Ph.D. Qualifying Examination
Controls

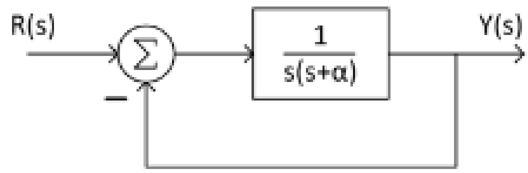
July 2023

Logistics Notes

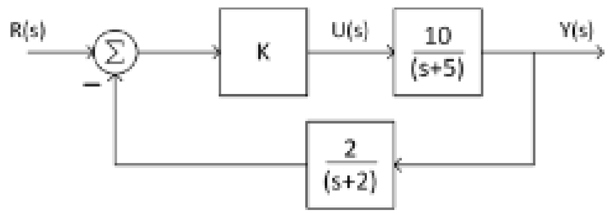
- Time allowed: 2.5 hours
- Closed book and closed notes; one sheet (8:5 $\times$ 11 in, 2-sided) of formulas is allowed
- Four problems
- Calculators are allowed
- Laptops, cell phones, and similar electronic devices with Internet access are not allowed

Show your work, including intermediate steps. State your assumptions clearly. Use as many sheets of paper as necessary to present each solution.

Problem 1 (25 points) Consider the unity-feedback system in the figure below. Plot the root locus as a function of the pole location α.



Problem 2 (25 points)
Consider the feedback system in the figure below. Determine the control gain K to provide a 2% steady-state error to a constant reference input.



Problem 3 (25 points) Match the transfer function on the left with its Bode magnitude plot on the right

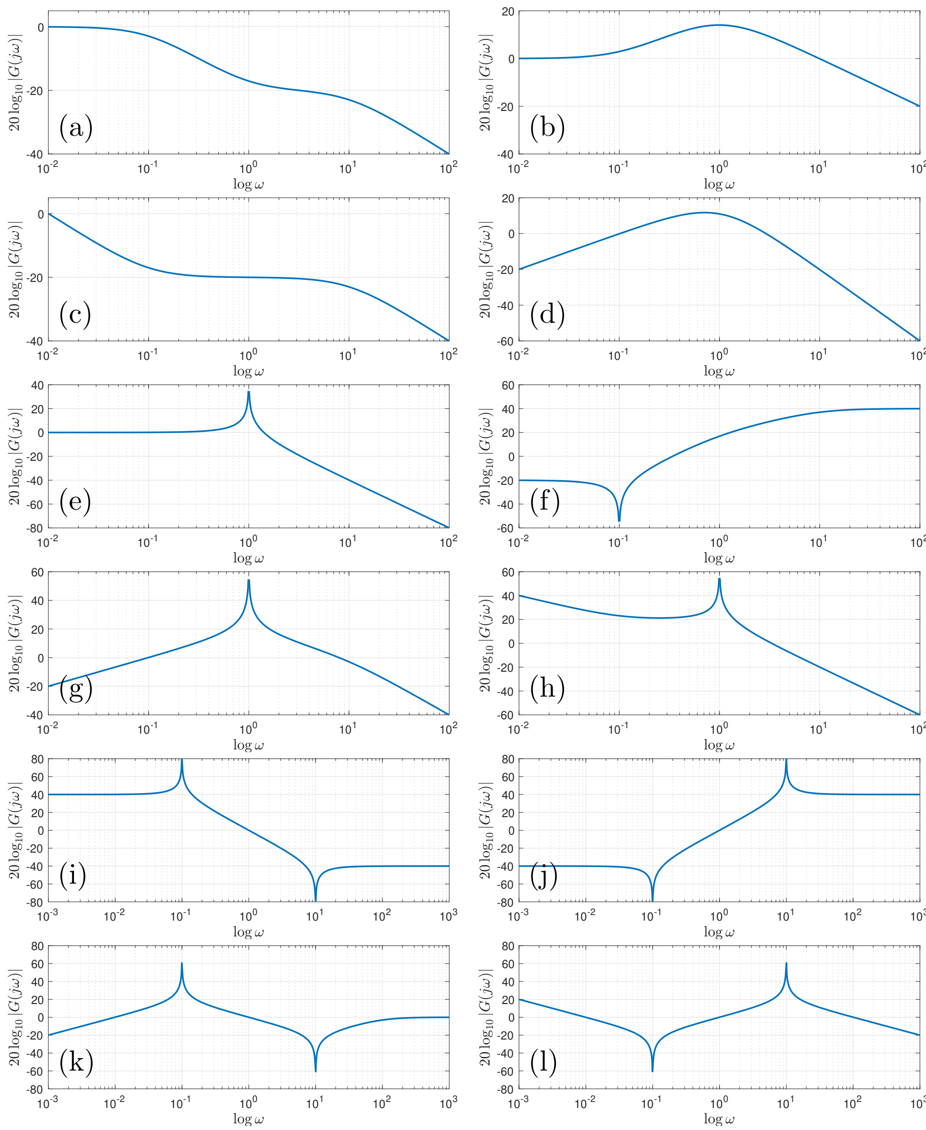
______ $G(s) = \dfrac{10s+1}{s^3+s}$

______ $G(s) = \dfrac{100s^2+1}{s^3+100s}$

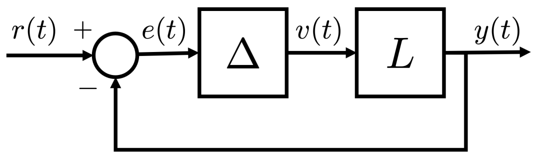
______ $G(s) = \dfrac{s+1}{s^2+10.1s+1}$

______ $G(s) = \dfrac{100s^2+1}{s^2+11s+10}$

______ $G(s) = \dfrac{10s+1}{s^2+2s+1}$



Problem 4 (25 points) Consider the feedback loop below.



The Bode plot of the loop transfer function $L(s) = P(s)C(s)$ is shown below. The block Δ represents a time-delay of T seconds i.e. for input $e(t)$ the block Δ produces output $v(t) = e(t - T)$. The closed-loop system is nominally stable for zero time-delay i.e. $T = 0$. What is the smallest time-delay $T > 0$ that causes the closed-loop system to become unstable?