UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	CONTROL SYSTEM THEORY
COURSE CODE	:	BEH 30603
PROGRAMME CODE	:	BEJ/BEV
EXAMINATION DATE	:	JUNE / JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

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

Q1 (a) Describe **two (2)** advantages and **two (2)** disadvantages of open loop system.

(4 marks)

(b) John was assigned to obtain the transfer function, $\frac{C(s)}{R(s)}$ for casting system as shown in **Figure Q1(b)**. The resulted transfer function obtained by John is as shown below:

$$\frac{C(s)}{R(s)} = \frac{(G1G2G3)(G2G3)}{(1+G1G2G4)+G1G2G3(H4H1H2G2+H4H2H3G3+H4G2G3+H4G4G2)}$$

By using block diagram algebra approach, investigate either the transfer function, $\frac{C(s)}{R(s)}$ obtained by John is correct or not.

(16 marks)

Q2 (a) List **two (2)** conditions of armature control for Direct Current (DC) motor.

(2 marks)

(b) The schematic diagram of a DC motor with gear is shown in **Figure Q2(b).** The DC motor is controlled by armature voltage. Construct the transfer function $G(s) = \frac{V_a(s)}{\theta_L(s)}$ for the DC motor.

(11 marks)

(c) Determine the transfer function $\frac{\theta_2(s)}{T(s)}$, for the gearing system as shown in **Figure Q2(c).**

(7 marks)

Q3 (a) Differentiate between stable systems, unstable systems and marginally stable system.

(6 marks)

(b) Aydan has developed closed loop system for line follower robot and the block diagram of the system is shown in **Figure Q3(b).** By using Routh Hurwitz stability Criterion, analyze the range of *K* that need to be choose by Aydan so that the robot provide stable performance during tracking the line.

(14 marks)

Q4 (a) A ship undergo motion about their roll axis as shown in **Figure Q4(a)**. Fins called stabilizers are used to reduce the rolling motion. The stabilizer can be positioned by closed–loop control system that consists of component such as fin actuators and sensors, as well as the ship's roll dynamics. Assume the roll dynamics, which relates the roll–angles output, θ(s) to a disturbance-torque input, T_D, is

$$\frac{\theta(s)}{T_D} = \frac{2.25}{s^2 + 0.5s + 2.25}$$

(i) Find the natural frequency ω_n, damping ratio ζ, peak time $T_{p,}$ rise time T_r, and percentage of overshoot, $\%\mu_s$ of the system.

(5 marks)

(ii) Investigate the characterizing response of the system

(2 marks)

(ii) The percentage maximum overshoot obtained in **Q4a(i)** is reduced by 50%. Calculate the new value of damping ratio, ζ for the system.

(4 marks)

(b) A boat is circling a ship that is using a tracking radar with speed of 20 knots, and it is circling the ship at a distance of 1 nautical mile as shown in **Figure Q4(b)(i).** A simplified model of the tracking system is shown in **Figure Q4 (b)(ii)**.

(i) Find the system type.

(1.5 marks)

(ii) Given that the value of K = 200 and the system has been tested with three different reference inputs, $\theta i(t)$ which are 10 $u(t)$, 10t $u(t)$ and $10t^2$ $u(t)$. By using steady state error analysis, analyze which $\theta_i(t)$ could give infinite (∞)steady state error.

(7.5 marks)

Q5 The simplified block diagram for antenna tracking system is shown in **Figure Q5**.

(a) By using root locus sketching approach, investigate either each of these statement is correct or incorrect to represent the root locus characteristics for the system shown in **Figure Q5**: number of branches is 3, there is no angle of departure and angle of arrival, root locus exists on real axis between: 0 and -3, intersect of asymptotes is at -1.5, the system is stable when the value of K less than 0, and if the value of K is equal to -2.25225 the system is stable.

(15 marks)

(b) Sketch the root locus of the system.

