UNIVERSITI SAINS MALAYSIA

First Semester Examination
2007/2008 Academic Session
Peperiksaan Semester Pertama
Sidang Akademik 2007/2008

October/November 2007
Oktober/November 2007

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

Duration : 3 hours
[Masa : 3 jam]

INSTRUCTION TO CANDIDATES
ARAHAN KEPADA CALON

Please ensure that this paper contains **NINE (9)** printed pages and **SIX (6)** questions before you begin examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **SEMBILAN (9)** mukasurat bercetak dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.*

Answer **FOUR (4)** questions.
*Jawab **EMPAT (4)** soalan.*

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

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

1. Consider the damped spring pendulum system below in **Figure 1**.

*Pertimbangkan sistem bandul pegas terendam seperti dalam **Rajah 1** di bawah.*

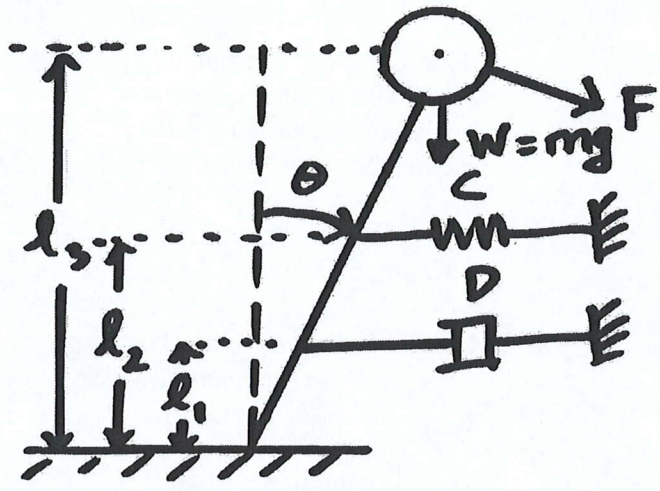


Figure 1 : Damped spring pendulum system in deflected position
Rajah 1 : Sistem bandul pegas terendam dalam kedudukan terpesong

Assume that the spring and damper force acting on the pendulum is zero when the pendulum is vertical or $\theta = 0$. Assume also that the friction involved is negligible and the angle of oscillation θ is small.

Anggapkan bahawa daya pegas dan daya terendam yang bertindak ke atas bandul adalah sifar bila bandul berada dalam keadaan mendatar atau $\theta = 0$. Anggapkan juga bahawa geseran yang terlibat boleh diabaikan dan sudut ayunan θ adalah kecil.

(a) Obtain the mathematical model of the system in form of.

Dapatkan model matematik bagi sistem itu dalam bentuk.

(i) The differential equation

Persamaan perbezaan

(ii) State Space Representation

State Space Representation

(iii) Transfer function

Fungsi pindah

(50 marks/*markah*)

(b) Determine dynamic parameter of the system natural frequency (w_o), damping ratio (ρ) and damped frequency (w_d).

Tetapkan parameter dinamik sistem frekuensi tabii (w_o), nisbah redaman (ρ) *dan frekuensi terendam (w_d).*

(25 marks/*markah*)

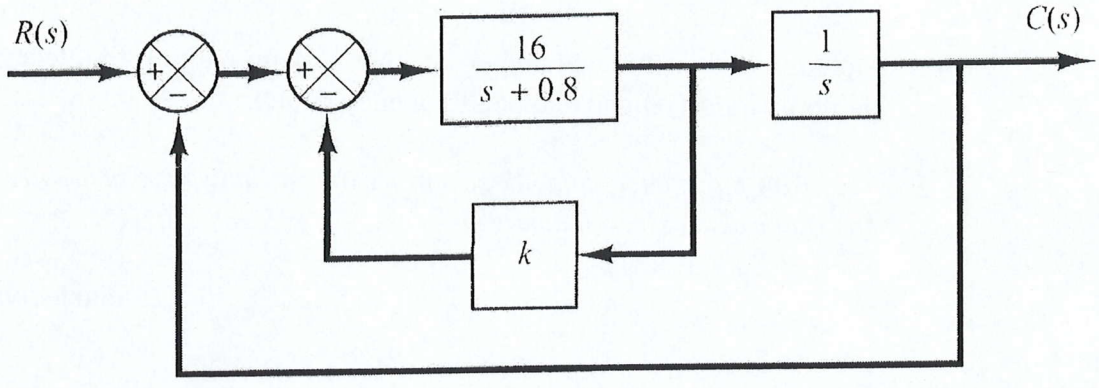
(c) Please predict the initial and stationary step-response using initial final theorems.

Sila ramalkan sambutan awal dan akhir sistem dengan menggunakan teori awal dan akhir.

(25 marks/*markah*)

2. (a) Consider the system shown in **Figure 2(a)**. Determine the value of k such that the damping ratio is 0.5. Then obtain the rise time, peak time, maximum overshoot and the settling time in unit step response.

