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UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama  
Sidang Akademik 2004/2005  
*First Semester Examination  
2004/2005 Academic Session*

Oktober 2004  
*October 2004*

**ESA243/3 – Aerodinamik**  
*Aerodynamics*

Masa : 3 jam  
*Hour : 3 hour*

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**ARAHAN KEPADA CALON :**

Sila pastikan bahawa kertas soalan ini mengandungi **DUABELAS (12)** mukasurat dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.

*Please ensure that this paper contains **TWELVE (12)** printed pages and **SIX (6)** questions before you begin examination.*

Jawab **LIMA (5)** soalan sahaja.

*Answer **FIVE (5)** the questions only.*

Calon boleh menjawab semua soalan dalam Bahasa Malaysia. Sekiranya calon ingin menjawab dalam Bahasa Inggeris, sekurang-kurangnya satu soalan perlu dijawab dalam Bahasa Malaysia.

*Student may answer all the questions in Bahasa Malaysia. If you want to answer in English, at least one question must be answered in Bahasa Malaysia.*

Setiap soalan mestilah dimulakan pada mukasurat yang baru.

*Each questions must begin from a new page.*

**Lampiran :**

1. Persamaan

[1 mukasurat]

1. [a] Terangkan apakah yang yang di sebut dengan model aliran : *Source* , *vortex* dan *doublet*.

*Explain what does it means with the flow model : source , vortex and doublet .*  
(4 markah/marks)

- [b] Dengan anggapan bahawa aliran adalah sebagai aliran tak mampat, (*incompressible*), tak lekat (*inviscid*) dan "*irrotational*" , tunjukkan bagaimana memperoleh persamaan Bernoulli dari persamaan momentum.

*With assumption that the flow is incompressible, inviscid and irrotational, shows that how to derive the Bernoulli equation from the momentum equation.*  
(4 markah/marks)

- [c] Diberikan suatu medan aliran potensial disepanjang permukaan datar terdiri 3 aliran potensial elementer, iaitu :

- Aliran seragam  $U_{\infty} = 10 \frac{\text{m}}{\text{sec}}$

- source kekuatan  $\sigma = 10 \frac{\text{m}^2}{\text{sec}}$  terletak di titik A(2,3)

- Vorteks dalam arah berlawanan jarum jam dengan kekuatan  $\Gamma = 10 \frac{\text{m}^2}{\text{sec}}$  terletak di titik B (2,3)

Jika tekanan statik di jarak tak berhingga (*at infinity*)  $P_{\infty} = 10^5 \frac{\text{N}}{\text{m}^2}$ .

Dengan menggunakan Kaedah Image : Tentukan :

*Given a potential flow field flat surface which consist of three elementary potential flow models namely :*

- *Uniform flow with the free stream velocity*  $U_{\infty} = 10 \frac{\text{m}}{\text{sec}}$

- *Source with strength of*  $\sigma = 10 \frac{\text{m}^2}{\text{sec}}$  *is located at point A (2,3)*

- *Vortex is in the counter clock wise direction with strength of*  
 $\Gamma = 10 \frac{\text{m}^2}{\text{sec}}$  *is located at point B (2,3)*

If the static pressure at infinity far away is  $P_{\infty} = 10^5 \frac{\text{N}}{\text{m}^2}$

Use the Image method so determine :

- (i) Fungsi potensial  $\Phi(x, y)$

*The potential function  $\Phi(x, y)$*

**(2 markah/marks)**

- (ii) Fungsi arus (*stream function*)  $\Psi(x, y)$

*The stream function  $\Psi(x, y)$*

**(2 markah/marks)**

- (iii) Fungsi potensial kompleks  $F(z)$

*The complex potential function  $F(z)$*

**(3 markah/marks)**

- (iv) Halaju komponen  $u$  dan  $v$  pada titik  $(1, 1)$

*The velocity components  $u$  and  $v$  at the point  $(1, 1)$*

**(3 markah/marks)**

- (v) Tekanan static  $P$  pada titik  $(1, 1)$

*The static pressure  $P$  at the point  $(1, 1)$*

**(2 markah/marks)**

2. Suatu airfoil unsimetris hasil transformasi Joukowski terletak dalam aliran seragam  $U_\infty = 10 \frac{\text{m}}{\text{sec}}$  dan bersudut  $\alpha = 4.0$ . Tekanan statik di jarak tak berhingga (at infinity)  $P_\infty = 10^5 \frac{\text{N}}{\text{m}^2}$ . Geometri airfoil tersebut dengan data sebagai berikut : panjang chord airfoil = 0.3 m dan ketebalan maximum airfoil (maximum thickness) = 0.03 m dan maximum camber (maximum camber) = 0.006 m

