Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	INSTRUMENTATION AND CONTROL SYSTEM
COURSE CODE	:	BEH22003
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE / JULY 2016
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Give **one (1)** practical example of open loop system and **one (1)** practical example of closed loop system.

(2 marks)

(b) Discuss the difference between of open loop system and closed loop system with reflect to the complexity and accuracy of the system.

(6 marks)

(c) Determine the transfer function $\frac{C(s)}{R(s)}$ of the system shown in **Figure Q1(c)**.

(12 marks)

Q2 (a) Describe the important of Laplace transform in control engineering.

(2 marks)

(b) Determine the transfer function $\frac{\theta_3(s)}{T(s)}$ of the system shown in **Figure Q2(b)**.

(10 marks)

(c) A Direct Current (DC) motor is available for a speed control regulator and has the following properties:

- On no load its speed increases linearly with input voltage with a sensitivity at 15 rev/s per input voltage.
- Its speed falls linearly on a torque load with a sensitivity of 2 rev/s per Nm of load torque.
- A tachogenerator is available as a speed to voltage transducer and this has a sensitivity of 10 volts per 1000 rev/s.

Calculate the gain of the d.c. amplification required in a closed-loop negative feedback system which will produce a regulation of 0.5% when no load speed is 200 rev/s and the load torque is 20 Nm.

(8 marks)

Q3 (a) The closed loop transfer function of a system is given as below.

$$G(s)=\frac{C(s)}{R(s)}=\frac{(s-1)}{(s+4)(s^2+5s+6)}$$

(i) Categorize either the system is stable or unstable based on poles location on s-plane

(4 marks)

(ii) Justify your answer on **Q3(a)(i)**.

(2 marks)

(b) A transfer function for a positioning system is shown as below;

$$G(s)=\frac{C(s)}{R(s)}=\frac{2.7}{s^2+0.918s+2.7}$$

(i) Calculate the peak time, T_p.

(3 marks)

(ii) Calculate the rise time, T_r.

(2 marks)

(iii) Calculate the settling time, T_s with 5% band.

(1 marks)

(iv) Determine the value of damping ratio, ζ if the system is designed to have a 15% overshoot,

(3 marks)

(v) By choosing at least **two (2)** difference value of damping ratio, ζ, proved that the percentages of overshoot, $\%\mu_s$ of the system can be adjusted by adjusting the value of damping ratio, ζ.

(5 marks)

Q4 (a) Explain clearly why dead-zone or neutral zone is implemented in an on-off controller.

(5 marks)

(b) A 5m diameter cylindrical tank is emptied by a constant outflow of 1.0 m^3/min. An ON-OFF controller is used to open and close a fill valve with an open flow of 2.0 m^3/min. For level control, the neutral zone is 1 m and the set-point or input is 12 m.

(i) Illustrate the control system described in **Q4(b)** above by using a schematic diagram.

(5 marks)

(ii) Calculate the cycling period.

(5 marks)

(iii) Plot the level versus time

(5 marks)

Q5 (a) Explain the basic principle in the conversion of analog angle directly into its digital Value.

(5 marks)

(b) Differentiate the working principles between an incremental encoder and an absolute encoder.

(10 marks)

(c) Design a measurement system where an incremental encoder is being used in determining the distance travelled by a mobile robot in real-time.

(5 marks)

