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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

COURSE NAME	:	CONTROL SYSTEM THEORY
COURSE CODE	:	BEH 30603
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2016/JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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THIS QUESTION PAPER CONSISTS **OF FIVE (5)** PAGES ONLY

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Q1 (a) Draw the general block diagram for the closed loop control system.

(4 marks)

(b) Differentiate clearly the function of each component in the block diagram that you have drawn in question **Q1**(a).

(10 marks)

(c) By using a practical example, analyse the effect of disturbance on a closed loop control system.

(6 marks)

Q2 **Figure Q2** shows a block diagram of a position control system which employs velocity feedback. The amplifier gain and tachometer constant for this control system are given by K_s and K_g respectively.

(a) Formulate the transfer function C(s)/R(s).

(4 marks)

(b) Select suitable values for K_s and K_g so that the output response for a unit step input, will have a maximum overshoot of 9.47% at time t = 0.3927 second.

(8 marks)

(c) By using these selected values for K_s and K_g, derive the unit step response c(t) of the system.

(8 marks)

Q3 (a) Define the term *root locus* which applies to control system.

(2 marks)

(b) Consider a control system with unity feedback which has the open-loop transfer function:

$$G(s) = \frac{K}{(s+4)^3}$$

(i) By using Routh-Hurwitz stability criteria, investigate the values of K for this control system to be stable.

(4 marks)

(ii) Produce the root locus for this control system based on the procedure for sketching root locus.

(10 marks)

(iii) Select a suitable value for K from the root locus, so that the unit step response of this control system will be under damped.

(4 marks)

Q4 (a) Investigate the phenomenon that will occur in a control system when an on-off controller is being employed in the system.

(5 marks)

(b) Analyse the requirement of a dead-zone or neutral zone in an on-off controller.

(5 marks)

(c) The temperature of water in a tank is controlled by an on-off controller. When the heater is *off* the temperature drops at 2°C per minute. When the heater is *on* the temperature rises at 4°C per minute. The setpoint or the input is 50°C and the neutral zone is ±20% of the setpoint. There is a 0.5 min lag at the *on* and *off* switch points.

(i) Plot the water temperature versus time.

(7 marks)

(ii) Determine the period of oscillation.

(3 marks)

Q5 A single input single output control system can be represented by the state equation and output equation respectively as $\dot{\underline{x}}(t) = A\,\underline{x}(t) + B\,\underline{u}(t)$ and $y(t) = C\underline{x}(t)$, where the matrices A, B and C are given respectively by:

$$A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}, \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \text{ and } C = \begin{bmatrix} 1 & 0 \end{bmatrix}$$

(a) Write down an expression for the transformed states X(s).

(3 marks)

(b) Formulate the state transition matrix Φ(t) for this system.

(10 marks)

(c) Formulate the output y(t) when the system is subjected to a unit step input and the initial states are given by $\underline{x}(0) = [0 \;\; 0]^T$.

(7 marks)

– END OF QUESTIONS –

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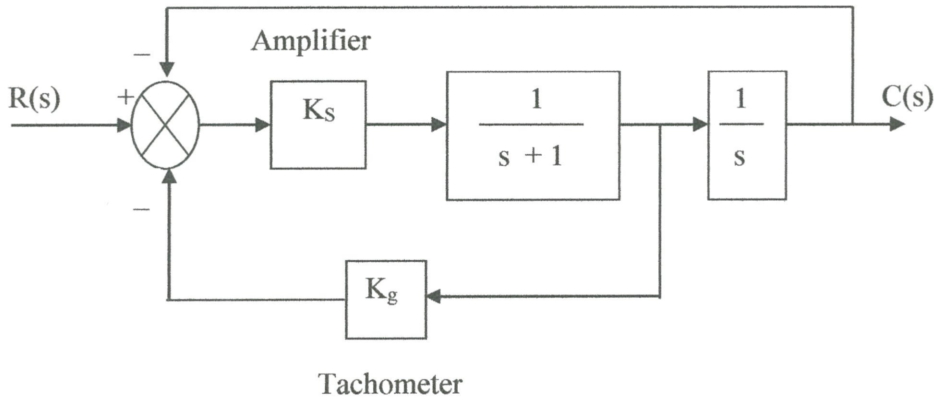

FIGURE Q2

Table 1 : Laplace Transform Table

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

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Table 2 : Second order prototype equations

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

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