UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2009/2010

April/May 2010

EBB 338/3 – Process Control
[Kawalan Proses]

Duration : 3 hours
[Masa : 3 jam]

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

This paper consists of ONE question from PART A, THREE questions from PART B and THREE questions from PART C.
[Kertas soalan ini mengandungi SATU soalan dari BAHAGIAN A, TIGA soalan dari BAHAGIAN B dan TIGA soalan dari BAHAGIAN C.]

Instruction: Answer **ALL** questions from PART A, **TWO** questions from PART B and **TWO** questions from PART C. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **SEMUA** soalan dari BAHAGIAN A, **DUA** soalan dari BAHAGIAN B dan **DUA** soalan dari BAHAGIAN C. 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.]

In the event of any discrepancies, the English version must be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

PART A / *BAHAGIAN A*

1. [a] PID algorithms have been widely used in processing industries. It is consists of three important modes of control: proportional, derivative and integral. By using appropriate block diagrams and mathematical representations, explain each of these control modes and explain why PID algorithm is widely applied.

Algoritma PID digunakan secara meluas di dalam industri pemprosesan. Ianya mempunyai tiga mod kawalan yang penting: berkadar terus, diterbitkan dan dikamirkan. Dengan menggunakan gambarajah blok dan gambaran matematik yang sesuai, terangkan setiap mod kawalan ini dan terangkan kenapa algoritma PID ini diterimapakai secara meluas.

(30 marks/*markah*)

[b] Find the range of gain, K, for the system in Figure 1 that will cause the system to be stable, unstable and marginally stable. Assume $K > 0$.

Kirakan julat gandaan, K, untuk sistem dalam Rajah 1 yang akan menyebabkan sistem tersebut menjadi stabil, tidak stabil dan separa stabil. Andaikan $K > 0$.

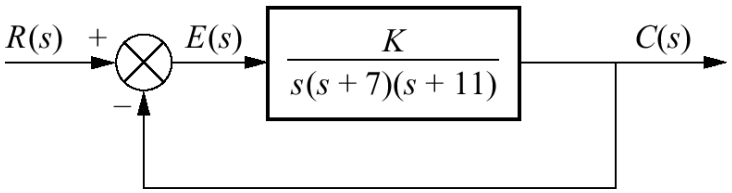

Figure 1: Feedback control system
Rajah 1: Sistem kawalan tertutup

(30 marks/*markah*)

[c] Plant units (distillation columns, reactors, etc.) that are arranged in series Figure 2 will provide smooth flow rates that contribute to good operation. Explain briefly the reason why.

"Plant" (penyulingan turus, reaktor, dan lain-lain) yang disusun bersiri akan menghasilkan kadar pengaliran lancar yang menyumbang kepada pengoperasian yang baik. Jelaskan secara ringkas, apakah sebabnya.

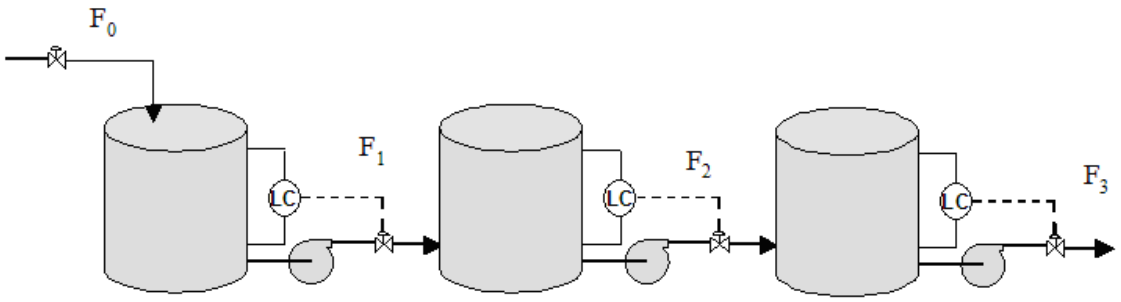

Figure 2 / *Rajah 2*

(40 marks/*markah*)

