UNIVERSITI SAINS MALAYSIA

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

Oktober/November 2006
October/November 2006

ESA 481/3 – Rekabentuk Kapal Angkasa

Spacecraft Design

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

ARAHAN KEPADA CALON :
INSTRUCTION TO CANDIDATES

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

Bahagian 1 : Jawab **SATU (1)** soalan daripada soalan 1 dan 2.
Bahagian II : Jawab **SATU (1)** soalan daripada soalan 3, 4 dan 5.
Bahagian III : Jawab **EMPAT (4)** soalan daripada soalan 6-10.
Part I : Do **ONE (1)** *problem from questions 1 and 2.*
Part II : Do **ONE (1)** *problem from questions 3, 4 and 5.*
Part III : Do ***FOUR (4)*** *problems from questions 6-10.*

Soalan boleh dijawab dalam Bahasa Inggeris kecuali satu soalan mestilah dijawab dalam Bahasa Malaysia.
The questions can be answered in English but one question must be answered in Bahasa Malaysia.

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

Bahagian 1. (Jawab 1 soalan daripada soalan 1 dan 2)
Part I. (Do 1 problem from questions 1 and 2).

1. Berikan dan terangkan gambarajah rekabentuk kapal angkasa dalam struktur sistem angkasa. Terangkan ciri-ciri utama dalam merekabentuk.

   Present and describe space vehicle design diagram in the structure of space systems. Explain main designing criteria.

   (20 markah/*marks*)

2. (a) Terangkan (secara ringkas) sistem orientasi jet.

   Describe a jet orientation system (briefly).

   (b) Selesaikan masalah di bawah:

   Sebuah satelit terletak di orbit Bumi. Dalam sebahagian besar penerbangan satu sistem orientasi jet (menggunakan gas sejuk sebagai medium bertindak) membekalkan orientasi satelit relatif kepada Matahari dan Bumi dan kejituan arah semasa pembetulan amplitud dan eksperimen saintifik.
   Satelit tersebut mempunyai keupayaan di bawah:
   I_{Sat} = 50 kg×m^2 – momen inersia satelit; P_{sp} =70 s – kawalan muncung jet (CJN) tujah tentu (medium bertindak ialah helium (He); l = 0.2 m – lengan operasi tujah bagi CJN ; g_0 =9.806 m/s^2 – pecutan gravity rupa bumi.
   Buktikan formula kiraan bagi keperluan margin medium bertindak (m, kg) dan kirakan operasi berikut:

   (i) Tokokan atau susutan halaju sudut satelit $\Delta\omega$ ($\Delta\omega$=2 deg/s)

   (ii) Masalah orientasi satelit

   Dalam mod penstabilan (dengan alat pengesan yang mempunyai sensitiviti pemprosesan $\Delta\omega$ =0.1 deg/s – bagi halaju sudut, $\Delta\varphi$=0.5 deg – bagi sudut) kapal angkasa menjalankan gerakan getaran dengan amplitud $\pm\Delta\varphi$ (bersamaan 2$\Delta\varphi$) dan halaju sudut $\Delta\omega$. Masa proses penstabilan ialah τ^* = 50 s.

Solve a problem below:

A satellite is in 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:
I_{Sat} *= 50 kg×m² – satellite moment of inertia;* P_{sp} *=70 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:

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

(ii) *Satellite orientation problem.*

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 space vehicle 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.*

(20 markah/*marks*)

Bahagian II. (Jawab 1 soalan daripada soalan 3, 4 dan 5).
Part II. (Do 1 problem from questions 3, 4 and 5).

3. Huraikan keperluan am rekabentuk kapal angkasa bagi yang berikut :

a) keperluan kebolehharapan

b) spesifikasi kendalian

c) keperluan ekonomik

d) jism terkecil dan isipadu

e) kekuatan perlu

f) kekakuan perlu

g) penekanan perlu

h) keperluan tenaga minimum perlu

i) kompleks teknologi-industri perlu

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

a) Reliability requirements.

b) Operational specifications.

c) Economic requirements.

d) Least mass and volume requirements.

e) Strength requirements.

f) Stiffness requirements.

g) Pressurization requirements.

h) Requirements on minimum energy demand.

i) Requirements on industrial-technological complex.

(20 markah/*marks*)

4. Gambarkan satu peringkat rekabentuk modul roket yang bertindak terhadap beban bayar maksimum. Terangkan formula Korolev's di bawah.

