UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2013/2014

COURSE NAME	:	INSTRUMENTATION AND CONTROL SYSTEMS
COURSE CODE	:	BEH 22003
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JANUARY 2014
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 Figure **Q1** shows the ammeter with Ayrton Shunt connection. D' Arsonval meter with internal resistance (R_m) 50Ω and full scale current (I_m) 1 mA is connected to the Ayrton Shunt. If Ayrton shunt need to be used as a multi range ammeter with the range of 1A at point 1, 5A at point 2 and 10A at point 3, determine the value of R_a, R_b and R_c.

(20 marks)

Q2 (a) Draw and name four main components of conventional cathode ray tube.

(8 marks)

(b) In an experiment, the voltage across a 10kΩ resistor is measured using oscilloscope. The screen shows a sinusoidal signal of total vertical occupancy 3cm and total horizontal occupancy 2cm. The front panel controls of V/div and time/div are on 2V/div and 2ms/div respectively.

(i) Calculate the voltage peak to peak, $\mathbf{V_{pp}}$.

(1 mark)

(ii) Determine the root mean square value of the voltage across the resistor, $\mathbf{V_{rms}}$.

(2 marks)

(iii) Calculate the period and frequency of the signal.

(2 marks)

(iv) Sketch the output display

(2 marks)

(c) Figure **Q2(c)** shows the Lissajous figure obtained on the oscilloscope. Analyze the phase difference between the two applied signals.

(2.5 marks)

(d) The Lissajous pattern is obtained on the screen by applying horizontal signal of frequency 1kHz as shown in Figure **Q2(d)**. Determine the unknown frequency of vertical signal.

(2.5 marks)

Q3 (a) Figure **Q3(a)** shows a part of a wind tunnel aircraft-pitch-control system. The pitch angle is θ_o and the pilot input is θ_i, the vertical velocity signal is V_v, while θ_e is the elevation angle. Solve the transfer function $G(s) = \theta_o(s)/\theta_i(s)$.

(10 marks)

(b) Figure **Q3(b)** shows a resistor-capacitor-inductance system. Determine the 2nd order transfer function of $\frac{V_C(s)}{V(s)}$.

The voltage-current of each component can be represented as below;

$$v_R(t) = Ri(t), \qquad v_C(t) = \frac{1}{C}\int_0^1 i(\tau)\,d\tau, \qquad v_L(t) = L\frac{di}{dt}$$

(10 marks)

Q4 (a) Explain clearly with the help of the diagram to modify an open loop control system into a closed loop control system.

(10 marks)

(b) Elaborate the factor that must be considered in order to implement an open loop control system. Give a practical control system example to support your arguments.

(5 marks)

(c) Summarize the factors that must be considered in order to implement a closed loop control system. Give a practical control system example to support your arguments.

(5 marks)

Q5 (a) A unit ramp input $r(t) = tu(t)$ is applied at time t = 0 to the system in Figure **Q5(a)**. Determine the output response and sketch the resulting time history. [Assume that all initial condition is zero].

(5 marks)

(b) Figure **Q5(b)** shows a block diagram of servo system with position feedback. Solve the overall transfer function of the system.

(4 marks)

(c) If the system in Figure **Q5(b)** is required to obtain system response with 20% of maximum overshoot and 1sec of the peak time, determine the following performance specification when the system is subjected to a unit step input. [Assume that $J = 1$ kg-m^2 and $B = 1$ N-m/rad/sec]

(i) Possible value for gain, K and K_h.

(5 marks)

(ii) The rise-time, T_r.

(2 marks)

(iii) The settling-time, T_s for ±2%.

(2 marks)

(d) Sketch the transient response of the system in Figure **Q5(b)** in time domain.

