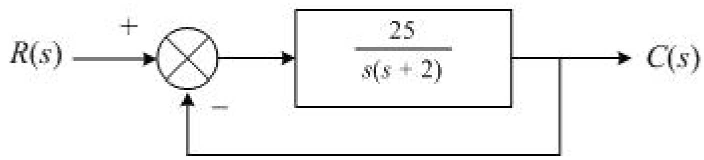
SEHS4653 Control System Analysis
Tutorial Questions (Part 2)

System Analysis

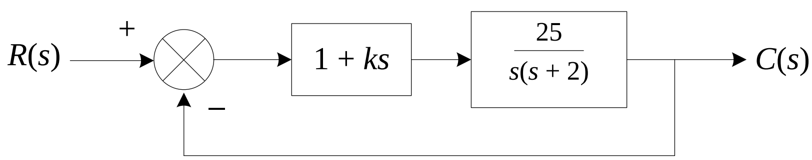
1. Given the following system,



(a) Determine the damping ratio, undamped natural frequency and damped natural frequency.
(b) Obtain the unit-step response $c(t)$ of this system when all initial conditions are zero.
(c) Determine the rise time, t_r, the peak time t_p, the 2% settling time t_s and the percentage of overshoot.

Ans: (a) $\zeta = 0.2$, $\omega_n = 5$ rad/s, $\omega_d = 4.899$ rad/s; (b) $c(t) = 1 - 1.021e^{-t}\sin(4.899t + 1.369)$; (c) $t_r = 0.362$ sec, $t_p = 0.641$ sec, $t_s = 4$ sec, $M_p = 52.66\%$

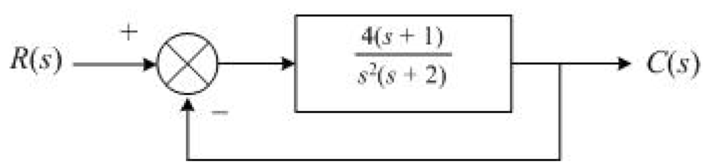
2. To improve the transient behavior of the system in Question 1, a proportional and derivative controller is added as shown below.



(a) Determine the value of k such that the resulting system will have a damping ratio of 0.5.
(b) Obtain the unit-step response $c(t)$ of this system when all initial conditions are zero.

Ans: (a) $k = 0.12$; (b) $c(t) = 1 + 0.693e^{-2.5t}\sin 4.33t - 1.15e^{-2.5t}\sin(4.33t + 1.047)$

3. Given the following unity feedback system.



(a) Find the position, velocity, and acceleration error constants.
(b) Determine the steady-state error when the input is $R(s) = \frac{3}{s} - \frac{1}{s^2} + \frac{1}{2s^3}$.

Ans: (a) $K_p = \infty$, $K_v = \infty$, $K_a = 2$; (b) $e_\infty = 0.25$

System Stability

4. Given the following characteristic equations, determine the system stability.

   (a) $\Delta(s) = s^3 + 4s^2 + 8s + 12 = 0$

   (b) $\Delta(s) = 2s^3 + 4s^2 + 4s + 12 = 0$

   Ans: (a) Stable; (b) Unstable

5. Determine the range of K such that the system with the characteristic equation, $\Delta(s) = s^4 + 6s^3 + 11s^2 + 6s + K = 0$, is stable.

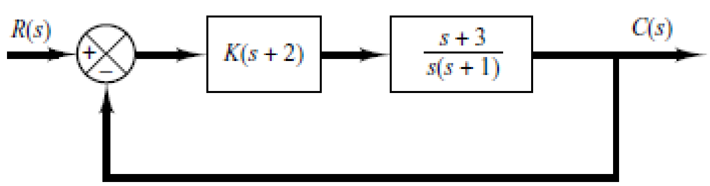
   Ans: $0 < K < 264$

Root Locus

6. Sketch the root loci for the systems below, where $K > 0$

   (a) $G(s) = \dfrac{K}{s(s+3)(s+8)}$; $H(s) = 1$

   (b)



7. Sketch the root locus for the open-loop transfer function,

$$G(s)H(s) = \frac{K}{s(s+4)}, \qquad K > 0$$

   Comment on the system stability if (a) a pole at $s = -1$ or (b) a zero at $s = -1$ was introduced to the above transfer function.

End of Tutorial Questions (Part 2)