UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	CONTROL SYSTEM / CONTROL SYSTEM THEORY
COURSE CODE	:	BEV 30503 / BEH 30603
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Explain the closed-loop control system performance characteristic.

(4 marks)

(b) List **three (3)** translation motion components of mechanical system with each impedance, force displacement and analogous with electrical system.

(4 marks)

(c) Determine the transfer function $\frac{\theta_m(S)}{E_a(S)}$ of the electromechanical system in **Figure Q1(c)**.

(14 marks)

(d) Draw the mechanical system analogous for the electrical system in **Figure Q1(d)**.

(3 marks)

Q2 (a) Describe the definition of a stable system and an unstable system.

(1 mark)

(b) List **TWO (2)** advantages and **ONE (1)** disadvantage of the Routh Hurwitz criterion for analyzing stability of a system.

(3 marks)

(c) Determine the value of K for a system in **Figure Q2(c)** using the Routh Hurwitz criterion.

(13 marks)

(d) Show that system $s^3 - 3s^2 + s + 5$ is unstable using the S-Plane and the Routh Hurwitz criterion.

(8 marks)

Q3 (a) For the system shown in **Figure Q3(a)** do the following:

(i) Determine the transfer function of system with V_s as input variable and V_o as output variable.

(10 marks)

(ii) Determine T_r, T_p, %OS and T_s ($\pm 2\%$).

(7 marks)

(iii) Determine the step response of the system for t=0.1s.

(6 marks)

(b) Explain the **three (3)** cases for the value of frequency of a single real pole system in bode plot.

(2 marks)

Q4 (a) Explain five rules to sketch a root locus.

(2 marks)

(b) Sketch the root loci for the system shown in **Figure Q4(b)**. (The gain K is assumed to be positive.)

(9 marks)

(c) Explain what is frequency response of a system, bode plot, gain margin and phase margin.

(2 marks)

(d) List effect of factors constant, poles or zeros at origin, first order (simple) poles or zeros and quadratic poles or zeros to magnitude behavior and phase behavior.

(2 marks)

(e) Determine the gain K_p, integral time K_p and differential time K_p of Proportional, Integral and Derivative (PID) control for a system as follow:

$$G(s) = \frac{1}{s^3 + 4s^2 + 3s}$$

(10 marks)

-END OF QUESTIONS-

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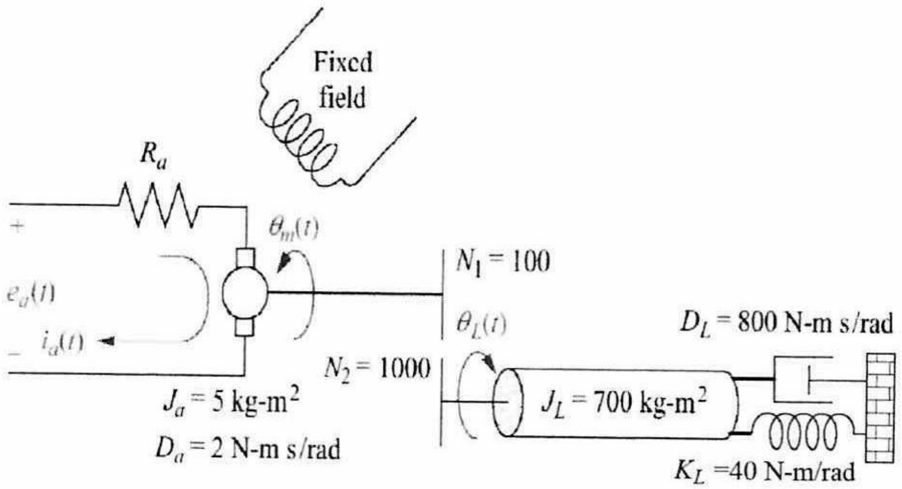

Figure Q1(c)

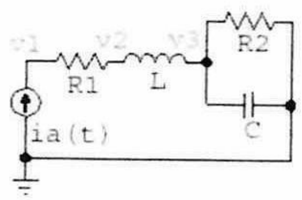

Figure Q1(d)

