UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2003/2004
First Semester Examination
2003/2004 Academic Session

September/Oktober
September/October

ESA 361/3 – Kestabilan dan Kawalan Penerbangan

(Flight Stability and Control)

Masa : 3 jam
Hour : [3 hours]

ARAHAN KEPADA CALON :
INSTRUCTION TO CANDIDATES:

Sila pastikan bahawa kertas soalan ini mengandungi **TUJUH** mukasurat bercetak ,**TIGA** mukasurat lampiran. dan **LIMA** soalan sebelum anda memulakan peperiksaan.
Please ensure that this paper contains SEVEN printed pages , THREE pages attachment and FIVE questions before you begin examination.

Jawab SEMUA soalan dari Bahagian A dan TIGA soalan dari Bahagian B.
Answer ALL the questions from section A and THREE questions from section B.

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.

Bahagian A: Teori Kawalan dan Kestabilan Pesawat (Jawab Semua)

Part A : Theory of Aircraft Stability and Control (All must be answered)

S1. [a] **Apakah syarat yang perlu dipenuhi oleh tatarajah "sayap sahaja" supaya ianya dapat distabilkan dan diseimbangkan?**

Which conditions should be met by the "wing only" configuration so that it can be stabilized and balanced ?

[b] **Apakah fungsi-fungsi yang dimiliki oleh ekor mendatar sebuah pesawat (Minimum 3 fungsi)?**

Which functions does the horizontal tail of an aircraft have (Minimum 3 functions)?.

[c] **Terangkan apakah yang dimaksudkan dengan istilah "relaxed static stable".**

Explain the meaning of term "relaxed static stable".

[d] **Apakah yang akan terjadi dengan titik neutral pesawat jika juruterbang itu melepaskan batang kawalan dan mengapa ianya berlaku?**

What will be happen with the aircraft's neutral point if the pilot releases the control stick and why ?

[e] **Terangkan bagaimana titik netral pesawat boleh di tentukan dari hasil pengukuran ujian penerbangan pesawat?**

How can the neutral point be determined from the flight test measurement?

[f] **Terangkan secara fizikal terbitan redaman** C_{mq}

Explain the physical meaning of a damping derivative C_{mq}.

[g] **Mengapakah sebuah pesawat mesti memiliki** $C_{n\beta}$ ***yang positive untuk gerak melintang yang stabil ?***

Why should an aircraft have positive $C_{n\beta}$ *for static stable directional motion.*

[h] **Mengapakah pesawat tidak memiliki kestabilan statik dalam gerak memusing ?**

Why doesn't the aircraft have the static stability in rolling.

[i] **Sebutkan terbitan-terbitan pesawat termasuk terbitan redaman pesawat.**

Mention the aircraft derivatives belonging to damping derivative of the aircraft.

[j] **Nyatakan langkah-langkah dalam menentukan saiz awal ekor mendatar pesawat menggunakan pekali isipadu ekor V_H**

Mention the steps in initial sizing the horizontal tail using Tail Volume Coefficient V_H.

(100 markah/marks)

Bahagian B : Pengiraan Kawalan dan Kestabilan Pesawat (Jawab 3 Soalan SAHAJA)

Part B : Calculation of Aircraft Stability and Control (Answer 3 from 4 problems)

S2. [a] **Sebuah model tatarajah "sayap - badan pesawat" telah diuji di dalam sebuah terowong angin subsonik. Pekali daya angkat adalah sama dengan sifar pada sudut serang α = - 1.5 darjah. Pada alpha α = 5 darjah, pekali daya angkat $C_{L,WB}$ adalah 0.52 .**

Selain daripada itu, pada sudut alpha α = 1.0 darjah dan 7.88 darjah, pekali momen sekitar pusat graviti (cg) adalah masing-masingnya – 0.01 dan 0.05 . Pusat graviti di tempatkan pada 0.35 $\bar{c}$. Sila lakukan analisis sama ada model tatarajah "sayap – badan pesawat" ini mempunyai kestabilan membujur statik dan boleh di trim ataupun tidak.

A model of wing-body configuration has been tested in a subsonic wind tunnel. The lift coefficient is found to be zero at a geometric angle of attack α = -1.5 degree. At alpha α = 5 degree, the lift coefficient $C_{L,WB}$ is measured as 0.52 . Besides, at alpha α= 1.0 degree and 7.88 degree, the moment coefficients about the centre of gravity (cg) C_m are measured as –0.01 and 0.05, respectively. The cg is located at 0.35 $\bar{c}$. Please analyse whether this model of wing-body configuration has the static longitudinal stability and can be trimmed or not.

