UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	CONTROL ENGINEERING
COURSE CODE	:	BDA30703
PROGRAMME	:	BDD
EXAMINATION DATE	:	JUNE/ JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	PART A: ANSWER **ALL** QUESTIONS PART B: ANSWER **ONE (1)** QUESTION ONLY

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

PART A:

Q1 (a) Precision is often confused with accuracy. High precision does not imply anything about measurement accuracy. Elaborate **TWO (2)** differences between precision and accuracy.
(4 marks)

(b) A circuit known as a summing amplifier is illustrated in **Figure Q1(a)**. Use the ideal-op-amp assumption to solve for the output voltage in terms of the input voltages and resistor values.
(6 marks)

(c) Find an expression for the output voltage of the circuit, shown in **Figure Q1(b)**.
(5 marks)

(d) Find an expression for the output voltage in in terms of the resistance and input voltages for the differential amplifier shown in **Figure Q1(c)**.
(5 marks)

Q2 **Figure Q2** shows a schematic diagram of an automobile suspension system. As the car moves along the road, the vertical displacements at the tires act as the motion excitation to the automobile suspension system. The motion of this system consists of a translational motion of the center of mass and a rotational motion about the center of mass. Mathematical modeling of the complete system is simplified of the suspension system. Assuming that the motion x_i at point P is the input to the system and the vertical motion x_o of the body is the output, obtain the transfer function (Consider the motion of the body only in the vertical direction) Displacement x_o is measured from the equilibrium position in the absence of input x_i.

(a) Draw a free body diagram for this system (5 marks)

(b) Find the differential equations relating the displacement x_o to the vertical motion of x_o.
(8 marks)

(c) Calculate the transfer function for this system Y(s)/U(s) (7 marks)

Q3 (a) A plant with transfer function, $G(s)=\dfrac{10}{s(s+10)}$ is controlled using a PD controller given by $G_c(s)=K_p+K_d s$. Drive the closed loop transfer function and find the values for K_p and K_d to give a closed loop natural frequency of 10 rad/sec and critical damping. (8 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) 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. Write the form of the open loop step response (do not solve the equations). (6 marks)

Q4 (a) Consider the transfer function of the system such that the damping ratio ζ is 0.5, in the unit-step response.

$$\frac{C(s)}{R(s)}-\frac{16}{s^2+(0.8+16k)s+16}$$

Determine ;

(i) the value of k

(ii) maximum overshoot M_p,

(iii) settling time t_s (5 marks)

(b) The open loop transfer function of a humanoid's arm control system is given as G(s) = K_p / [s(0.1s+1)]

(i) Clearly locate all poles and zeros on a linear graph paper. Determine asymptote angles, centroid for asymptotes. Plot the complete root locus, with the locus on the real axis is clearly shown. (5 marks)

(ii) Then determine the operational point, S_m (poles) for damping ratio, $\zeta=0.5$. Also determine natural frequencies (ω_n and ω_d) and gain K at this operational point. (5 marks)

PART B:

Q5 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.

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

(a) Use a proportional controller K_p that satisfies this specification.

(10 marks)

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

(10 marks)

Q6 (a) By using straight line asymptote methods, state **FOUR(4)** steps to sketch Bode diagram in control design techniques. (2 marks)

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

(c) The transfer function of an electric shredding 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 estimates the values.

(3 marks)

(iii) Comment on the stability of the system. (2 marks)

- END OF QUESTION –

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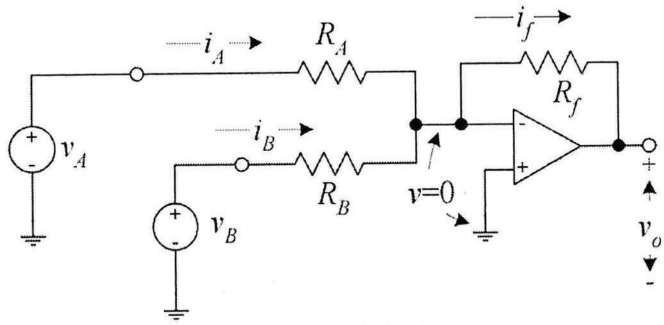

Figure Q1(a)

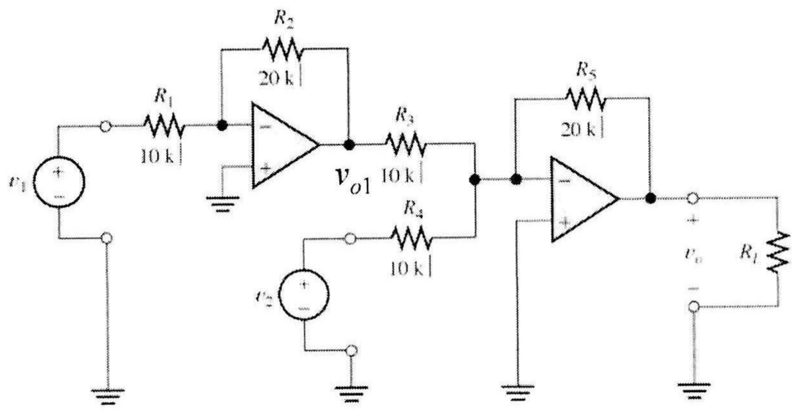

Figure Q1(b)

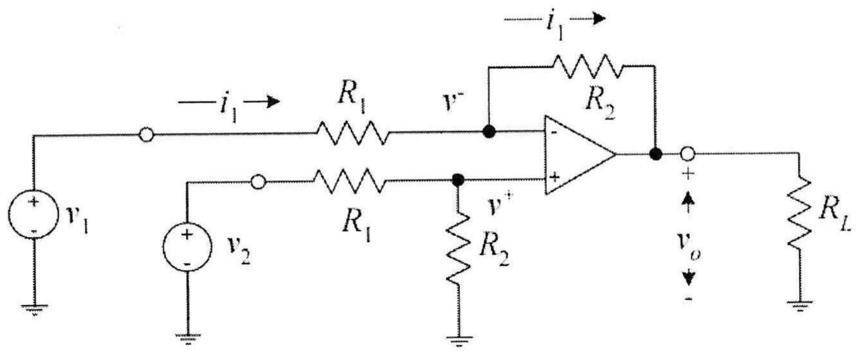

Figure Q1(c)

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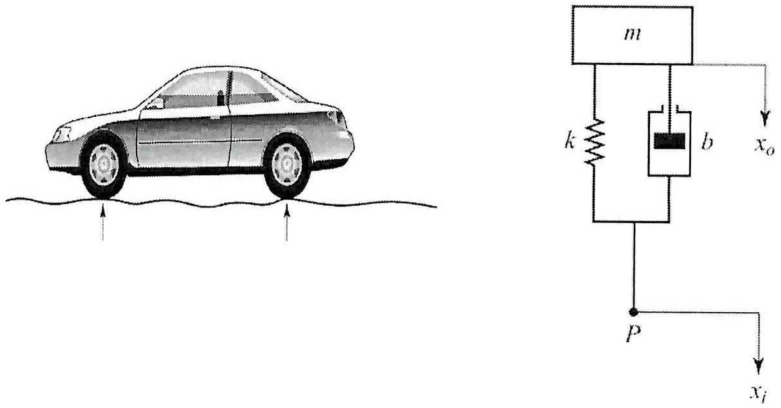

Figure Q2.