UNIVERSITI SAINS MALAYSIA

First Semester Examination
2012/2013 Academic Session

January 2013

ESA 321/3 – Aerospace Structure
[Struktur Aeroangkasa]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this paper contains **NINE (9)** printed pages, **ONE (1)** page appendix and **FIVE (5)** questions before you begin examination.

*Sila pastikan bahawa kertas soalan ini mengandungi **SEMBILAN (9)** mukasurat bercetak, **SATU (1)** mukasurat lampiran dan **LIMA (5)** soalan sebelum anda memulakan peperiksaan.*

Instructions : Answer **ALL** questions.
Arahan : *Jawab **SEMUA** soalan.*

1. **Appendix**/*Lampiran* **[1 page/*mukasurat*]**

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 soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.

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

1. [a] Using Figure. 1, derive the equilibrium equation in the z-direction.

Menggunakan Rajah 1, terbitkan persamaan keseimbangan pada arah-z.

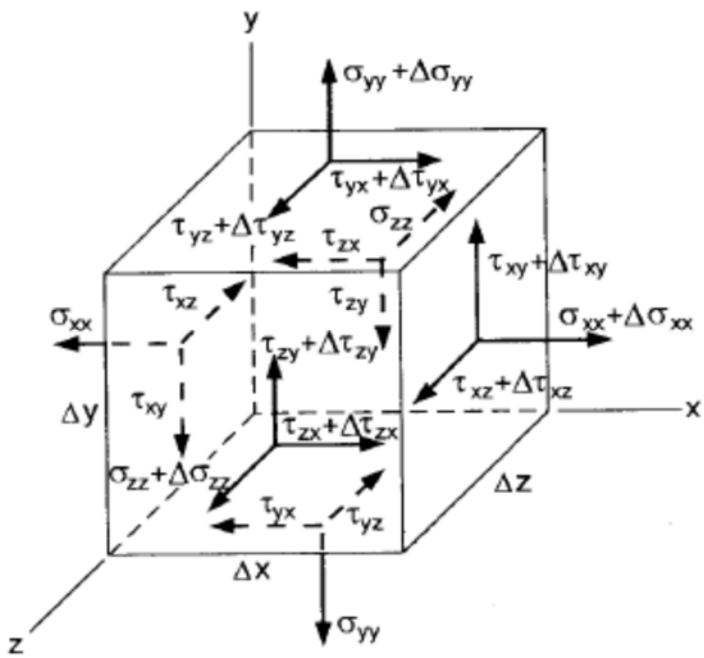


Figure 2/*Rajah 2*

(4 marks/*markah***)**

[b] Show that $\tau_{zy} = \tau_{yz}$.
Tunjukkan bahwa $\tau_{zy} = \tau_{yz}$.

(2 marks/*markah***)**

[c] Derive the 2D compatibility equation in stress form.
Terbitkan persamaan keserasian 2D dalam bentuk tegasan.

$$\left(\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial x^2}\right)\left(\sigma_x+\sigma_y\right)=0$$

using:

menggunakan:

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

(10 marks/*markah***)**

2. Using Figure 2 shown below, draw the load, shear and bending moment diagrams.

Dengan menggunakan Rajah 2 di bawah, lukiskan rajah beban, ricih dan momen lentur.

