UNIVERSITI SAINS MALAYSIA

First Semester Examination
2011/2012 Academic Session

January 2012

ESA461/2 – Flight Stability and Control II
[Kawalan dan Kestabilan Pesawat II]

Duration : 2 hours
Masa : 2 jam

Please check that this paper contains **EIGHT (8)** printed pages, **TWO (2)** pages appendix and **FOUR (4)** questions before you begin the examination.
Sila pastikan bahawa kertas soalan ini mengandungi ***LAPAN (8)*** *mukasurat bercetak,* ***DUA (2)*** *mukasurat lampiran dan* ***EMPAT (4)*** *soalan sebelum anda memulakan peperiksaan.*

Instructions : Answer **FOUR (4)** questions.
Arahan *: Jawab* ***EMPAT (4)*** *soalan.*

1. Appendix A/*Lampiran A :* **[2 pages/*mukasurat*]**

Answer all questions in **English** or **Bahasa Malaysia.**
Menjawab semua soalan dalam ***Bahasa Inggeris atau Bahasa Malaysia.***

Answer to each question must begin from a new page.
Jawapan untuk 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 **FOUR (4)** questions.
*Jawab **EMPAT (4)** soalan.*

1. [a] Briefly explain about directional stability and state the conditions required for an aircraft to remain stable in this motion.

Terangkan dengan ringkas tentang kestabilan berarah dan nyatakan keadaan yang diperlukan untuk sebuah kapal terbang kekal stabil dalam pergerakan ini.

(5 marks/*markah*)

[b] Briefly explain about directional-lateral stability and state the conditions required for an aircraft to remain stable in this motion.

Terangkan dengan ringkas tentang kestabilan berarah-sisian dan nyatakan keadaan yang diperlukan untuk sebuah kapal terbang kekal stabil dalam pergerakan ini.

(5 marks/*markah*)

[c] The fuselage and the vertical tail are the two most influential components in directional stability. The wing fuselage contribution to directional stability can be calculated from the following equation

Fiuslaj dan ekor menegak merupakan dua komponen terpenting dalam kestabilan berarah. Sumbangan fiuslaj pada kestabilan berarah boleh dikira menggunakan persamaan yang berikut

$$C_{n_{\beta_{wf}}} = -k_n k_{Rl} \frac{S_{fs} l_f}{S_w b}$$

while, the vertical tail contribution can be calculated as follow

manakala, sumbangan ekor menegak boleh dikira seperti berikut

$$C_{n_{\beta_v}} = V_v \eta_v C_{L_{\alpha_v}} \left(1 + \frac{d\sigma}{d\beta}\right)$$

Given an aircraft with configurations as shown in Figure 1,

Diberi sebuah kapal terbang dengan konfigurasi seperti dalam Gambarajah 1,

$S_w = 20.27\ m^2$	$b = 10.4\ m$	$Z_w = 0.4\ m$	$d = 1.6\ m$
$l_f = 13.7\ m$	$X_m = 8.0\ m$	$W_f = 1.6\ m$	$S_{f_s} = 15.4\ m^2$
$h = 1.6\ m$	$h_1 = 1.6\ m$	$h_2 = 1.07\ m$	

[i] Define its wing fuselage contribution, $C_{n_{\beta_{wf}}}$(Refer appendix). Assume $V = 150\ m/s$.

Tentukan sumbangan kepak fiuslaj, $C_{n_{\beta_{wf}}}$ (Rujuk lampiran). Andaikan $V = 150\ m/s$.

[ii] Using your answer in [i], define the vertical tail contribution, $C_{n_{\beta_v}}$ so that its weathercock stability has a value of $C_{n_\beta} = +0.1\ rad^{-1}$.

Dengan menggunakan jawapan dalam [i], tentukan sumbangan ekor tegak, $C_{n_{\beta_v}}$ supaya kestabilan mata angin mempunyai nilai $C_{n_\beta} = +0.1\ rad^{-1}$.

