UNIVERSITI SAINS MALAYSIA

First Semester Examination
2006/2007 Academic Session
Peperiksaan Semester Pertama
Sidang Akademik 2006/2007

October/November 2006
Oktober/November 2006

ESA 251/3 – Theory of Control System
Teori Sistem Kawalan

Hour : [3 hours]
Masa : [3 jam]

INSTRUCTION TO CANDIDATES:
ARAHAN KEPADA CALON :

Please ensure that this paper contains **TEN(10)** printed pages and **SIX (6)** questions before you begin examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **SEPULUH (10)** mukasurat bercetak dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.*

Part A: Answer **TWO (2)** questions. Part B: Answer **TWO(2)** questions.
*Bahagian A: Jawab **DUA (2)** soalan. Bahagian B: Jawab **DUA (2)** soalan.*

Student may answer the questions either in English or Bahasa Malaysia.
Pelajar boleh menjawab soalan dalam Bahasa Inggeris atau Bahasa Malaysia.

Each questions must begin from a new page.
Setiap soalan mestilah dimulakan pada mukasurat yang baru.

PART A/*BAHAGIAN A*

1. (a) Find the Laplace transform of the following function.

$$f(t) = 0 \qquad \text{for } t \lhd 0$$
$$= t^2\ e^{-t} \sin 5t \qquad \text{for } t \geq 0$$

Cari penjelmaan laplace untuk fungsi berikut.

$$f(t) = 0 \qquad \text{for } t \lhd 0$$
$$= t^2\ e^{-t} \sin 5t \qquad \text{for } t \geq 0$$

(25 marks/markah)

(b) . By applying the final value theorem, find the final value of f (t) whose Laplace transform is given by:

$$F(s) = \frac{10}{s(s+1)}$$

Dengan menggunakan teorem nilai akhir, carikan nilai akhir bagi f(t) di mana penjelmaan Laplace diberikan ialah:

$$F(s) = \frac{10}{s(s+1)}$$

Verify this result by taking the inverse Laplace transform of F(s) and letting $t \rightarrow \infty$

Buktikan setiap jawapan dengan mengambil songsangan penjelmaan Laplace bagi F(s) dan membiarkan $t \rightarrow \infty$

(25 marks/markah)

2. (a) Simplify the block diagram and obtain the closed loop transfer function C(s)/R(s) of the following block diagram shown in **Figure 2(a)**.

*Permudahkan gambarajah blok dan dapatkan fungsi pindah gelung tertutup C(s)/R(s) bagi gambarajah blok seperti ditunjukkan dalam **Rajah 2(a)**.*

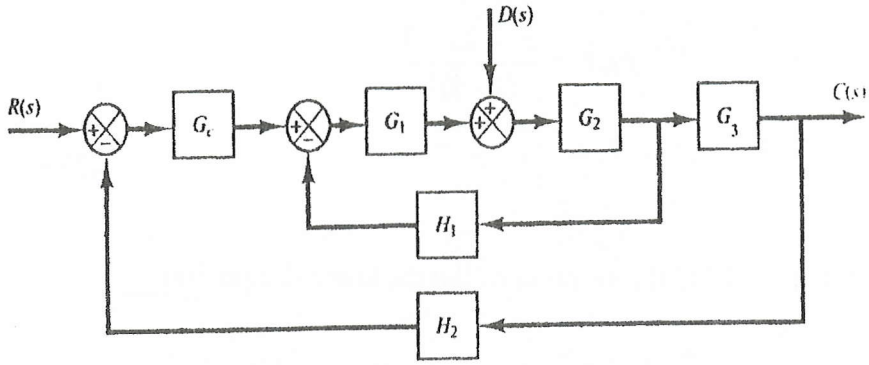

Figure 2(a): Block diagram of closed loop system
Rajah 2(a): Gambarajah blok fungsi pindah gelung tertutup

(40 marks/*markah*)

(b) Find the transfer function of the following signal flow graph using Mason's gain formula of the following **Figure 2(b).**

*Cari fungsi pindah bagi graf aliran isyarat seperti dalam **Rajah 2(b)** dengan menggunakan formula gandaan Mason's.*