(5 marks)

- END OF QUESTIONS –

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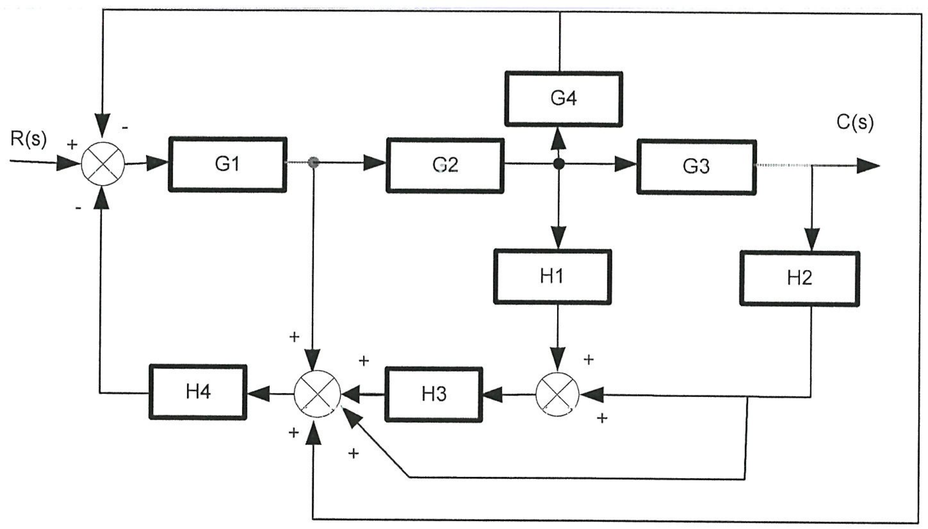

Figure Q1(b)

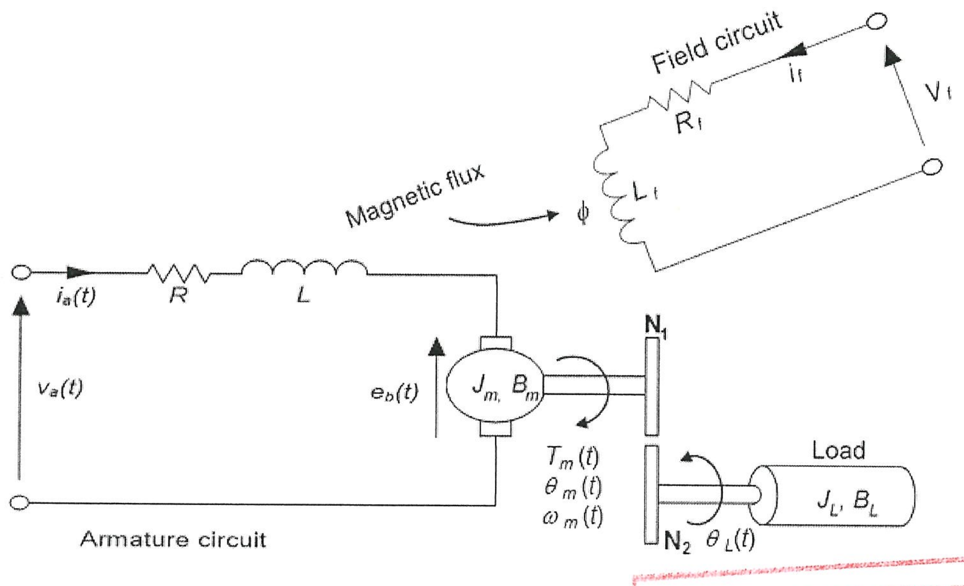

Figure Q2(b)

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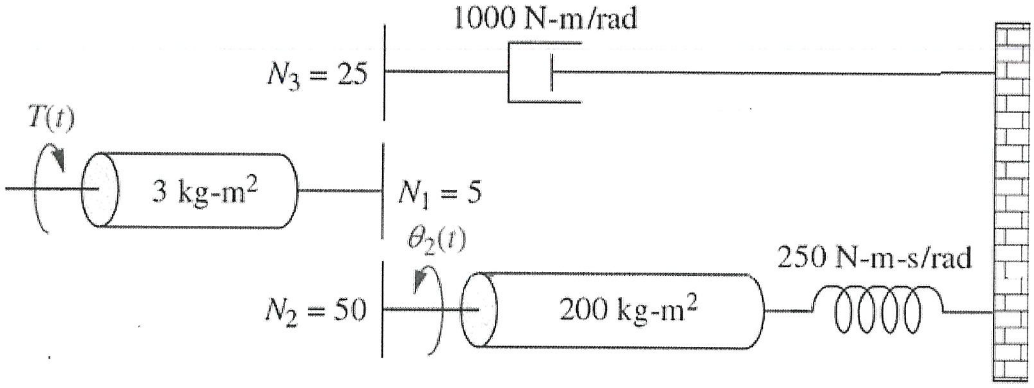