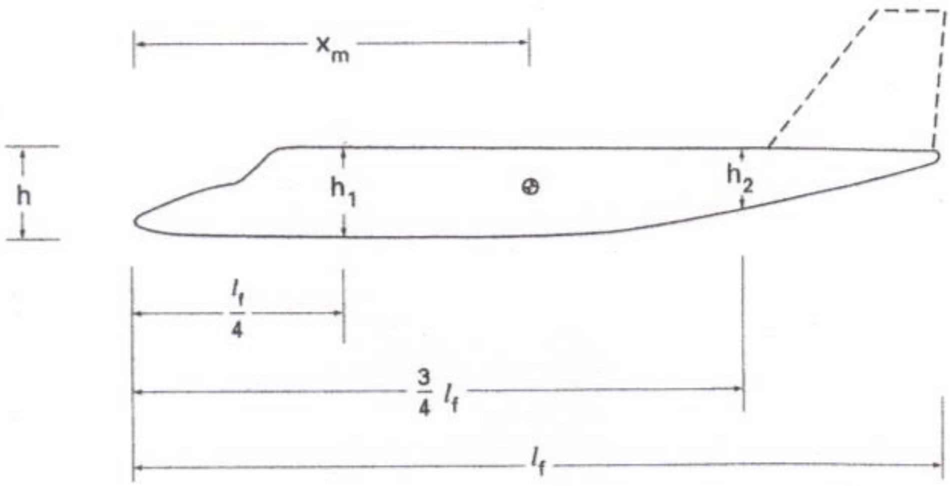

Figure 1/*Gambarajah 1*

(15 marks/*markah*)

2. [a] Briefly explain the following terms

Terangkan dengan ringkas istilah-istilah berikut

[i] adverse yaw

adverse yaw

[ii] dihedral effect

kesan dihedral

(10 marks/*markah*)

[b] The twin engine airplane with the following flight information is shown in Figure 2.

Kapal terbang dengan enjin berkembar dengan informasi penerbangan seperti berikut ditunjukkan dalam Gambarajah 2.

Wing: *Sayap:*	$S = 980\ ft^2 \quad b = 93\ ft$
Vertical tail: *Ekor tegak:*	$S_v = 330\ ft^2 \quad AR_v = 4.3 \quad l_v = 37\ ft \quad \eta_v = 1.0$ $C_{L_{\alpha_v}} = 4.02\ rad^{-1}$
Rudder: *Kemudi:*	$\delta_r = \pm 15°$
Propulsion: *Pendorongan:*	$T = 14\ 000\ lb$ each $\quad y_T = 16\ ft$
Flight condition: *Keadaan penerbangan:*	$V = 250\ ft/s \quad \rho = 0.002378\ slug/ft^3$

Determine the rudder size to control the airplane if one engine needs to be shut down (Refer appendix). Given the rudder control power expression as follow

Tentukan size kemudi untuk mengawal kapal terbang jika salah satu daripada enjin tersebut perlu dimatikan (Rujuk lampiran). Diberi eksperesi untuk kuasa kawalan kemudi seperti berikut

$$C_{n_{\delta_r}} = -\eta_v V_v C_{L_{\alpha_v}} \tau$$

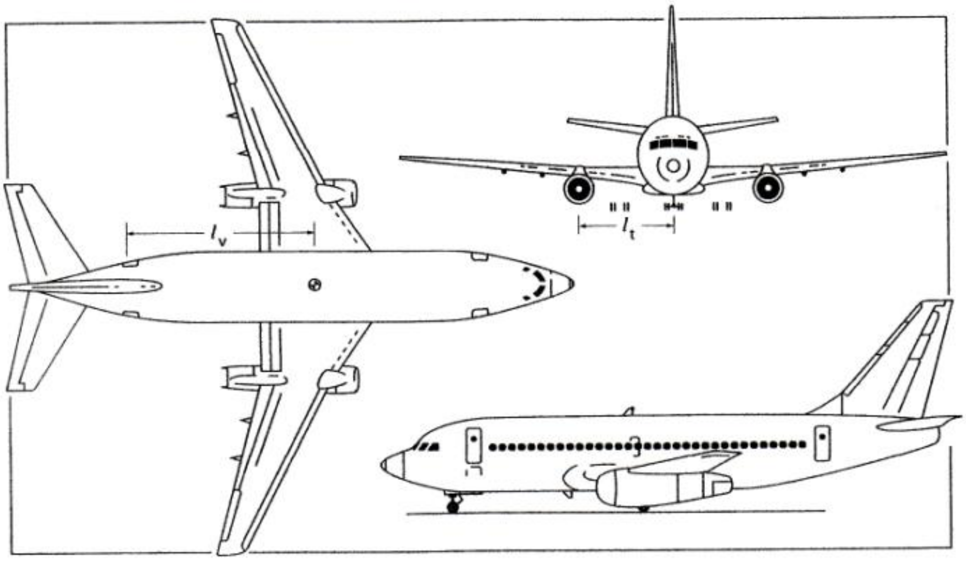

Figure 2 / *Rajah 2*

(15 marks/*markah*)

