UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/Mei 2009

EBB 338/3 - Process Control
[Kawalan Proses]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains THIRTEEN printed pages and ONE page APPENDIX before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA BELAS muka surat yang bercetak dan SATU muka surat LAMPIRAN sebelum anda memulakan peperiksaan ini.]

This paper contains SEVEN questions. ONE question in PART A, TWO questions in PART B, TWO questions in PART C and TWO questions in PART D.
[Kertas soalan ini mengandungi TUJUH soalan. SATU soalan di BAHAGIAN A, DUA soalan di BAHAGIAN B, DUA soalan di BAHAGIAN C dan DUA soalan di BAHAGIAN D.]

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A, **ONE** question from PART B, **ONE** question from PART C, **ONE** question from PART D and **ONE** question from any sections. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **LIMA** soalan. Jawab **SEMUA** soalan dari BAHAGIAN A, **SATU** soalan dari BAHAGIAN B, **SATU** soalan dari BAHAGIAN C, **SATU** soalan dari BAHAGIAN D dan **SATU** soalan dari mana-mana bahagian. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

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PART A

BAHAGIAN A

1. [a] Control can be applied using several methods, including, but not limited to, feedback. Give an example of a feedback control system in your everyday life. Is it an automated control system? Explain your answer.

Kawalan dapat diaplikasi menggunakan beberapa kaedah, termasuk tetapi tidak terhad kepada maklumbalas. Berikan satu contoh sistem kawalan maklumbalas dalam kehidupan anda seharian. Adakah sistem kawalan itu automatik? Jelaskan jawapan anda.

(30 marks/*markah*)

[b] For each of the characteristic equations given below estimate the locations of multiple roots (if any), and the order of multiplicity of these roots. Roughly sketch the root locus plot in each case showing clearly the direction of root loci approaching the points of multiple roots, and the directions at which the loci break away from these points:

Bagi setiap persamaan yang diberikan di bawah, anggarkan lokasi punca berganda (jika ada), dan susunan punca berganda. Lakarkan plot lokus punca bagi setiap kes dengan jelas yang menunjukan arah lonkus punca menuju ke beberapa titik punca, dan arah yang mana punca tersebut berpecah daripada titik.

(i) $$1+\frac{K}{s(s^2+6s+10)}=0; K \geq 0$$

(ii) $$1+\frac{K(s+1)}{s^2(s+9)}=0; K \geq 0$$

(35 marks/*markah*)

[c] A typical operational block diagram is shown in Figure 1. Explain this figure by stating each of the element and signal presents and its significance in controlling a system.

Gambarajah blok tipikal ditunjukkan dalam Rajah 1. Terangkan gambarajah ini dengan menyatakan setiap elemen dan isyarat yang ada dan apakah kepentingan setiap elemen dalam mengawal sistem.