(2 marks)

- END OF QUESTION –

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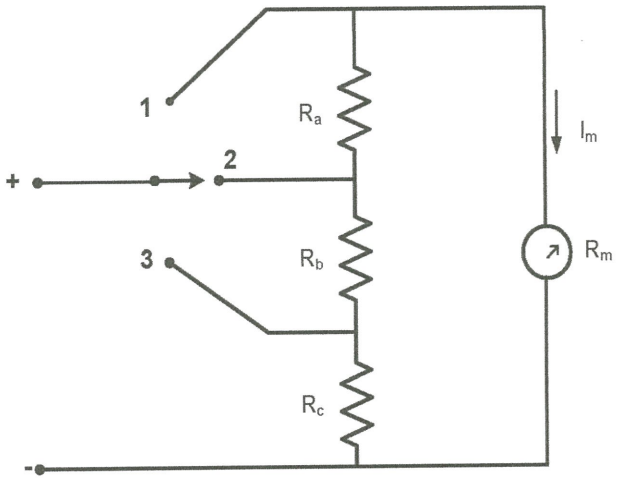

FIGURE Q1

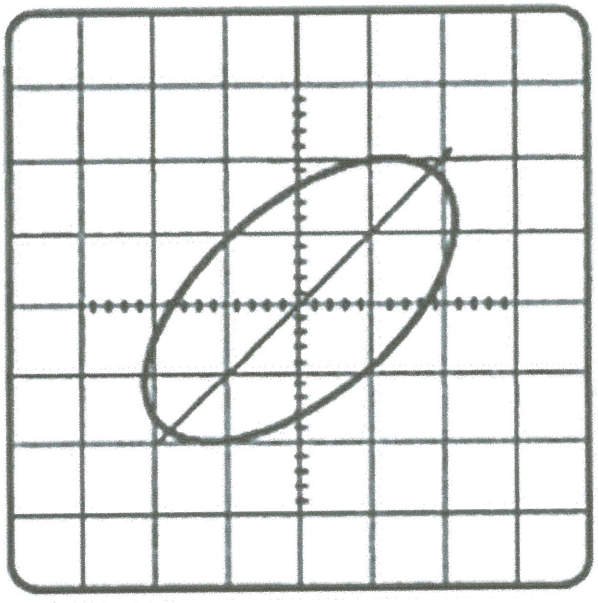

FIGURE Q2(c)

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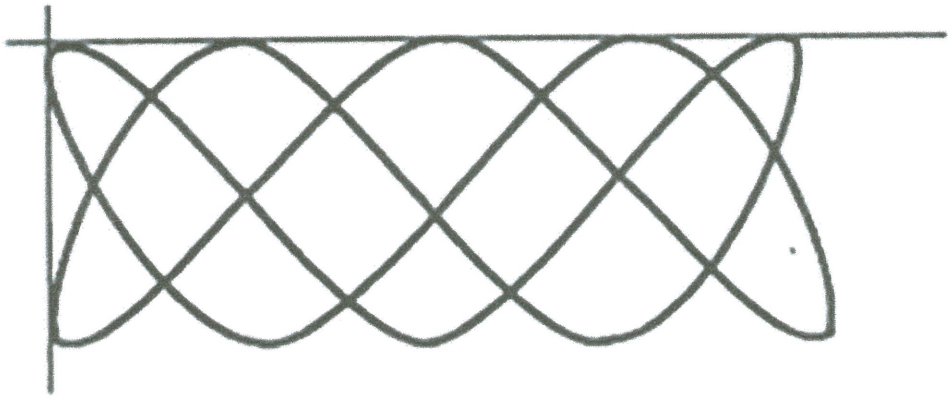

FIGURE Q2(d)