*A unsymmetrical airfoil is generated by Joukowski transformation immersed in the uniform flow of  $U_\infty = 10 \frac{\text{m}}{\text{sec}}$  and the angle of attack  $\alpha = 4.0^\circ$ . The static pressure at far away is  $P_\infty = 10^5 \frac{\text{N}}{\text{m}^2}$ . The airfoil data is given as follows : the airfoil chord length  $c = 0.3 \text{ m}$  and the maximum airfoil thickness is  $0.030 \text{ m}$  and the maximum camber line is  $0.003 \text{ m}$*

tentukan :

*determine :*

- (i) jari jari dan letak koordinat titik pusat sirkular silender yang digunakan dalam transformasi Joukowski ini.

*The circle radius and the location of the centre of circle is used in this Joukowski's transformation .*

**(3 markah/marks)**

- (ii) Persamaan transformasi Joukowski dan kekuatan vorteks yang diperlukan

*The equation of Joukowski transformation and the strength of required vortex.*

**(3 markah/marks)**

- (iii) Persamaan potential kompleks untuk aliran disekitar sirkular silinder

*The complex potential function for the flow past through circular cylinder*

**(3 markah/marks)**

- (iv) Persamaan kecepatan aliran di sekitar sirkular silinder

*The velocity equation for the flow past through circular cylinder.*

**(3 markah/marks)**

- (v) Koordinat airfoil dan besar halaju kecepatan aliran nya untuk suatu titik pada airfoil yang berhubungan dengan sudut  $\theta = 30^\circ$  disirkular silindernya

*The airfoil coordinates and velocity on the airfoil which corresponding to the point on circle at  $\theta = 30^\circ$*

**(3 markah/marks)**

- (vi) Tekanan static di titik seperti soalan e

*The static pressure as given by question e*

**(3 markah/marks)**

- (vii) Pengkali daya angkat  $C_L$  dan *moment pitching*  $C_m$

*The lift coefficient  $C_L$  and moment pitching coefficient  $C_m$*

**(2 markah/marks)**

3. [a] Terangkan anggapan dan keterbatasan kaedah "*Thin airfoil theory*" dalam menyelesaikan persoalan aerodynamic

*Explain the assumption and limitation of the Thin airfoil theory in solving aerodynamics problems.*

**(4 markah/marks)**

- [b] Terangkan mengapa dalam *thin airfoil theory* menggunakan vorteks dalam menentukan pengaruh sudut serang atau garis camber dan menggunakan source untuk menentukan pengaruh ketebalan airfoil.

*Explain why in the thin airfoil used a vortex in order to include the angle of attack and camber line effects and the source for the thickness effect.*

**(4 markah/marks)**

- [c] Suatu airfoil Naca xxxx dengan koordinat chamber  $\frac{y_c}{c} \left( \frac{x}{c} \right)$  diberikan sebagai berikut :

*Given an airfoil Naca xxxx with the camber line coordinate as defined as follows*

$$\begin{aligned} \frac{y_c}{c} \left( \frac{x}{c} \right) &= 0.125 \left[ 0.8 \left( \frac{x}{c} \right) - \left( \frac{x}{c} \right)^2 \right] & 0 \leq \left( \frac{x}{c} \right) \leq 0.4 \\ &= 0.0555 \left[ 0.2 + 0.8 \left( \frac{x}{c} \right) - \left( \frac{x}{c} \right)^2 \right] & 0.4 < \left( \frac{x}{c} \right) \leq 1.0 \end{aligned}$$

Airfoil ini berada dalam aliran seragam (*uniform flow*) yang bersudut serang  $\alpha = 5^\circ$ .