Formula Korolev's

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

Describe the one-stage rocket module's design with respect to maximum payload. Explain Korolev's formula below.

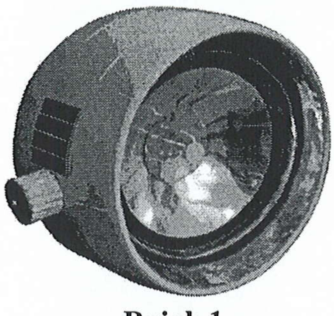
Korolev's formula

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

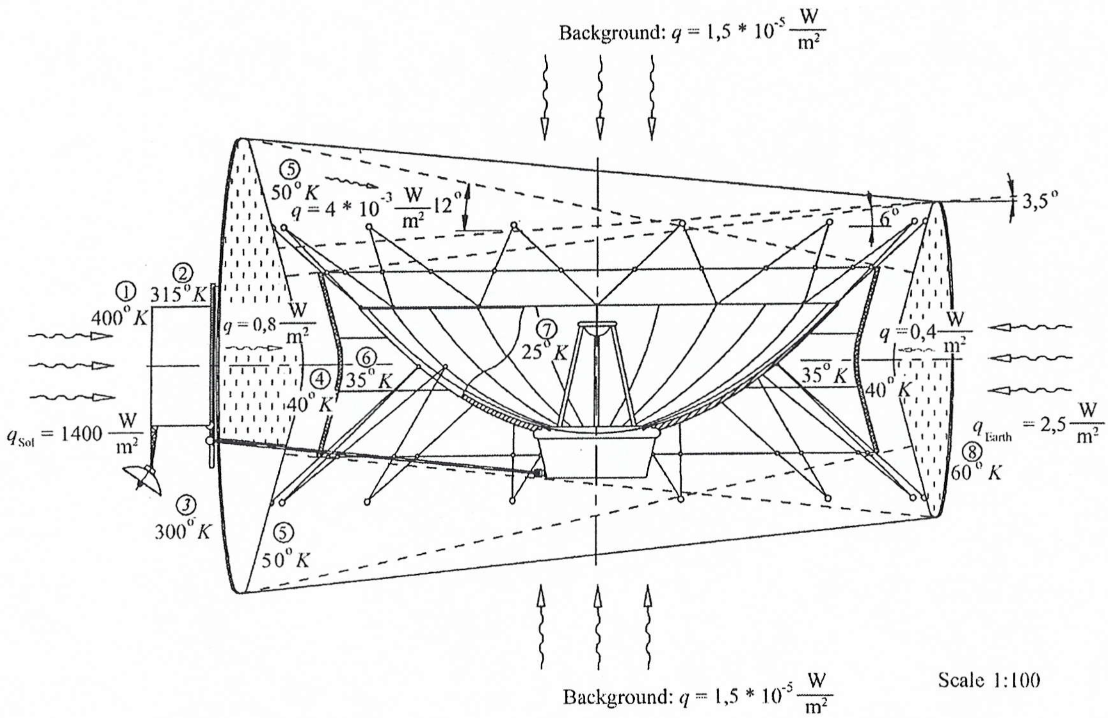
(20 markah/*marks*)

5. Gambarkan dan terangkan sistem perlindungan radiasi teleskop radio angkasa di mana sistem perlindungan terma tidak piawai seperti di dalam lukisan di bawah. (rujuk Rajah 1 dan Rajah 2).

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 Fig. 1 and Fig. 2).



Rajah 1
Fig. 1



Rajah 2
Fig. 2

(20 markah/*marks*)

<u>Bahagian III. (Jawab 4 soalan daripada soalan 6-10).</u>
<u>Part III. (Do 4 problems from questions 6-10).</u>

6. Berikan dan terangkan keputusan terhadap konfigurasi kompleks dalam penerbangan dengan kebolehharapan bebas. Tentukan jumlah kebarangkalian kegagalan operasi (P_Σ). (P_I=0.6 – kebarangkalian kegagalan operasi bagi kapal angkasa tunggal, N = 3 –bilangan satelit).

   Present and explain the decision on in-flight complex configuration with independent reliability. Determine the total probability of faultless operation (P_Σ). (P_I=0.6 – probability of faultless operation of a single space vehicle, N = 3 - number of satellite).

