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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	CONTROL SYSTEM
COURSE CODE	:	BEV 30503
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY/AUGUST 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

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Q1 (a) List down of the **EIGHT (8)** components in control system.

(4 marks)

(b) Draw the block diagram for a system control in **Figure Q1(b)**.

(4 marks)

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

(17 marks)

Q2 (a) Define a stable and an unstable system based on complex plane.

(2 mark)

(b) Describe absolute stability, relative stability, and stability margin.

(3 marks).

(c) Determine the value of K_p and T_i using the Routh Hurwitz criterion for the following system to be stable.

$$G(s) = \frac{K_p\left(1 + \frac{1}{T_i s}\right)\left(\frac{1}{s(s+1)(s+3)}\right)}{1 + K_p\left(1 + \frac{1}{T_i s}\right)\left(\frac{1}{s(s+1)(s+3)}\right)}$$

(15 marks)

(d) Show that the system with characteristic equation bellows is unstable using the S-Plane / Complex Plane.

$$(s+3)(s^3 - 3s^2 + s + 5)(s+2)$$

(5 marks)

Q3 (a) The second order system has closed loop transfer function as follows:

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

Consider that percentage of maximum overshoot (%OS) of its response is 5% and settling time $\pm 2\%$ band $(t_s \pm 2\%)$ is $600\ msec$. Determine damping ratio (ζ), natural undamped frequency (ω_n), b and K_c.

(10 marks)

(b) Determine the position error constant (K_p), velocity error constant (K_v), and acceleration error constant (K_a) for the system in **Figure Q3(b)**.

(6 marks)

(c) Explain gain margin and phase margin using a bode plot.

(3 marks)

(d) Sketch bode plot for magnitude and phase angle for the following system:

$$G(s) = \frac{a}{s + a}$$

(6 marks)

Q4 (a) Describe **FOUR (4)** observations related to Root Locus Plot than can be achieved from the closed loop transfer function of a system as below:

$$T(s) = \frac{KG(s)}{1 + KG(s)H(s)}$$

(4 marks)

(b) Sketch the root loci for the system shown in **Figure Q4(b)**.

(13 marks)

(c) Consider the following system is controlled using Proportional, Integral and Derivative (PID),

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

Determine:

(i) Proportional gain (K_P)

(ii) Integral gain (K_I)

(iii) Derivative gain (K_D).

(8 marks)

-END OF QUESTIONS-

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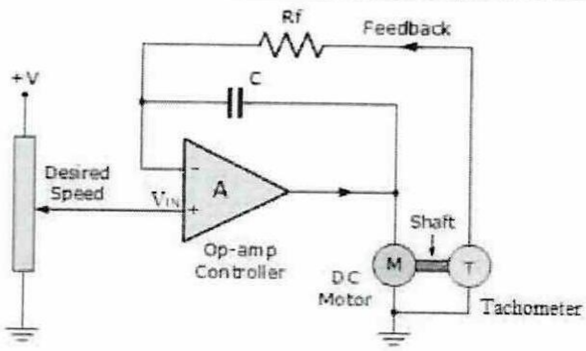

Figure Q1(b)

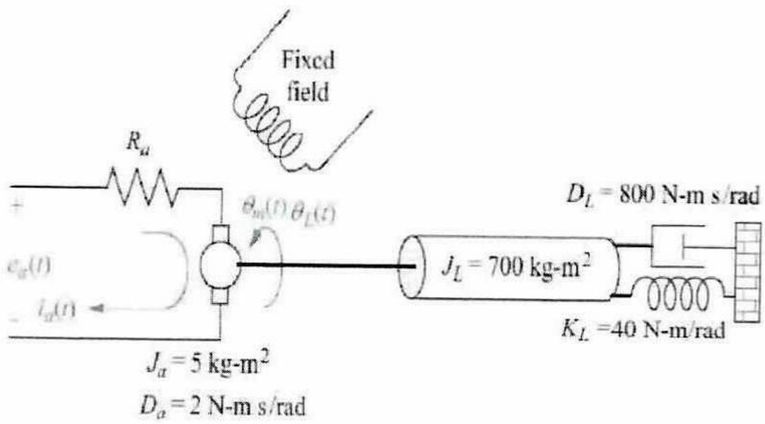

Figure Q1(c)

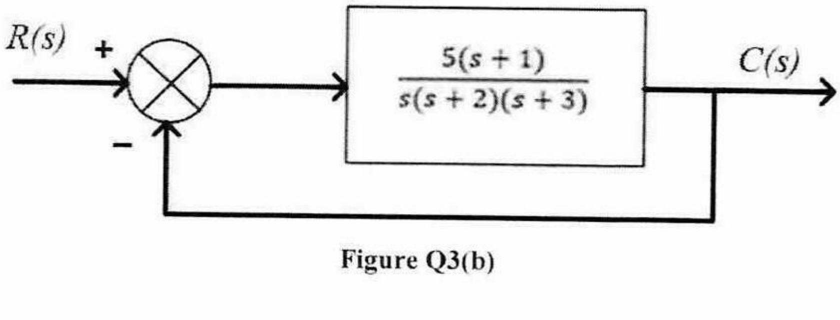

Figure Q3(b)

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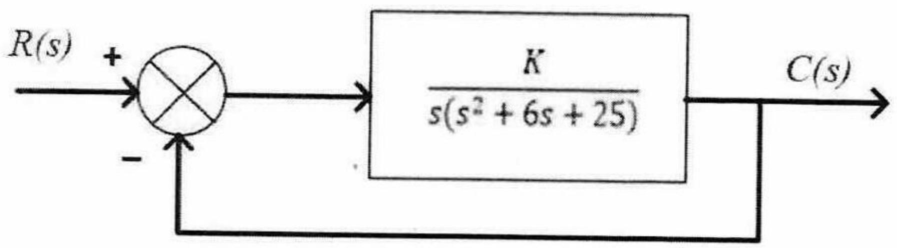

Figure Q4(b)

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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)