UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

November 2010

ESA 481/3 – Spacecraft Design
Rekabentuk Kapal Angkasa

Duration : 3 hours
[Masa : 3 jam]

INSTRUCTION TO CANDIDATES
ARAHAN KEPADA CALON

Please ensure that this paper contains **ELEVEN (11)** printed pages and **TEN (10)** questions before you begin examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **SEBELAS (11)** mukasurat bercetak dan **SEPULUH (10)** soalan sebelum anda memulakan peperiksaan.*

Answer **SIX (6)** questions only.
*Jawab **ENAM (6)** soalan sahaja.*

Part I: Answer **ONE (1)** questions. *Bahagian I: Jawab **SATU (1)** soalan.*
Part II : Answer **ONE (1)** questions. *Bahagian II: Jawab **SATU (1)** soalan.*
Part III Answer **FOUR (4)** question. *Bahagian III: Jawab **EMPAT (4)** soalan.*

Answer **ALL** questions in English
*Jawab **SEMUA** soalan dalam Bahasa Inggeris*

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

In the event of any discrepancies, the English version shall be used.
Sekiranya terdapat sebarang percanggahan pada kertas soalan, versi Bahasa Inggeris hendaklah digunakan pakai.

PART I / *BAHAGIAN I*

1. Design space vehicle design diagram in the structure of space systems. Explain main designing criteria.

Bina diagram rekabentuk pesawat angkasa dalam struktur sistem angkasa. Jelaskan kriteria utama untuk merekabentuk.

(20 marks/*markah*)

2. (a) Describe a jet orientation system (briefly).

Jelaskan secara ringkas tentang sistem orientasi jet.

(b) Solve a problem below:

Selesaikan masalah di bawah:

A satellite is on the Earth orbit. A jet orientation system (using a cold gas as a working medium) during the most part of the flight provides approximate orientation of the satellite relative to the Sun, Earth and accurate pointing during corrections and scientific experiments. The satellite has the following performances:

Sebuah satelit berada di orbit bumi dan sebuah sistem orientasi jet (menggunakan gas sejuk sebagai medium operasi) menghasilkan anggaran orientasi semasa sebahagian besar penerbangan terhadap satelit merujuk kepada matahari, bumi dan menunjukkan posisi yang tepat semasa pembetulan dan eksperimen saintifik. Satelit tersebut mempunyai prestasi seperti berikut:

I_{Sat} = 50 kg×m^2 – satellite moment of inertia;
P_{sp} = 180 s - controlled jet nozzles (CJN) specific thrust (the working medium is helium (He)); l = 0.2 m - arm of CJN thrust operation;
g_0 = 9.806 m/s^2 - terrestrial gravity acceleration.

Derive formulas for calculation of the required working medium margin (m, kg) and calculate it for the following operations:

Dapatkan rumus pengiraan 'working medium margin (m,kg)' yang diperlukan dan buat pengiraan untuk operasi berikut:

(i) Increase or decrease of satellite angular velocity $\Delta\omega$ ($\Delta\omega$=2 deg/s).

Pertambahan dan pengurangan halaju sudut $\Delta\omega$ ($\Delta\omega$=2 deg/s).

(ii) Satellite orientation problem.

Masalah orientasi satelit.

In stabilizing mode (with sensors possessing sensitivity of $\Delta\omega$ =0.1 deg/s – for angular velocity, $\Delta\varphi$=0.5 deg – for an angle) the SV performs vibrating motion with amplitude of $\pm\Delta\varphi$ (equal $2\Delta\varphi$) and angular velocity of $\Delta\omega$. The stabilization process duration $\tau^* = 50$ s.

Dalam mod penstabilan (Kepekaan pemprosesan penderia : untuk halaju sudut $\Delta\omega$ =0.1 deg/s ,untuk sudut ,$\Delta\varphi$=0.5 deg) SV menghasilkan getaran dengan amplitud $\pm\Delta\varphi$ (equal $2\Delta\varphi$) dan halaju sudut $\Delta\omega$. Masa untuk proses penstabilan $\tau^* = 50$ s.

(20 marks/*markah*)

PART II/*BAHAGIAN II*

3. Describe space vehicle general requirements and space vehicle design general requirements of the following:

Jelaskan keperluan umum dan rekabentuk untuk sesebuah kenderaan angkasa lepas seperti berikut:

(a) Reliability requirements.
Kebolehpercayaan.

