UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 1
SESSION 2016/2017

COURSE NAME	:	CONTROL ENGINEERING
COURSE CODE	:	BDA 30703
PROGRAMME	:	BDD
EXAMINATION DATE	:	DECEMBER 2016/JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTIONS	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **ONE (1)** QUESTION ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

PART A: ANSWER ALL QUESTIONS

Q1 (a) Differentiate the terms static and dynamic characteristics of an instrument.

(4 marks)

(b) Given expected voltage value across a resistor is 80V.The measurement is 79V. Calculate the absolute error and its percentage (%).

(3 marks)

(c) Given a 600 V voltmeter with accuracy ±2% full scale. Calculate limiting error when the instrument is used to measure a voltage of 250V?

(4 marks)

(d) List FIVE (5) basic characteristics of an ideal Op-Amp.

(5 marks)

(e) Name the Op-Amp in **Figure Q1** and obtain its transfer function, V_{out}/ V_{in}.

(5 marks)

Q2 (a) Prove that the block diagram in **Figure Q2(a)** is equivalent to the one shown in **Figure Q2(b)**

(4 marks)

(b) Obtain the transfer function *C(s)/R(s)* of the block diagram shown in **Figure Q2(c)**

(8 marks)

(c) Find the transfer function x_5/x_1 of the signal flow graph shown in **Figure Q2(d)** by using Mason's Gain Formula

(8 marks)

Q3 (a) **Figure Q3(a)** shows a rotational mechanical system with one (1) gear reduction unit installed on both shaft. Model the system and find the transfer function, $G(s) = \theta_2(s)/T_1(s)$ for the system. Assume the system with lossless gears.

(10 marks)

(b) **Figure Q3(b)** shows a translational mechanical system used in production control system.

i. Draw the free body diagram of the system.

(2 marks)

ii. Using Newton's law of motion, write an appropriate equation of motion representing the system.

(2 marks)

iii. Transform the equation obtained in Q3(b)ii. into s-domain using the Laplace transform with the assumption of zero initial condition.

(2 marks)

iv. Sketch the block diagram of the system.

(4 marks)

Q4 (a) Given a second-order system with a transfer function as shown in **Figure Q4(a)**:

i. Find and sketch the time response, $y(t)$, of the system when the input to the system is a unit step, $m(t)=1$.

(6 marks)

ii. Calculate peak time, 2% settling time, percent overshoot and steady-state value and show them in the sketch.

(4 marks)

(b) Given the unity feedback control system shown in **Figure Q4(b)**. Sketch the root locus for the system. Clearly shows the asymptotes, their angle and intersection point.

(10 marks)

PART B: ANSWER ONE (1) OUT OF TWO (2) QUESTIONS

Q5 For the system shown in **Figure Q5(a)**, where

$$G_P(s)=\frac{1}{(s^2+3s+25)} \text{ and } G_C(s)=K+\frac{K_I}{s}$$

(a) Use Bode plot to determine the range of K within the unity feedback system if the system in **Figure Q5(a)** is stable. Given the ratio, $K_I/K=4$.

(12 marks)

(b) If $K=10$ in the system, find the gain margin, phase margin, phase crossover frequency, and gain crossover frequency.

(3 marks)

(c) Evaluate the gain margin, phase margin, phase crossover frequency, and gain crossover frequency from your Bode plot for $K=40$.

(5 marks)

Q6 (a) State the transfer function of a PID controller and give THREE (3) advantages of using PID controller.

(4 marks)

(b) Consider the satellite control problem shown in **Figure Q6** with $J=10$ and $H_y=H_r=1$. Examine the system type and error constants with respect to the reference θ_r and disturbance w, inputs if proportional controller $D(s)=k_p$ is applied, and determine the range of k_p for which the system is stable.

(6 marks)

(c) If $D(s)$ in Q6(b) is changed to PD Controller, where $D(s)=k_p+k_Ds$, examine the system type and error constants with respect to the reference, θ_r and disturbance, w.