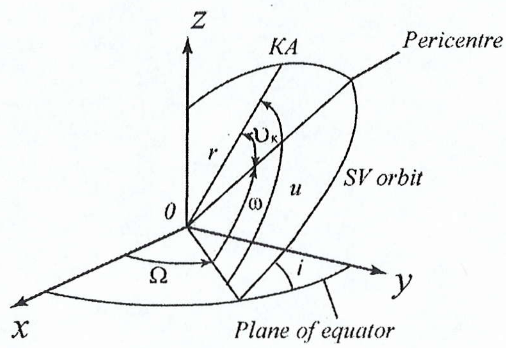
   (15 markah/*marks*)

7. Terangkan keupayan daya melawan pesawat dalam penerbangan orbit dan jisim pusat persamaan gerakan pesawat. (gerakan pesawat ialah di dalam medan gravity Bumi di mana anggap ianya sfera penuh). Gambarkan elemen-elemen orbital. (rujuk rajah 3)

$$\frac{d^2\bar{r}}{dt^2} = \bar{u}_G + \bar{u}_{at} + \bar{u}_m + \bar{u}_s + \bar{u}_c$$

   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 Fig. 3).

$$\frac{d^2\bar{r}}{dt^2} = \bar{u}_G + \bar{u}_{at} + \bar{u}_m + \bar{u}_s + \bar{u}_c$$



Rajah 3
Fig. 3

   (15 markah/*marks*)

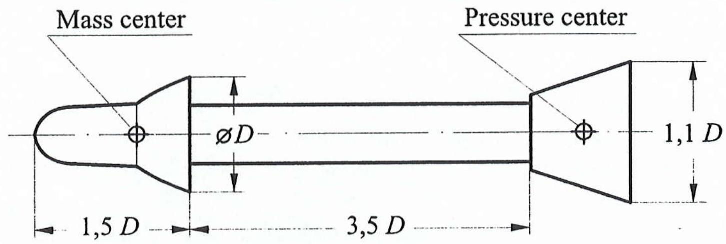
8. Konfigurasi Tank's. Gambarkan dan terangkan keputusan tentang bilangan tangki sfera.

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

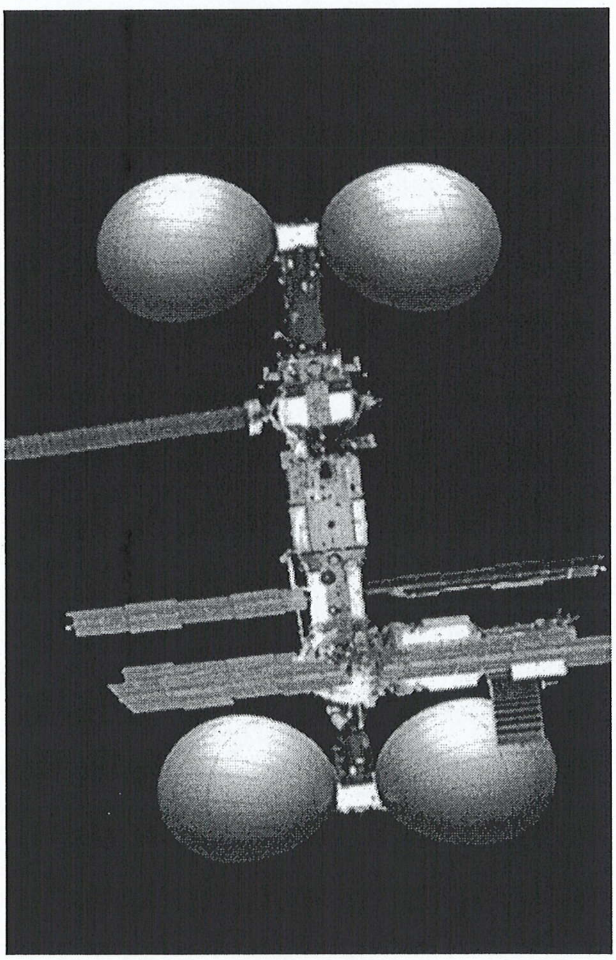
   (15 markah/*marks*)

9. Gambarkan konfigurasi satelit orbit rendah. Terangkan pengaruh aerodinamik dan tekanan solar pada satelit orbit rendah. (rujuk Rajah 4 dan Rajah 5).

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



Rajah 4
Fig. 4



Rajah 5
Fig. 5

(15 markah/*marks*)