Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	CONTROL ENGINEERING
COURSE CODE	:	BDA30703
PROGRAMME	:	BDD
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **ONE (1)** QUESTION ONLY **OPEN BOOK EXAMINATION**

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

PART A: ANSWER ALL QUESTIONS

Q1 Referring to the op-amp arrangement in **Figure Q1**,

(a) How should we set the positive and negative inputs so that the op-amp could act as inverting and non-inverting amplifier?

(4 marks)

(b) Calculate the output voltage v_o of the system by using superposition method

(8 marks)

(c) Kirchhoff's Current Law (KCL) can also be used to solve this problem, explain this statement.

(2 marks)

(d) Use KCL to find the output voltage v_o of the system and compare the result with the one calculated in (b)

(6 marks)

Q2 (a) A plant with the following transfer function

$$G(s) = \frac{4(s+2.1)}{(s^2+2s+4)(s+2)(s+4)(s+11)}$$

is subjected to unit step input. Identify the form of the open loop step response without solve the equations.

(6 marks)

(b) A system of unknown transfer function was subjected to a unit impulse input. The output is measured experimentally and approximated by the following function:

$$c(t) = e^{-2t}\sin(2t+45^o)$$

Derive the system transfer function.

(6 marks)

(c) Justify the transfer function, *Y(s)/R(s)*, for the system in **Figure Q2(c)**, using Block Reduction Methods.

(8 marks)

Q3 Obtain the transfer function $\frac{X_1(s)}{Y(s)}$ of the mechanical system shown in **Figure Q3** by following the instructions below. Note that Y is a displacement input.

(a) Construct the block diagram of the system.

(8 marks)

(b) Find the transfer function by using Block Diagram Reduction Method

(6 marks)

(c) Find the transfer function by using Mason's Rule (Signal Flow Graph)

(6 marks)

Q4 (a) Apply Routh's Stability Criterion to the following polynomial to determine the condition for the existence of stable roots

$$a_0 s^3 + a_1 s^2 + a_2 s^1 + a_3 s^0 = 0$$

(6 marks)

(b) Construct the root locus for the system shown in **Figure Q4 (b)** and determine the location of dominant closed loop poles to yield maximum overshoot of less than 30%.

(14 marks)

PART B: ANSWER ONE (1) QUESTION ONLY

Q5 (a) By using straight line asymptote methods, explain **FOUR(4)** steps to sketch Bode diagram in control design techniques.

(2 marks)

(b) Compare **THREE (3)** reasons Bode plots have more advantages over Nyquist plots.

(3 marks)

(c) The transfer function of an electric coffee mixer machine system is given by;

$$G(s) = \frac{100}{(s+2)(s^2+10s+24)}$$

(i) Sketch the Bode diagram for the system.

(10 marks)

(ii) Show the GM and PM from the Bode plot and justify the values.

(3 marks)

(iii) Comment on the stability of the system.

(2 marks)

Q6 (a) A plant with transfer function, $G(s) = \frac{10}{s(s+10)}$ is controlled using a PD controller given by $G_c(s) = K_p + K_d s$. Construct the closed loop transfer function and calculate the values for K_p and K_d to give a closed loop natural frequency of 10 rad/sec and critical damping.

(4 marks)

(b) Consider the feedback control system shown below in which a proportional compensator is employed. A specification on the control system is that the steady state error must be less than two per cent for constant inputs.

$$G(s) = \frac{2}{(s^3 + 4s^2 + 5s + 2)}; D(s) = K_p$$

Identify a proportional controller K_p that satisfies this specification.

(6 Marks)

(c) If the steady-state criterion cannot be met with a proportional compensator, appraise a dynamic compensator D(s) = 3+ K_I/s. Evaluate the range of K_I that satisfies the requirement of steady-state error.