(35 markah/marks)

[b] **Berdasarkan daripada hasil analisis bahagian (a), apakah model di atas memerlukan ekor mendatar ataupun tidak untuk menstabil dan men-trim ianya sendiri ? Jika jawapan adalah benar, buktikan bahwa pemasangan ekor mendatar pada bahagian belakang badan pesawat terbang itu boleh menstabilkan and men-trim tatarajah "sayap -badan pesawat".**

Based on the analysis result performed at the problem 1a, does the model above need the horizontal tail (HT) or not to stabilise and to trim itself? If the answer is yes, proof that the attachment of the horizontal tail on the aft of the fuselage can stabilize and trim the "wing- body" configuration.

(40 markah/marks)

[c] **Kirakan kedudukan paling belakang pusat graviti untuk margin kestabilan SM = 5% dan pada sudut serang yang manakah model pesawat yang lengkap boleh di trim ?**

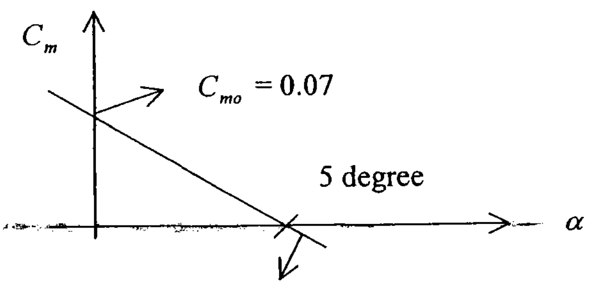
Calculate the most rearward position of the cg for stability margin SM = 5 % and at which angle of attack the complete model now can be trimmed?

Data :

Luas Sayap/Wing Area S $= 0.1\ m^2$
Luas HT/ Area of HT $S_H = 0.02\ m^2$
mac $\bar{c} = 0.1$ m
Sudut angguk HT/ Incidence angle of HT $i_H = 2.7$ degree
Tangan momen/ Moment arm $l_H = 0.17$ m
Kecerunan HT/ Slope of HT $C_{LH\alpha H} = 0.1$ per degree
Kesan Down-wash/ Down-wash effect $\varepsilon_H = 0.35\ \alpha$
Nisbah tekanan dinamik/ Dynamic. Pressure Ratio $\frac{\bar{q}_H}{\bar{q}} = 1.0$

(25 markah/marks)

S3. Katakan sebuah pesawat terbang mempunyai sifat momen yang berikut:
Consider an airplane having following moment characteristic



Gambarajah 1 : Pekali moment C_m *lawan alpha* α
Figure 1 : Moment coefficient C_m versus alpha α

Sebuah pesawat mempunyai luas sayap $19\,m^2$, berat, W = 22700 Newton dan keberkesanan kawalan elevator adalah 0.04. Tentukan sudut pemesongan penaik yang diperlukan untuk men-trim pesawat yang terbang pada halaju 61 m/s di atas aras laut.

The airplane has a wing area of 19 m^2, a weight W of 22700 Newton, and an elevator control effectiveness of 0.04 . Determine the elevator deflection angle necessary to trim the airplane at a velocity of 61 m/s at the sea level.

Data :

$C_{L\alpha,WB}$	$= 0.09$ *per degree*	$C_{LH\alpha H}$	$= 0.11$ *per degree*
mac $\bar{c}$	$= 1.9$ *meter*	ε	$= 0.35\ \alpha$
V_H	$= 0.34;$	$\bar{q}_H / \bar{q}$	$= 1.0$
l_H^*	$= 6$ *meter*		

(100 markah/marks)

S4. **Sebuah syarikat pesawat terbang di Malaysia telah mendapat arahan untuk melakukan pensaizan awal ekor mendatar sebuah pesawat baling-baling. Susunan lukisan badan pesawat ditunjukan seperti dalam gambarajah Q2 dilampiran.**

Kirakan saiz ekor mendatar pesawat sehingga pesawat itu mempunyai beban sayap (berat/luas sayap) yang tinggi. Data geometri sayap adalah AR = 8, luas sayap = 16 m^2 dan mac $\bar{c} = 1.5$ meter.

Catatan : Gunakan jadual 1a dilampiran untuk menyelesaikan soalan ini.

A Malaysian aircraft company get an order to carry out the initial sizing of the horizontal tail for a Twin Engine Propeller Driven airplane, whose the general arrangement drawing of the fuselage is shown in figure Q2 Appendix

Please determine the size of horizontal tail so that the airplane has a higher wing-loading (Weight/ Wing Area). Geometric data of the wing is Aspect Ratio AR = 8, Wing Area S = 16 square meter, and m.a.c $\bar{c}$ = 1.5 meter
Note : Use also the table 1 a to solve this problem.

