Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	FLIGHT STABILITY AND CONTROL
COURSE CODE	:	BDL 30102
PROGRAMME CODE	:	BDC / BDM
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	2 HOURS
INSTRUCTION	:	PART A : ANSWER **ALL** QUESTIONS PART B : ANSWER **ONE**(1) QUESTION

THIS QUESTION PAPER CONSISTS OF **FOUR** (4) PAGES

PART A: ANSWER **ALL** QUESTIONS

Q1 (a) Explain the reason why in designing the airplane, it is preferred to use T-Tail configuration.

(5 marks)

(b) Show that, in a longitudinal symmetric small perturbation, the components of aircraft weight resolved into the ox and oz axes are given by

$$X_g = -mg\,\theta\cos\theta_e - mg\sin\theta_e$$
$$Z_g = mg\cos\theta_e - mg\,\theta\sin\theta_e$$

where θ is the perturbation in pitch attitude and θ_e is the equilibrium pitch attitude.

(20 marks)

Q2 Show that through evaluating the moment pitching works on the airplane, one can state that an airplane with high wing has more longitudinal static stability than the one with low wing.

(25 marks)

Q3 (a) The aircraft can rotate with respect to the longitudinal axis, lateral axis or to the directional axis. Name the control surfaces used to achieve equilibrium about these three axes.

(5 marks)

(b) In point of view aircraft handling quality gives example what kind the expected longitudinal and lateral characteristics aircraft should have?

(5 marks)

(c) The governing equation of flight motion in a six degrees of freedom aircraft can be written as :

The equation of translational motion:

$$\text{In x-direction : } m(\dot{U} + QW - RV) = -mg\sin\theta + F_{Ax} + F_{Tx}$$

$$\text{In y-direction : } m(\dot{V} + UR - PW) = mg\cos\theta\sin\Phi + F_{Ay} + F_{Ty}$$

$$\text{In z-direction : } m(\dot{W} + PV - QU) = mg\cos\theta\,\text{Cos}\,\Phi + F_{Az} + F_{Tz}$$

The equation of rotational motion:

$$\text{In x-rotation : } \dot{P}I_{xx} - \dot{R}I_{xz} - PQI_{xz} + RQ(\dot{I_{zz}} - I_{yy}) = l_A + l_T$$

$$\text{In y-rotation : } \dot{Q}I_{yy} + PR(I_{xx} - I_{zz}) + (P^2 - R^2)I_{xz} = M_A + M_T$$

$$\text{In z-rotation : } \dot{R}I_{zz} - \dot{P}I_{xz} + PQ(I_{yy} - I_{xx}) + QR\,I_{xz} = N_A + N_T$$

Where

U, V, W : translational velocity in x, y and z direction

$\dot{U}, \dot{V}, \dot{W}$: translational acceleration in x, y and z direction

P, Q, R : translational velocity in x, y and z direction

$\dot{P}, \dot{Q}, \dot{R}$: translational acceleration in x, y and z direction

I_{xx}, I_{yx}, I_{zx} : Inertia and moment of moment inertia in x direction

I_{xy}, I_{yy}, I_{zy} : Inertia and moment of moment inertia in y direction

I_{xz}, I_{yz}, I_{zz} : Inertia and moment of moment inertia in y direction

F_{Ax}, F_{At}, F_{Az} : aerodynamic forces in x, y and z direction

T_{Ax}, T_{At}, T_{Az} : engine thrust in x, y and z direction

L_A, M_A, N_A : aerodynamic moment of rolling, pitching and yawing

L_T, M_T, N_T : rolling, pitching and yawing moment due to engine thrust.

Based on general equation of motion above formulate to the case

(i) Aircraft flies in steady state
(ii) Aircraft flies in steady state and rectilinear flight motion

(15 marks)

PART B: ANSWER **ONE (1)** QUESTION

Q4 The characteristics of longitudinal flight motion had been identified has a fourth-degree polynomial in the form as:

$$\lambda^4 + 5.05\lambda^3 + 13.15\,\lambda^2 + 0.6735\,\lambda + 0.593 = 0$$

Extract the roots and describe the motion depicted by them.

(25 marks)

Q5 A transport aircraft whose wing span b is 35.8 m is flying at $U_0 = 262\ kts$ at an altitude where the lateral relative density parameter $\mu_2 = 524.4$. The dimensionless controls-fixed lateral directional characteristic equation is

$$\lambda^4 + 15.8\lambda^3 + 20.3\lambda^2 + 79.0\lambda + 0.37 = 0$$

(a) What can be deduced about the lateral-directional stability of the aircraft from inspection of the characteristic equation?

(5 marks)

(b) Solve the characteristic equation approximately; determine the estimated time constants of the non-oscillatory modes and also the frequency and damping ratio of the oscillatory mode.

(15 marks)

(c) Comment on the acceptability of this aircraft

(5 marks)

-END OF QUESTIONS -