(10 marks)

-END OF QUESTIONS-

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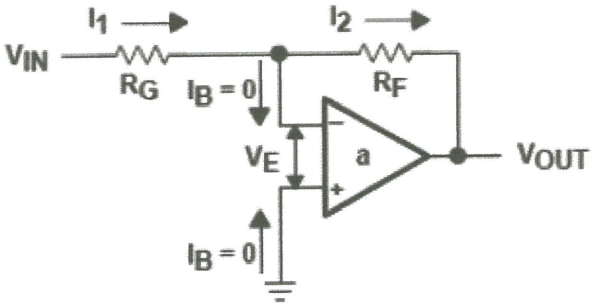

Figure Q1

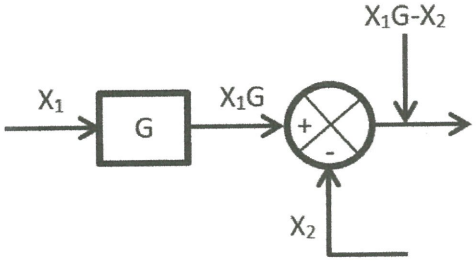

Figure Q2(a)

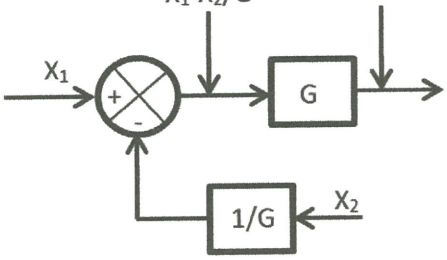

Figure Q2(b)

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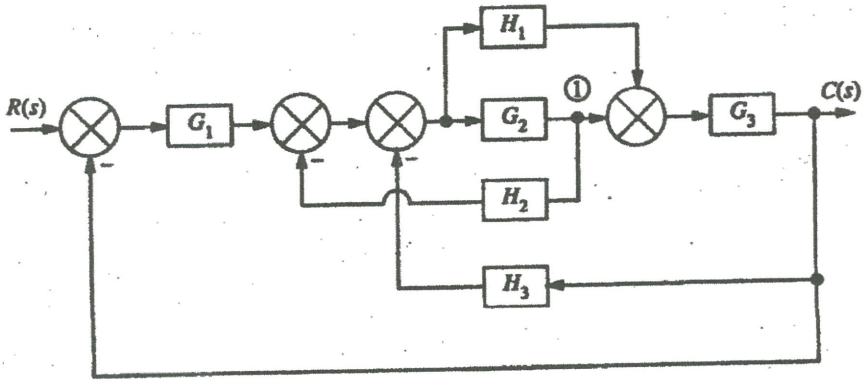

Figure Q2(c)

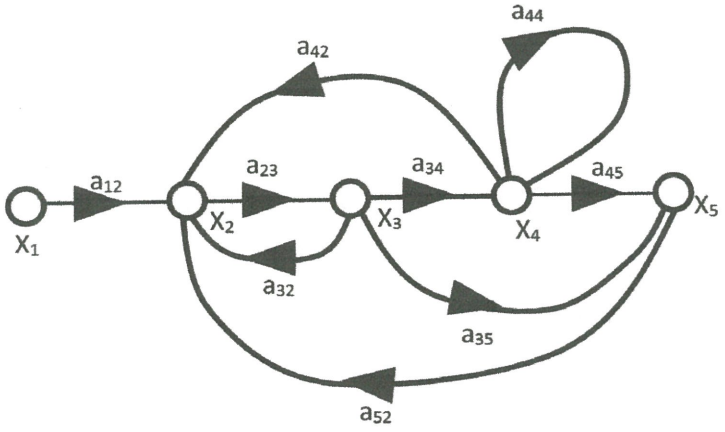

Figure Q2(d)