(b) Operational specifications.
Spesifikasi operasi.

(c) Economic requirements.
Spesifikasi ekonomi.

(d) Minimum mass and volume requirements.
Berat dan isipadu minimum.

(e) Strength requirements.
Kekuatan.

(f) Stiffness requirements.
Kekerasan.

(g) Pressurization requirements.
Tekanan.

(h) Requirements on minimum energy demand.
Keperluan tenaga minimum

(i) Requirements on industrial-technological complex.
Kompleksiti.

(20 marks/*markah*)

4. Explain Korolev's formula below.

Jelaskan tentang rumus Korolev di bawah.

Korolev's formula.

$$\underbrace{V_{\mathrm{f}} = -gP_{\mathrm{sp.thr.v.}} \ln \mu_{\mathrm{f}}}_{\substack{\text{Tsiolkovski's} \\ \text{formula}}} \underbrace{- \frac{P_{\mathrm{sp.thr.0}}}{n_0} \int_{\mu_{\mathrm{f}}}^{1} g \sin\theta \frac{\mathrm{d}\mu}{\mu}}_{\Delta V_{\mathrm{grav}}} \underbrace{- \frac{P_{\mathrm{sp.thr.0}}}{n_0} \frac{g}{P_{\mathrm{m}}} \int_{\mu_{\mathrm{f}}}^{1} q c_{\mathrm{x}} \frac{\mathrm{d}\mu}{\mu}}_{\Delta V_{aer}} \underbrace{- \Delta P_{\mathrm{sp.thr.}} g \int_{\mu_{\mathrm{f}}}^{1} \frac{P(H)}{P(0)} \frac{\mathrm{d}\mu}{\mu}}_{\Delta V_{\mathrm{e.u.}}}$$

(20 marks/*markah*)

5. Describe and explain a Space radio telescope radiation protection system which is nonstandard thermal protection system design as depicted in the sketch below (refer to **Figure 1** and **Figure 2**).

Jelaskan dan terangkan sebuah 'radio telescope radiation protection system' yang merupakan rekabentuk ***'****nonstandard thermal protection system' seperti yang digambarkan dalam lakaran di bawah (rujuk* ***Rajah 1*** *dan* ***Rajah 2****)*

