UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

ESA 367/2 – Flight Stability & Control I
Kestabilan & Kawalan Penerbangan I

Duration : 2 hours
[Masa *: 2 jam]*

INSTRUCTION TO CANDIDATES
ARAHAN KEPADA CALON

Please ensure that this paper contains **SEVEN (7)** printed pages and **THREE (3)** questions before you begin examination.
Sila pastikan bahawa kertas soalan ini mengandungi ***TUJUH (7)*** *mukasurat bercetak dan* ***TIGA (3)*** *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 question 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.

1. (a) With the aid of a diagram, describe the axes systems used in aircraft stability and control analysis. State the conditions when the use of each axis system might be preferred.

Dengan bantuan gambarajah lakarkan sistem-sistem koordinat yang digunakan dalam kajian kestabilan dan kawalan kapal terbang. Nyatakan keadaan bila setiap sistem koordinat itu digunakan.

(20 marks/*markah*)

(b) By using Figure 1, develop an expression for the moment coefficient about the center of gravity for wing contribution.

Dengan menggunakan Rajah 1, hasilkan ungkapan untuk pekali momen pada titik graviti yang disumbangkan oleh sayap.

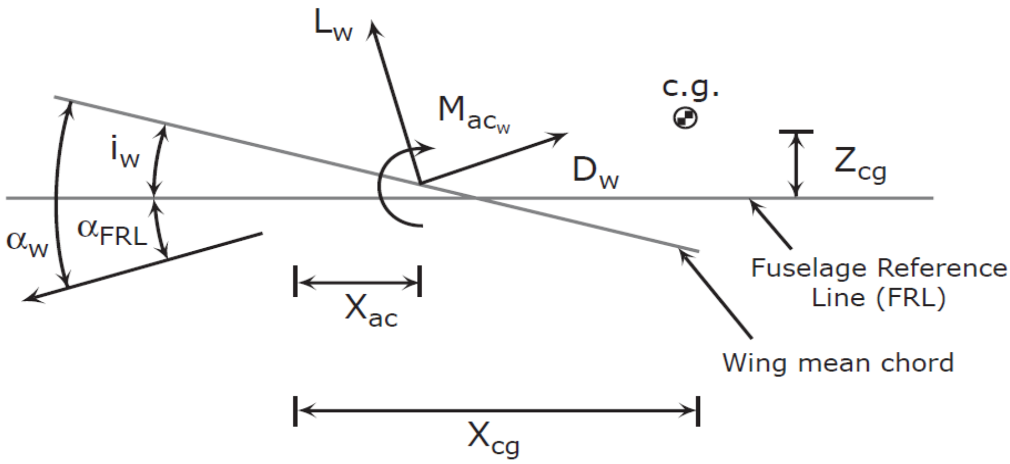

Figure 1/*Rajah 1*

(20 marks/*markah*)

(c) The change in pitching moment with angle of attack of a fuselage can be approximated by

Perubahan momen anggul dengan sudut serang fiuslaj boleh dianggarkan oleh

$$C_{m_{\alpha_f}} = \frac{1}{36.5S\bar{c}} \sum_{x=0}^{x=l_f} w_f^2 \frac{\partial \varepsilon_u}{\partial \alpha} \Delta x \ (deg^{-1})$$

By using this equation, estimate the fuselage contribution for the STOL transport shown in Figure 2. The aircraft has been divided into 12 sections where the section length, width, and distance from the wing leading or trailing edge to the midpoint of each section are given in Table 1. Assume that $S = 945ft$ (the wing reference area), $c = 10.1\ ft$ (the fuselage region between the wing leading and trailing edge), $l_h = 34\ ft$ (the distance from the wing trailing edge to the quarter chord of the horizontal tail), $\partial\varepsilon/\partial\alpha = 0.16$ (the downwash at tail).

