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UTM UNIVERSITI TEKNOLOGI MALAYSIA

Sekolah Pendidikan Profesional dan Pendidikan Berterusan (UTMSPACE)

FINAL EXAMINATION / *PEPERIKSAAN AKHIR*
SEMESTER 1 – SESSION 2016 / 2017
PROGRAM KERJASAMA

COURSE CODE / *KOD KURSUS* : DDPE 3133

COURSE NAME / *NAMA KURSUS* : CONTROL SYSTEMS / *SISTEM KAWALAN*

YEAR / PROGRAMME / *TAHUN / PROGRAM* : 3 / DDPB / DDPE / DDPK / DDPP

DURATION / *TEMPOH* : 2 HOURS 30 MINUTES / 2 *JAM 30 MINIT*

DATE / *TARIKH* : OCTOBER 2016

INSTRUCTION/*ARAHAN* :

SECTION A : ANSWER **BOTH** QUESTIONS.
BAHAGIAN A : *JAWAB **KEDUA-DUA** SOALAN.*

SECTION B : ANSWER **TWO (2)** QUESTIONS ONLY.
BAHAGIAN B : *JAWAB **DUA (2)** SOALAN SAHAJA.*

(You are required to write your name and your lecturer's name on your answer script)
(Pelajar dikehendaki tuliskan nama dan nama pensyarah pada skrip jawapan)

NAME / *NAMA*	:	.....
I.C NO. / *NO. K/PENGENALAN*	:	.....
YEAR / COURSE *TAHUN / KURSUS*	:	.....
COLLEGE NAME *NAMA KOLEJ*	:	.....
LECTURER'S NAME *NAMA PENSYARAH*	:	.....

This examination paper consists of ...10... pages including the cover
Kertas soalan ini mengandungi .....10..... muka surat termasuk kulit hadapan

SECTION A [*BAHAGIAN A]*
ANSWER **BOTH** QUESTIONS
*[JAWAB **KEDUA-DUA** SOALAN]*

Q1. (a) Describe the Routh-Hurwitz criterion for stability.

Huraikan kriteria Routh-Hurwitz bagi kestabilan.

(5 marks/*markah*)

(b) Construct a Routh table and determine the number of roots with positive real parts for the equation

$$2s^3 + 4s^2 + 4s + 12 = 0$$

Binakan jadual Routh dan tentukan bilangan punca dengan bahagian nyata yang positif bagi persamaan

$$2s^3 + 4s^2 + 4s + 12 = 0$$

(8 marks/*markah*)

(c) Given a unity feedback system that has the forward transfer function

$$G(s) = \frac{K}{s(s+1)(s+3)(s+4)}$$

(i) Determine the root locus starting point.
(ii) Determine the root locus ending point.
(iii) Determine the number of branches.
(iv) Determine the real-axis intercept and angle of the asymptotes.
(v) Determine the imaginary axis crossing point.
(vi) Given the breakaway points are at -0.42 and -3.58 , sketch the root locus.

Diberikan sistem suapbalik unit mempunyai rangkap pindah ke hadapan

$$G(s) = \frac{K}{s(s+1)(s+3)(s+4)}$$

(i) Tentukan titik permulaan londar punca.
(ii) Tentukan titik akhir londar punca.
(iii) Tentukan bilangan cabang.
(iv) Tentukan silangan paksi-nyata dan sudut asimptot-asimptot.
(v) Dapatkan titik persilangan pada paksi khayal.
(vi) Diberikan titik pecah ialah pada -0.42 dan -3.58, lakarkan londar punca.

(12 marks/*markah*)

Q2. A unity feedback system has an open-loop transfer function given below:

$$G(s) = \frac{K}{s(s+5)(s+10)}$$

For K = 5000, draw the Bode magnitude and phase plots using straight-line approximation on the two semi-log graph papers provided. Determine

(i) the gain margin, G_M

(ii) the phase margin, Φ_M

(iii) the range of K for stability

[For the magnitude plot, use a scale of 2 cm = 20 dB with a maximum value of 80 dB and a minimum value of -60 dB. For the phase plot, use a scale of 2 cm = 45^0 with a maximum value of 45^0 and a minimum value of - 270^0]

Satu sistem suapbalik unit mempunyai rangkap pindah gelung-buka seperti berikut:

$$G(s) = \frac{K}{s(s+5)(s+10)}$$

Bagi K = 5000, lukiskan plot Bode magnitud dan fasa menggunakan kaedah penghampiran garis lurus di atas dua kertas graf semi-log yang disediakan. Tentukan

(i) jidar gandaan, G_M

(ii) jidar fasa, Φ_M

(iii) julat K supaya sistem stabil

[Untuk plot magnitud, gunakan skala 2 cm = 20 dB dengan nilai maximum 80 dB dan nilai minimum -60 dB. Untuk plot fasa, gunakan skala 2 cm = 45^0 dengan nilai maksimum 45^0 dan nilai minimum -270^0].

