UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2010/2011

November 2010

ESA 321/3 – Aerospace Structure
Struktur Aeroangkasa

Duration : 3 hours
[Masa : 3 jam]

INSTRUCTION TO CANDIDATES
ARAHAN KEPADA CALON

Please ensure that this paper contains **SEVEN (7)** printed pages, **ONE (1)** pages appendix and **FIVE (5)** questions before you begin examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **TUJUH (7)** mukasurat bercetak, **SATU (1)** mukasurat lampiran dan **LIMA (5)** soalan sebelum anda memulakan peperiksaan.*

Answer **ALL** questions.
*Jawab **SEMUA** soalan.*

Student may answer the questions either in English or Bahasa Malaysia but not both.
Pelajar boleh menjawab soalan dalam Bahasa Inggeris atau Bahasa Malaysia tetapi bukan kedua-duanya sekali.

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.

1. Apendix/Lampiran [1 page/mukasurat]

1. **Figure 1** shows an aircraft landing gear unit. The brace struts BF and DE are pinned at each end. The support at C is of telescopic type (like shock absorber, i.e. free to move longitudinally but constrained laterally) thus no vertical reaction, only horizontal reaction acting here. Determine load on struts BF and DE and reaction at C.

Rajah 1 *menunjukkan unit alat pendaratan kapalterbang. Topang rembat BF dan DE adalah dipinkan di hujungnya. Penyokong di C adalah jenis teleskop (seperti penyerap kejutan di mana bebas bergerak membujur tetapi dikekang gerakan sisi) oleh itu tiada tindakbalas tegak, hanya tindakabalas mendatar). Tentukan beban pada topang rembat BF dan DE dan tindakabalas di C.*

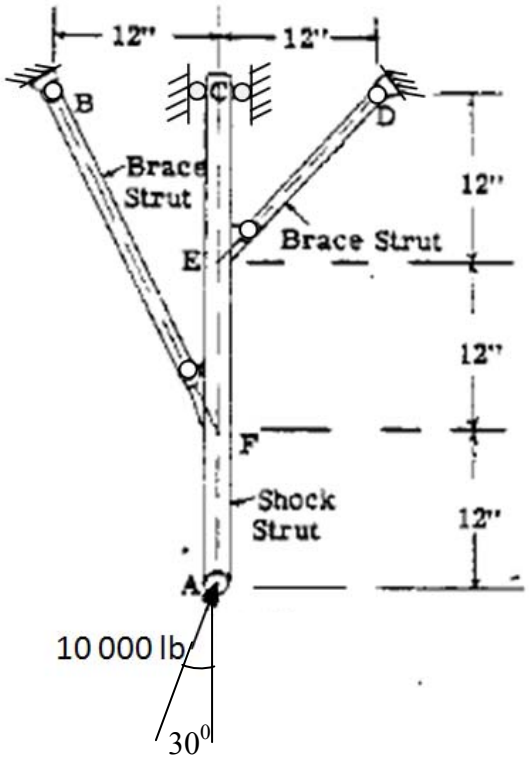


Figure 1/*Rajah 1*

(15 marks/*markah*)

2. (a) Using **Figure 2(a)**, derive the equilibrium equation in the z-direction.