Dengan menggunakan persamaan ini, anggarkan sumbangan fiuslaj untuk pesawat STOL yang ditunjukkan dalam gambar rajah 2. Pesawat dibahagikan kepada 12 bahagian di mana panjang setiap bahagian, lebar, dan jarak daripada pinggir depan sayap atau daripada pinggir belakang sayap ke titik tengah bagi setiap bahagian diberi di dalam jadual 1. Anggap $S = 945ft$ *(luas sayap rujukan)* $c = 10.1\ ft$ *(Kawasan fiuslaj dintara pinggir depan dan pinggir belakang sayap),* $l_h = 34\ ft$ *(jarak dari pinggir belakang sayap ke suku perentas ekor pesawat mengufuk),* $\partial\varepsilon/\partial\alpha = 0.16$ *(landa bawah pada ekor pesawat).*

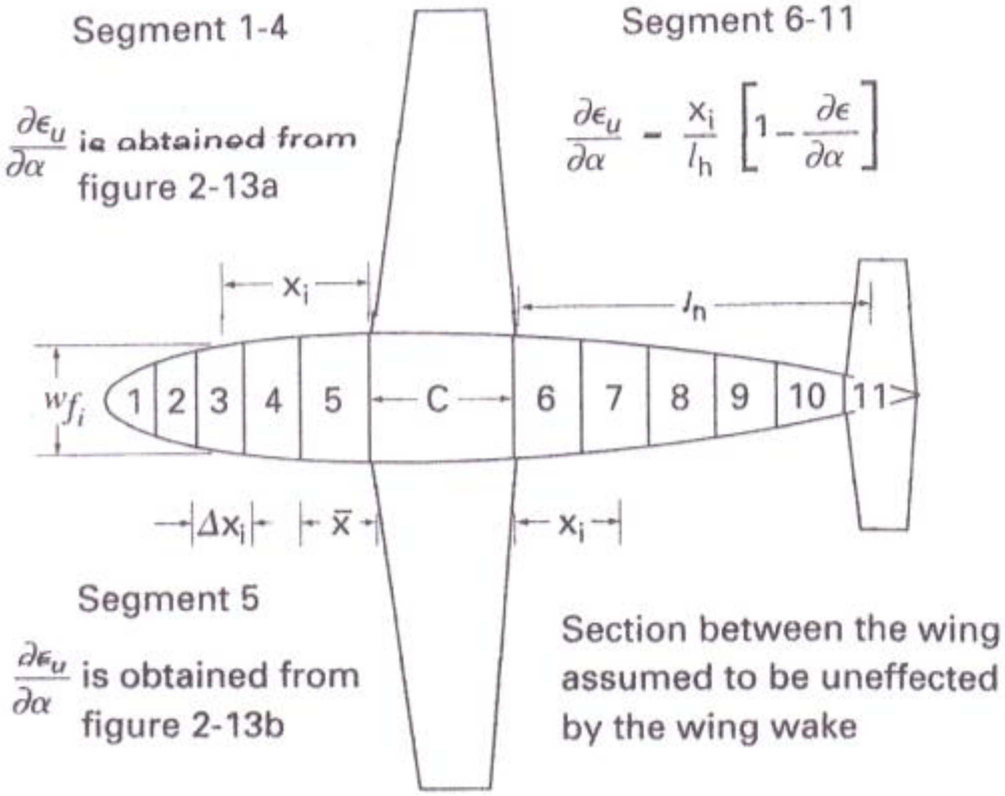

Figure 2/ *Rajah 2*

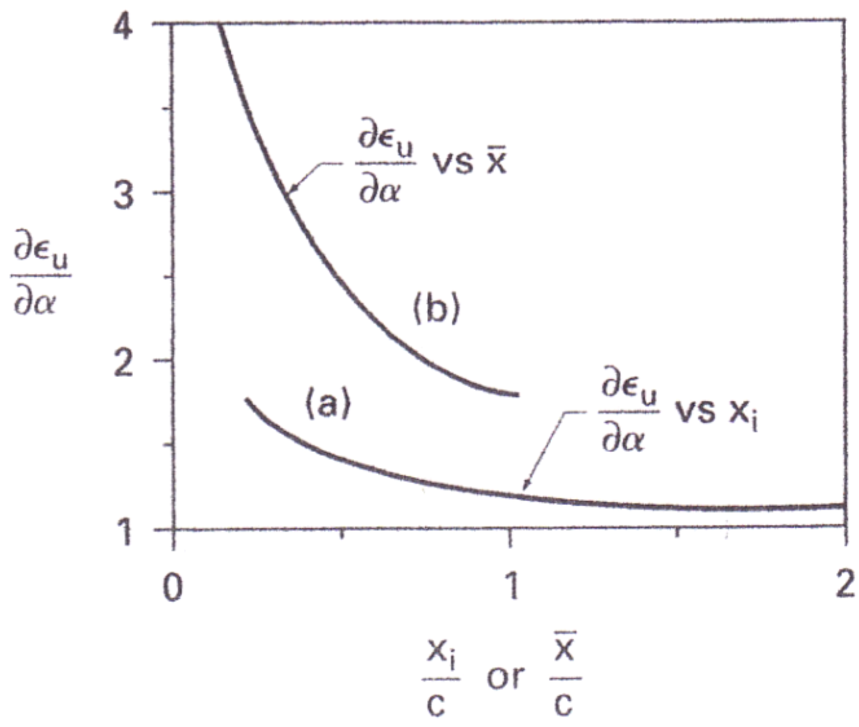

Figure 3/ *Rajah 3*

Station	$\Delta x\ (ft)$	$w_f\ (ft)$	$x_i\ (ft)$
1	4.4	4.4	20.2
2	2.5	6.9	17.0
3	5.0	8.8	13.9
4	5.0	9.5	7.6
5	5.0	10.1	2.5
6	6.3	10.1	2.5
7	6.3	10.1	8.8
8	6.3	10.1	15.1
9	6.3	8.2	21.4
10	6.3	7.6	27.7
11	5.0	5.1	33.4
12	5.0	2.5	39.7

Table 1/ *Jadual 1*

(60 marks/*markah*)

2. (a) An airplane has the following pitching moment characteristics at the center of gravity position

Sebuah pesawat mempunyai sifat momen anggul pada posisi titik tengah graviti

$$\frac{x_{cg}}{\bar{c}} = 0.3$$