- END OF QUESTIONS -

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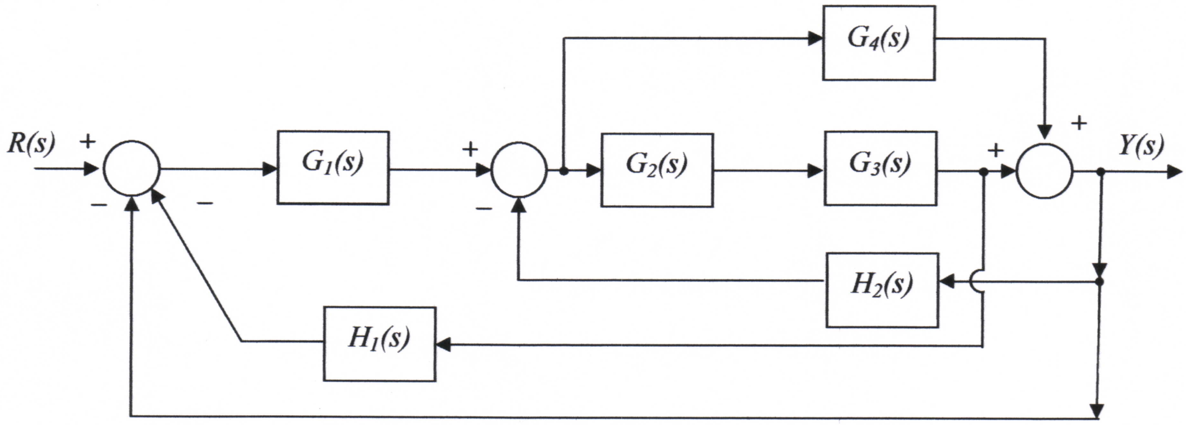

Figure Q1(c)

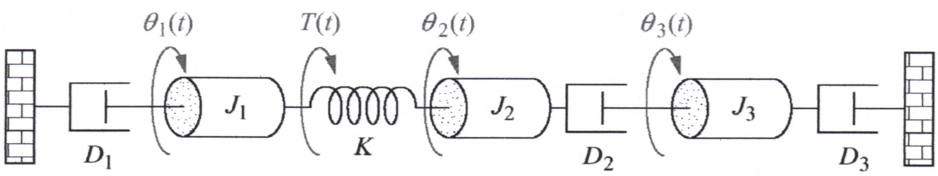

Figure Q2(b)

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FORMULA

Table A
Laplace transform table

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$tu(t)$	$\frac{1}{s^2}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-at}u(t)$	$\frac{1}{s+a}$
$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

Table B
Laplace transform theorems

Name	Theorem
Frequency shift	$\mathscr{L}\left[e^{-at}f(t)\right] = F(s+a)$
Time shift	$\mathscr{L}\left[f(t-T)\right] = e^{-sT}F(s)$
Differentiation	$\mathscr{L}\left[\frac{d^n f}{dt^n}\right] = s^n F(s) - \sum_{k=1}^{n} s^{n-k} f^{k-1}(0^-)$
Integration	$\mathscr{L}\left[\int_{0^-}^{t} f(\tau)d\tau\right] = \frac{F(s)}{s}$
Initial value	$\lim_{t\to 0} f(t) = \lim_{s\to\infty} sF(s)$
Final value	$\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s)$

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Table C

Open loop speed regulation

Name	Formula
No load speed, (ω_{NL})	$= K_s K_m V_e$
Speed with load, (ω_L)	$= K_s K_m V_e - K_L T_L$
% regulation	$= \dfrac{(\omega_{NL}) - (\omega_L)}{\omega_{ONL}} X100\%$ $= \dfrac{K_L T_L}{\omega_{ONL}} X100\%$

Table D

Open loop speed regulation

Name	Formula
No load speed, (ω_{NL})	$= \dfrac{K_s K_m}{1 + K_s K_m K_g} V_i$
Speed with load, (ω_L)	$= \dfrac{K_s K_m}{1 + K_s K_m K_g} V_i - \dfrac{K_L}{1 + K_s K_m K_g} T_L$
% regulation	$= \dfrac{(\omega_{NL}) - (\omega_L)}{\omega_{ONL}} X100\%$ $= \dfrac{\dfrac{K_L T_L}{1 + K_s K_m K_g}}{\omega_{ONL}} X100\%$

Table E

2nd Order prototype system equations

$\dfrac{C(s)}{R(s)} = \dfrac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$	$T_r = \dfrac{\pi - \cos^{-1}\zeta}{\omega_n \sqrt{1-\zeta^2}}$
$\mu_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$	$T_p = \dfrac{\pi}{\omega_n \sqrt{1-\zeta^2}}$
$T_s = \dfrac{4}{\zeta\omega_n}$ (2% criterion)	$T_s = \dfrac{3}{\zeta\omega_n}$ (5% criterion)