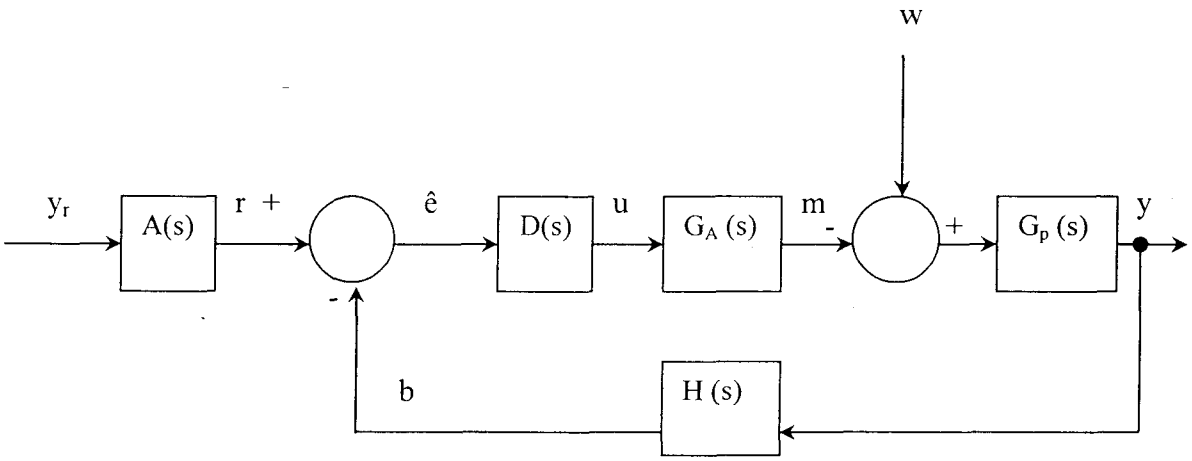

Figure 1

Rajah 1

(35 marks/*markah*)

PART B

BAHAGIAN B

2. A chemical process with recycle is shown in Figure 2. Explain whether the following variable can be controlled by feedback?

Suatu proses kimia dengan kitar semula ditunjukkan dalam Rajah 2. Bolehkah pembolehubah berikut dikawal oleh maklumbalas? Jelaskan jawapan anda.

(a) L2 - Flash Drum Liquid Level

L2 - Paras cecair dalam tong imbas

(b) T5 - Reactor Temperature

T5 - Suhu reaktor

(c) P1 - Flash Drum Pressure

P1 - Tekanan tong imbas

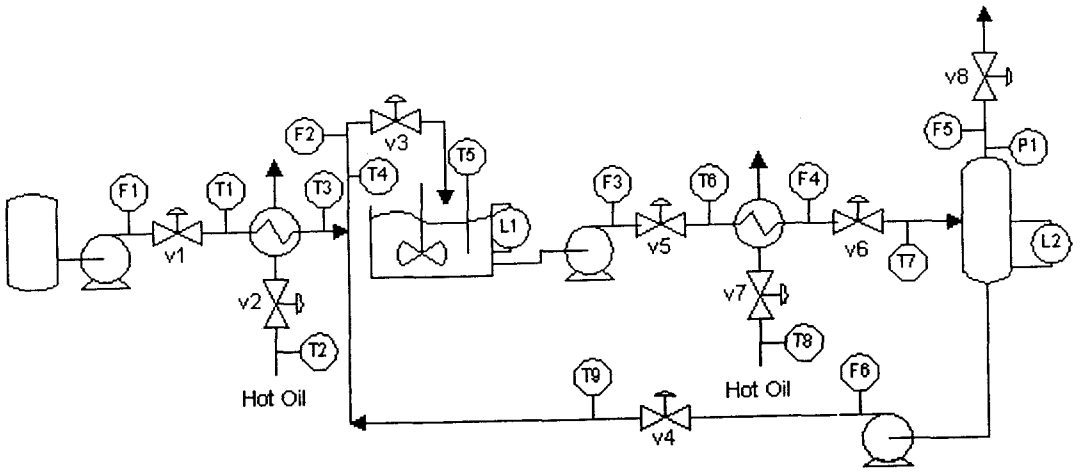

Figure 2

Rajah 2

(60 marks/*markah*)

(d) Solve the following equation using Laplace Transforms:

Selesaikan persamaan berikut menggunakan jelmaan Laplace:

$$\frac{d^2y}{dt^2} + 8\frac{dy}{dt} + 15y = 1; \quad y(0) = 0$$

(40 marks/*markah*)

3. Find the transfer function between output and input for the following cases:

Tentukan fungsi pertukaran di antara keluaran dan kemasukan bagi:

(a) A single-loop electrical system as shown in Figure 3a. Given R = 20 Ohm, C = 2 F, L = 5 H, and V (t) = 10 V.

Suatu gelung tunggal sistem elektrik ditunjukkan dalam Rajah 3a. Diberikan R = 20 Ohm, C = 2 F, L = 5 H, dan V (t) = 10 V.

(25 marks/*markah*)

(b) A two-loop electrical system as shown in Figure 3b. Given R = 20 Ohm, C = 2 F, L = 5 H, and V (t) = 10 V.

