Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	INSTRUMENTATION AND CONTROL SYSTEMS
COURSE CODE	:	BEH 22003
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

TERBUKA

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

Q1 (a) List down the advantages and disadvantages of the open loop control system.

(3 marks)

(b) Explain clearly how one of the disadvantages of the open loop control system that you have listed in question **Q1(a)** can occur in a practical control system.

(7 marks)

(c) List down the advantages and disadvantages of the closed loop control system.

(3 marks)

(d) Explain clearly how one of the advantages of the closed loop control system that you have listed in question **Q1(c)** can occur in a practical control system.

(7 marks)

Q2 **Figure Q2** shows a schematic diagram for a field control direct current motor. Given that the motor torque $T_m(t)$ is proportional to the field current i(t) i.e. $T_m(t) = K_t i(t)$ where K_t is the motor torque constant. The armature current I_a is assumed to be constant. J_m and B_m are the moment of inertia and the viscous frictional torque constants respectively referred to the motor shaft.

(a) Determine the relevant equations for this system.

(4 marks)

(b) Build the block diagram for this system.

(5 marks)

(c) Obtain the transfer function of $\theta_m(s)/V(s)$ where $\theta_m(s)$ and V(s) are the Laplace transformations of the angular position $\theta_m(t)$ and the motor voltage v(t) respectively.

(5 marks)

(d) By using a suitable schematic diagram, design a closed-loop control system to control the angular position $\theta_m(t)$.

(6 marks)

Q3 (a) Describe the type of responses of a second order prototype closed loop control system that relates to the values of the damping ratio ζ.

(8 marks)

(b) **Figure Q3(b)** shows the block diagram of a control system where K_S and K_g are the amplifier gain and the tachometer constant respectively where $K_S = 100$ and $K_g = 0.11$.

(i) Determine the percentage maximum overshoot μ_p and the time this maximum overshoot to occur T_p.

(4 marks)

(ii) Obtain the unit step response c(t), of this control system.

(6 marks)

(iii) Sketch the response c(t) obtained in **Q3(b)(ii)**.

(2 marks)

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

(5 marks)

(b) Explain clearly why dead-zone or neutral zone is implemented in a 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) Explain the difference between active and passive transducers.

(4 marks)

(b) A resistive potentiometer transducer with a shaft stroke of L cm is applied in the circuit of **Figure Q5**. The total resistance of the potentiometer is R Ω, and the applied voltage is V_T V. The travel distance from the wiper to point B is x cm.

(i) By assuming that the transducer is linear, obtain the relationship between the output voltage V_o and the distance x.

(6 marks)

(ii) Given that $L = 12$ cm, $x = 3$ cm, $R = 10$ kΩ and $V_T = 10$ volts, calculate the voltage V_o.

(2 marks)

(iii) Propose a suitable method where this resistive transducer can be used to measure the bumpiness or the unevenness of a roadway.

(8 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER/SESSION: SEMESTER II/2016/2017 PROGRAMME : BEJ
COURSE NAME : INSTRUMENTATION AND CONTROL SYSTEMS COURSE CODE : BEH22003

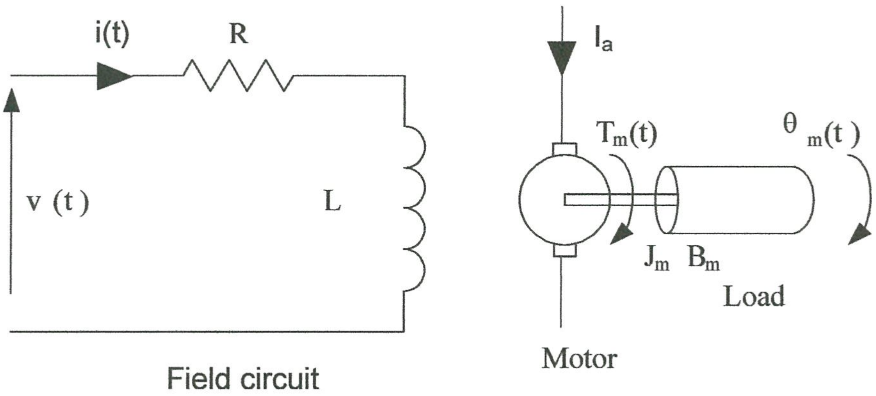

Figure Q2

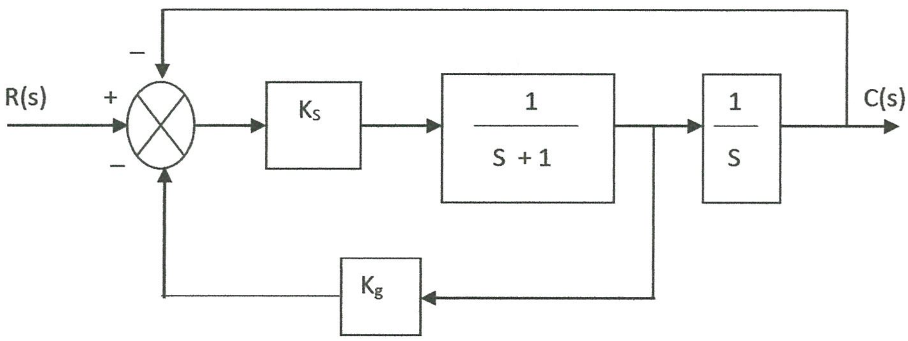

Figure Q3(b)

FINAL EXAMINATION

SEMESTER/SESSION: SEMESTER II/2016/2017
COURSE NAME : INSTRUMENTATION AND CONTROL SYSTEMS

PROGRAMME : BEJ
COURSE CODE : BEH22003

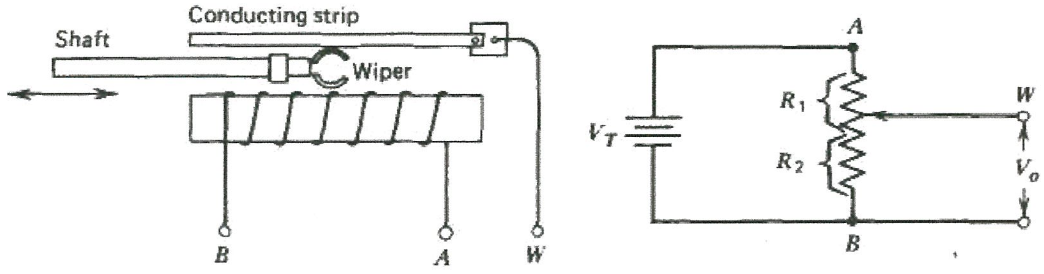

Figure Q5

FINAL EXAMINATION

SEMESTER/SESSION: SEMESTER II/2016/2017 PROGRAMME : BEJ
COURSE NAME : INSTRUMENTATION AND CONTROL SYSTEMS COURSE CODE : BEH22003

Table 1 : Laplace Transform Table

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

FINAL EXAMINATION

SEMESTER/SESSION: SEMESTER II/2016/2017
COURSE NAME : INSTRUMENTATION AND CONTROL SYSTEMS

PROGRAMME : BEJ
COURSE CODE : BEH22003

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)