UNIVERSITI SAINS MALAYSIA

First Semester Examination
2013/2014 Academic Session

December 2013/January 2014

ESA 321/3 – Aerospace Structure
[Struktur Aeroangkasa]

Duration : 3 hours
Masa : 3 jam

Please ensure that this paper contains **EIGHT (8)** printed pages, **TWO (2)** pages appendix and **FIVE (5)** questions before you begin examination.

Sila pastikan bahawa kertas soalan ini mengandungi ***LAPAN (8)*** *mukasurat bercetak,* ***DUA (2)*** *mukasurat lampiran dan* ***LIMA (5)*** *soalan sebelum anda memulakan peperiksaan.*

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

1. **Appendix**/*Lampiran* **[2 pages/*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. Using **Figure 1** shown below, draw the load, shear and bending moment diagram.

   *Dengan menggunakan **Rajah 1** di bawah, lukiskan rajah beban, ricih dan momen lentur.*

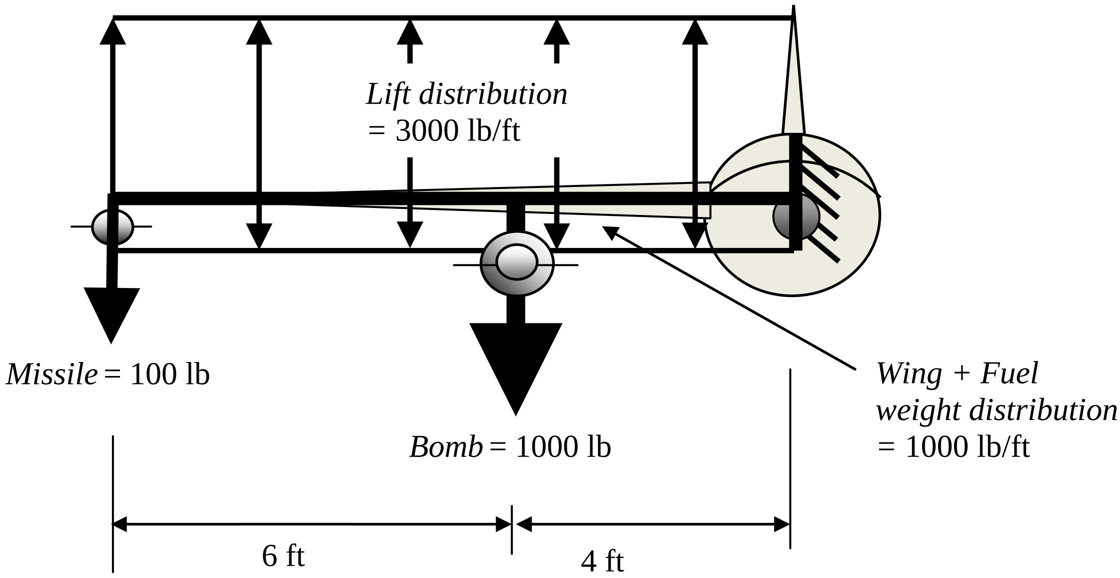


Figure 1

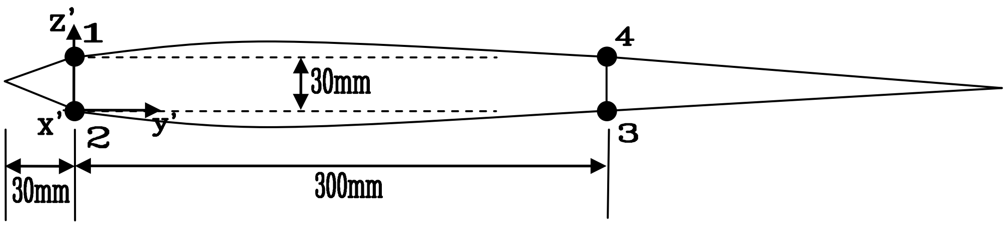
(20 marks/*markah*)

2. 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 2**.

Determine the axial stresses in all booms.

*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 2.***

Tentukan tegasan paksi pada setiap gelegar.



