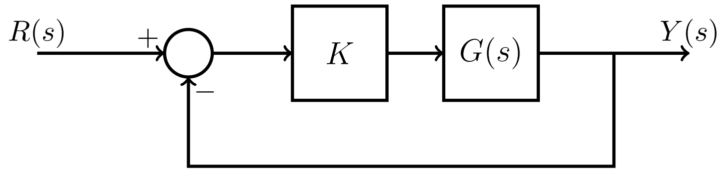


(a) Sketch the root locus on the complex plane. Mark and label the Im$\{s\}$ and Re$\{s\}$ axis at important values.

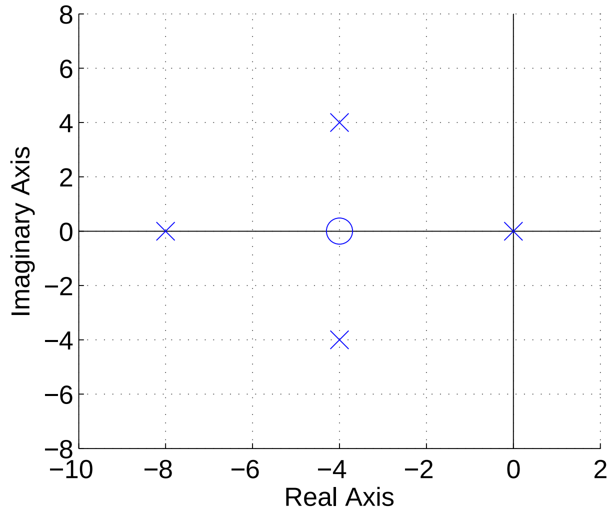


(b) On the same graph as the preceeding question, shade the regions of the complex plane where the dominant closed loop poles should lie for all specifications to be met. Can all the specifications be met?

6. Quiz Question Monday: Consider a closed loop system in the standard negative unity feedback configuration shown below



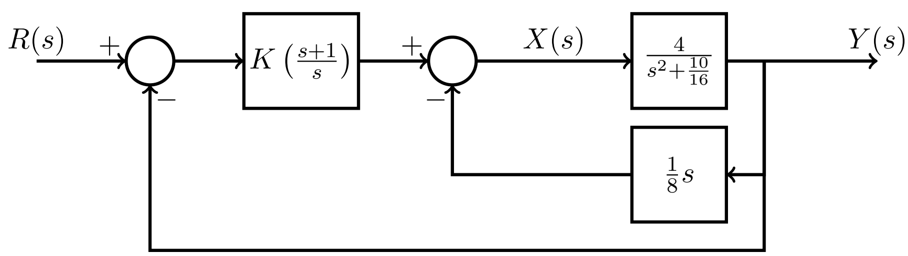
The pole zero map of the transfer function $G(s)$ is as follows:



(a) Sketch the root locus of closed loop poles as K goes from 0 to ∞. Include arrows designating the direction the roots travel along the loci as K increases.

(b) Based on your sketch, is it possible to choose a value of K such that the closed loop system is unstable?

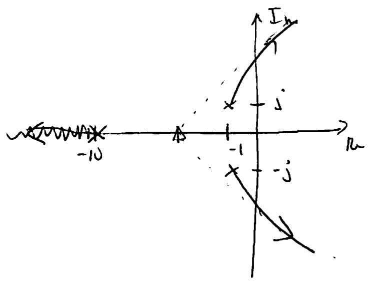
7. Quiz Question Wednesday: Consider the following system.



Sketch the root locus of closed loop poles that can be achieved by varying K. Is there a K for which the closed loop system is unstable?

Solutions:

1. (a) No partial solution
   (b) Not all poles enter desired region
2. (a)



   (b) $a = 8$
3. (a) No partial solution.
   (b) A PD controller can be used to add damping to a system.
   (c) Many possible solutions.
4. (c) Case (b) only
5.
   - (a) 4 poles at $s = -2, -4, -1 \pm j$, 1 zero at $s = 1$. Center of asymptotes $\sigma_A = -3$, asymptotes $\phi_A = 60°, 180°, 300°$
   - (b) $t_s = 2.3$ imples $\sigma = 2$ $t_r = 2.2$ implies $\omega_n = 1$, so no complex poles enter shaded region.