Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	INSTRUMENTATION AND CONTROL
COURSE CODE	:	BNR 20703
PROGRAMME CODE	:	BND / BNE / BNF
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) Describe **THREE (3)** method to reduce instrumental error.

(3 marks)

(b) The output of a Resistance Temperature Detector (RTD) is shown in **Table Q1(c)**. Draw an output versus input graph. From the graph, determine the sensitivity of the equipment.

(5 marks)

(c) A 820 Ω ± 10 % resistor, R carries a current of 10 mA. The current was measured by an analog ammeter on a 25 mA range with an accuracy of ± 2 % of full scale. Determine the total error of power dissipated in the resistor.

(5 marks)

(d) **Figure Q1(d)** shows a graph of measurement for 'Length of Car Injector Needle' that has been recorded by car manufacturing company. Ten samples have been identified for technical analysis. Use Chauvenet's criterion to test the possibility of inconsistent data measurement by calculating the mean, $\bar{x}$ and the standard deviation, σ. Then, calculate the new value of standard deviation.

(7 marks)

Q2 (a) State **THREE (3)** basic elements of instrumentation.

(3 marks)

(b) A Resistance Temperature Detector (RTD) has resistance of 500 Ω, temperature coefficient of a resistance, α of 0.005 °C^{-1} and a dissipation constant, P_D of 30 mW/°C at 25 °C. The RTD is used in a bridge circuit such as that in **Figure Q2(b)** with $R_1 = R_2 = 500\ \Omega$. If the voltage supply is 10 V and the RTD is placed in a bath at 0 °C, determine the value of the variable resistor, R_3 to null the bridge.

(6 marks)

(c) An iron-constantan thermocouple has a cold junction at 0 °C and is to be used for the measurement of temperatures between 0 °C and 400 °C. Determine the non-linearity error at 100 °C, as a percentage of the full-scale reading, if a linear relationship is assumed over the full range. The electromotive force (E.M.F) measured by the thermocouple at different temperatures are shown in **Table Q2(c)**.

(4 marks)

(d) Formulate overall voltage gain, $\left(A_v = \frac{V_{out}}{V_{in}}\right)$ of the operational amplifier shown in **Figure Q2(d)** in terms of R_2 and R_F with ideal case assumptions.

(5 marks)

(e) An operational amplifier circuit is required to produce an output that ranges from 0 to -15 V when the input goes from 0 to 100 μV. Calculate the multiplication factor of the feedback resistance to the input resistance.

(2 marks)

Q3 (a) With the aid of block diagram, draw the control system of an aircraft flight path control using Global Positioning System (GPS).

(7 marks)

(b) Many applications of the electronics system around us implement closed-loop control. List **THREE (3)** advantages of using feedback in a closed-loop system.

(3 marks)

(c) **Figure Q3(c)** shows an electrical network consisting of a resistor, *R*, an inductor, *L*, and a capacitor, *C*. $V(s)$ is the input voltage and $V_L(s)$ is the voltage across the inductor. Find the transfer function, $G(s) = \frac{V_L(s)}{V(s)}$ of the system.

(10 marks)

Q4 (a) For the translational mechanical system shown in **Figure Q4(a)**, determine the model of the system in the frequency domain, $G(s) = \frac{X_2(s)}{F(s)}$.

(8 marks)

(b) For the block diagram shown in **Figure Q4(b)**, determine the relationship between the output variable *C(s)* and the input variable *R(s)* by analyzing the system's variables using block diagram reduction method.

(12 marks)

Q5 (a) Explain the following control terminologies with the aid of respecting plotting:

(i) Steady state response
(ii) Steady-state error
(iii) Rise time
(iv) Settling time

(8 marks)

(b) A transfer function of an open loop control system is shown in **Figure Q5(b)**. Identify the poles and zeros and plot the system's zeros on *s*-plane. Then, conclude the stability of the system.

(6 marks)

(c) **Table Q5(c)** contains the relationship between the damping ratio, pole locations and unit step response of a second order system. Complete the table for the given damping ratio, pole locations or unit step response by rewriting the **Table Q5(c)** in your answer booklet.