*Perhatikan sistem kawalan tertutup pada **Rajah 2(a)**. Tentukan harga k sehingga nisbah redaman adalah 0.5. Kemudian dapatkan harga untuk "rise time", " peak time", " maximum overshoot" dan "settling time".*

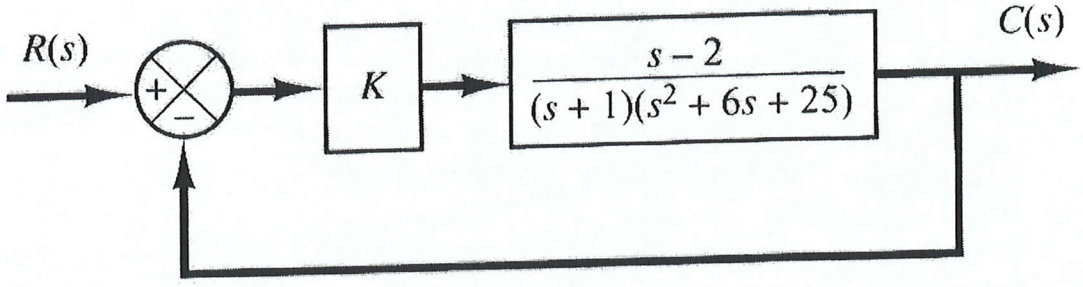


Rajah 2(a): Blok diagram sistem kawalan gelung tertutup
Figure 2(a): Block diagram of a closed loop control system

(50 marks/*markah*)

(b) Consider the closed loop system shown in **Figure 2(b)**. Determine the range of K for Stability. Assume that K >0.

*Perhatikan sistem kawalan tertutup pada **Rajah 2(b)**. Tentukan harga K untuk kestabilan. Anggap bahawa K > 0.*



Rajah 2(b): Blok diagram sistem kawalan gelung tertutup
Figure 2(b): Block diagram of a closed loop control system

(50 marks/*markah*)

3. **Figure 3** shows a block diagram of a space vehicle attitude control system. Assuming the time constant T of the controller to be 3 sec and the ratio K/J to be 2/9 rad/sec. Show that the controller can stabilized the neutral stable space vehicle and find the natural frequency and the damping ratio of the system.

Rajah 3 *menunjukan sebuah sistem kawalan untuk kapal angkasa. Anggap harga* $T = 3$ *saat dan nisbah* $K/J = 2/9$ *rad/saat. Buktikan bahawa kawalan boleh menstabilkan sistem kapal angkasa yang neutral stabil serta tentukan natural frequency dan nisbah pelembapan dari sistem di atas.*

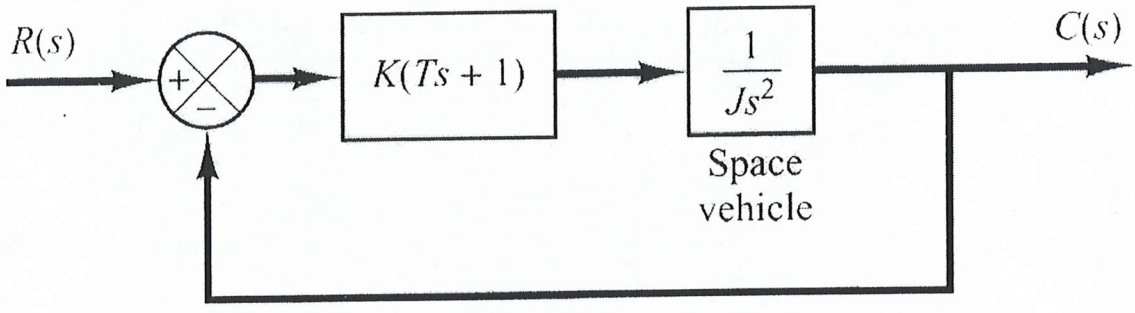


Figure 3: Block diagram of attitude determination and control system of space vehicle

Rajah 3:Blok diagram sistem kawalan kapal angkasa.

(100 marks/*markah*)

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

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

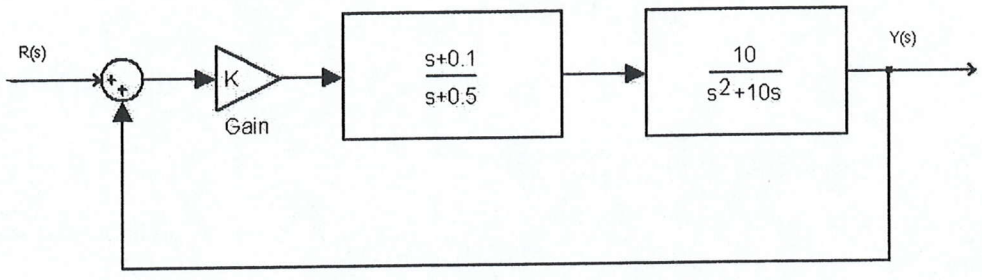


Figure 4 : Block diagram of hydraulic servo actuator
Rajah 4: Rajah blok bagi penggerak servo hidraulik

(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 $F_o(s) = K/(1-Ts)$

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

(a) Draw the Nyquist plot of $F_o(s)$ above

Lukiskan plot Nyquist untuk $F_o(s)$ *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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