Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	CONTROL SYSTEM
COURSE CODE	:	DAE 32103
PROGRAMME CODE	:	DAE
EXAMINATION DATE	:	JANUARY/ FEBRUARY 2024
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ 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 **SEVEN (7)** PAGES

Q1 Control system is an important part of technology nowadays. Its application can range from house appliances to large industrial machines then categorized into the open-loop system and closed-loop system.

(a) For the closed-loop system, there are components of feedback in the system.

(i) Define a feedback system with the aid of a block diagram.

(3 marks)

(ii) Explain the purpose of a feedback system.

(2 marks)

(b) Consider the electrical network shown in **Figure Q1(b)**.

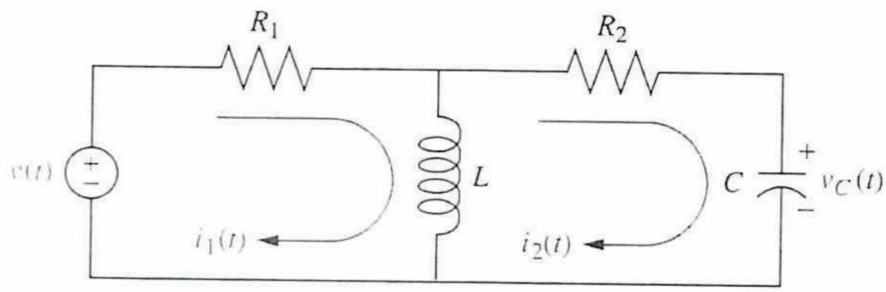

Figure Q1(b)

(i) Find the transfer function $I_2(s)/V(s)$.

(8 marks)

(ii) Draw the block diagram for **Q1(b)(i).**

(2 marks)

(c) **Figure Q1(c)** shows a block diagram of a closed-loop system. Find the transfer function of the system.

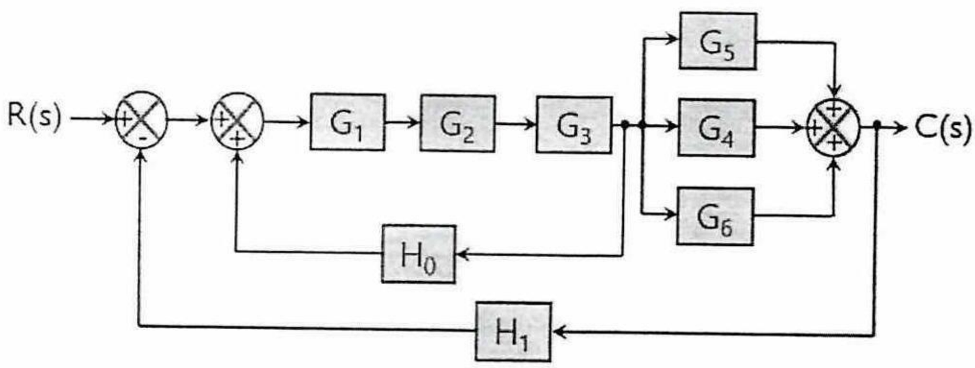

Figure Q1(c)

(10 marks)

Q2 The output response of a system with respect to time consists of two different types of response. The response will determine the characteristics of a first-order system and a second-order system.

(a) Name the **two (2)** types of response in an output time response system.

(2 marks)

(b) Illustrate a graph and label the component of both types of response specifically.

(2 marks)

(c) Identify the function of a pole in the transfer function of a system.

(2 marks)

(d) Find the output response of the following transfer function for a step input:

(i) $G(s) = \frac{s+3}{(s+2)(s+4)(s+5)}$

(6 marks)

(ii) $G(s) = \frac{s+2}{s+5}$

(4 marks)

(e) A first-order system has a transfer function, $G(s) = \frac{180}{s+60}$. Discover the following transient response performance of the system:

(i) Time constant, t_c

(1 mark)

(ii) Settling time, t_s

(1 mark)

(iii) Rise time, t_r

(1 mark)

(f) Produce the transfer function of a second-order system that yields a 12.3% overshoot and a settling time of 1 second.

(6 marks)

Q3 The system with transfer function:

$$G(s) = \frac{2000(s+0.5)}{s(s+10)(s+50)}$$

(a) Plot the Bode diagram for the system

(i) Convert the function to the $j\omega$ form and find the low frequency asymptote.

(3 marks)

(ii) Bode magnitude.

(8 marks)

(iii) Bode phase.

(6 marks)

(b) Find the phase margin.

(2 marks)

(c) Find the gain margin.

(2 marks)

(d) Analyse the stability of the system.

(2 marks)

(e) Give **one (1)** advantage of the Bode plot over step response analysis.

