Summer 2023

AME 455: Control System Design

Final Exam

Start Date: July 6, 2023 @ 8:00 AM

End Date: July 7, 2023 @ 7:59 AM

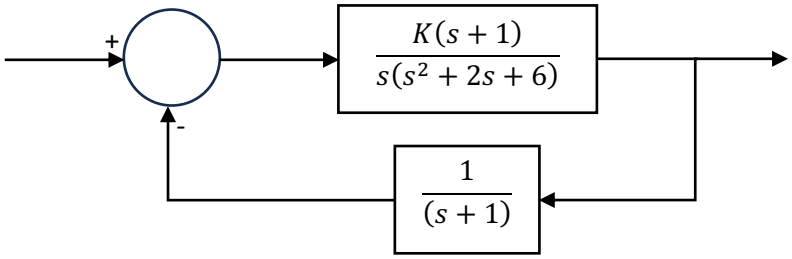
Student Name: _____

Instructions:

- Use MATLAB.
- Submit **ONLY 1 PDF** containing all code, plots, and written work (if any).
- **TIP:** Submit the work the previous night before going to sleep. This will avoid any issues later (in case you wake up after the deadline) on Friday. LATE submissions will NOT be accepted.

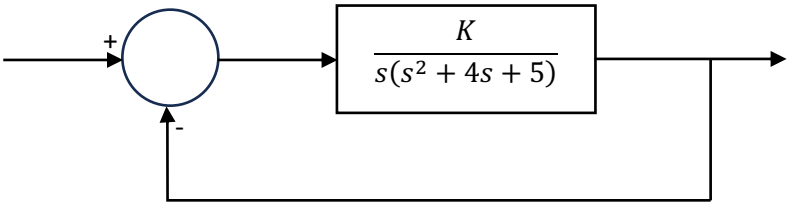
Problem 1 (15 points): ROOT LOCUS

I. **(5 points)** Consider the system shown below.



Plot the root loci with MATLAB. Locate the closed-loop poles when the gain K is set equal to 2.

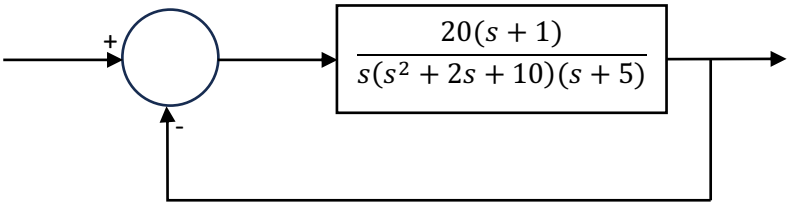
II. **(10 points)** Consider the following system shown below.



Plot the root loci for the system with MATLAB. Determine the value of K such that the damping ratio ζ of the dominant closed-loop poles is 0.5. Then determine all closed loop poles. Plot the unit-step response curve with MATLAB.

Problem 2 (10 points): BODE DIAGRAM

Consider the system shown below.



Draw a Bode diagram of the **open-loop** transfer function. Determine the phase margin and gain margin with MATLAB.

Problem 3 (15 points): NYQUIST PLOT

I. **(7.5 points)** Consider the unity-feedback control system with the following open-loop transfer function:

$$G(s) = \frac{s^2 + 2s + 1}{s^3 + 0.2s^2 + s + 1}$$

Draw a Nyquist plot of $G(s)$ and examine the stability of the closed-loop system.

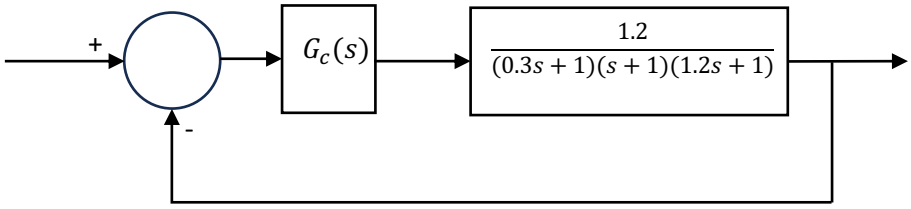
II. **(7.5 points)** Consider a unity-feedback control system with the following open-loop transfer function:

$$G(s) = \frac{1}{s^3 + 0.2s^2 + s + 1}$$

Draw a Nyquist plot of G(s) and examine the stability of the closed-loop system.

Problem 4 (20 points): CONTROLLER DESIGN

Consider the following control system.



The PID controller is given by.

$$G_c(s) = K\frac{(s+a)^2}{s}$$

It is desired to determine the values of K and a such that the unit-step response of the system exhibits the maximum overshoot of less than 8%, but more than 3%, and the settling time is less than 2 sec. Choose the search region to be $2 \leq \mathrm{K} \leq 4$, $0.5 \leq a \leq 3$. Choose the step size for K and a to be 0.05.

I. **(10 points)** First, write a MATLAB program such that the nested loops in the program start with the highest values of K and a and step toward the lowest and the computation stops when a successful set of K and a is found for the first time.

II. **(5 points)** Next write a MATLAB program that will find all possible sets of K and a that will satisfy the given specifications.

III. **(5 points)** Among multiple sets of K and a that satisfy the given specifications, determine the best choice. Then, plot the unit-step response curve of the system with the best choice of K and a.