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UNIVERSITI SAINS MALAYSIA

First Semester Examination  
Academic Session 2009/2010  
*Peperiksaan Semester Pertama  
Sidang Akademik 2009/2010*

November 2009  
*November 2009*

ESA 321/3 – **Struktur Aeroangkasa**  
*Aerospace Structure*

Duration : 3 hours  
*[Masa : 3 jam]*

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**INSTRUCTION TO CANDIDATES**  
**ARAHAN KEPADA CALON**

Please ensure that this paper contains **EIGHT (8)** printed pages and **FIVE (5)** questions before you begin examination.

*Sila pastikan bahawa kertas soalan ini mengandungi **LAPAN (8)** mukasurat bercetak 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.  
*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.*

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.*

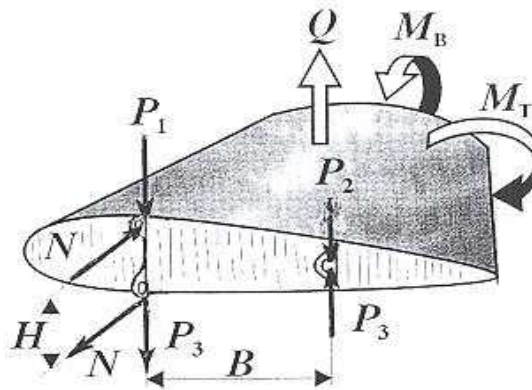
**APPENDIX/LAMPIRAN**

[1 page/mukasurat]

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1. Internal loads, transverse load of  $Q = 1000$  kN, bending moment of  $M_B = 50$  kN.m and torque of  $M_T = 1.5$  kN.m are acting on the cross-section at the wing root in **Figure 1**. Determine the loads  $P_1$ ,  $P_2$ ,  $P_3$  and  $N$  if  $H=100$  mm and  $B = 500$  mm. Assume  $Q$  is located at  $0.5B$  behind front spar. Hint: Let  $P_3$  and  $M_T$  resist each other only.

*Bebanan dalaman, beban lintang  $Q = 1000$  kN, momen lentur  $M_B = 50$  kN.m dan kilas  $M_T = 1.5$  kN.m beraksi pada rentasan di akar sayap di **Rajah 1**. Tentukan beban  $P_1$ ,  $P_2$ ,  $P_3$  dan  $N$  jika  $H=100$  mm and  $B = 500$  mm. Andaikan  $Q$  berada  $0.5B$  di belakang spar hadapan. Petua: Biarkan  $P_3$  dan  $M_T$  hanya melawan sesama mereka.*

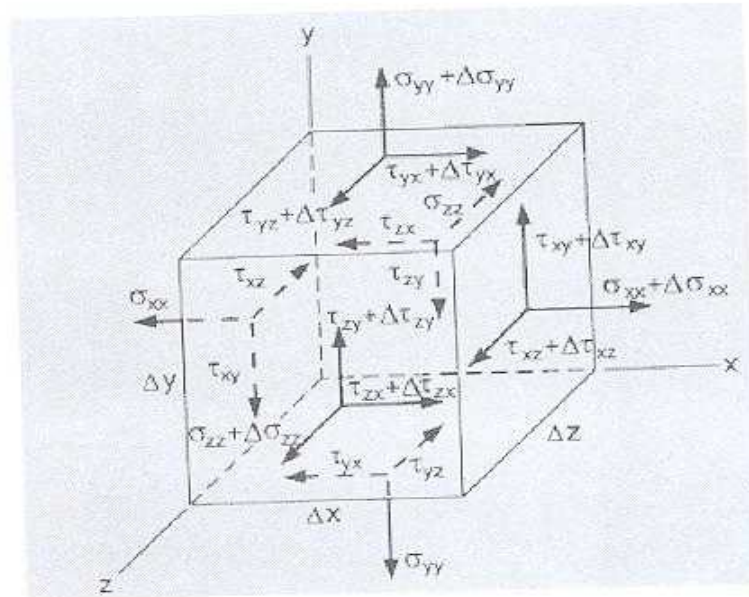


**Figure 1/Rajah 1**

(15 marks/markah)

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

*Menggunakan Rajah 2, terbitkan persamaan keseimbangan pada arah-x.*



**Figure 2/Rajah 2**

(10 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) Explain the importance of compatibility equations in elasticity.