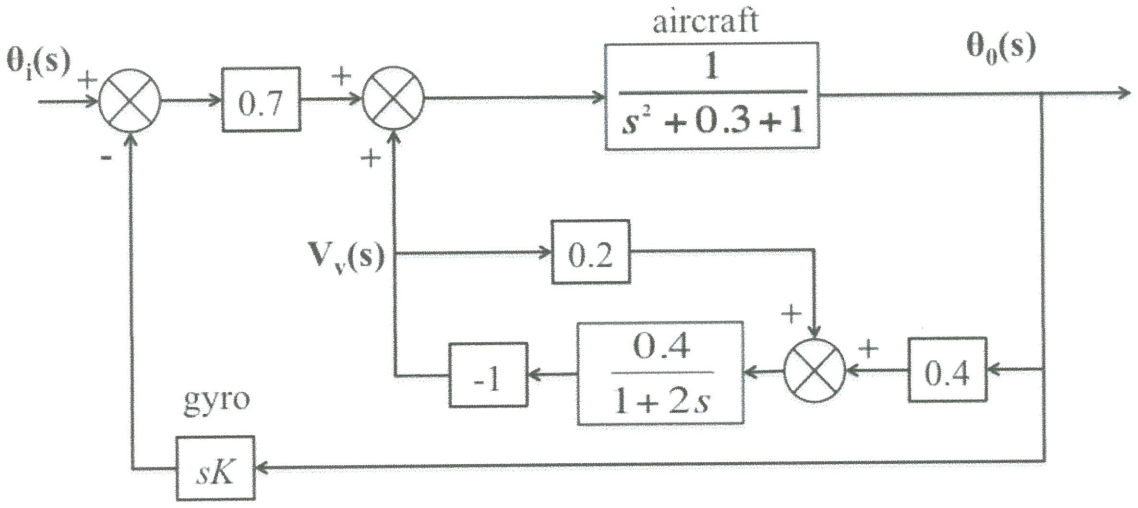

FIGURE Q3(a)

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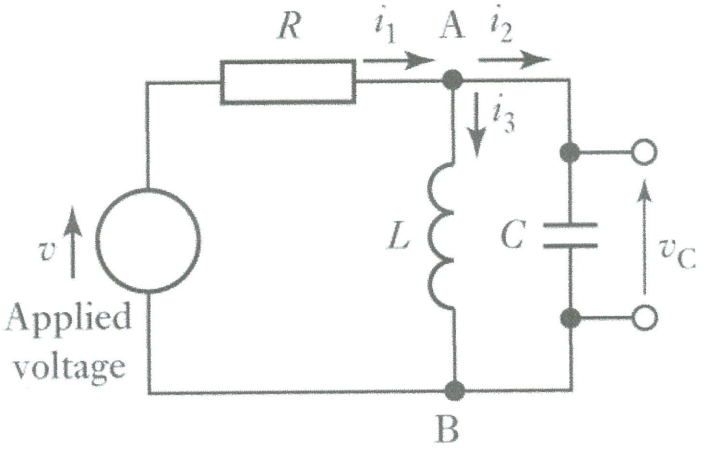

FIGURE Q3(b)

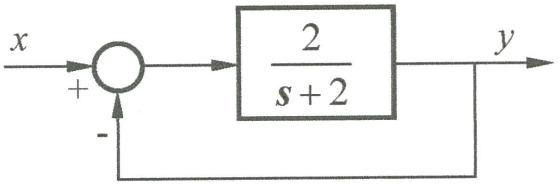

FIGURE Q5(a)

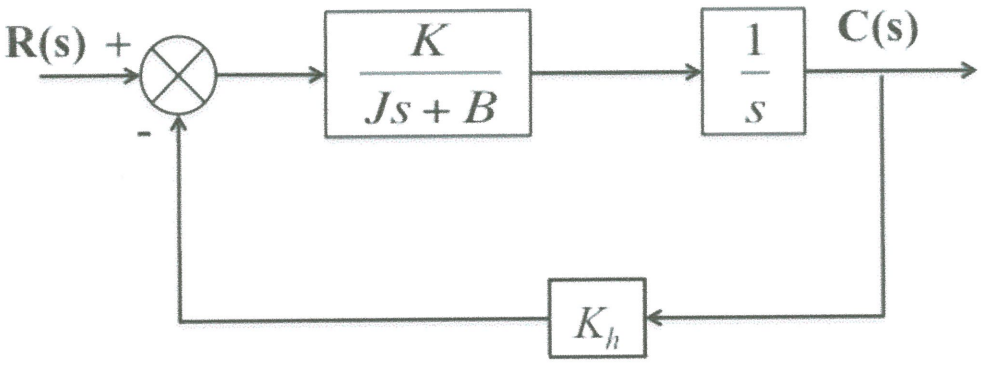

FIGURE Q5(b)

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TABLE 1

Item no.	$f(t)$	$F(s)$
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	$t^n u(t)$	$\frac{n!}{s^n + 1}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

TABLE 2

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