$$C_{m_{cg}} = C_{m_0} + \frac{dC_{m_{cg}}}{dC_L} C_L + C_{m_{\delta_e}} \delta_e$$

where

di mana

$$C_{m_0} = 0.05$$

$$\frac{dC_{m_{cg}}}{dC_L} = -0.1$$

$$C_{m_{\delta_e}} = -0.01\ deg^{-1}$$

If the airplane is loaded so that the centre of gravity position moves to $x_{cg}/\bar{c} = 0.10$, can the airplane be trimmed during landing, $C_L = 1.0$? Assume that C_{m_0} and $C_{m_{\delta_e}}$ are unaffected by the center of gravity travel and that $\delta_e = \pm 20°$.

Jika pesawat diisi dan menyebabkan posisi pusat gravitinya bergerak ke $x_{cg}/\bar{c} = 0.10$, bolehkan pesawat tersebut ditrim ketika mendarat, $C_L = 1.0$? Anggap C_{m_0} dan $C_{m_{\delta_e}}$ tidak dijejaskan oleh pergerakan titik tengah graviti dan $\delta_e = \pm 20°$.

(40 marks/*markah*)

(b) The pitching moment characteristics of a general aviation airplane with the landing gear and flaps in their retracted position are given in Figure 2.

Sifat momen anggul sebuah pesawat penerbangan am dengan peralatan pendaratan dan kepak dengan posisi ke dalam adalah seperti di dalam Rajah 2.

(i) Where the stick fixed neutral point is located?

Di manakah posisi titik neutral ‘stick’ tetap?

(ii) If the airplane weighs $2500\ lbs$ and is flying at $150\ ft/s$ at sea level, $\rho = 0.002378\ slug/ft^3$, what is the elevator angle required for trim?