*Terangkan arti penting persamaan-persamaan keserasian di dalam teori elastik.*

(2 marks/markah)

(d) Consider the following strain fields:

*Pertimbangkan medan terikan berikut:*

$$\epsilon_x = a(x^2 + y^2) \quad \epsilon_y = a(x^2 + y^2) \quad \gamma_{xy} = 4axy$$

Are these strains compatible? Why?

*Adakah terikan-terikan ini serasi? Mengapa?*

**(4 marks/markah)**

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

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

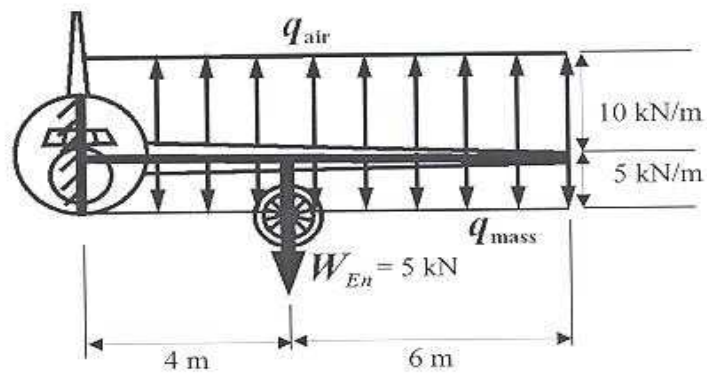


Figure 3/Rajah 3

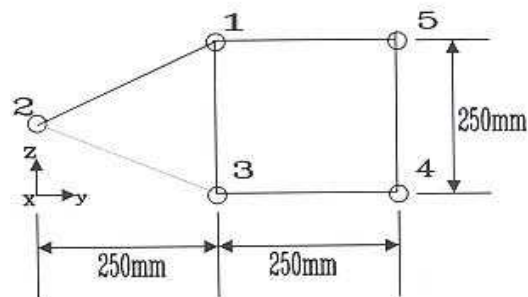
(15 marks/markah)

4. Bending moments of  $M_y = -50 \text{ kNm}$  and  $M_z = 10 \text{ kNm}$  are applied on the thin-walled 5 stringers beam section shown in **Figure 4**.

*Momen lentur  $M_y = -50 \text{ kNm}$  dan  $M_z = 10 \text{ kNm}$  dikenakan ke atas keratan-rentas rasuk dinding-nipis 5 gelegar yang ditunjukkan di **Rajah 4**.*

Determine the stresses in all stringers.

*Tentukan tegasan pada setiap gelegar.*



Thickness of all walls

*Tebal semua dinding*

= 0.25 mm

Area of all stringers,

*Luas semua gelegar,*

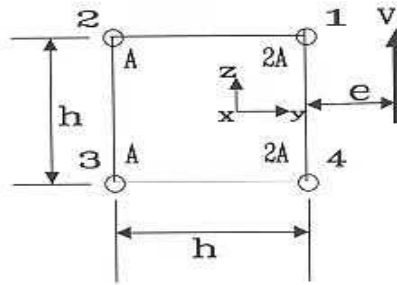
$A_1 = A_2 = A_3 = A_4 = A_5 = 1000 \text{ mm}^2$

**Figure 4/Rajah 4**

(25 marks/markah)

5. Determine  $e$ , the shear center of the 4-stringer box beam shown below.

Tentukan  $e$ , pusat ricih rasuk kotak 4-gelegar yang ditunjukkan di bawah.



Area of stringers,  
*Luas gelegar,*  
 $A_1 = A_4 = 2A$   
 $A_2 = A_3 = A$ .

**Figure 5/Rajah 5**

(25 marks/markah)

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...8/-

## APPENDIX/LAMPIRAN

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

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

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

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

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

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

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