*This airfoil immersed in the uniform flow at an angle of attack  $\alpha = 5^\circ$*

Dengan kaedah *Thin Airfoil Theory* tentukan :

*Use Thin airfoil Theory and determine :*

- (i) Koefisien *thin airfoil theory*  $A_0$

*The thin airfoil theory's coefficients  $A_0$*

**(2 markah/marks)**

- (ii) Koefisien *thin airfoil theory*  $A_1$

*The thin airfoil theory's coefficients  $A_1$*

**(2 markah/marks)**

- (iii) Koefisien *thin airfoil theory*  $A_2$   
*The thin airfoil theory's coefficients*  $A_2$  (2 markah/marks)
- (iv) Pengkali daya angkat  $C_l$   
*The lift coefficient*  $C_l$  (2 markah/marks)
- (v) Pengkali daya moment pitching  $C_m$   
*The moment pitching coefficient*  $C_m$  (2 markah/marks)
- (vi) Sudut serang pada daya angkat sama dengan nol  $\alpha_{L=0}$   
*The zero lift angle of attack*  $\alpha_{L=0}$  (2 markah/marks)

4. [a] Terangkan perbezaan antara kaedah Panel (*Panel Method*) dan *thin airfoil theory*.

*Explain the difference between Panel Method and thin airfoil theory.*

**(3 markah/marks)**

- [b] Terangkan bagaimana menerapkan Kondisi Kutta untuk soalan aliran melalui airfoil dalam Kaedah Panel

*Explain how to implement the Kutta Condition in flow analysis around airfoil by using The Panel Method.*

**(3 markah/marks)**

- [c] Suatu vortex dalam arah jarum jam ditaburkan diatas panel sepanjang 3 unit , kekuatan singularity ini seragam sebesar  $\gamma(x) = 5$  unit . Panel ini berada dalam aliran seragam  $U_{\infty} = 10 \frac{\text{m}}{\text{sec}}$  dan bersudut  $\alpha = 3^{\circ}$  . dimana Tekanan statik di jarak tak berhingga ( at infinity )  $P_{\infty} = 10^5 \frac{\text{N}}{\text{m}^2}$  .

*A continues vortex in clock wise direction was distributed over a panel length of 3 units. The strength of sink is uniforms equal to  $\gamma(x) = - 5$  units . If such panel immersed in the uniform flow with free stream velocity  $U_{\infty} = 10 \frac{\text{m}}{\text{sec}}$  and the static pressure at infinity is  $P_{\infty} = 10^5 \frac{\text{N}}{\text{m}^2}$  .*

Tentukan :

*Determine :*

- (i) Komponen halaju  $u$  dan  $v$  pada titik (2,5)

*The velocity components  $u$  and  $v$  at point (2,5)*

**(3 markah/marks)**

- (ii) Tekanan statik di titik tersebut.

*The static pressure at that point.*

**(3 markah/marks)**



- [d] Seperti soalan diatas (nombor 4c) dengan kekuatan vorteks ditaburkan ini secara linear dimana pada  $x = -1.5$  unit dengan  $\gamma(x) = 2$  unit dan  $x = 1.5$  unit dengan  $\gamma(x) = 5$  unit

*As problem given in 4c , the strength of vortex source vary linearly where at  $x = -1.5$  units is  $\sigma(x) = 2$  units while at  $x = 1.5$  units is*

Tentukan :

*Determine :*

- (i) Komponen halaju  $u$  dan  $v$  pada titik (4,4)

*The velocity components  $u$  and  $v$  at point (4,4)*

**(6 markah/marks)**

- (ii) Tekanan statik di titik tersebut

*The static pressure at that point.*

**(2 markah/marks)**

5. [a] Terangkan konsep kaedah Lifting Line Theory dan keterbatasannya.

*Explain the basic idea of Lifting Line Theory and its limitations.*

**(5 markah/marks)**

- [b] Terangkan Kaedah Vortex lattice dan terangkan pula mengapa dalam kaedah ini tidak memerlukan data aerodinamik airfoil nya

*Explain the basic idea of vortex lattice and explain also why this method was not need the aerodynamic data for its airfoil.*

**(5 markah/marks)**

- [c] Terangkan mengapa “ induced drag” meningkat dengan meningkatnya daya angkat.