(6 marks)

-END OF QUESTIONS-

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Table Q1(b)

Input (°C)	Output (kOhm)
0	0
10	0.59
20	1.19
30	1.8
40	2.42

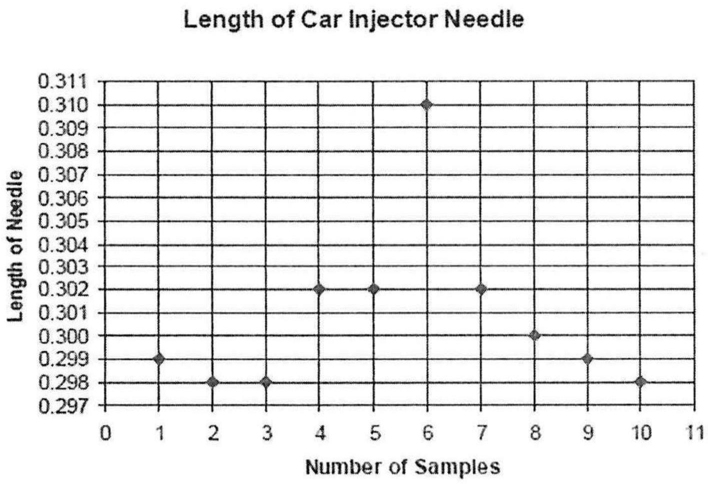

Figure Q1(d)

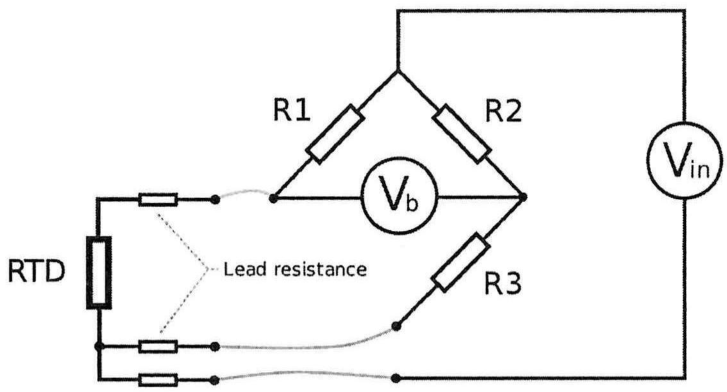

Figure Q2(b)

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Table Q2(c)

Temperature (°C)	0	100	400
E.M.F (mV)	0	5.268	21.846

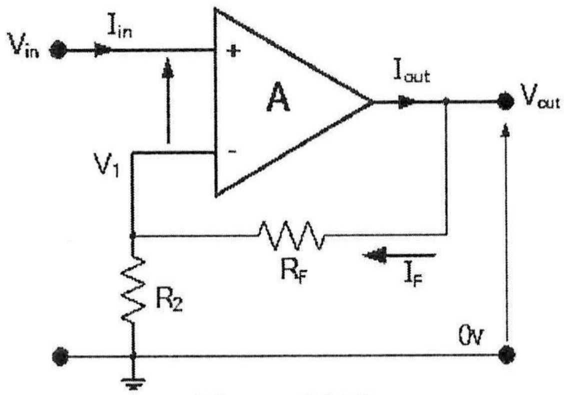

Figure Q2(d)

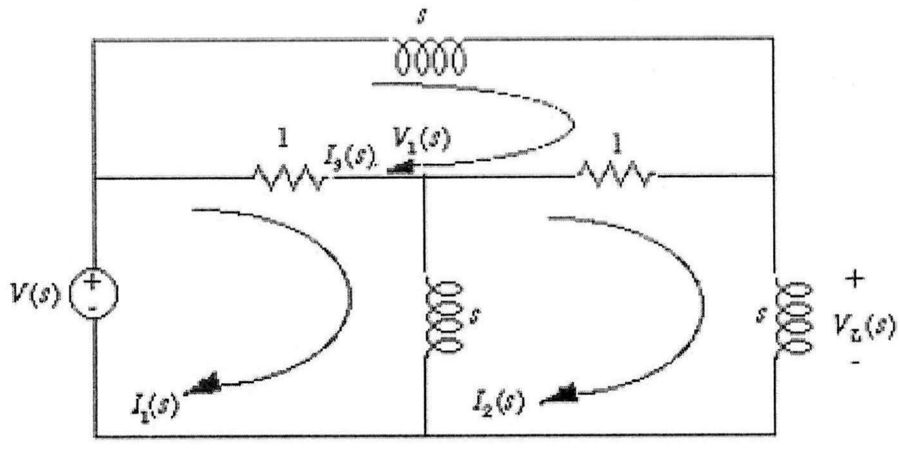

Figure Q3(c)