Jika berat pesawat adalah $2500\ lbs$ *dan terbang pada* $150\ ft/s$ *pada paras laut,* $\rho = 0.002378\ slug/ft^3$*, apakah sudut penaik yang dikehendaki untuk trim?*

(60 marks/*markah*)

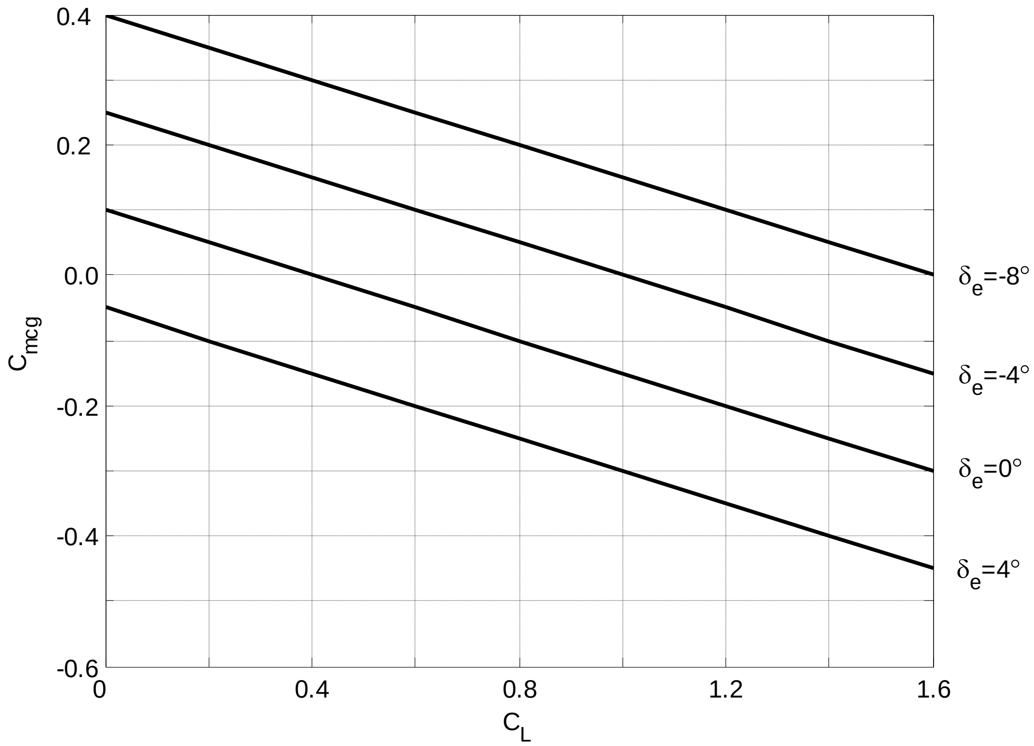

Figure 2 / *Rajah 2*

3. (a) Define the body angular velocities of the airplane in terms of Euler angles and Euler rates.

Tentukan halaju membulat jasad pesawat dalam sebutan sudut Euler dan kadar sudut Euler.

(25 marks/*markah*)

(b) Describe two modes of longitudinal motion.

Terangkan dua mod gerakan membujur

(25 marks/*markah*)

(c) Given the differential equations that follow

Diberi persamaan pembezaan seperti berikut

$$\dot{x}_1 + 0.5x_1 - 10x_2 = -\delta$$

$$\dot{x}_2 - x_2 + x_1 = 2\delta$$

where x_1 and x_2 are the state variables and δ is the forcing input to the system

di mana x_1 dan x_2 adalah pembolehubah keadaan dan δ adalah masukan daya pada sistem

(i) Rewrite these equations in state space form; that is

Tulis kembali persaamaan-persamaan yang dinyatakan di atas dilam bentuk persamaan keadaan ruang, seperti berikut

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}\boldsymbol{\eta}$$

(ii) Find the free response eigenvalues

Cari nilai gerak balas bebas eigen.

(iii) What do these eigenvalues tell us about the response of this system?

Bagaimana nilai-nilai eigen ini boleh memberi maklumat mengenai gerak balas sistem?

(50 marks/*markah*)

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