(10 marks)

- END OF QUESTION –

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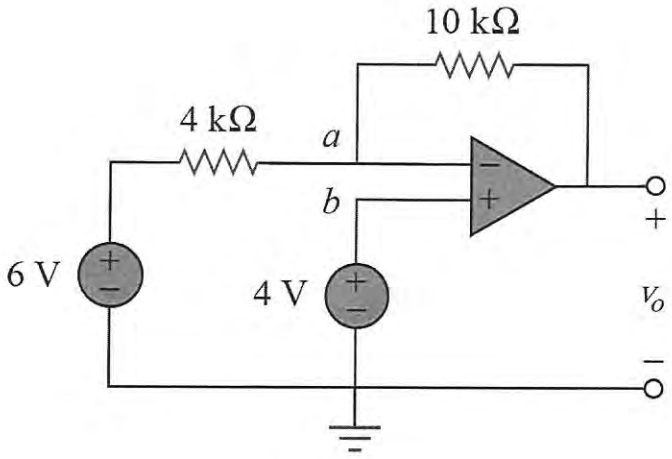

Figure Q1

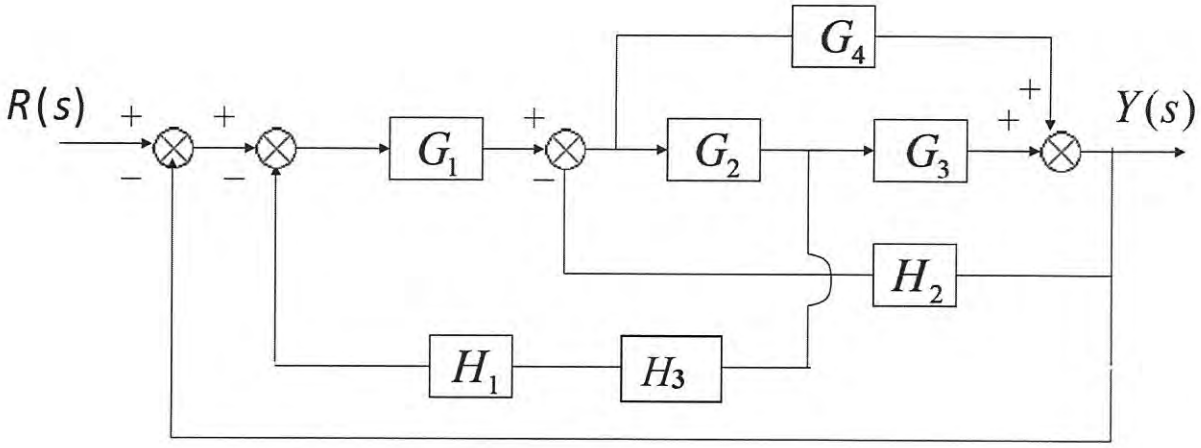

Figure Q2(c)

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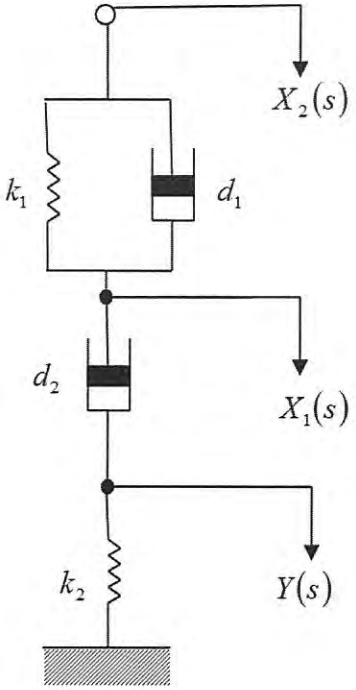

Figure Q3

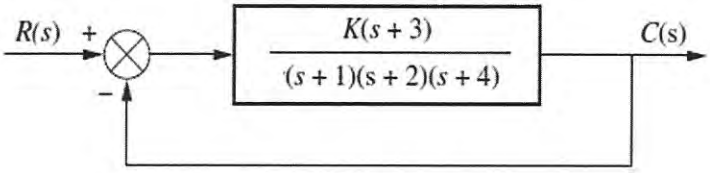

Figure Q4 (b)