Université d'Ottawa
Faculté de génie

École d'ingénierie et de
technologie de l'information

uOttawa

L'Université canadienne
Canada's university

University of Ottawa
Faculty of Engineering

School of Information
Technology and Engineering

ELG 3155 Introduction to Control Systems Winter 2023

Final EXAMINATION (2.5 hours)

Professor: H. Jleed **Nom/Name:** ________________________

Date April, 27, 2023 **Student /Étudiant #:** ________________________

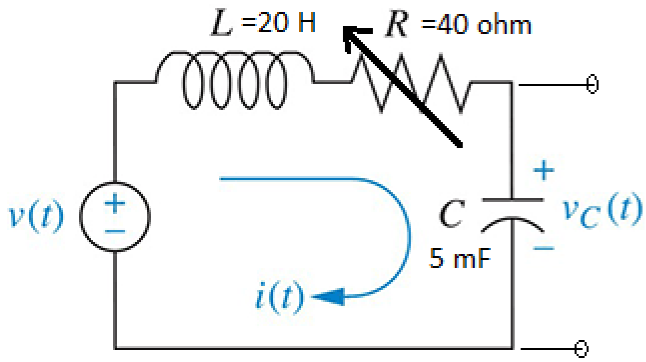
\

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 (24)	Q2 (20)	Q3 (16)	Q4 (25)	Q5 (15)	Total (100)
Mark/Point						

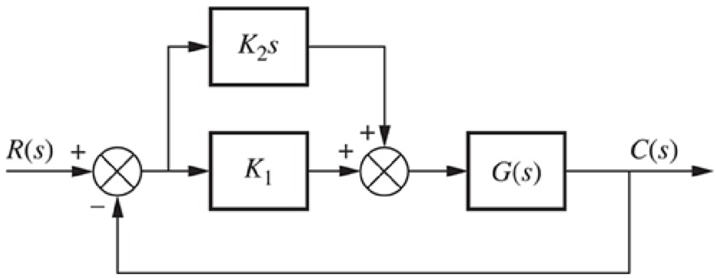
Helpful formula
$s_{1,2} = \sigma_d \pm j\omega_d$, $T_s = \frac{4}{\xi\omega_n}$, $T_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}} = \frac{\pi}{\omega_d}$, $\%OS = e^{-(\xi\pi/\sqrt{1-\xi^2})} \times 100$
$f(\infty) = \lim_{s\to 0} sF(s)$, $e(\infty) = \lim_{s\to 0} \frac{sR(s)}{1+G(s)}$
$\sigma_a = \frac{\sum p_i - \sum z_i}{\#p - \#z}$ $\theta_a = \frac{(2k+1)\pi}{\#p-\#z}$ $KG(s)H(s) = 1\angle(2k+1)180^0$
$Z_c(s) = \frac{1}{Cs}$, $Z_L(s) = Ls$, $Z_R(s) = R$

Q1. **(24)** Given the network of the following Figure.



a. Find the transfer function. Vc(s)/Vi(s).
b. Is the system shown below underdamped? If so, find the percent overshoot, the settling time, and the peak time for a step input.
c. Find the value of resistance (R) that makes the damping ratio $\xi = 0.475$

Q2. **(20)** Consider the unity-feedback system, with

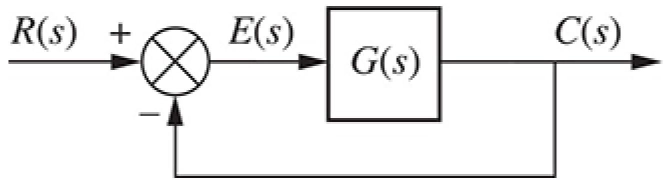


$$G(s) = \frac{1}{s(s+2)}$$

a. For PD compensator, find k_1 and k_2 that satisfy the desired closed loop system, whose Poles are located at $-2 \pm j2$.
b. Compare the settling time performance of the uncompensated and compensated systems.

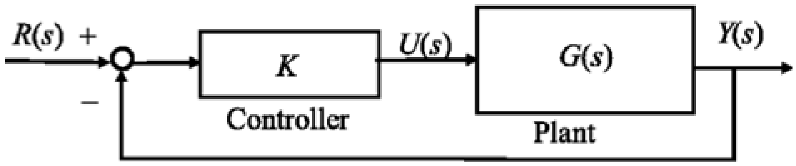
Q3. **(16)** For the unity-feedback system, using the Routh-Hurwitz criterion.

$$G(s)=\frac{K}{s(s^2+2s+4)}$$



a. Determine the range of k for stability.
b. Find the value of k for marginal stability.

Q4. **(25)** A unity feedback control system is shown in this block diagram.

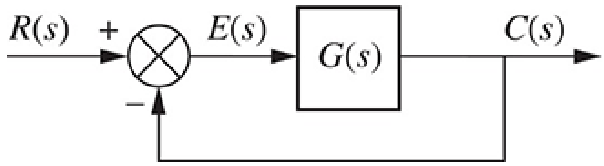


$$G(s) = \frac{1}{s(s^2 + 4s + 13)}$$

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 $j\omega$
d. Maximum value of k for stability.

Q5. **(15)** For the unity feedback system shown bellow



$$G(s) = \frac{450(s+12)(s+8)(s+15)}{s(s+38)(s^2+2s+28)}$$

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

$$25u(t);\ 37tu(t);\ 47t^2u(t)$$