(25 marks/ *markah*)

SECTION B [*BAHAGIAN B*]
ANSWER **TWO** QUESTIONS ONLY
*[JAWAB **DUA** SOALAN SAHAJA]*

Q3. (a) Figure Q3(a) shows a schematic diagram of an ordinary water closet tank filling system. The ball floats on the water. As the ball gets closer to the top of the container, the stopper decreases the flow of water. When the container becomes full, the stopper shuts off the flow of water. Sketch a functional block diagram for the system, identifying the components which represent the plant, the controller and the feedback.

Rajah Q3(a) menunjukkan gambar rajah skema sistem pengisian tangki air tandas. Pelampung terapung di atas air. Ketika pelampung tersebut menghampiri atas bekas, penutup mengurangkan aliran air. Apabila bekas penuh, penutup menutup terus aliran air. Lakarkan gambar rajah blok fungsi bagi sistem tersebut, dengan mengenalpasti komponen yang mewakili loji, pengawal dan suapbalik.

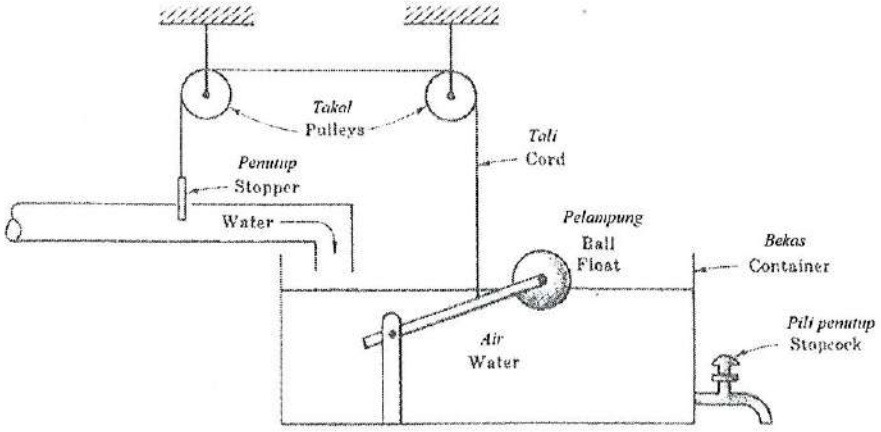

Figure Q3(a)/*Rajah Q3(a)*

(10 marks/*markah*)

(b) For the mechanical system shown in Figure Q3(b)

(i) draw its parallel electrical analog circuit

(ii) write the equations of motion for the system

(iii) obtain its transfer function, $\frac{X_2(s)}{F(s)}$.

Bagi sistem mekanik yang ditunjukkan dalam Rajah Q3(b)

(i) *lukiskan litar analog elektrik selari*

(ii) *tuliskan persamaan anjakkan bagi sistem tersebut*

(iii) *dapatkan rangkap pindah,* $\frac{X_2(s)}{F(s)}$.

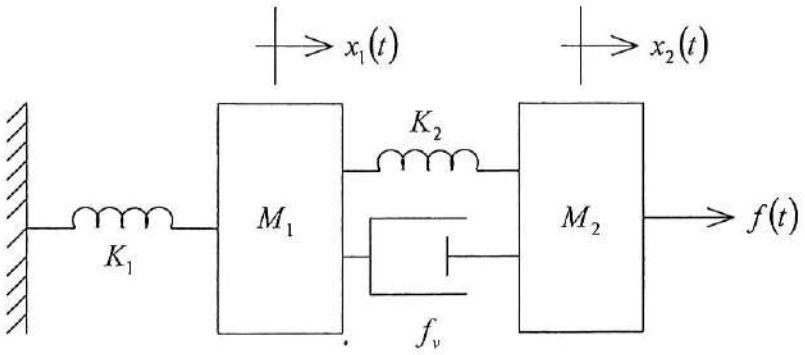

Figure Q3(b)/*Rajah Q3(b)*

(15 marks/*markah*)

Q4. (a) State the three constants associated with the steady state error.

Nyatakan tiga pemalar yang berkaitan dengan ralat keadaan mantap.