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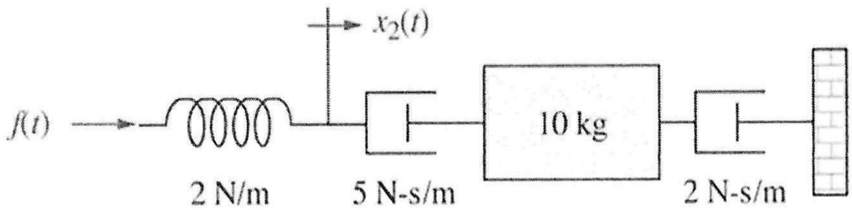

Figure Q4(a)

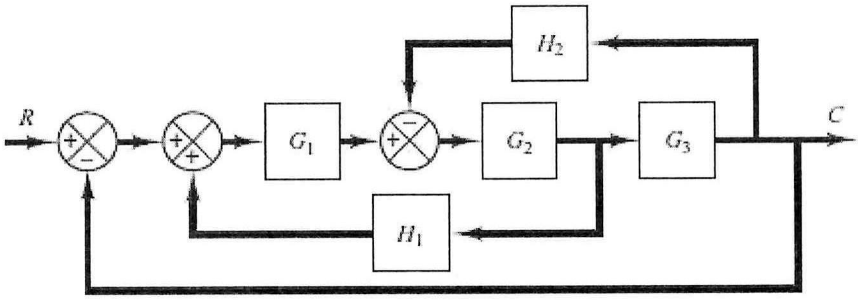

Figure Q4(b)

$$G(s) = \frac{(s-2)(s+5)(s+8)}{s(s+1)(s+6)(s+9)(s+1-j3)(s+1+j3)}$$

Figure Q5(b)

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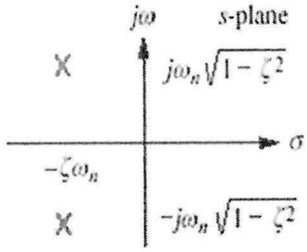
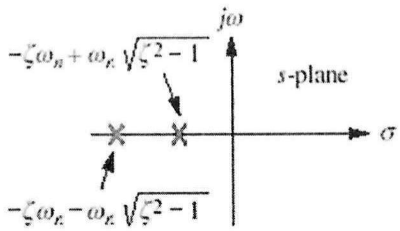
Table Q5(c)

No	Damping ratio, ζ	Poles location	Unit step response
1	$0 < \zeta < 1$		
2	$\zeta = 1$		
3	$\zeta > 1$		
4	0		

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APPENDIX

LAPLACE TRANSFORM TABLE

Item no.	Theorem	Name
1.	$\mathscr{L}[f(t)] = F(s) = \int_{0-}^{\infty} f(t)e^{-st}dt$	Definition
2.	$\mathscr{L}[kf(t)] = kF(s)$	Linearity theorem
3.	$\mathscr{L}[f_1(t) + f_2(t)] = F_1(s) + F_2(s)$	Linearity theorem
4.	$\mathscr{L}[e^{-at}f(t)] = F(s+a)$	Frequency shift theorem
5.	$\mathscr{L}[f(t-T)] = e^{-sT}F(s)$	Time shift theorem
6.	$\mathscr{L}[f(at)] = \frac{1}{a}F\left(\frac{s}{a}\right)$	Scaling theorem
7.	$\mathscr{L}\left[\frac{df}{dt}\right] = sF(s) - f(0-)$	Differentiation theorem
8.	$\mathscr{L}\left[\frac{d^2f}{dt^2}\right] = s^2F(s) - sf(0-) - f'(0-)$	Differentiation theorem
9.	$\mathscr{L}\left[\frac{d^nf}{dt^n}\right] = s^nF(s) - \sum_{k=1}^{n} s^{n-k}f^{k-1}(0-)$	Differentiation theorem
10.	$\mathscr{L}\left[\int_{0-}^{t} f(\tau)d\tau\right] = \frac{F(s)}{s}$	Integration theorem
11.	$f(\infty) = \lim_{s\to 0} sF(s)$	Final value theorem[1]
12.	$f(0+) = \lim_{s\to\infty} sF(s)$	Initial value theorem[2]