Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	CONTROL SYSTEM THEORY
COURSE CODE	:	BEJ 20503
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

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

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

(2 marks)

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

(4 marks)

(c) The schematic diagram of a wind turbine system is as shown in **Figure Q1(c)** and the resulted transfer function $\frac{\theta_2(s)}{T(s)}$ obtained for the system is shown below:

$$\frac{\theta_2(s)}{T(s)} = \frac{s^4 + 9s^3 + 11s^2 + 27s + 24}{s^6 + 7s^5 + 8s^4 + 84s^4 + 84s^3 + 178s^2 + 168s + 8}$$

Investigate either the transfer function, $\frac{\theta_2(s)}{T(s)}$ obtained for the system is correct or not.

(14 marks)

Q2 (a) Describe the definition of electromechanical system.

(2 marks)

(b) Machine Drill Sdn. Bhd. in a process to develop robust position control for conveyer system and the schematic diagram of Direct Current (DC) motor used for the conveyer system is shown in **Figure Q2(b).** By assuming in load condition, determine the transfer function $\frac{\theta_m(s)}{V_a(s)}$, for the DC motor shown in **Figure Q2(b).**

(14 marks)

(c) The schematic diagram of a DC motor shown in **Figure Q2(b)** is operated in open loop system. Identify the components that are required for converting the DC motor operation in closed loop system for accurate position control.

(4 marks)

Q3 (a) The block diagram for hair dryer system is shown in **FigureQ3(a).** Based on Routh Hurwitz stability criterion, point out the total poles located on the left hand side of s-plane.

(8 marks)

(b) Ali has developed closed loop system for robotic arm for stable positioning and the block diagram of the system is shown in **Figure Q3(b).** By using Routh Hurwitz stability criterion, outline the range of K that need to be chosen by Ali so that the robotic arm provides stable performance during position tracking.

(12 marks)

Q4 (a) A lift system for a 10 storey building has following response specifications, 10% overshoot and 5 second settling time for 2% band.

(i) Determine the transfer function for the system.

(8 marks)

(ii) The damping ratio, ζ, of the system obtained in Q4(a)(i) is changed and the new damping ration, ζ=0.8. Analyze the impact of this changes on the percentages overshoot, $\%\mu_s$ and settling time, T_s (2% band) of the system .

(4 marks)

(b) The block diagram of lift system is shown in **Figure Q4(b)** has been tested with three different reference inputs, *rt)* which are $2u(t)$, $2t\ u(t)$ and $2t^2\ u(t)$. By using steady state error analysis, analyze which $r(t)$ could give infinite (∞) steady state error.

(8 marks)

Q5 The simplified block diagram for double-acting single piston system is shown in **Figure Q5.** By using root locus approach, investigate either each of these statement is correct or incorrect to represent the root locus characteristics for the system.

(a) There are **four (4)** locus end at infinity.

(7 marks)

(b) The location of asymptotes point is at -2.

(3 marks)

(c) Angle of departure is at $\pm 43.8^o$

(10 marks)

- END OF QUESTIONS –

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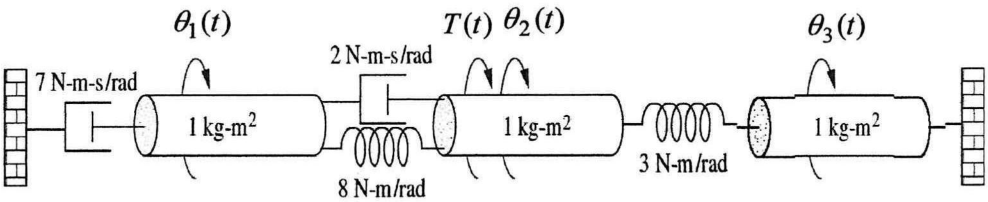


Figure Q1(c)