Suatu gelung kembar sistem elektrik seperti dalam Rajah 3b. Diberikan R = 20 Ohm, C = 2 F, L = 5 H, dan V (t) = 10 V.

(50 marks/*markah*)

(c) A restaurant plate dispenser system as shown in Figure 3c. Given k = 3 N/m, f_v = 4 N.sec/m, m = 2 kg. Assume mass of each plate is 0.2 kg.

Suatu sistem mesin pembahagi pinggan restoran ditunjukkan dalam Rajah 3c. Diberikan k = 3 N/m, f_v = 4 N.sec/m, m = 2 kg. Anggapkan jisim sebuah pinggan 0.2 kg.

(25 marks/*markah*)

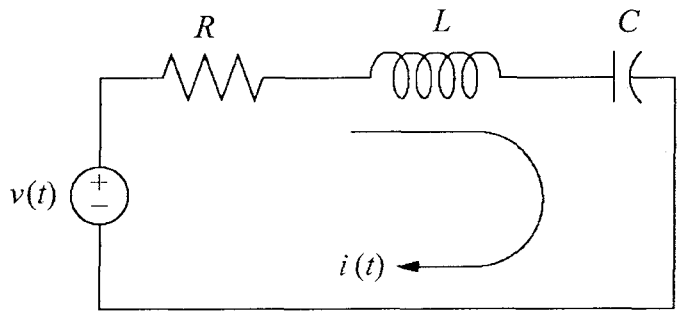

Figure 3a

Rajah 3a

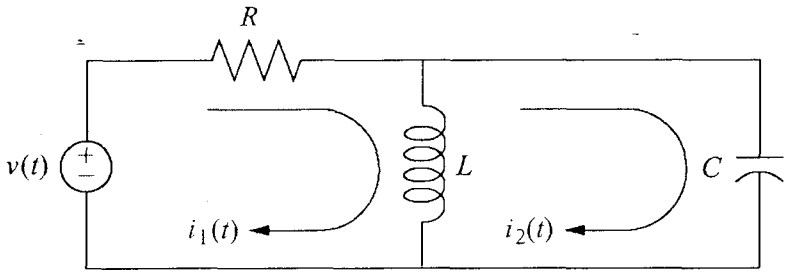

Figure 3b

Rajah 3b

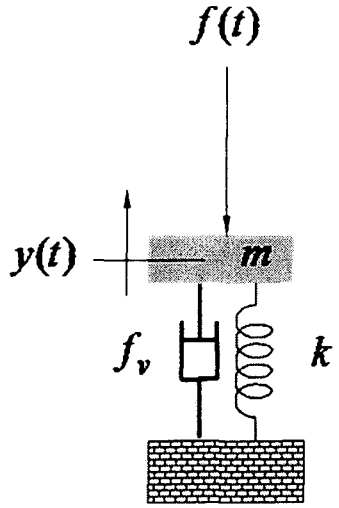

Figure 3c

Rajah 3c

PART C

BAHAGIAN C

4. [a] Define the Gain Margin and Phase Margin.

Berikan definisi margin gandaan dan margin fasa.

(20 marks/*markah*)

[b] Use the Routh stability criteria to determine the number of roots in the left-half plane, the right half plane, and on the imaginary axis for the following characteristic equations:

(i) $s^4 + 2s^3 + 8s^2 + 4s + 3 = 0$

(ii) $s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$

Gunakan kriteria kestabilan Routh untuk mengira jumlah londar punca di satah sebelah kiri, satah sebelah kanan, dan di atas paksi khayalan bagi persamaan-persamaan yang diberi:

(i) $s^4 + 2s^3 + 8s^2 + 4s + 3 = 0$

(ii) $s^5 + s^4 + 2s^3 + 2s^2 + 3s + 5 = 0$

(20 marks/*markah*)

[c] Consider the system shown in Figure 4. Sketch the root locus plot of the system shown in Figure 4 as gain K varies from 0 to ∞. Determine the value of K such that the damping ratio ζ of the dominant closed-loop poles is 0.5. For the determined value of K, find all the closed-loop poles.