3. Starting with the Y force equation

Dimulakan dengan persamaan daya Y

$$Y + mg\cos\theta\sin\phi = m(\dot{v} + ru - pw)$$

use the small-disturbance theory to determine the linearized force equation

gunakan teori gangguan kecil untuk menentukan

$$\left(\frac{d}{dt} - Y_v\right)\Delta v - Y_p\Delta p + (u_0 - Y_r)\Delta r - (g\cos\theta_0)\Delta\phi = Y_{\delta_r}\Delta\delta_r$$

Assume a steady-level flight for the reference flight conditions.

Anggap penerbangan mendatar stabil untuk rujukan keadaan penerbangan.

(15 marks/*markah*)

4. A wind tunnel model is constructed of two small lifting surfaces mounted to an ax symmetric body as illustrated in Figure 3. The body houses a set of ball bearings that permit the model to roll freely about the longitudinal or x axis. The right lifting surface (positive y axis) is mounted to body at a $-3°$ and the left lifting surface is set at a $+3^{\circ}$.

Model terowong angin dibina daripda dua permukaan kecil pengangkat yang dipasang kepada sebuah badan paksi simetri seperti yang ditunjukkan dalam Rajah 3. Badan rumah-rumah satu set galas bebola yang membenarkan model bebas untuk melancarkan kira-kira membujur atau paksi x. Permukaan mengangkat kanan (positif paksi y) bagi memastikan ia dipasang kepada badan di $-3°$ *dan permukaan mengangkat kiri yang ditetapkan pada* $+3^{\circ}$.

[a] Evaluate the rolling moment of inertia, I_x of the model. Approximate the lifting surfaces as thin flat pages. Neglect the body contribution.

Anggarkan masa rolling inersia, I_x *model. Anggaran mengangkat permukaan sebagai halaman nipis rata. Abaikan sumbangan badan.*

(5 marks/*markah*)

[b] Evaluate the roll torque due to the differential mounting incidence. Express your answer as a roll moment coefficient per unit deflection, C_{l_δ}.

Anggarkan tork roll disebabkan kejadian kebezaan penggantung. Nyatakan jawapan anda sebagai roll pekali momen per pesongan unit, C_{l_δ}.

(10 marks/*markah*)

[c] Evaluate the roll damping coefficient, C_{l_p}.

Anggarkan pekali roll redaman, C_{l_p}.

(10 marks/*markah*)

[d] Calculate the response of the model if it is released from the rest. Neglect the friction of the bearings.

Kira sambutan model jika ia dilepaskan dari yang lain. Abaikan geseran galas.

(10 marks/*markah*)