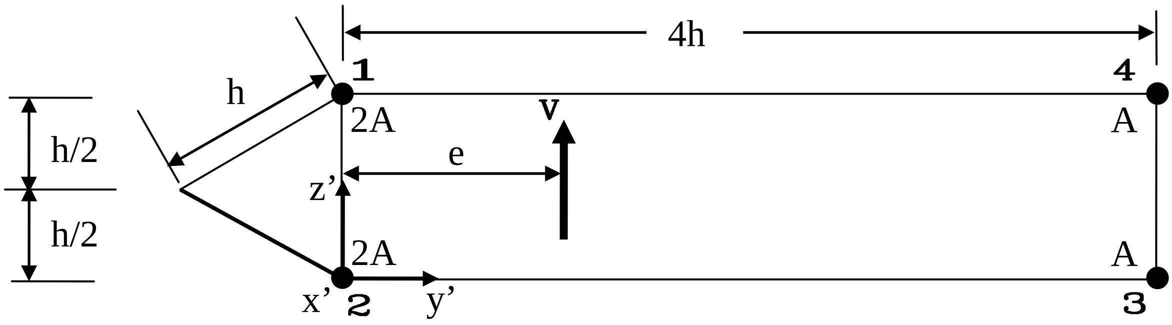
Area of booms */Luas gelegar,*
$A_1 = A_2 = A_4 = 3000\ mm^2$
$A_3 = 2000\ mm^2$

Figure 2
Rajah 2

(20 marks/*markah*)

3. Determine ***e***, the shear center of the idealized thin-walled 4-boom wing beam section shown in **Figure 3**.

. *Tentukan **e**, pusat ricih rasuk kotak 4-gelegar ideal yang ditunjukan di **Rajah 3.***



Thickness of all walls/ *Tebal semua dinding* = t
Area of booms/ *Luas gelegar*
$A_1 = A_2 = 2A$
$A_3 = A_4 = A$

Figure 3
Rajah 3

(20 marks/*markah*)

4. **Figure 4** shows 2-spar wing structure.

Rajah 4 *menunujukkan struktur sayap 2-spar.*

- Wing box skins are considered flat/ *Kulit kotak sayap dianggap rata*
- Structure made of aluminum/*Struktur dibuat dari aluminum*:
  $E = 10 \times 10^6$ psi; $\upsilon = 0.32$; $\sigma_{yield} = 37$ ksi; $\sigma_{ult} += 42$ ksi
- Max compressive load/*Beban mampat mak*, N_x 1200 lb/in
- Skin thickness/ *Tebal kulit* , t_{sk} 0.05 in
- Stringer thickness */Tebal gelegar*, t_{st} 0.04 in
- Rib spacing/ *jarak rusuk*, a 24 in
- Stringer spacing/ *Jarak gelegar*, b 3 in

[a] Determine if the skin and stringer can fail in buckling.

Tentukan jika kulit dan gelegar boleh gagal secara lengkokan

(5 marks/*markah*)

[b] Optimize the skin-stringer structure design by finding appropriate rib and stringer spacing's, ***a*** & ***b*** so that the structure fail simultaneously in buckling.

*Optimumkan rekabentuk struktur kulit-stringer dengan mencari jarak sesuai, **a** & **b** rusuk dan gelegar, supaya struktur gagal serentak secara lengkokan.*

- Ratio **a/b** > 3
  Nisbah **a/b** > 3

(15 markah/*markah*)