(100 markah/marks)

S5. [a] **Seorang pemandu pesawat terbang yang mempunyai data seperti di bawah seharusnya terbang pada halaju V_1 = *100 m/s.* Berapa darjah sudut pemesongan penaik mesti diubah supaya pesawat itu mempunyai halaju trim yang baru $V_2 = 130$ m/s ?**

A pilot of an airplane having the data below should fly at a speed V_1 = 100 m/s. How many degree must the elevator be changed, so that the airplane has new trim speed V_2 of 130 m/s ?

(50 markah/marks)

[b] **Berdasarkan dua penerbangan dengan pusat graviti yang berbeza $X_{cg,1}$ dan $X_{cg,2}$, nilai-nilai untuk kecerunan pemesongan adalah seperti berikut :**

$$X_{cg,1} = 0.3\bar{c} \quad ;\left(\frac{d\eta}{dV}\right)_1 = 0.085\,\text{degree}/(m/s)$$

$$X_{cg,2} = 0.25\bar{c} \quad ;\left(\frac{d\eta}{dV}\right)_2 = 0.110\,\text{degree}/(m/s)$$

Di manakah letaknya titik *neutral* pesawat terbang ini?

Based on two flights with different centre of gravity positions $X_{cg,1}$ *and* $X_{cg,2}$ *the following values for elevator gradients are available :*

$$X_{cg,1} = 0.3\bar{c} \quad ;\left(\frac{d\eta}{dV}\right)_1 = 0.085\,\deg ree/(m/s)$$

$$X_{cg,2} = 0.25\bar{c} \quad ;\left(\frac{d\eta}{dV}\right)_2 = 0.110\,\deg ree/(m/s)$$

Where does the neutral point of the aircraft lie?.

Data :

$$C_{m\alpha} = -0.9 \quad ; \rho = 1.0\, kg/m^3$$
$$C_{L\alpha} = 5.0 \quad ; m/S = 300\, kg/m^2$$
$$C_{m\eta,NP} = -0.7$$

(50 markah/marks)

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Table [1a] – Twin Engine Propeller Driven Airplanes : Horizontal Tail Volume and Elevator Data

Type	Wing Area S ft^2	Wing mgc $\bar{c}$ ft	Wing Airfoil root/tip NACA*	Hor. Tail Area S_h ft^2	S_e/S_h	x_h ft	$\bar{V}_h$	Elevator Chord root/tip fr.c_h
CESSNA								
310R	179	4.77	23018/23009	54.3	0.41	14.9	0.95	.42/.39
402B	196	4.77	23018/23009	60.7	0.29	16.5	1.07	.41/.39
414A	226	4.73	23018/23009	60.7	0.27	16.4	0.93	.37/.38
T303	189	4.9	23017/23012	48.1	0.42	14.9	0.78	.41/.44
PIPER								
PA-31P	229	5.79	$63_2$415/$63_1$212	68.7	0.44	16.2	0.84	.41/.51
PA-44-180T	184	4.34	NA	23.4	1.0	15.7	0.46	stabilator
Chieftain	229	6.00	63_2A415/63_1A212	61.4	0.38	16.1	0.72	0.38
Cheyenne I	229	5.69	63_2A415/63_1A212	70.5	0.40	15.7	0.85	.40/.41
Cheyen.III	293	7.33	63_2A415/63_1A212	61.8	0.39	23.7	0.68	.35/.44
BEECB								
Duchess	181	5.08	63_2A415	39.4	0.35	15.6	0.67	0.40
Duke B60	213	6.60	23016.5/23010.5	62.0	0.27	14.5	0.64	0.39
Lear Ƒan 2100	163	4.36	NA	55.0	0.23	13.1	1.01	.36/.31
Rockwell Comdr 700	200	5.28	NA	55.4	0.37	19.7	1.03	0.37
Piaggio P166-DL3	286	6.06	230 series	51.6	0.27	17.2	0.51	.40/.50
EMB-121	296	6.62	NA	62.9	0.43	20.3	0.65	.39/.46

* Unless otherwise indfcated

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Table [1b] – Twin Engine Propeller Driven Airplanes : Vertical Tail, Rudder and Aileron Data