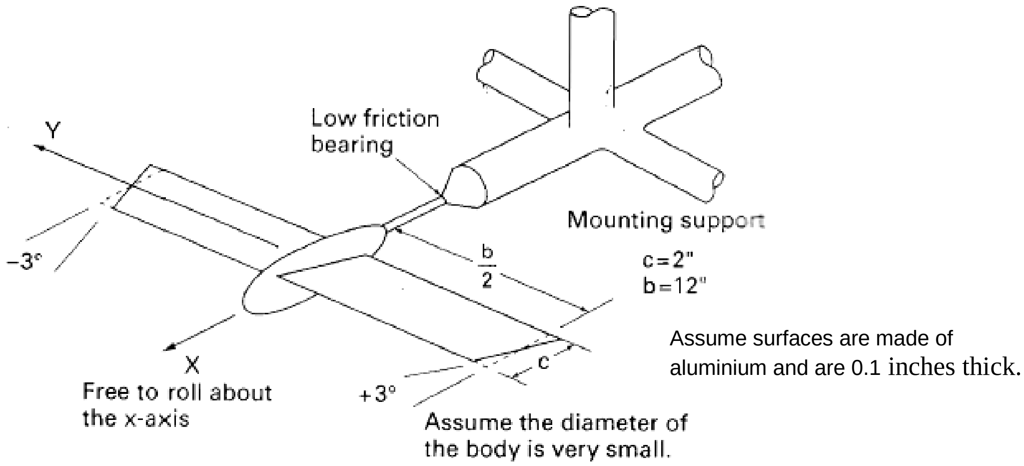

Figure 3 / *Rajah 3*

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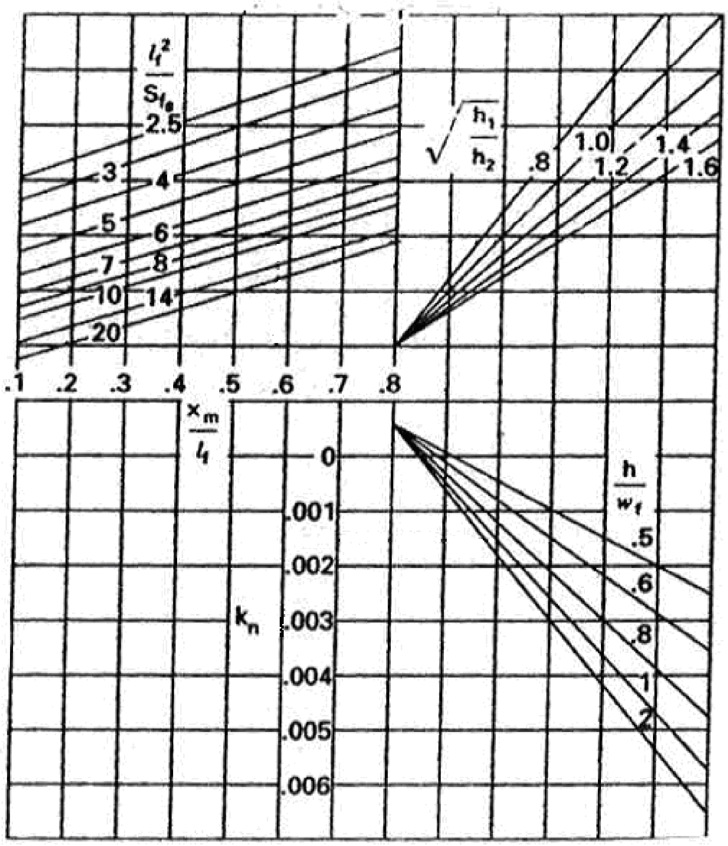
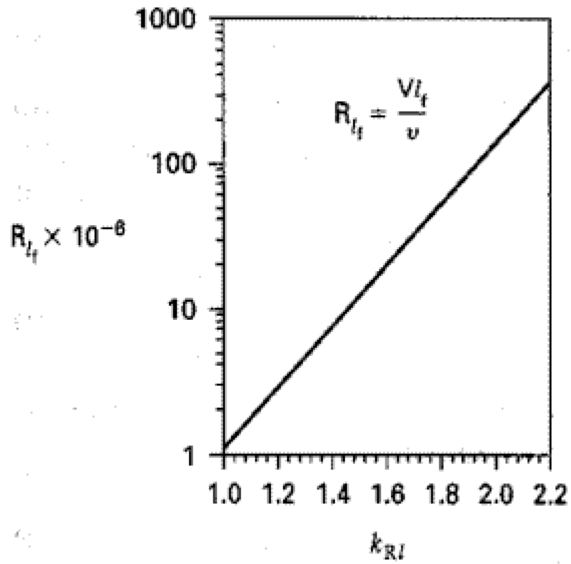
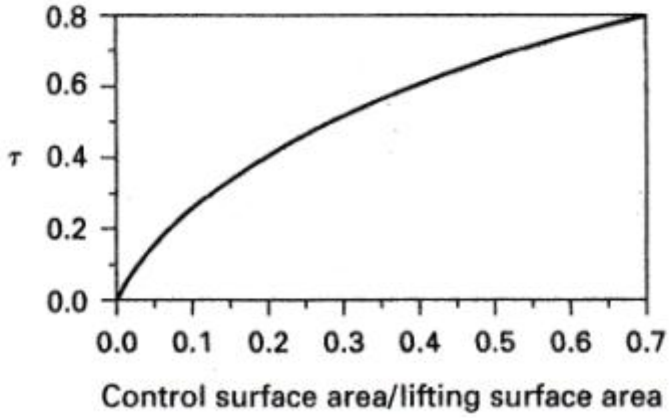
Appendix A/ *Lampiran A*



Wing body interference factor



Reynolds Number correction factor



Flap effectiveness parameter