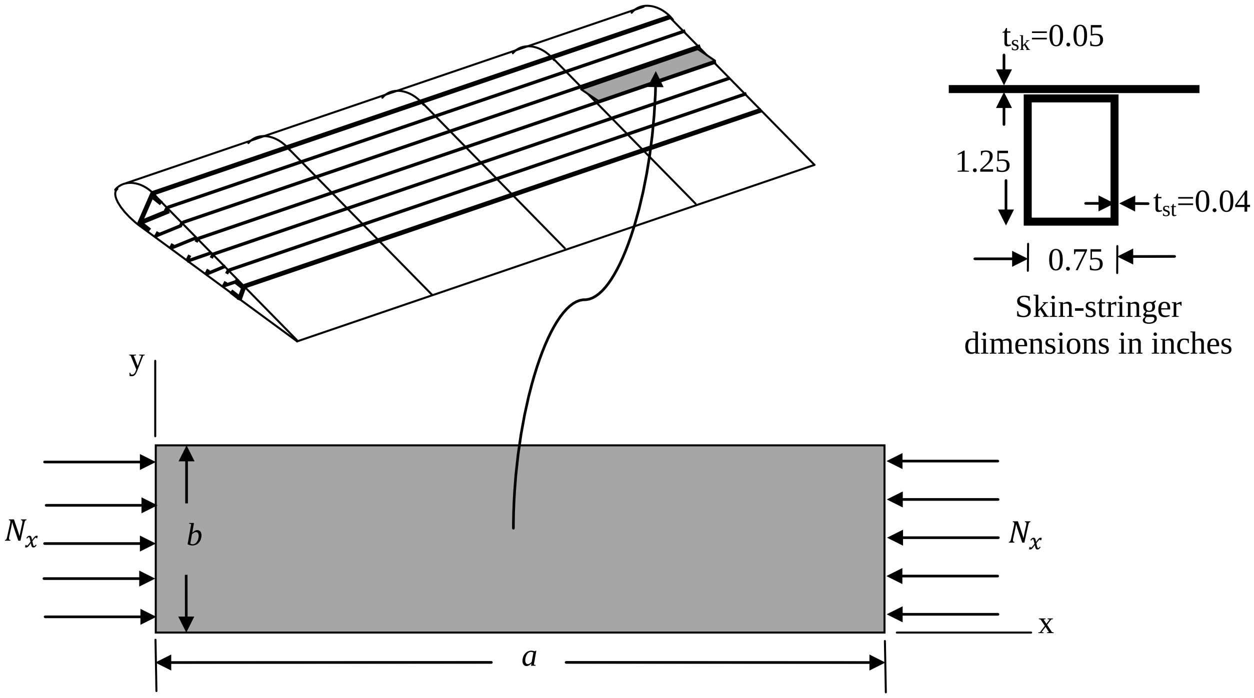


Figure 4
Rajah 4

(15 marks/*markah*)

5. [a] Using **Figure 5[a]**, derive the equilibrium equation in the y-direction.