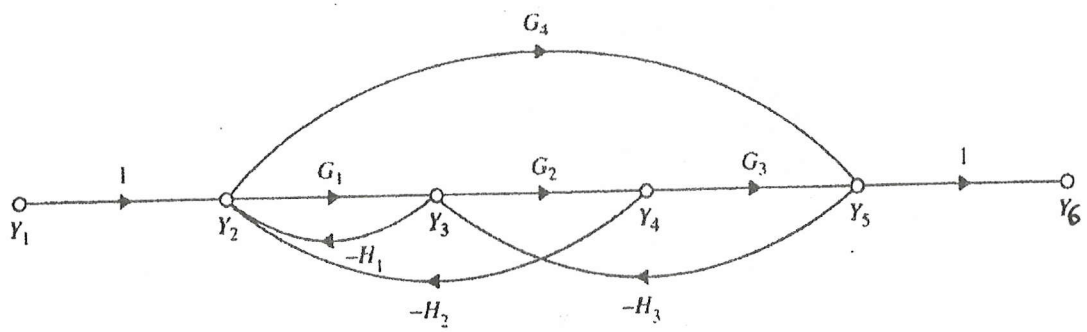

Figure 2(b): Signal flow graph
Rajah 2(b): Graf aliran isyarat

(30 marks/*markah*)

(c) Simplify the block diagram and obtain the closed loop transfer function C(s)/R(s) of the following block diagram shown in **figure 2(c).**

Permudahkan gambarajah blok dan dapatkan fungsi pindah litar tertutup C(s)/R(s) bagi gambarajah blok ditunjukkan dalam ***Rajah 2(c).***

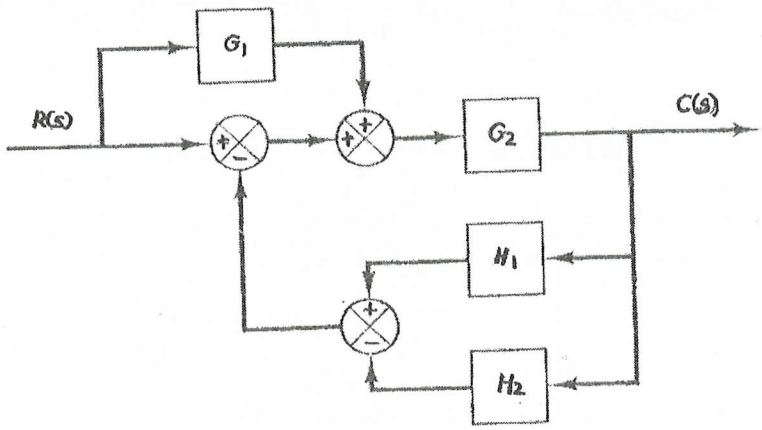

Figure 2(c): Block diagram of closed loop system
Rajah 2(c): Gambarajah blok sistem gelung tertutup

(30 marks/*markah*)

3. (a) Obtain a state- representation of the mechanical system and determine the transfer functions $\frac{X_1(s)}{R(s)}$ *and* $\frac{X_2(s)}{R(s)}$ of the **Figure 3(a)** shown below.

Dapatkan keadaan-perwakilan bagi sistem mekanikal dan tentukan fungsi pindah $\frac{X_1(s)}{R(s)}$ *and* $\frac{X_2(s)}{R(s)}$ *untuk* ***Rajah 3(a)*** *seperti di bawah.*

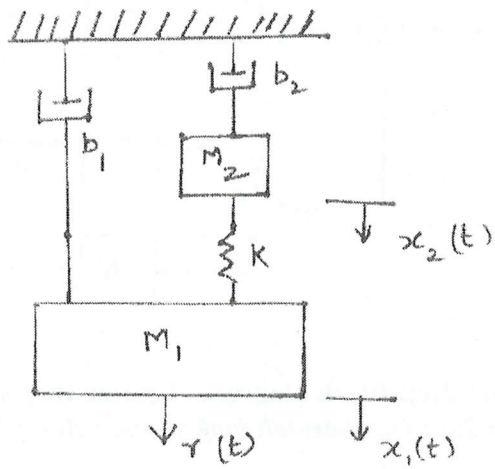

Figure 3(a): Mechanical system
Rajah 3(a): Sistem Mekanikal

(40 marks/*markah*)

(b) Determine the range of K for stability using Routh's criterion.

$$s^4 + 2s^3 + (4+k)s^2 + 9s + 25 = 0$$

Tentukan julat nilai K untuk kestabilan dengan menggunakan kriterium Routh's.

$$s^4 + 2s^3 + (4+k)s^2 + 9s + 25 = 0$$

(30 marks/*markah*)

(c) A control system is represented by block diagram as shown in **Figure 3(c)** below. Determine the transfer function of the system and obtain the natural un-damped frequency ω_n and damping ratio ξ for the closed loop system expressed in terms of K. Then determine the value of K that will give ω_n=12 rad/sec. Also compute the damping ratio of the system.