(3 marks/*markah*)

(b) For a unity feedback control system with an open-loop transfer function

$$G(s)=\frac{10(s+2)}{s^2(s+1)}$$

determine the steady-state error when the input

$$R(s)=\frac{3}{s}-\frac{2}{s^2}+\frac{1}{s^3}$$

Bagi sistem kawalan suapbalik unit dengan rangkap pindah gelung-buka

$$G(s)=\frac{10(s+2)}{s^2(s+1)}$$

tentukan ralat keadaan-mantap ketika masukan

$$R(s)=\frac{3}{s}-\frac{2}{s^2}+\frac{1}{s^3}$$

(10 marks/*markah*)

(c) A unity feedback system has an open-loop transfer function

$$G(s)=\frac{10}{s(s+2)}$$

Determine

(i) the closed-loop transfer function, $C(s)/R(s)$

(ii) the natural frequency, ω_n and the damping ratio, ζ

(iii) the peak time, T_p

(iv) the percentage overshoot, %OS

(v) the settling time, T_s

(vi) the rise time, T_r

Sistem suapbalik unit mempunyai rangkap pindah gelung-buka

$$G(s)=\frac{10}{s(s+2)}$$

Tentukan

(i) rangkap pindah gelung-tertutup, $C(s)/R(s)$

(ii) frekuensi tabii, ω_n *dan nisbah redaman,* ζ

(iii) masa puncak, T_p

(iv) peratus lajakan lampau, %OS

(v) masa pengenapan, T_s

(vi) masa naik, T_r

(12 marks/*markah*)

Q5. (a) State two advantages of signal-flow graphs compared to block diagrams.

Nyatakan dua kelebihan graf aliran-isyarat berbanding dengan gambar rajah blok.

(5 marks/*markah*)

(b) Reduce the system shown in Figure Q5(b) to a single block and determine the transfer function relating the output C(s) to the input R(s).

Ringkaskan sistem bagi Rajah Q5(b) kepada satu blok dan tentukan rangkap pindah yang menghubungkan keluaran C(s) terhadap masukan R(s).

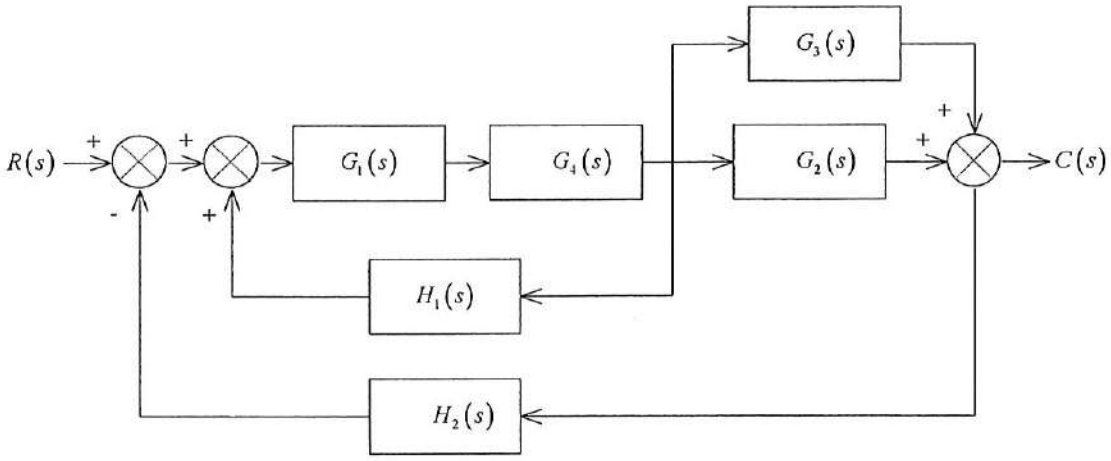

Figure Q5(b)/*Rajah Q5(b)*

(10 marks/*markah*)

(c) Find the transfer function $\frac{C(s)}{R(s)}$ for the system in Figure Q5(c) by using Mason's Rule.

Dapatkan rangkap pindah $\frac{C(s)}{R(s)}$ *bagi sistem dalam Rajah Q5(c) dengan menggunakan Aturan Mason.*