Perhatikan sistem yang ditunjukkan dalam Rajah 4. Lakarkan londar punca bagi sistem tersebut dengan nilai gandaan K berubah daripada 0 kepada ∞. Kirakan nilai K jika nisbah redaman ζ bagi kutub dominan gelung tertutup adalah 0.5. Bagi nilai K tertentu, kirakan semua kutub gelung tertutup.

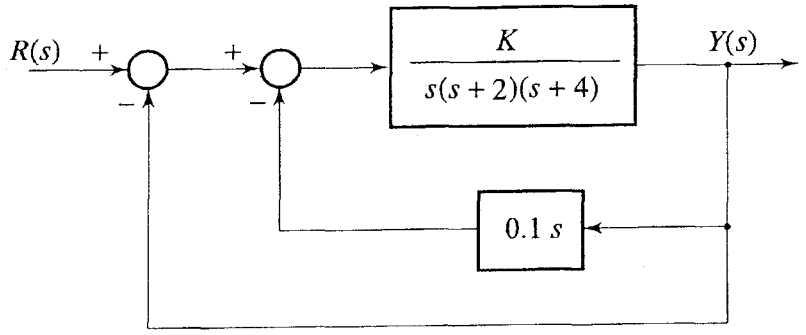

Figure 4

Rajah 4

(60 marks/*markah*)

5. Open-loop transfer functions of a certain unity-feedback systems are given below.

Fungsi pindah gelung terbuka bagi suap balik unit tertentu dinyatakan di bawah.

(a) $G(s) = \dfrac{K(s+13)}{s(s+3)(s+7)}$

(b) $G(s) = \dfrac{K(s+2)}{s(s+5)(s^2+2s+5)}$

In each case, determine:

Bagi setiap kes, kirakan:

(i) The range of values of K (K > 0) for which the system is stable.

Julat nilai K (K > 0) bagi sistem yang stabil.

(30 marks/*markah*)

(ii) The value of K that will result in the system being marginally stable.

Nilai K yang akan menyebabkan sistem sedikit stabil.

(30 marks/*markah*)

(iii) The location of the roots of the characteristics equation for the value of K found in (ii).

Lokasi bagi punca persamaan yang diberikan bagi nilai K yang diperolehi dalam (ii).

(40 marks/*markah*)

PART D

BAHAGIAN D

6. [a] In steel mills for rolling to produce steel sheet, several speed control systems are used to ensure the steel sheet produced is of the quality required by the customers. The speed of the rollers is controlled by an armature controlled *dc* motor. Sketch an operational block diagram of the speed control system by using the information below:

Di dalam mill penggulingan keluli untuk menghasilkan kepingan keluli, beberapa sistem kawalan halaju digunakan untuk memastikan yang keluli terhasil adalah berkualiti seperti yang dikehendaki oleh pembeli. Halaju pengguling dikawal oleh motor dc yang dikawal oleh amatur. Lakarkan satu gambarajah blok untuk menunjukkan kawalan halaju pengguling dengan menggunakan pernyataan di bawah:

e_q (t)	=	armature applied voltage *voltan yang diberikan pada amartur*
R_a	=	armature resistance *rintangan amartur*
K_b	=	motor back-emf constant *konstant emf-belakang motor*
K_T	=	motor torque constant *konstant torque motor*
J	=	moment of inertia of motor and load *momen inertia motor dan beban*
B	=	viscous friction coefficient of motor and load *rintangan viskos motor dan beban*
T_w(t)	=	disturbance *kekacauan*
ω (t)	=	motor velocity *laju motor*
K_A	=	amplifier gain *konstant takometer*
K_t	=	tachometer constant *pencapaian amatur*

(30 marks/*markah*)

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[b] The position of an inertia load can be controlled by an actuator. An electric motor is an example of an actuator. Answer the following questions.