*Menggunakan **Rajah 5[a],** terbitkan persamaan keseimbangan pada arah-y.*

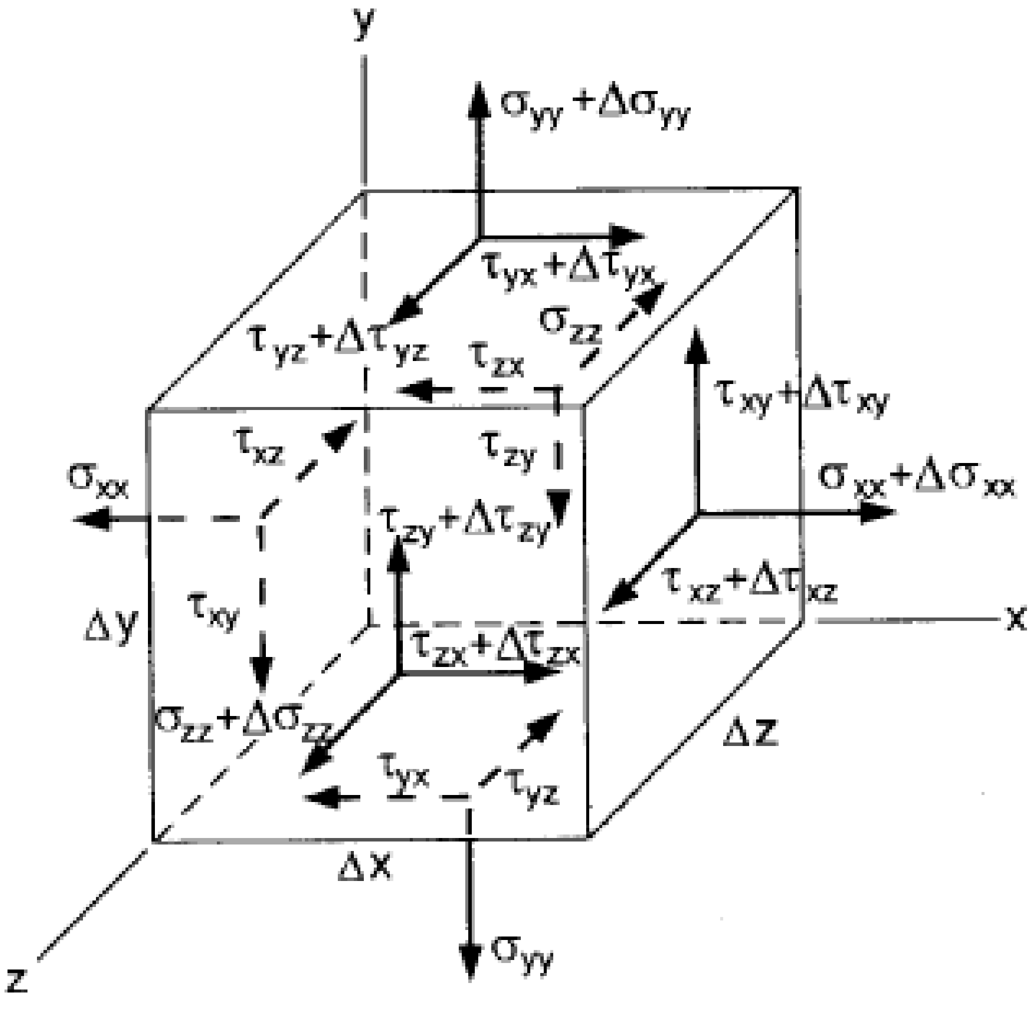


Figure 5[a]
Rajah 5[a]

(5 marks/*markah*)

[b] In **Figure 5[b],** determine using energy method vertical displacement, e_v and rotation θ at the wing tip at A subjected to wing load ***w***. Wing shape is rectangle and straight with constant thickness.

*Di **Rajah 5[b],** dengan menggunakan cara tenaga tentukan anjakan menegak* e_v *dan putaran θ pada hujung sayap di A akibat beban sayap* **w**. *Bentuk sayap adalah segiempat tepat dan tegak dengan ketebalan yang seragam.*

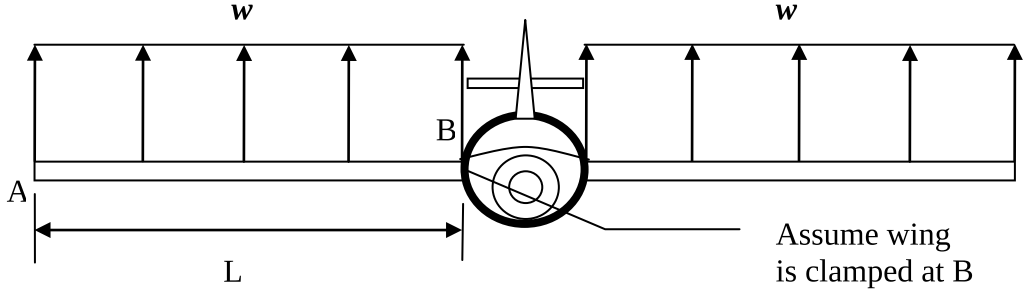


Figure 5[b]
Rajah 5[b]

(15 marks/*markah*)

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APPENDIX/*LAMPIRAN*

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

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

$$q_i = \frac{\partial U}{\partial F_i}$$

$$= \sum_{j=1}^{m}\left(\int \frac{N_j}{E_j A_j}\frac{\partial N_j}{\partial F_i}\,dz + \int \frac{k_j V_j}{G_j A_j}\frac{\partial V_j}{\partial F_i}\,dz + \int \frac{M_j}{E_j I_j}\frac{\partial M_j}{\partial F_i}\,dz + \int \frac{T_j}{G_j J_j}\frac{\partial T_j}{\partial F_i}\,dz\right)$$

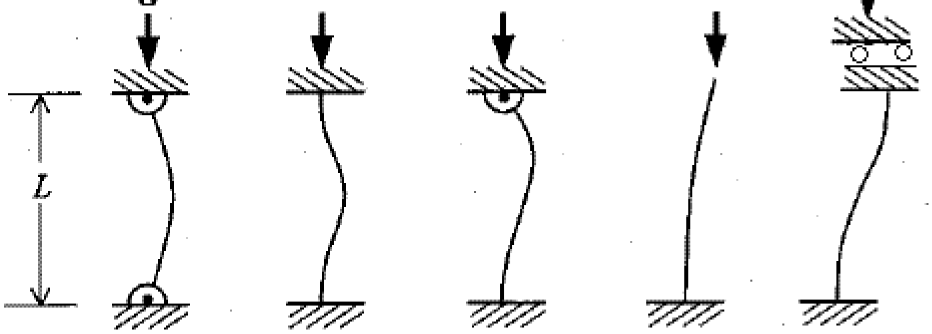
$$\theta_i = \frac{\partial U}{\partial M_i}$$