Figure Q2(c)

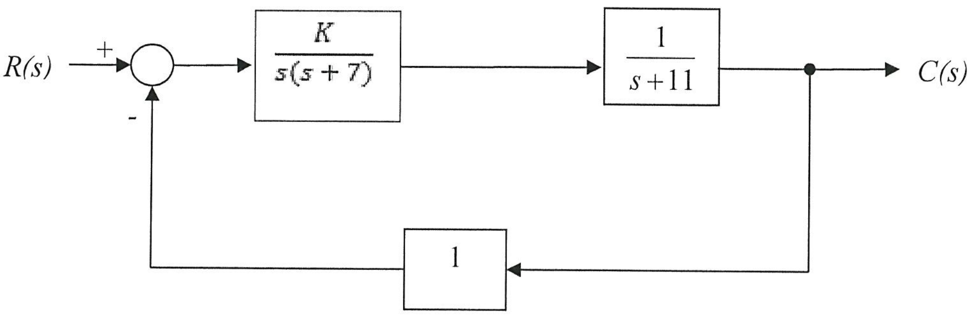

Figure Q3(b)

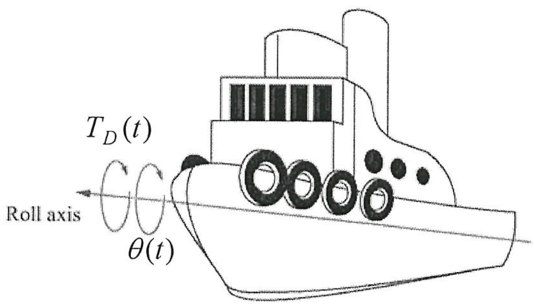

Figure Q4(a)

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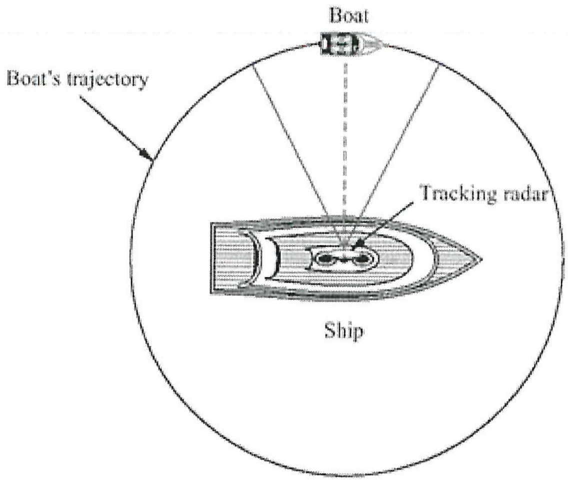

Figure Q4(b)(i)

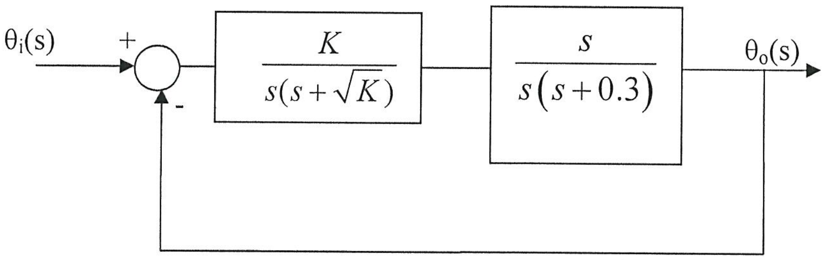

Figure Q4(b)(ii)

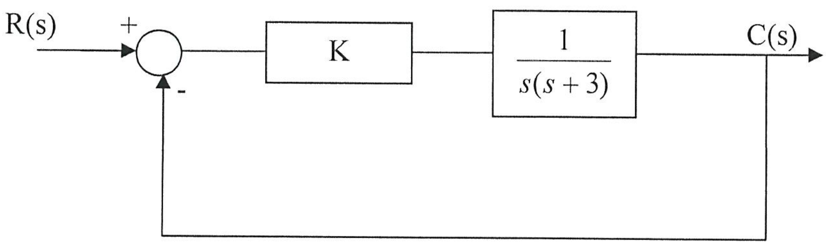

Figure Q5

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

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