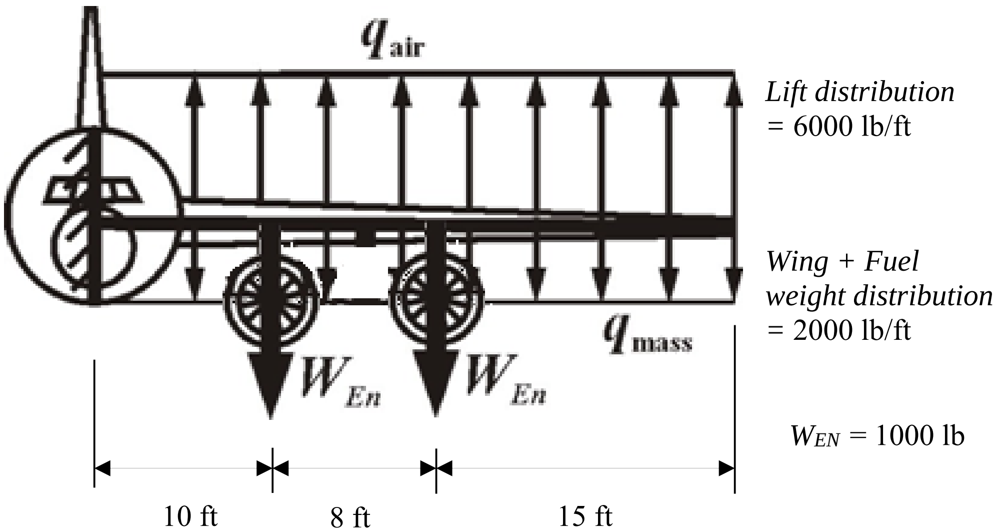


Figure 2/*Rajah 2*

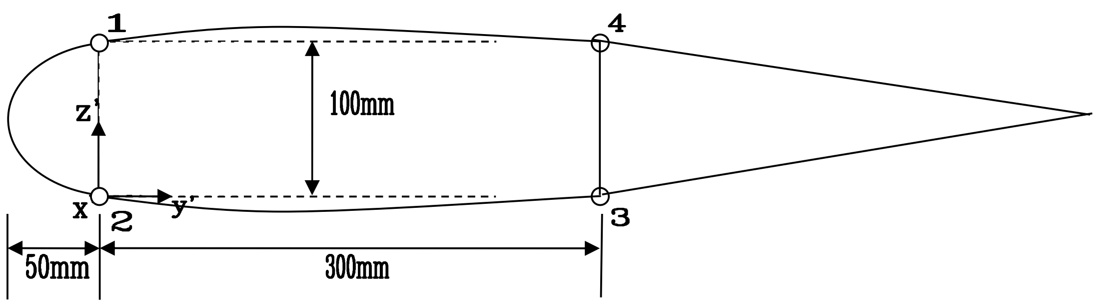
(20 marks/*markah***)**

3. 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 3.

Momen lentur M_y = -50 kNm dan M_z = 10 kNm dikenakan ke atas keratan–rentas rasuk dinding-nipis 4 gelegar yang ditunjukan di Rajah 3.

Determine the stresses in all booms.

Tentukan tegasan pada setiap gelegar.



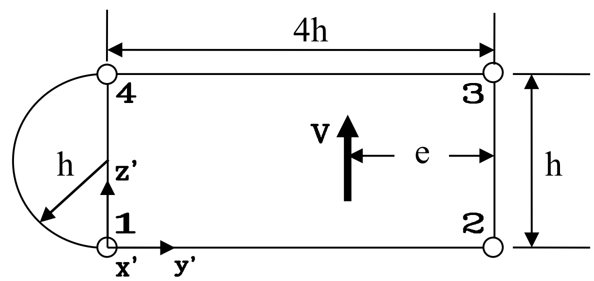
Thickness of all walls/*Tebal semua dinding* = 0.25 mm
Area of all booms/*Luas semua gelegar,*
$A_1 = A_2 = 2000\ mm^2$
$A_3 = A_4 = 1000\ mm^2$

Figure 3/*Rajah 3*

(**20 marks**/*markah*)

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

Tentukan e, pusat ricih rasuk kotak 4-gelegar ideal yang ditunjukkan di Rajah 4.



Thickness of all walls/*Tebal semua dinding* = t

Area of booms/*Luas gelegar,*
$A_1 = A_2 = 2A$
$A_3 = A_4 = A$

Figure 4/*Rajah 4*

(**20 marks**/*markah*)

5. In Figure 5, wings are pin-jointed to the struts and fuselage.

Di Rajah 5, sayap adalah disambungkan dengan pin kepada strut dan fuselaj.

Assumptions

Andaian:

- Wing structure + Fuel in wing tanks weight/= 250 lbs
  Berat struktur sayap + bahanapi di tangki sayap/= 250 lbs
- Max Take-off weight/= 1100 lbs
  Berat berlepas maksima/= 1100 lbs
- Max. landing load factor/= 3g
  Faktor beban pendaratan maksima/= 3g
- Max. positive load factor/= 4 g
  Faktor beban positif maksima/= 4 g

