Université d'Ottawa
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ELG 3155 Introduction to Control Systems Winter 2023

Final EXAMINATION (2.5 hours)

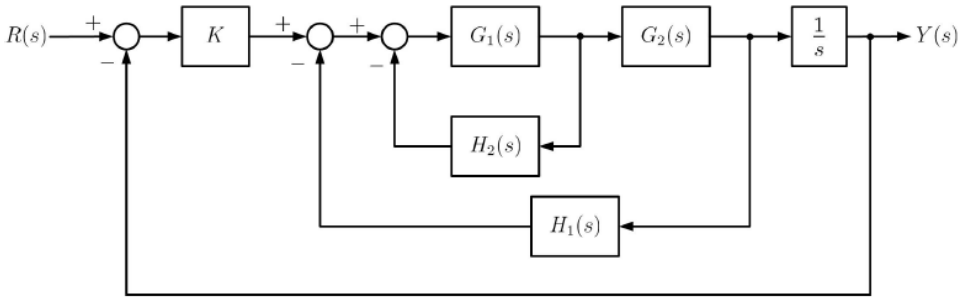
Professor: Hitham Jleed **Date:** 2023-07-13

This is a closed book exam **C'est un examen à livres fermés**
Answer all questions **Répondre à toutes les questions**
The problems are not ordered by difficulty **Les problèmes ne sont pas classés par difficulté**

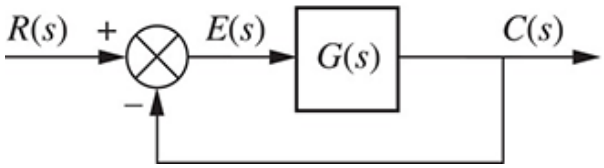
Question (weight)	**Q1 (18)**	**Q2 (21)**	**Q3 (21)**	**Q4 (25)**	**Q5 (15)**	**Total (100)**
Mark/Point						

Helpful formula
$s_{1,2} = \sigma_d \pm j\omega_d = -\xi\omega_n \pm j\omega_n\sqrt{1-\xi^2}$, $G(s) = \frac{\omega_n^2}{s^2+2\xi\omega_n+\omega_n^2}$
$f(\infty) = \lim_{s\to 0} sF(s)$, $e(\infty) = \lim_{s\to 0} \frac{sR(s)}{1+G(s)}$
$\sigma_a = \frac{\sum p_i - \sum z_i}{\#p-\#z}$ $\theta_a = \frac{(2k+1)\pi}{\#p-\#z}$ $KG(s)H(s) = 1\angle(2k+1)180^0$
$Z_c(s) = \frac{1}{Cs}$, $Z_L(s) = Ls$, $Z_R(s) = R$

Problem 1: (18 points) Block-Diagram Reduction. Find the transfer function Y (s)/R(s).



Problem 2. (21 points) For the unity feedback system shown bellow

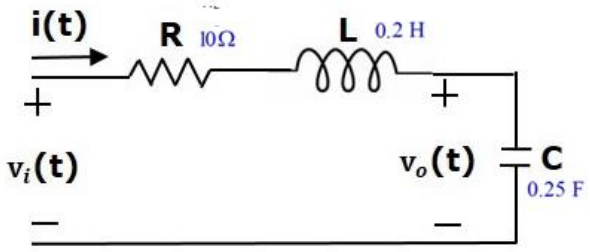


$$G(s) = \frac{450(s + 7)(s - 8)(s + 15)}{s(s + 38)(s^2 + 2s + 28)}$$

find the steady-state errors for the following test inputs:

a. $15u(t)$; b. $3tu(t)$; c. $4t^2u(t)$

Problem 3: (21 points) In the given electrical network, the input is the dc-voltage (V_i) and the output voltage is V_o.



a. Find the transfer function V_o/V_i

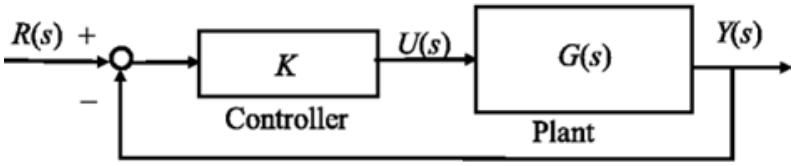
b. Is the system underdamped or overdamped?

c. Assuming $x_1=i_L$ and $x_2= v_c$, write the state equation in the following form,

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

Problem 4: (25 points) A unity feedback control system is shown in this block diagram.

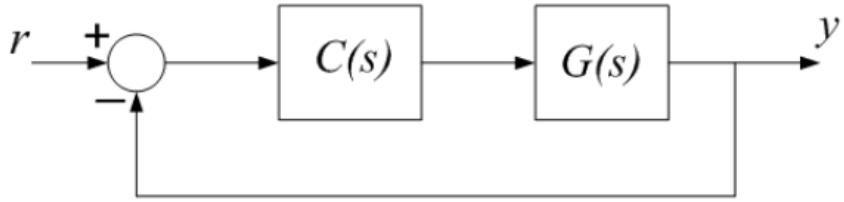


$$G(s) = \frac{1}{s(s^2 + 2s + 2)}$$

Make a rough sketch of root locus plot by determining the following.

a. Centroid, number and angle of asymptotes.
b. Angle of departure of root loci from the poles.
c. Points of intersection with $j\omega$

Problem 5: (15 points) Consider the following LTI system:



$$\text{where } C(s) = \frac{K}{s+4} \text{ and } G(s) = \frac{3s+3}{s^2-2s-3}$$

Determine for what values of K the system is stable and unstable.