Kedudukan beban inertia boleh dikawal dengan aktuator. Motor elektrik adalah contoh aktuator. Jawab soalan-soalan di bawah.

(i) Differentiate between the concept of operation of a DC and AC motor.

Bezakan di antara operasi servomotor DC dan AC.

(ii) Explained using a labeled diagram the operational of an armature controlled dc motor. Derive the transfer function.

Terangkan dengan menggunakan gambarajah berlabel bagaimana motor dc (armature) beroperasi. Terbitkan fungsi perubahan.

(40 marks/*markah*)

[c] In designing a control system, several objectives of the system must be fulfilled. State the 7 objectives of a control system and explain each term.

Di dalam merekabentuk satu kawalan sistem, beberapa objektif perlu dicapai. Nyatakan 7 objektif sistem kawalan dan terangkan setiap terma.

(30 marks/*markah*)

7. [a] In designing a control system, the following are the most important aspects to be taken into consideration. Explain the significance of each aspect.

(i) Stability

(ii) Disturbance rejection

(iii) Sensitivity and robustness

Di dalam merekabentuk satu sistem kawalan, aspek-aspek di bawah adalah penting untuk diambilkira. Terangkan signifikasi setiap aspek.

(i) kestabilan

(ii) kekacauan tertolak

(iii) kesensitifan dan kekuatan

(30 marks/*markah*)

[b] Sketch a block diagram to show:

(i) PI control

(ii) PD control

(iii) PID control

Explain each of the terms briefly by including the control gain parameter.

Lakarkan satu gambarajah blok untuk menunjukkan:

(i) kawalan PI

(ii) kawalan PD

(iii) kawalan PID

Terangkan setiap terma ini secara ringkas dengan mengambilkira parameter perolehan kawalan.

(30 marks/*markah*)

[c] The servomechanism for the steering radar of an antenna is a typical example of a closed loop system. Answer the following questions:

Servomekanisma untuk mengerakkan antenna di dalam radar adalah contoh tipikal sistem gelung tertutup. Jawab soalan berikut:

(i) A tachogenerator is one of the most important devices in performing the feed back in the system. Using a labeled diagram, explain how a tachogenerator operates and where will it be used.

Takogenerator adalah salah satu peranti terpênting yang melakukan maklum balas pada sistem. Dengan menggunakan diagram yang berlabel, terangkan bagaimana takogenerator berfungsi dan di mana kegunaannya.

(20 marks/*markah*)

(ii) Sketch a functional block diagram of the azimutal servomechanism to show the position of a tachogenerator. In this diagram, load disturbance must be included. Explain a typical disturbance occurring during the steering of an antenna.

Lakarkan satu blok berfungsi servomekanisme azimutal untuk menunjukkan posisi takogenerator. Di dalam diagram, kekacauan beban mesti diambil kira. Terangkan satu kekacauan yang berlaku ketika pergerakan antenna.

(20 marks/*markah*)

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APPENDIX

LAMPIRAN

Table 1 - Table of Laplace Transformations

Jadual 1 - Jadual Jelmaan Laplace

	Functions of time, $f(t)$	Laplace Transforms of $f(t)$, $L\{f(t)\}$
1.	$f(t)$	$F(s)$
2.	$x(t)+y(t)$	$X(s)+Y(s)$
3.	$k.f(t)$	$k.F(s)$
4.	$df(t)/dt$	$sF(s)-f(0)$
5.	$d^n f(t)/dt^n$	$s^n F(s)-s^{n-1}f(0)-s^{n-2}f^1(0)-\ldots-f^{n-1}(0)$
6.	$\int_0^t f(\tau).d\tau$	$F(s)/s$
7.	1	$1/s$
8.	t	$1/s^2$
9.	e^{-at}	$\frac{1}{(s+a)}$
10.	te^{-at}	$\frac{1}{(s+a)^2}$
11.	$1-e^{-at}$	$\frac{a}{s(s+a)}$
12.	$f(t-a), \quad t>a$	$e^{-as}F(s)$