Figure 1/*Rajah 1*

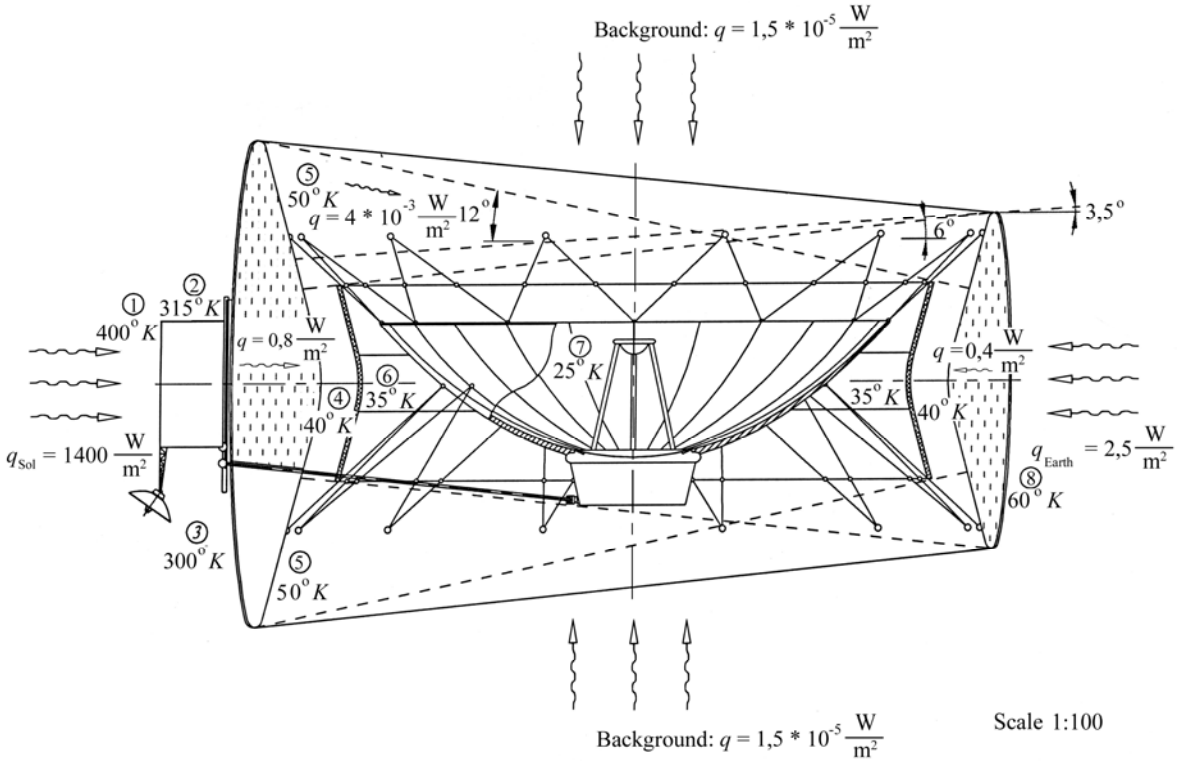

Figure 2/*Rajah 2*

(20 marks/*markah*)

PART III/*BAHAGIAN III*

6. Present and explain the decision on in-flight complex configuration with independent reliability.

Tunjuk dan terangkan keputusan konfigurasi tentang 'in-flight complex' dengan kebolehpercayaan bebas.

(a) Determine the total probability of faultless operation (P_Σ). (P_1=0.65 - probability of faultless operation of a single SV, N = 3 - number of satellite).

Tentukan jumlah kebarangkalian untuk operasi tanpa gagal ((P_Σ).(P_1=0.65 kebarangkalian operasi tanpa gagal untuk sebuah SV, N = 3 – bilangan satelit).

(b) Calculate a number of satellites to provide the total probability of a faultless operation $P_\Sigma = 0.9$, if the probability of a faultless operation of a single satellite is P_1=0.6.

Kira bilangan satelit untuk menghasilkan kebarangkalian operasi tanpa gagal $P_\Sigma = 0.9$, jika kebarangkalian operasi tanpa gagal untuk sebuah satelit adalah, P_1=0.6.

(15 marks/*markah*)

7. Describe the forces exerted against a spacecraft in orbital flight and spacecraft center-of-mass motion equation. (The spacecraft motion is in the gravitational field of Earth which is assumed to be a perfect sphere). Describe orbital elements (refer to **Figure 3**).

*Terangkan daya yang dikenakan terhadap sebuah kapal angkasa dalam orbit dan persamaan pergerakan 'center-of-mass' sesebuah kapal angkasa. Terangkan elemen-elemen orbit (rujuk **Rajah 3**)*

$$\frac{d^2\bar{r}}{dt^2} = \bar{u}_{\mathrm{G}} + \bar{u}_{\mathrm{at}} + \bar{u}_{\mathrm{m}} + \bar{u}_{\mathrm{s}} + \bar{u}_{\mathrm{c}}.$$

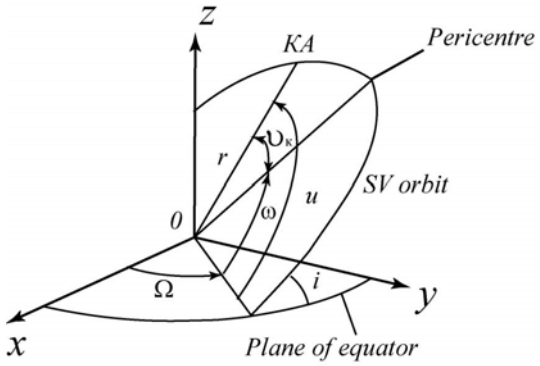

Figure 3/*Rajah 3*

(15 marks/*markah*)

8. Tanks' configuration. Present and explain the decision upon the number of spherical tanks.

Terangkan keputusan terhadap bilangan 'spherical tanks' untuk konfigurasi Tanks'.

(15 marks/*markah*)

9. Describe the low orbit satellite configuration. Explain the influence of aerodynamic and solar pressure on low orbit satellite. (refer to **Figure 4** and **Figure 5**).