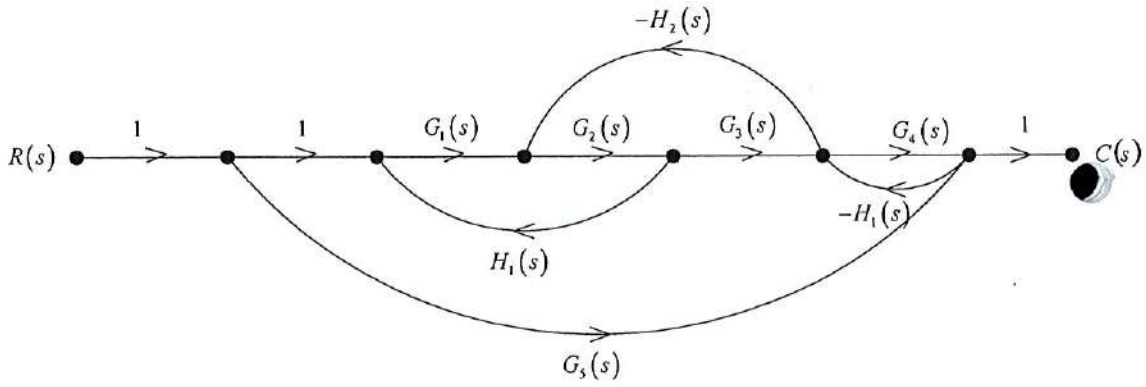

Figure Q5(c)/*Rajah Q5(c)*

(10 marks/*markah*)

APPENDIX/ *LAMPIRAN*

LAPLACE TRANSFORMS

JELMAAN LAPLACE

Laplace transform	Time function
$\frac{1}{s}$	1
$\frac{1}{s^2}$	t
$\frac{1}{s+a}$	e^{-at}
$\frac{a^2}{s(s+a)^2}$	$1-e^{-at}-ate^{-at}$
$\frac{\omega}{s^2+\omega^2}$	$\sin \omega t$
$\frac{s}{s^2+\omega^2}$	$\cos \omega t$
$\frac{\omega^2}{s(s^2+\omega^2)}$	$1-\cos \omega t$
$\frac{\omega}{(s+\alpha)^2+\omega^2}$	$e^{-\alpha t} \sin \omega t$
$\frac{s+\alpha}{(s+\alpha)^2+\omega^2}$	$e^{-\alpha t} \cos \omega t$
$\frac{1}{s}\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$	$1-\frac{1}{\sqrt{1-\zeta^2}} e^{-\zeta\omega_n t} \cos\left(\omega_n\sqrt{1-\zeta^2}\,t-\varphi\right)$

SECOND ORDER TIME DOMAIN SPECIFICATION

(*PENENTUAN DOMAIN MASA SISTEM TERTIB KEDUA*)

% Maximum overshoot, $\%OS = 100e^{-\left[\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right]}$

(% *Lajakan maksimum*) $\zeta = \dfrac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$

Peak time, *Masa puncak*, $T_p = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

Settling time, *Masa pengenapan*, $T_s = \dfrac{4}{\zeta\omega_n}$ (for 2% criteria/*untuk kriteria 2%*)

Damping ratio	Normalized rise time
0.1	1.104
0.2	1.203
0.3	1.321
0.4	1.463
0.5	1.638
0.6	1.854
0.7	2.126
0.8	2.467
0.9	2.883

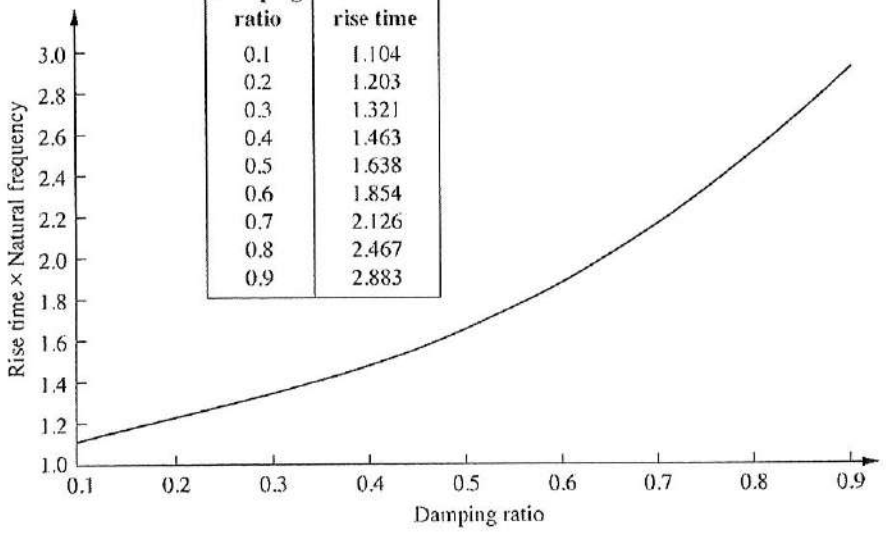

Figure 4.16

Steady state error, *Ralat keadaan mantap*, $e_{ss} = \lim_{s\to 0} \dfrac{sR(s)}{1+G(s)}$