PART B / *BAHAGIAN B*

2. [a] Speed controls of the steel bar entering the rolls for steel sheet production in a steel mill are very important in ensuring that the sheet formed is of the dimensions required by customers. Answer the following questions:

Kawalan terhadap kelajuan batang besi yang memasuki pengguling bagi penghasilan kepingan keluli dalam loji keluli adalah sangat penting untuk memastikan kepingan terhasil mempunyai dimensi yang diminta oleh pelanggan. Jawab soalan berikut:

(i) Suggest equipment that can control the speed of the steel bar. Explain how it works.

Cadangkan satu alat yang boleh digunakan untuk mengawal kelajuan batang besi. Terangkan bagaimana ia berfungsi.

(30 marks/*markah*)

(ii) Draw a closed-loop speed control system for this process.

Lukiskan satu sistem kawalan kelajuan gelungan-tertutup untuk proses ini.

(30 marks/*markah*)

[b] Sensitivity, robustness and stability are among the important aspects to be taken into consideration in designing a control system. You are requested to control the temperature in a drying furnace for producing ceramic tiles. Explain the significant of these aspects in performing a good control over the drying process.

Kesensitifan, keteguhan dan kestabilan adalah di antara aspek terpenting untuk diambil kira semasa merekabentuk satu sistem kawalan. Anda diminta untuk mengawal suhu di dalam relau pengering untuk menghasilkan jubin seramik. Terangkan kepentingan aspek-aspek ini untuk mendapatkan satu kawalan yang baik terhadap proses pengeringan yang dinyatakan.

(40 marks/*markah*)

3. In knowing the feedback control for a typical robotic arm, a desired dynamic response can be achieved by using an electric motor. Answer the following questions:

Untuk mengetahui kawalan maklumbalas yang tipikal untuk satu lengan robotik, tindakbalas dinamik boleh dicapai dengan menggunakan motor elektrik. Jawab soalan-soalan di bawah:

[a] State the major differences between and ac and dc motors.

Nyatakan perbezaan di antara motor ac dan dc.

(20 marks/*markah*)

[b] For an armature controlled dc motor, sketch a block diagram to include all the necessary blocks and signals. Use input as applied voltage and output as the motor velocity.

Untuk motor dc dikawal dengan armature, lakarkan gambarajah blok merangkumi kesemua blok dan signal yang diperlukan. Gunakan masukan sebagai voltan yang dikenakan dan kelajuan motor sebagai keluarannya.

(30 marks/*markah*)

[c] Derive the transfer function of the system in 3[b].

Terbitkan fungsi perubahan sistem di dalam 3[b].

(20 marks/*markah*)

[d] If displacement is now used as the output, what is transfer function?

Jika sebarang perubahan sesaran digunakan sebagai keluaran, apakah fungsi perubahannya?

(10 marks/*markah*)

[e] Show that for the system, the integrating effect naturally appears.

Tunjukkan bahawa untuk sistem ini, kesan pengkamiran akan wujud secara semulajadi.

(20 marks/*markah*)

4. [a] Discuss whether each of the common systems below uses automatic feedback to achieve its desired performance.

(i) Boiling water in a water heater.

(ii) Maintaining a temperature in an oven.

(iii) An alarm clock.

Bincangkan samada setiap sistem dibawah ini menggunakan "feedback" automatik untuk mencapai pencapaian tertentu.

(i) Memanaskan air dalam pemanas air.

(ii) Penyelarasan suhu dalam ketuhar.

(iii) Jam penggera.

(30 marks/*markah*)

[b] Automatic control has been used for a long time since the revolution of steam engine. However, digital computers were not available for automatic control till World War II. Explain how was automatic control implemented physically before the era of digital computation?

Kawalan automatik telah digunakan lama sejak revolusi enjin wap. Bagaimanapun, komputer digital belum tersedia untuk kawalan automatik sehingga selepas Perang Dunia II. Terangkan bagaimana kawalan automatik secara fizikal dilaksanakan sebelum era pengiraan digital?