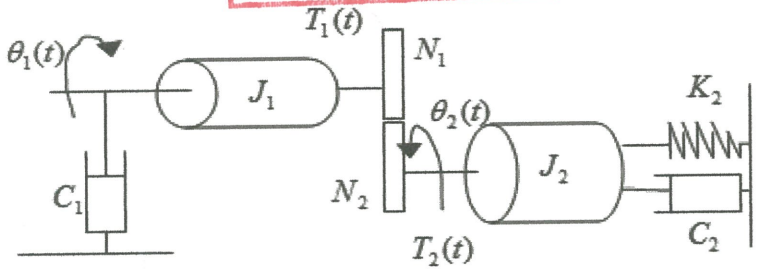

Figure Q3(a)

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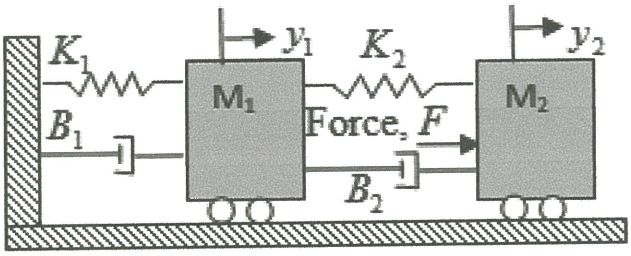

Figure Q3(b)

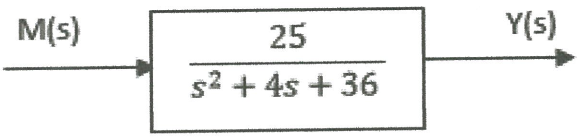

Figure Q4(a)

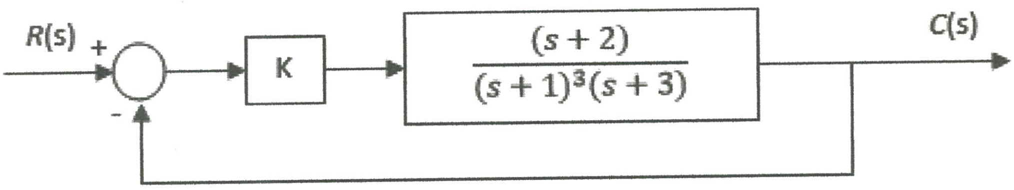

Figure Q4(b)

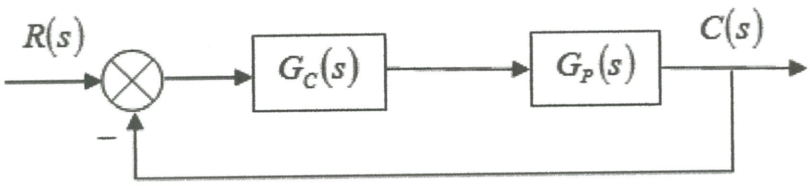

Figure Q5(a)

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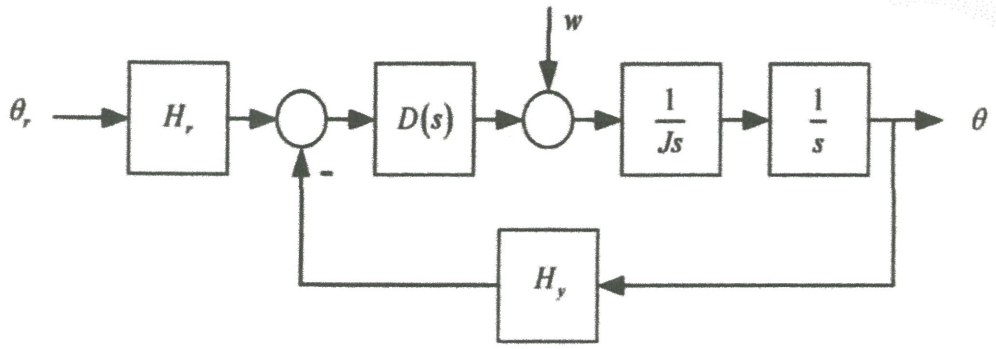

Figure Q6