*Explain why the induced drag increase by increasing the lift force.*

**(5 markah/marks)**

- [d] Terangkan mengapa kaedah *Lifting Line Theory* kurang tepat digunakan untuk analisis aerodinamik sayap dengan sudut “ *swept*” tinggi.

*Explain why The lifting line theory inadequate for aerodynamics analysis for flow pass through a highly swept wing.*

**(5 markah/marks)**

6. Sebuah pesawat udara dengan berat 6000 Kg dan rentang sayap 12 m dan kelajuan terbang 120 m/saat. Jika panjang chord sayap ini 0.6 m dan distribusi daya angkat yang terjadi pada sayap adalah elips ( elliptic loading ). Pesawat terbang dengan ketinggian 4000 meter dengan kondisi atmosphere : temperature  $10^0$  C , jisim udara  $\rho = 1.022 \text{ Kg/m}^3$  dan tekanan atmosphere  $P = 0.8 \cdot 10^5 \text{ N/m}^2$  , Pemalar udara  $R = 287 \text{ J/(Kg}^0\text{K)}$  dan  $\gamma = 1.4$

*An aircraft with maximum take off weight 6000 Kg and wing span of 10 m. The cruising speed is 150 m/sec. If the average of chord length is 0.6 and the wing loading is elliptic. At temperature  $10^0$  C, air density  $\rho = 1.022 \text{ Kg/m}^3$  and atmospheric pressure  $P = 0.8 \cdot 10^5 \text{ N/m}^2$ , Universal gas constant  $R = 287 \text{ J/(Kg}^0\text{K)}$  and  $\gamma = 1.4$*

Tentukan :

*Determine :*

- (i) Nombor Mach pesawat terbang dan nombor Reynolds

*The Mach Number and the Reynolds number of aircraft flight*  
(2 markah/marks)

- (ii) Jika pada suatu titik dipermukaan sayap, halaju udara adara 180 m/saat, tentukan besar tekanan static pada titik tersebut

*If at any control point over wing wing surface is found that the air velocity is 180 m/sec, determine the static pressure at that point.*  
(2 markah/marks)

- (iii) Besarannya sirkulasi  $\Gamma_0$  di pertengahan rentang sayap

*The strength of circulation  $\Gamma_0$  at the mid wing span*  
(3 markah/marks)

- (iv) Kirakan besar sudut serang teraruh (induced angle of attack)  $\alpha_i$

*Estimate the induced angle of attack  $\alpha_i$*   
(3 markah/marks)

- (v) Kirakan pekali daya seret teraruh  $c_{di}$

*Estimate the induced drag coefficient  $c_{di}$*   
(3 markah/marks)

- (vi) Terangkan mengapa nombor Mach dan nombor Reynolds penting dalam analisa aerodinamik pesawat terbang

*Explain why the mach number and Reynolds number are so important in aircraft aerodynamic analysis .*

**(3 markah/marks)**

- (vii) Jika sayap tersebut diatas dengan menggunakan penampang melintang (*cross section*) airfoil Naca 23012 dengan *lift slope airfoil*
- $$\left( \frac{dC_l}{d\alpha} \right)_{\text{airfoil}} = 0.108/\text{deg} \text{ tentukan } \left( \frac{dC_l}{d\alpha} \right)_{\text{sayap}}$$

*If this wing planform used Naca 23012 as its cross section with The airfoil's lift slope*

$$\left( \frac{dC_l}{d\alpha} \right)_{\text{airfoil}} = 0.108/\text{deg}, \text{ determine the wing's lift}$$

*slope*

$$\left( \frac{dC_l}{d\alpha} \right)_{\text{wing}}$$

**(2 markah/marks)**

- (viii) Airfoil Naca 23012 memiliki sudut serang pada lift sama dengan sifar adalah  $\alpha_{L=0} = -1.3^\circ$ , tentukan berapa besar sudut serang pesawat terbang ini.

*Airfoil Naca serie 23012 has the zero lift angle of attack  $\alpha_{L=0} = -1.3^\circ$ , determine the angle of attack of this airplane.*

**(2 markah/marks)**