(20 marks/*markah*)

[c] Feed liquid is delivered periodically to the plant side which is operating continuously. A tank is provided to store the feed liquid as shown in Figure 3. Assume that the storage tank is initially empty, determine the minimum height of the tank that will prevent overflow between 0 to 100 hours. Use Table 1 for your reference.

Cecair bekalan disalurkan secara periodik, ke plant yang beroperasi secara berterusan. Sebuah tangki disediakan untuk menyimpan cecair bekalan seperti dalam Rajah 3. Anggap tangki pada mulanya kosong. Tentukan ketinggian minimum tangki yang dapat mengelakkan pengaliran berlebihan pada 0 hingga 100 jam. Gunakan Jadual 1 sebagai rujukan.

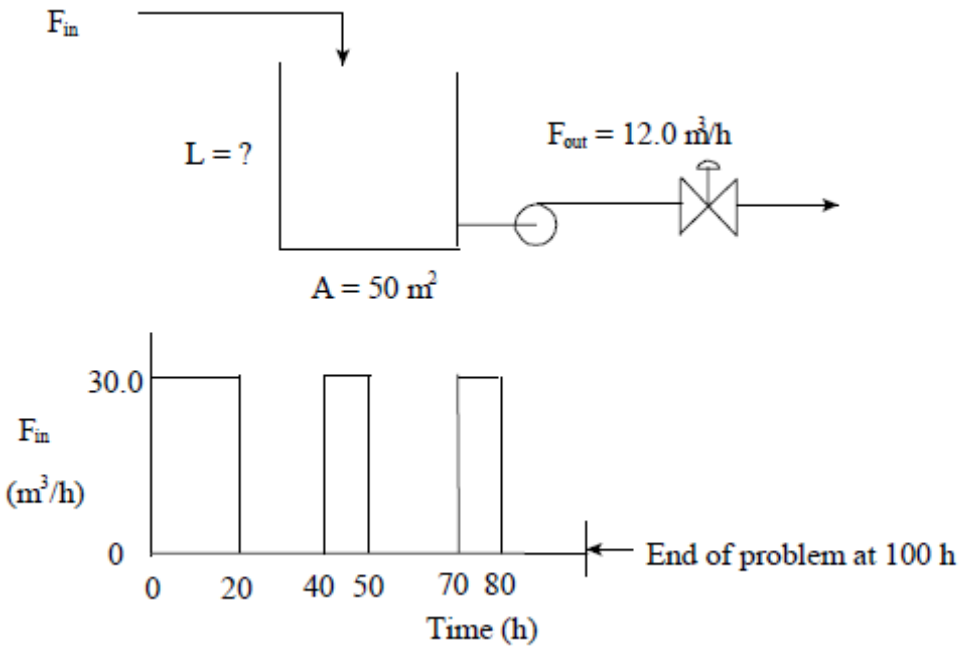

Figure 3 / *Rajah 3*

Time (h) / *Masa (jam)*	F_{in}	F_{out} (m^3/h)	$dV/dt = F_{in} - F_{out}$ (m^3/h)	V beginning of period (m^3) / *V masa mula (m^3)*	V end of period (m^3) / *V masa akhir (m^3)*
0-20					
20-40					
40-50					
50-70					
70-80					
80-100					

Table 1 / *Jadual 1*

(50 marks/*markah*)

PART C / *BAHAGIAN C*

5. [a] Given the transfer function:

Diberikan fungsi pertukaran:

$$G(s) = \frac{Y(s)}{R(s)} = \frac{1}{s^2 + 3s + 2};$$

Find the response y(t) to the input of r(t) = 5 μ(t).

Tentukan respon y(t) ke atas masukan r(t) = 5 μ(t).

(50 marks/*markah*)

[b] Find the transfer function between output and input for a two-loop electrical system as shown in Figure 4. Given *R* = 10 Ohm, *C* = 5 F, *L* = 7 H, and *V*(t) = 10 V.