Satu sistem kawalan diwakili dengan gambarajah blok seperti ditunjukkan dalam ***Rajah 3(c)*** *di bawah. Tentukan fungsi pindah bagi sistem tersebut dan dapatkan frekuensi asal tak terendam* ω_n *dan nisbah redaman* ξ *bagi sistem litar tertutup dalam ungkapan K. Kemudian tentukan nilak K yang akan memberikan* ω_n *=12 rad/sec. Kirakan juga nisbah terendam bagi sistem.*

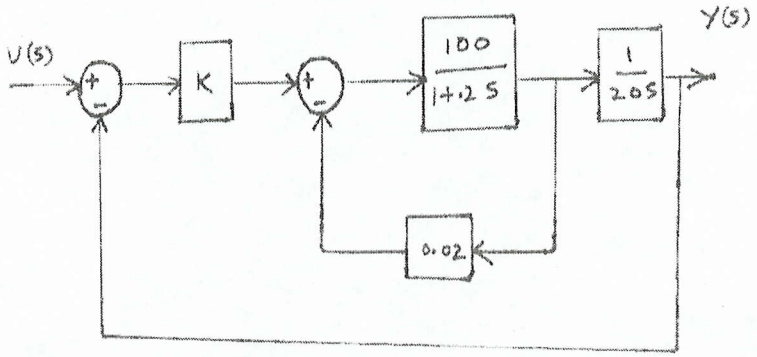

Figure 3(c): Control System
Rajah 3(c): Sistem kawalan

(30 marks/*markah*)

5. Consider the system shown in the **Figure 4**.

*Pertimbangkan sistem seperti yang ditunjukan dalam **Rajah 4**.*

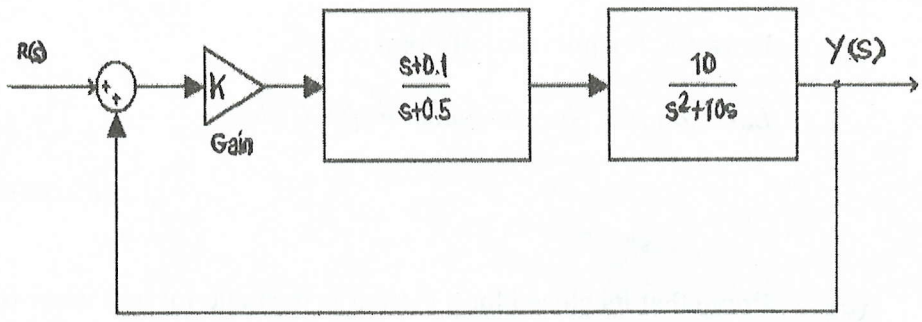

Figure 4 : Block diagram of hydraulic servo actuator
Rajah 4: Rajah blok bagi penggerak servo hidraulik

(a) Draw a bode diagram of the open loop transfer function for K-1, then determine their gain and phase margin.

Lukiskan rajah bode bagi fungsi pindah gelung terbuka untuk K= 1 kemudian tentukan margin fasa dan margin gandaan.

(60 marks/*markah*)

(b) Determine the value of gain K such that the phase margin of the open loop transfer function is 45 degree.

Tentukan nilai gandaan K supaya margin fasa fungsi gelung terbuka menjadi 45 darjah.

(20 marks/*markah*)

(c) What is the gain margin of the system with this gain K calculated in problem (b)?

Apakah margin gandaan bagi sistem dengan nilai gandaan K yang dikira pada soalan (b)?

(20 marks/*markah*)

6. Consider a system having the following open transfer function Fo(s) = K/(1-Ts).

Pertimbangkan sistem dengan fungsi pindah gelung terbuka Fo(s) = K/(1-Ts).

(a) Draw the Nyquist plot of Fo(s) above.

Lukiskan plot Nyquist untuk Fo(s) di atas.

(20 marks/*markah*)

(b) Prove that its closed loop system is unstable for any value of K .

Buktikan bahawa sistem gelung tertutupnya adalah tidak stabil untuk setiap nilai K.

(40 marks/*markah*)

(c) For what value of K so that the closed loop system will be stable?

Untuk nilai K berapa sistem gelung tertutupnya menjadi stabil?

(40 marks/*markah*)

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