*Menggunakan **Rajah 2(a)**, terbitkan persamaan keseimbangan pada arah-z.*

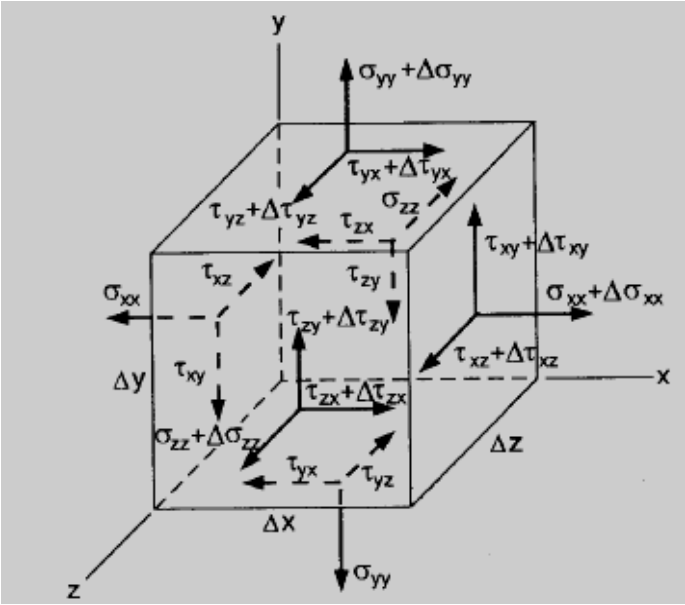


Figure 2(a)/ *Rajah 2(a)*

(8 marks/*markah*)

(b) State and explain the assumptions used in deriving the equations of elasticity.

Nyatakan dan terangkan andaian-andaian yang digunakan untuk menerbitkan persamaan-persamaan elastik.

(4 marks/*markah*)

(c) State and explain the compatibility equation of a three-cell closed section wing subjected to torsion.

Nyatakan dan terangkan persamaan keserasian untuk keratan sayap 3-sel tertutup akibat kilasan.

(4 marks/*markah*)

(d) Show if the following function φ is a valid Airy's stress function.

Pertimbangkan jika fungsi φ berikut adalah fungsi tegasan Airy's yang sah:

$$\varphi = c_1x^2+c_2xy+c_3y^2$$

(4 marks/*markah*)

3. Using **Figure 3** shown below, draw the load, shear and bending moment diagram.

*Dengan berpandukan **Rajah 3** di bawah, lukiskan rajah beban, ricih dan momen lentur.*

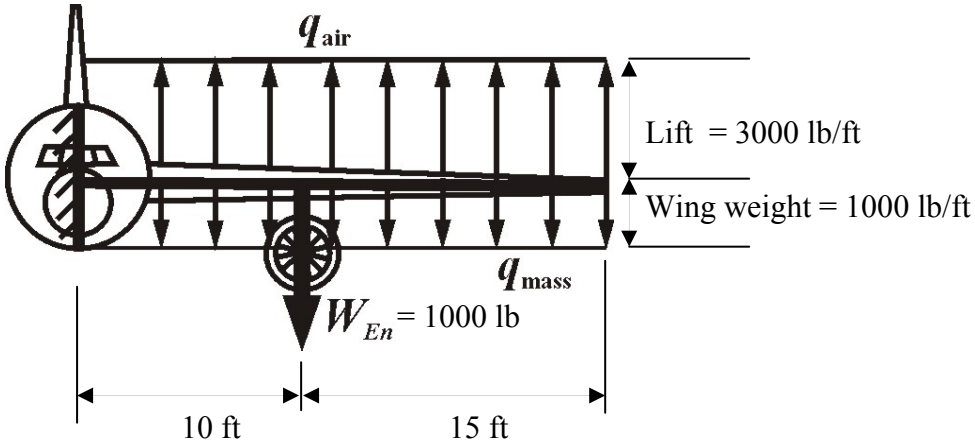


Figure 3/*Rajah 3*

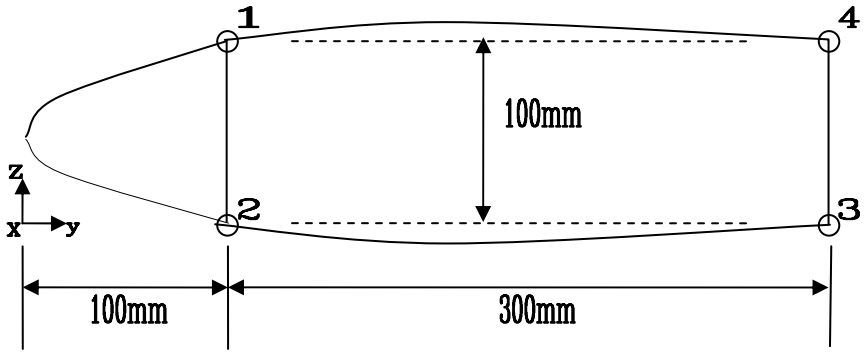
(15 marks/*markah*)

