UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	INSTRUMENTATION AND CONTROL SYSTEM
COURSE CODE	:	BEH 22003
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2018/JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

Q1 (a) Give **two (2)** practical example of open loop system and **two (2)** practical example of closed loop system.

(4 marks)

(b) Identify **two (2)** advantages and **two (2)** disadvantages of closed loop system.

(4 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 definition translational system.

(2 marks)

(b) Determine the transfer function, $H(s)=\frac{X(s)}{F(s)}$ of the system shown in **Figure Q2(b).** Let the parameter for the systems are as follow;

$M_1=M_2=M_3=1Kg$
$D_1=D_2=D_3=2N\text{-}s/m$
$K_1=K_2=K_3=1\ N/m$

(14 marks)

(c) The DC motor shown in **Figure Q2(c)** is operate in open-loop condition and does not provide precise angular velocity regulation. As an engineer, you are required to design a closed loop system for the DC motor so that a precise angular velocity regulation can be achieved. Identify the additional component required for controlling the angular velocity of the DC motor

(4 marks)

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

$$G(s)=\frac{C(s)}{R(s)}=\frac{(s+2)}{(s+4)(s^2+7s+12)}$$

(i) Sketch zeros and poles of the system on s-plane.

(5 marks)

(ii) Based on **Q3(a)(i),** determine either the system is stable or unstable.

(2 marks)

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

$$G(s)=\frac{C(s)}{R(s)}=\frac{10.8}{4s^2+3.672s+10.8}$$

(i) Calculate the peak time, T_p.

(5 marks)

(ii) Calculate the rise time, T_r.

(2 marks)

(iii) Calculate percentages overshoot, $\%\mu_s$.

(2 mark)

(iv) By choosing at least **two (2)** differences value of damping ratio, ζ , relate the relationship between damping ratio, ζ and the percentages of overshoot, $\%\mu_s$.

(4 marks)

Q4 (a) Explain the difference between direct action controller with reverse action controller.

(6 marks)

(b) The temperature of steam distillation system is controlled by an on-off controller. When the heater is *on* the temperature rises at 0.6 celcius per minute. When the heater is *off* the temperature drop at 0.4 celcius per minute. The set point or the input, is 90 celcius and the neutral zone is ±4% of the set point. There is a 2 min lag at the *on* and *off* switch points.

(i) Sketch the steam temperature versus time.

(10 marks)

(ii) Based on **Q4(b)(i),** determine the period of oscillation.

(4 marks)

Q5 (a) Describe the passive and active transducer.

(6 marks)

(b) Describe the detail working principles of thermistors.

(6 marks)

(c) As an engineer, you are required to design mobile robot that has capability to avoid the obstacle.

(i) Identify suitable sensor for this application.

(2 marks)

(ii) With proper sketching, illustrate the operation of the system .

(6 marks)

- END OF QUESTIONS -

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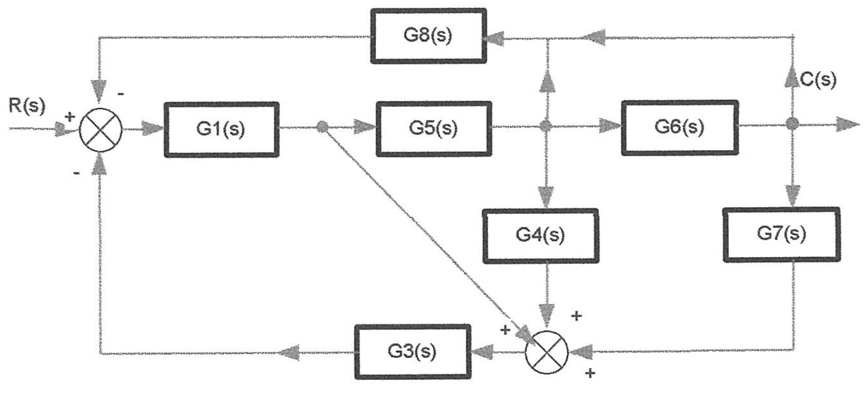

Figure Q1(c)

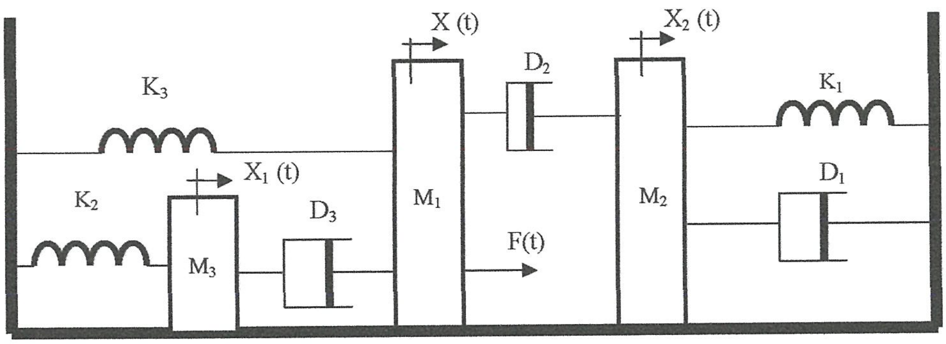

Figure Q2(b)

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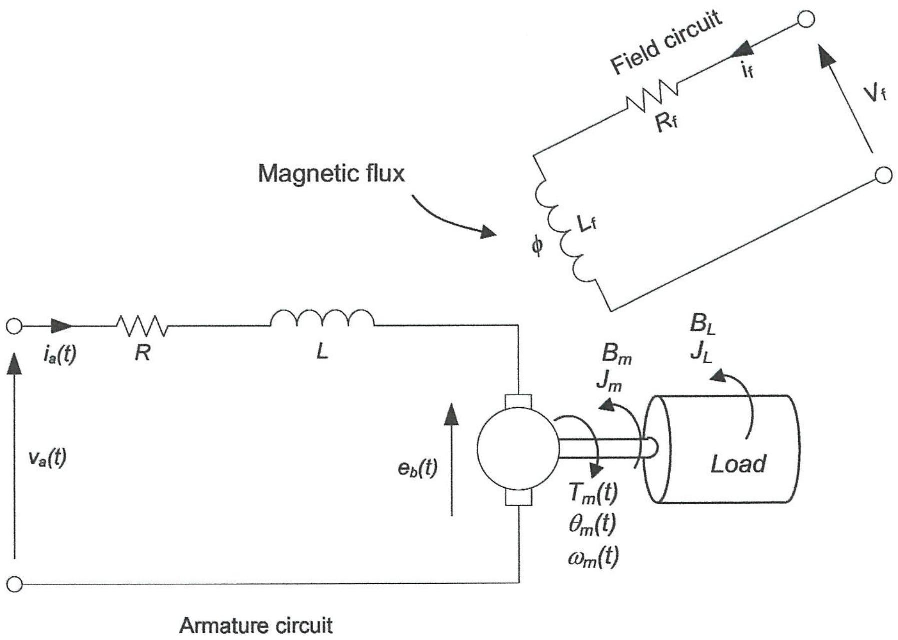

Figure Q2(c)

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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	$\mathscr{L}\left[\frac{d^n f}{dt^n}\right]=s^nF(s)-\sum_{k=1}^{n}s^{n-k}f^{k-1}(0^-)$
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
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)