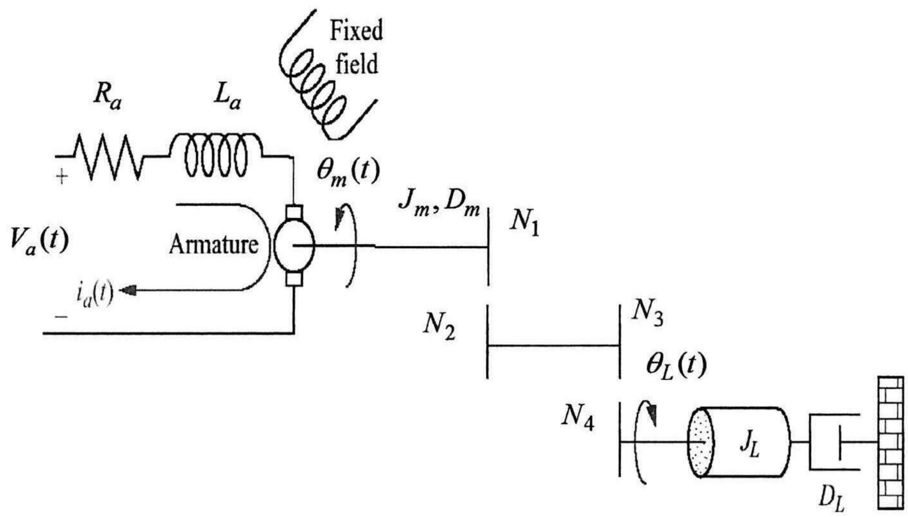
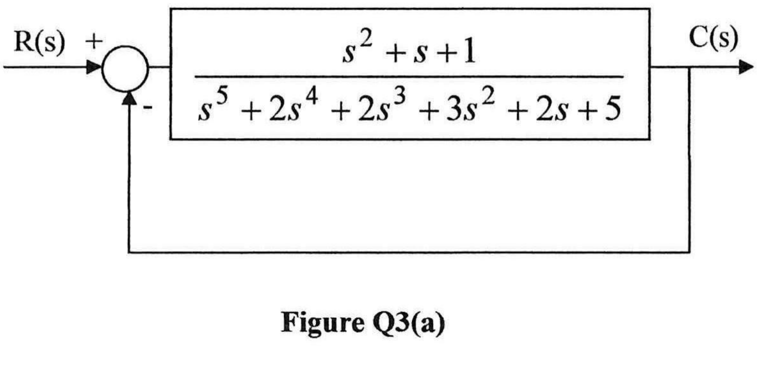


Figure Q2(b)



$$\frac{s^2+s+1}{s^5+2s^4+2s^3+3s^2+2s+5}$$

Figure Q3(a)

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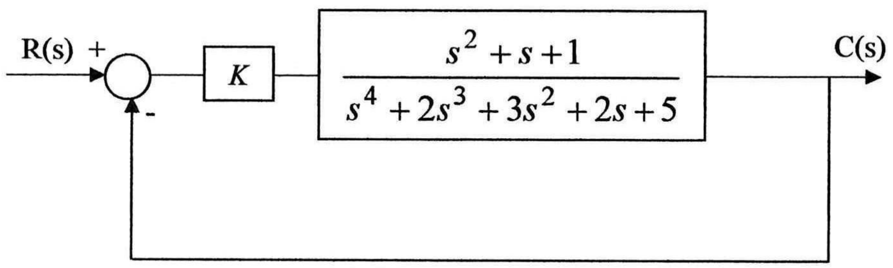

Figure Q3(b)

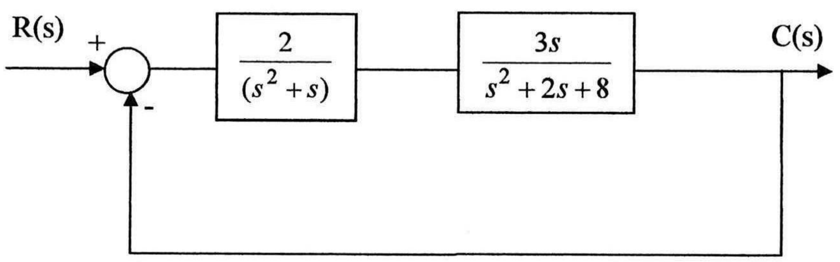

Figure Q4(b)

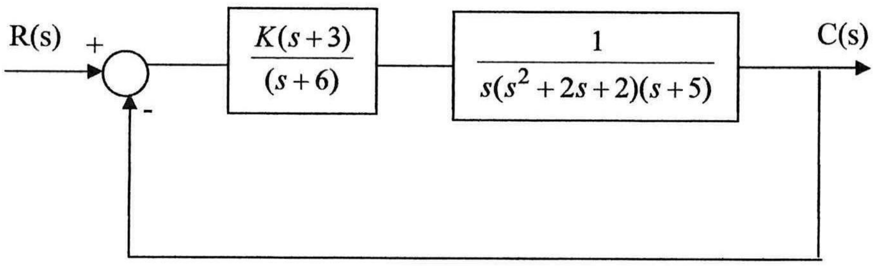

Figure Q5

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FORMULAE

Table A
Laplace transform table

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

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

2^{nd} Order prototype system 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)