4. Bending moments of M_y = -50 kNm and M_z = 10 kNm are applied on the idealized thin-walled 4 booms wing beam section shown in **Figure 4**.

*Momen lentur M_y = -50 kNm dan M_z = 10 kNm dikenakan ke atas keratan–rentas rasuk dinding-nipis 4 joran yang ditunjukan di **Rajah 4**.*

Determine the stresses in all booms.

Tentukan tegasan pada setiap joran.



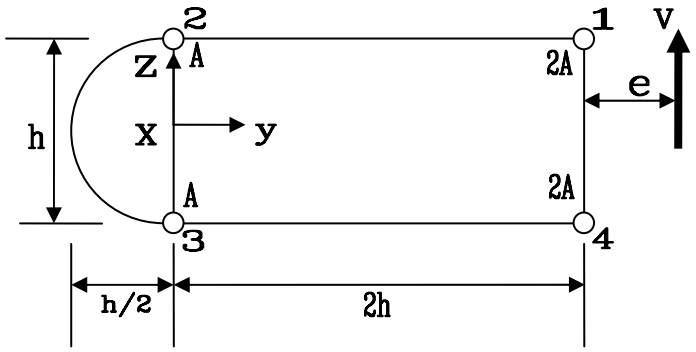
Thickness of all walls
Tebal semua dinding
= 0.25 mm
Area of booms,
Luas joran,
A1 = A2 =2000 mm^2
A3 = A4 =1000 mm^2

Figure 4/*Rajah 4*

(25 marks/*markah*)

5. Determine e, the shear center of the idealized thin-walled 4-boom wing beam section shown in **Figure 5**.

*Tentukan e, pusat ricih rasuk kotak 4-joran yang ditunjukkan di **Rajah 5**.*



Thickness of all walls
Tebal semua dinding
= t
Area of booms,
Luas joran,
A1 = A4 = 2A
A2 = A3 = A .

Figure 5/*Rajah 5*

(25 marks/*markah*)

Appendix/*Lampiran*

$$\sigma_x = \frac{P}{A} + \frac{-\left(M_z I_y + M_y I_{yz}\right)y + \left(M_y I_z + M_z I_{yz}\right)z}{I_y I_z - I_{yz}^2}$$

$$\Delta q = -\left[\frac{\left(V_y I_y - V_z I_{yz}\right)Q_z + \left(V_z I_z - V_y I_{yz}\right)Q_y}{I_y I_z - I_{yz}^2}\right]$$

$$\theta = \frac{q}{2AG}\oint\frac{ds}{t}$$

$$\varepsilon_x = \frac{\partial u}{\partial x} \qquad \varepsilon_y = \frac{\partial v}{\partial y} \qquad \gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$$

$$\sigma_x = \frac{\partial^2 \phi}{\partial y^2} \qquad \sigma_y = \frac{\partial^2 \phi}{\partial x^2} \qquad \tau_{xy} = -\frac{\partial^2 \phi}{\partial x \partial y}$$

$$\frac{\partial^2 \varepsilon_x}{\partial y^2} + \frac{\partial^2 \varepsilon_y}{\partial x^2} = \frac{\partial^2 \gamma_{xy}}{\partial x \partial y}$$

$$\frac{\partial^4 \phi}{\partial x^4} + 2\frac{\partial^4 \phi}{\partial x^2 \partial y^2} + \frac{\partial^4 \phi}{\partial y^4} = 0$$

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