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

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, (*icompressible),* 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 $U_\infty = 10 \frac{m}{sec}$

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

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

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

Dengan mengunakan 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* $U_\infty = 10 \frac{m}{sec}$

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

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

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

Use the Image method so determine :

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

The potential fungtion $\Phi(x, y)$

(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 Joukowsky terletak dalam aliran seragam $U_\infty = 10\frac{m}{sec}$ dan bersudut $\alpha = 4.0$. Tekanan statik di jarak tak berhingga *(at infinity)* $P_\infty = 10^5 \frac{N}{m^2}$. 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 Joukoswky transformation immersed in the uniform flow of $U_\infty = 15\frac{m}{sec}$ *and the angle of attack* $\alpha = 4.0^0$. *The static pressure at far away is* $P_\infty = 10^5 \frac{N}{m^2}$. *The airfoil data is given as follows : the airfoil chord length c = 0.3 m and the maximum airfoil thickness is 0.030 m and the maximum camber line is 0.003 m*

tentukan :

determine :

(i) jari jari dan letak koordinat titik pusat sirkular silender yang di gunakan dalam transformasi Joukoswky ini.

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

(3 markah/*marks*)

(ii) Persamaan transformasi Joukowsky dan kekuatan vorteks yang diperlukan

The equation of Joukowsky 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 $\theta = 30^0$ disirkular silindernya

The airfoil coordinates and velocity on the airfoil which corresponding to the point on circle at $\theta = 30^0$

(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

$$\frac{y_c}{c}\left(\frac{x}{c}\right) = 0.125\left[\,0.8\left(\frac{x}{c}\right)-\left(\frac{x}{c}\right)^2\,\right] \qquad 0\le\left(\frac{x}{c}\right)\le 0.4$$

$$= 0.0555\left[\,0.2+0.8\left(\frac{x}{c}\right)-\left(\frac{x}{c}\right)^2\,\right] \qquad 0.4<\left(\frac{x}{c}\right)\le 1.0$$

Airfoil ini berada dalam aliran seragam *(uniform flow)* yang bersudut serang $\alpha = 5^0$.

This airfoil immersed in the uniform flow at an angle of attack $\alpha = 5^0$

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) Koeficient *thin airfoil theory* A_1

The thin airfoil theory's coefficients A_1

(2 markah/*marks*)

(iii) Koeficient *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] Terangkang perbedaan 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 menerapakan 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 $\gamma(x) = 5\,\text{unit}$. Panel ini berada dalam aliran seragam $U_\infty = 10\frac{m}{sec}$ dan bersudut $\alpha = 3^0$. dimana Tekanan statik di jarak tak berhingga (at infinity) $P_\infty = 10^5 \frac{N}{m^2}$.

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

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 limitaitaions.

(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 ρ = 1.022 Kg/m^3 dan tekanan atmosphere P = 0.8 10^5 N/m^2 , Pemalar udara R = 287 J/(Kg ^{0}K) dan γ = 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 ρ = 1.022 Kg/m^3 and atmospherics pressure P = 0.8 10^5 N/m^2, Universal gas constant R = 287 J/(Kg ^{0}K) and γ = 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, haluju 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) Besaranya sirkulasi Γ_0 di pertengahan rentang sayap

The strength of circulation Γ_0 at the mid wing span

(3 markah/*marks*)

(iv) Kirakan besar sudut serang teraruh *(induced angle of attack)* α_i

Estimate the induced angle of attack α_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* $\left(\frac{dC_\ell}{d\alpha}\right)_{airfoil} = 0.108/\deg$ tentukan $\left(\frac{dC_\ell}{d\alpha}\right)_{sayap}$

If this wing planform used Naca 23012 as its cross section with The airfoi's lift slope $\left(\frac{dC_\ell}{d\alpha}\right)_{airfoil} = 0.108/\deg$, *determine the wing's lift slope* $\left(\frac{dC_\ell}{d\alpha}\right)_{wing}$

(2 markah/*marks*)

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

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

(2 markah/*marks*)

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