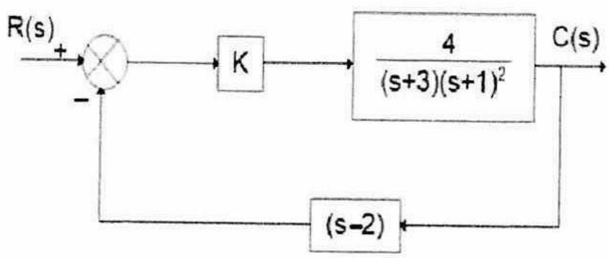

Figure Q2(c)

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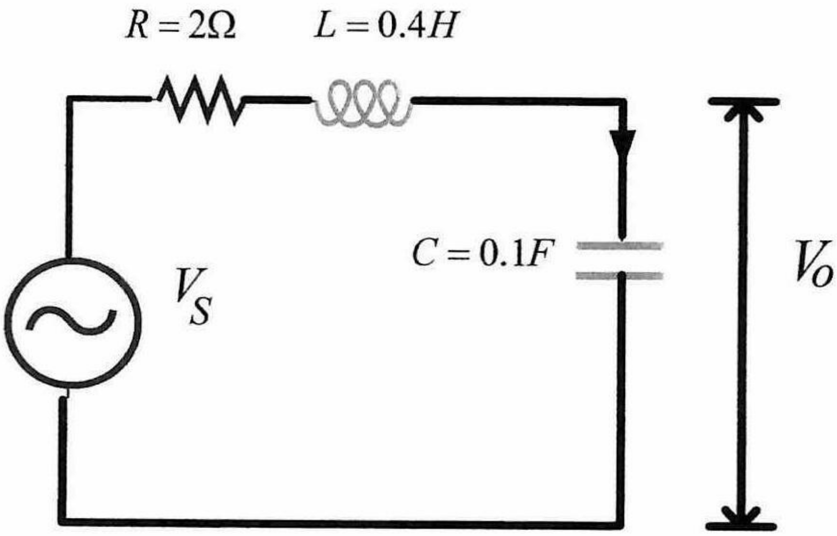

Figure Q3

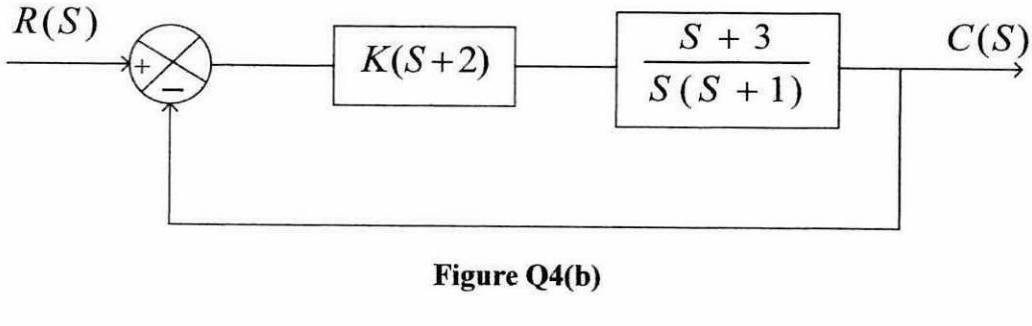

Figure Q4(b)

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FORMULAE

Table A
Laplace transform table

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$tu(t)$	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$	$\frac{1}{s+a}$
$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$
$e^{-at}\sin \omega t u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos \omega t u(t)$	$\frac{(s+a)}{(s+a)^2+\omega^2}$

TABLE 2

2nd order prototype system equation.

$\frac{C(s)}{R(s)}=\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$	$T_r=\frac{\pi-\cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$
$\mu_p=e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$	$T_p=\frac{\pi}{\omega_n\sqrt{1-\zeta^2}}=\frac{\pi}{\omega_d}$
$T_s=\frac{4}{\zeta\omega_n}=\frac{4}{\sigma_d}$ (2% criterion)	$T_s=\frac{3}{\zeta\omega_n}$ (5% criterion)