(2 marks)

Q4 **Figure Q4** shows a closed loop control system using PID controller.

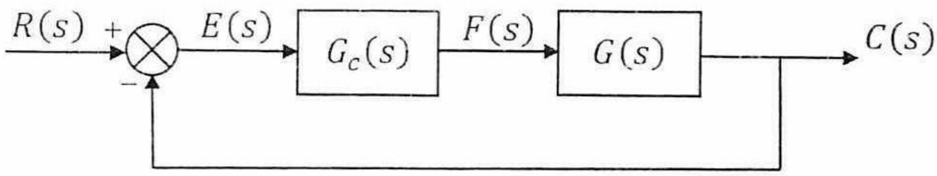

Figure Q4

Consider a feedback control system with the following plant transfer function:

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

A Proportional-Integral-Derivative (PID) controller is added to the system with the transfer function:

$$G_c(s) = K_p + \frac{K_i}{s} + K_d s^2$$

(a) Determine the closed-loop transfer function T(s) for the system in terms of parameters a, K_p, K_i and K_d

(9 marks)

(b) Set a=5 and K_d=2. Compute the value of K_p and K_i in order for the poles of the closed-loop system to be positioned at the s-plane locations at:

$$s = -2 \text{ and } s = -3$$

(6 marks)

(c) Describe the working concept of **two (2)** types of process control.

(4 marks)

(d) There are a few variables involved in process control. Explain,

(i) Controlled variable.

(2 marks)

(ii) Manipulated variable.

(2 marks)

(iii) Disturbance variable.

(2 marks)

- END OF QUESTIONS -

Appendix A

Laplace Transform Table

S.no	$f(t)$	$\mathcal{L}\{f(t)\}$	S.no	$f(t)$	$\mathcal{L}\{f(t)\}$
1	1	$\frac{1}{s}$	11	$e^{at}\sinh bt$	$\frac{b}{(s-a)^2-b^2}$
2	e^{at}	$\frac{1}{s-a}$	12	$e^{at}\cosh bt$	$\frac{s-a}{(s-a)^2-b^2}$
3	t^n	$\frac{n!}{s^{n+1}}$	13	$t\cos at$	$\frac{s^2-a^2}{(s^2+a^2)^2}$
4	$\sin at$	$\frac{a}{s^2+a^2}$	14	$t\sin at$	$\frac{2as}{(s^2+a^2)^2}$
5	$\cos at$	$\frac{s}{s^2+a^2}$	15	$f'(t)$	$sF(s)-f(0)$
6	$\sinh at$	$\frac{a}{s^2-a^2}$	16	$f''(t)$	$s^2F(s)-sf(0)-f'(0)$
7	$\cosh at$	$\frac{s}{s^2-a^2}$	17	$\int_0^t f(u)du$	$\frac{1}{s}F(s)$
8	$e^{at}t^n$	$\frac{n!}{(s-a)^{n+1}}$	18	$t^n f(t)$ Where $n=1,2,3,..$	$(-1)^n\frac{d^n}{ds^n}\{F(s)\}$
9	$e^{at}\cos bt$	$\frac{s-a}{(s-a)^2+b^2}$	19	$\frac{1}{t}\{f(t)\}$	$\int_s^\infty F(s)ds$
10	$e^{at}\sin bt$	$\frac{b}{(s-a)^2+b^2}$	20	$e^{at}f(t)$	$F(s-a)$

Appendix B

Electrical Network Transfer Function

Component	Voltage-current	Current-voltage	Voltage-charge	Impedance Z(s) = V(s)/I(s)	Admittance Y(s) = I(s)/V(s)
Capacitor	$v(t)=\frac{1}{C}\int_0^t i(\tau)d\tau$	$i(t)=C\frac{dv(t)}{dt}$	$v(t)=\frac{1}{C}q(t)$	$\frac{1}{Cs}$	Cs
Resistor	$v(t)=Ri(t)$	$i(t)=\frac{1}{R}v(t)$	$v(t)=R\frac{dq(t)}{dt}$	R	$\frac{1}{R}=G$
Inductor	$v(t)=L\frac{di(t)}{dt}$	$i(t)=\frac{1}{L}\int_0^t v(\tau)d\tau$	$v(t)=L\frac{d2q(t)}{dt2}$	Ls	$\frac{1}{Ls}$

Appendix C

The formulas are as follows

$$t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$$

$$M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}, \qquad \%M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} \times 100\%$$

$$t_r = \frac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$$

$$T_s = \frac{4}{\zeta\omega_n} \text{ (2\% criterion)}$$

$$T_s = \frac{3}{\zeta\omega_n} \text{ (5\% criterion)}$$