Tentukan fungsi pertukaran di antara keluaran dan masukan bagi suatu gelung kembar sistem elektrik seperti dalam Rajah 4. Diberikan R = 10 Ohm, C = 5 F, L = 7 H, dan V(t) = 10 V.

(50 marks/*markah*)

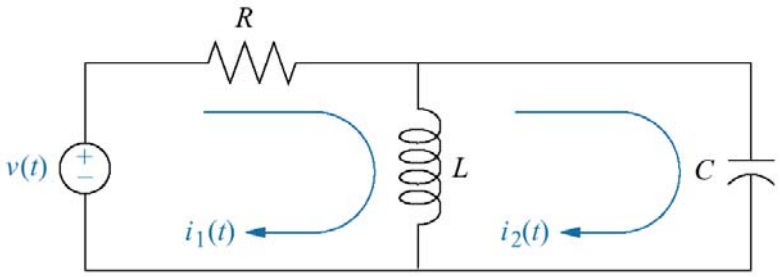

Figure 4 / *Rajah 4*.

6. [a] Consider the following Routh-Hurtzwiz Table (Table 2). Notice that the s^5 row was originally all zeroes. Describe how the table was completed. Determine how many roots in the right half plane, in the left half plane, and on the $j\omega$ axis.

Jadual Routh-Hurtzwiz (Jadual 2) dirujuk. Dapat diperhatikan kesemua nilai pada barisan s^5 adalah kosong. Terangkan bagaimana jadual tersebut dilengkapkan. Kirakan berapa punca berada pada bahagian satah kanan, bahagian satah kiri dan di atas paksi $j\omega$.

Table 2: Routh-Hurtzwiz Table

Jadual 2: Jadual Routh-Hurtzwiz

s^7	1	2	-1	-2
s^6	1	2	-1	-2
s^5	3	4	-1	0
s^4	1	-1	-3	0
s^3	7	8	0	0
s^2	-15	-21	0	0
s^1	-9	0	0	0
s^0	-21	0	0	0

(50 marks/*markah*)

[b] For the system in Figure 5, sketch the root locus, find the asymptotes and the range of *K* for stability.

Bagi sistem dalam Rajah 5, lakarkan londar punca, kirakan nilai asimptot dan julat K untuk kestabilan.

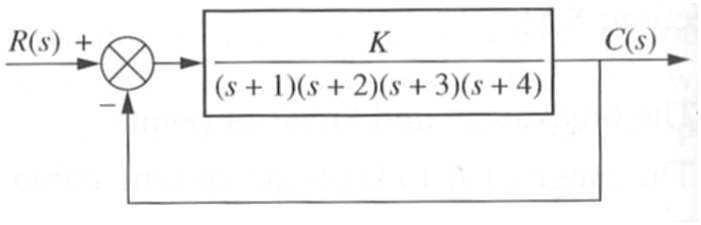

Figure 5 / *Rajah 5*

(50 marks/*markah*)

7. [a] What is the function of sketching the root locus in control process problems?

Apakah fungsi lakaran londar punca dalam masalah proses kawalan?

(20 marks/*markah*)

[b] Given a unity feedback system that has the forward transfer function:

Diberikan satu uniti sistem gelung tertutup yang mempunyai fungsi pindah gelung terbuka:

$$G(s) = \frac{K(s-2)(s-4)}{(s^2+6s+25)}$$

(i) Sketch the root locus

(ii) Find the imaginary axis crossing

(iii) Find the gain, *K*, at the $j\omega$ crossing

(iv) Find the range of gain, *K*, for which the system is stable

(v) Find the break in point

(i) Lakarkan londar punca

(ii) Kiraan pintasan pada paksi khayalan

(iii) Kirakan gandaan, K pada pintasan $j\omega$

(iv) Kirakan nilai gandaan K, supaya sistem tersebut stabil

(v) Cari titik pecah masuk

(80 marks/*markah*)

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