*Jelaskan konfigurasi satelit orbit rendah. Terangkan pengaruh aerodinamik dan tekanan solar terhadapnya.(rujuk **Rajah 4** dan **Rajah 5**).*

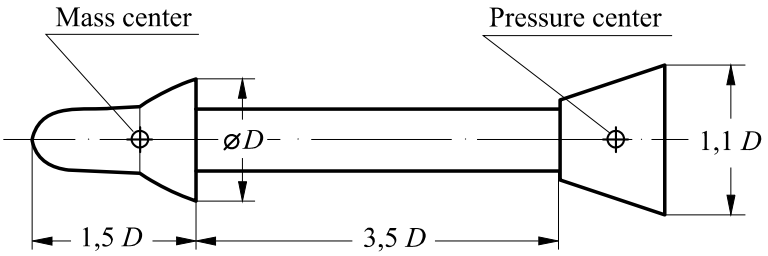

Figure 4/*Rajah 4*

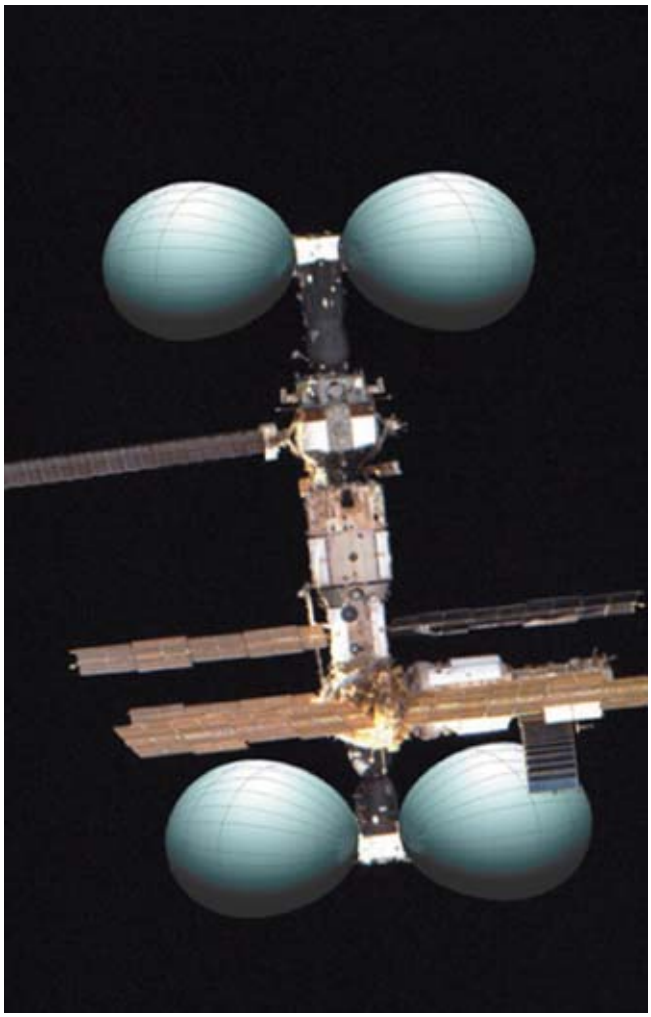

Figure 5/*Rajah 5*

(15 marks/*markah*)

10. Describe the spacecraft (SC) configuration in gravitational field. Explain the conditions of the stable position of a SC in gravitational field (refer to **Figure 6**).

*Jelaskan konfigurasi sesebuah kapal angkasa dalam medan graviti. Terangkan keadaan posisi stabil sesebuah kapal angkasa dalam medan graviti tersebut (rujuk **Rajah 6**).*

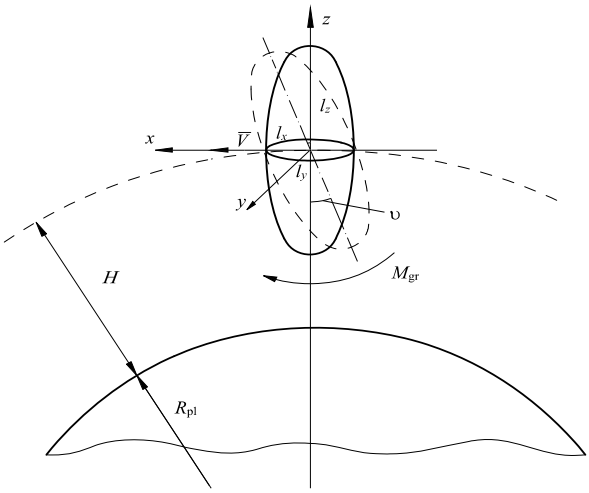

Figure 6/*Rajah 6*

(15 marks/*markah*)

~ooo000ooo~