Type	Wing Area S ft^2	Wing Span b ft	Vert. Tail Area S_v ft^2	S_r/S_v	x_v ft	$\bar{V}_v$	Rudder Chord root/tip fr.c_v	S_a/S	Ail. Span Loc. in/out fr.b/2	Ail. Chord in/out fr.c_w
CESSNA										
310R	179	36.9	26.1	0.45	15.9	0.063	.48/.41	0.064	.60/.90	.30/.29
402B	196	39.9	37.9	0.47	16.5	0.080	.48/.40	0.058	.64/.91	.29/.27
414A	226	44.1	41.3	0.38	17.0	0.071	.49/.37	0.061	.62/.87	.30/.28
T303	189	39.0	23.2	0.44	16.5	0.052	.46/.39	0.087	.64/.97	.31/.30
ConquestI	225	44.1	41.3	0.38	17.1	0.071	.47/.34	0.060	.61/.86	0.29
PIPER										
PA-31P	229	40.7	30.1	0.38	17.2	0.056	.37/.40	0.056	.59/.97	.24/.29
PA44-180T	184	38.6	21.5	0.37	14.4	0.044	.30/.50	0.077	.45/.90	.19/.18
Chieftain	229	40.7	29.5	0.40	17.3	0.055	.40/.38	0.060	.66/.98	.24/.30
Cheyen. I	229	42.7	26.5	0.40	16.5	0.045	.37/.42	0.057	.62/.93	.24/.29
Cheye.III	293	47.7	43.6	0.46	20.8	0.065	0.33	0.046	.66/.94	.23/.26
BEECH										
Duchess	181	38.0	25.6	0.29	14.2	0.053	.34/.42	0.059	.67/.97	0.28
Duke B60	213	39.3	28.8	0.43	17.4	0.060	.44/.46	0.054	.50/.84	.24/.26
Lear Fan										
2100	163	39.3	44.4	0.17	14.0	0.097	.32/.34	0.044	.72/.98	.31/.24
Rockwell										
Comdr 700	200	42.5	39.9	0.38	20.5	0.096	.37/.38	0.087	.58/.99	.28/.24
Piaggio										
P166-DL3	286	48.2	30.7	0.43	18.3	0.041	.38/.43	0.073	.61/.94	.19/.22
EMB-121	296	46.4	42.6	0.45	17.8	0.055	.42/.41	0.052	.71/.97	0.22

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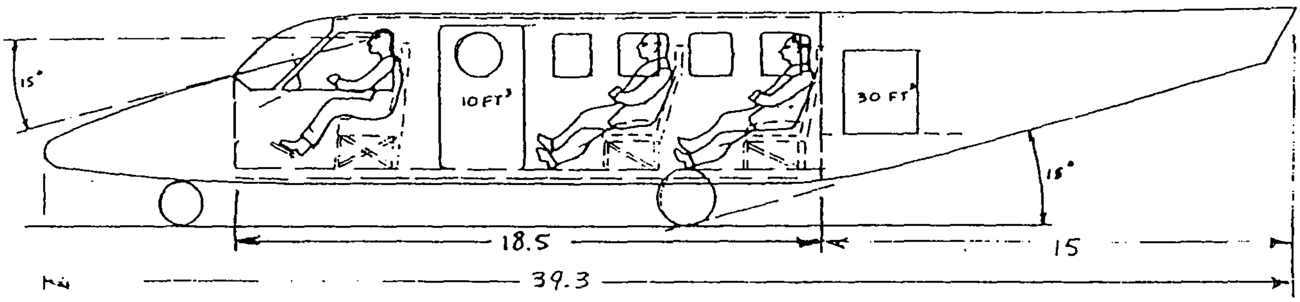
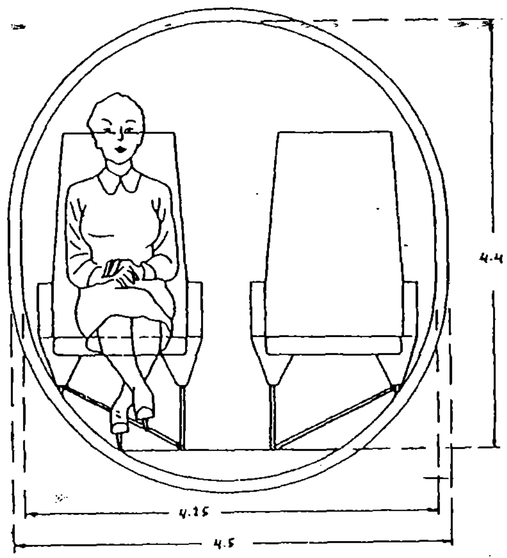
Gambarajah Soalan 3 [Bahagian B]



[i] Figure Q3 [a] Selene : General Arrangement of the Fuselage



[ii] Figure Q3 [b] Selene : Cabin Cross Section

(ALL DIMENSIONS IN FEET(FT) DO NOT SCALE)