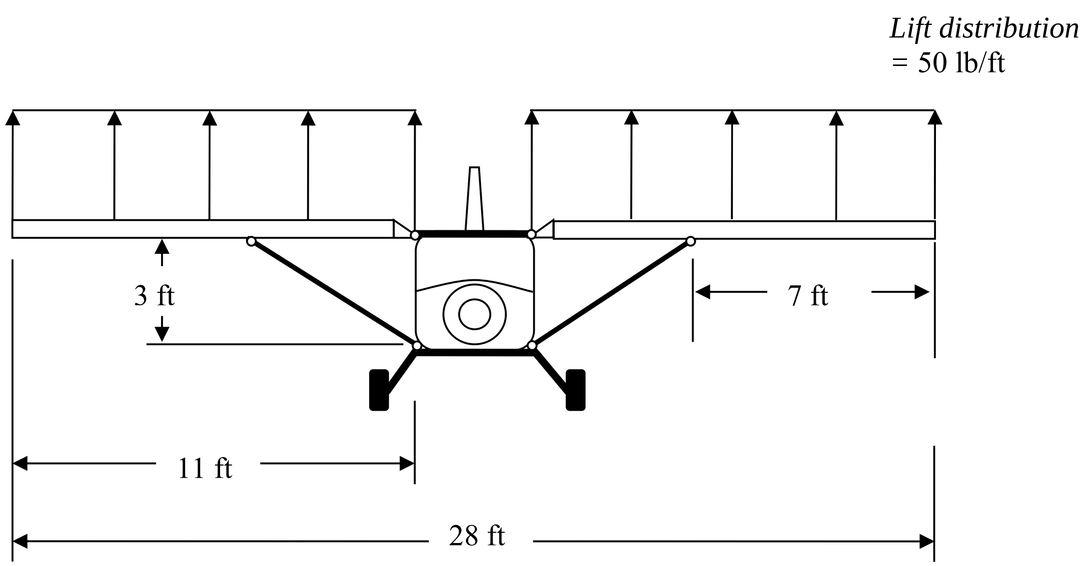


Figure 5/*Rajah 5*

[a] Determine the maximum tensile and compressive forces the struts could be subjected.

Tentukan beban maksima tegangan dan mampatan yang boleh ditanggung oleh strut.

(**10 marks**/*markah*)

[b] If the struts are hollow circular tubes made of aluminum with

Jika strut adalah tiub yang romping dibuat dari aluminum dengan

- $E = 10x10^6$ psi.
  $E = 10x10^6$ psi.
- Yield Strength/ =37 ksi and
  Kekuatan alah/ =37 ksi dan
- Ultimate Strength/ =42 ksi
  Kekuatan muktamad/ =42 ksi
- Safety factor/ = 1.5
  Faktor keselamatan/ = 1.5

Design the wing strut cross-sectional dimensions (inner and outer radii) taking consideration of tension, compression and buckling.

Rekabentuk strut dimensi keratin-rentas strut (jejari dalam dan luaran) dengan mengambil kira faktor tegangan, mampatan dan lengkokan.

(**10 marks**/*markah*)

APPENDIX/*LAMPIRAN*

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

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

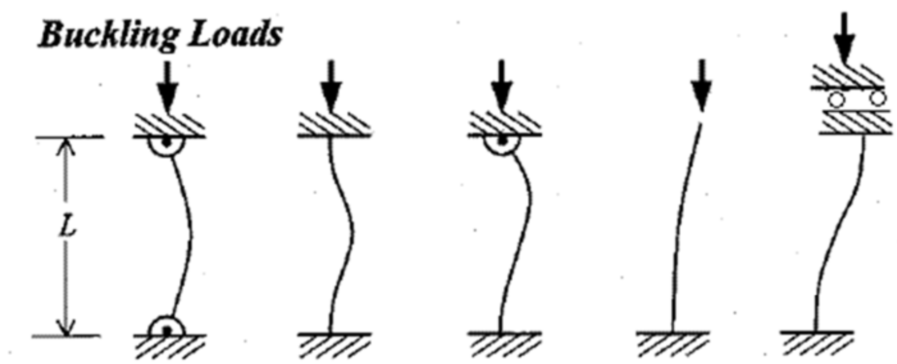
$$\varepsilon_x = \frac{\partial u}{\partial x} \qquad \varepsilon_y = \frac{\partial v}{\partial y} \qquad \gamma_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$$

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

$$\frac{\partial^2 \varepsilon_x}{\partial y^2} + \frac{\partial^2 \varepsilon_y}{\partial x^2} = \frac{\partial^2 \gamma_{xy}}{\partial x \partial y} \qquad \varepsilon_x = \frac{1}{E}\left(\sigma_x - \nu\sigma_y - \nu\sigma_z\right)$$

$$\sigma_{cr} = \frac{\pi^2 E}{\left(L_e / r\right)^2} \qquad P_{cr} = \frac{\pi^2 EI}{L_e^2} \qquad I = \frac{\pi\left(r_o^4 - r_i^4\right)}{4}$$

Buckling Loads



Buckling Load	$\frac{\pi^2 EI}{L^2}$	$\frac{4\pi^2 EI}{L^2}$	$\frac{2.045\pi^2 EI}{L^2}$	$\frac{\pi^2 EI}{4L^2}$	$\frac{\pi^2 EI}{L^2}$
Effective Length	L	$0.5L$	$0.699L$	$2L$	L

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