$$= \sum_{j=1}^{m}\left(\int \frac{N_j}{E_j A_j}\frac{\partial N_j}{\partial M_i}\,dz + \int \frac{k_j V_j}{G_j A_j}\frac{\partial V_j}{\partial M_i}\,dz + \int \frac{M_j}{E_j I_j}\frac{\partial M_j}{\partial M_i}\,dz + \int \frac{T_j}{G_j J_j}\frac{\partial T_j}{\partial M_i}\,dz\right)$$

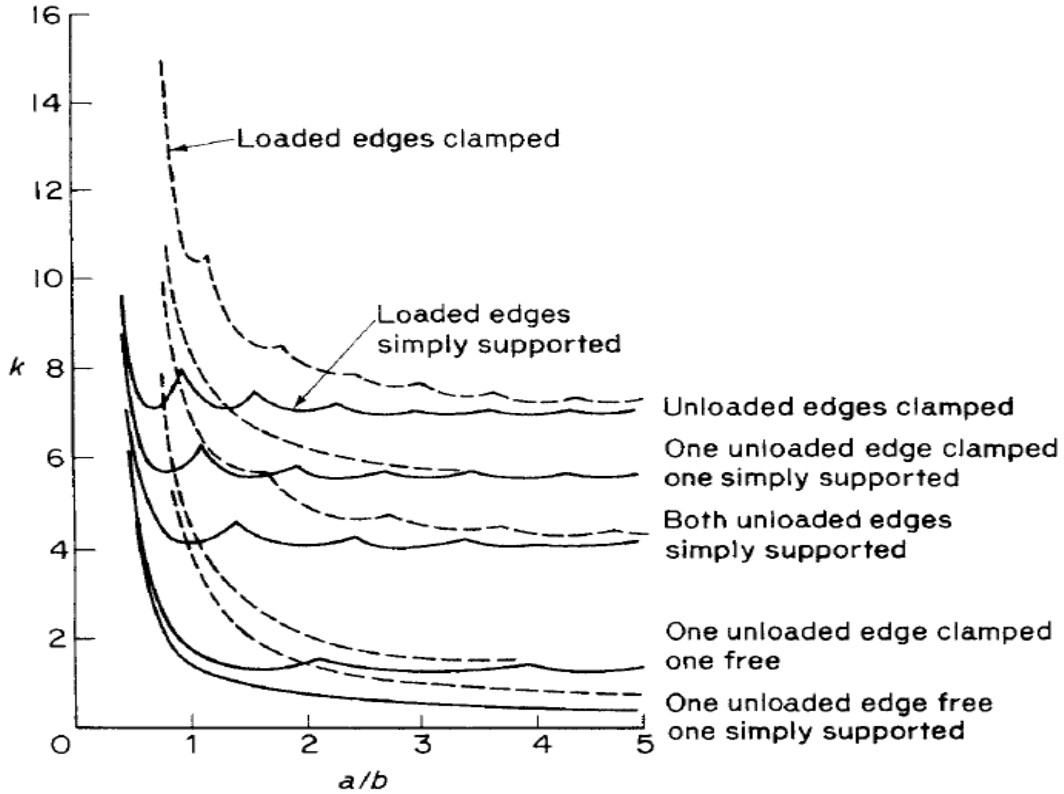
$$P_{cr} = \frac{\pi^2 EI}{L_e^2} \qquad \sigma_{cr} = \frac{\pi^2 EI}{AL_e^2} \qquad \sigma_{cr} = \frac{\pi^2 E}{\left(L_e / r\right)^2}$$

$$\sigma_{cr} = k\,\frac{\pi^2 E}{12\left(1-\nu^2\right)}\left(\frac{t}{b}\right)^2 \qquad \frac{b_{eff}}{2t} = 0.85\sqrt{\frac{E_s}{\sigma_{stiffener}}} \text{ (simply-supported)}$$

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_e	L	$0.5L$	$0.699L$	$2L$	L



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