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10AE73

Seventh Semester B.E. Degree Examination, Dec.2014/Jan.2015
Aircraft, Stability and Control

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***

PART – A

1 a. Explain the static and dynamic stability with suitable displacement and oscillators with respect time. **(03 Marks)**

b. Describe the motion of an aircrafts with coordinate system forming expressions for forces F_x, F_y, F_z and moments L, M and N. **(07 Marks)**

c. Differentiate between Fuselage Reference Line (FRL) and Wing Chord Line (WCL) along with Angle of Attack (AOA) and Angle of Incidence (AOI). **(10 Marks)**

2 a. Explain the fuselage contribution due to induced flow proposed by Multhop. Giving expression for C_{mof}, $C_{m\alpha t}$ giving the profile of flow field along the fuselage. **(08 Marks)**

b. Prove that aerodynamic centre must lie aft of the center of gravity to have $C_{m\alpha} < 0$. **(06 Marks)**

c. An experimental aircraft model tested in a subsonic wind tunnel. The lift is found to be zero at AOA, $\alpha = -1.5°$, at $\alpha = 5°$, the lift is measured as 0.52. Also, at $\alpha = 1.0°$ and 7.88°, the coefficient of moment about c.g are measured -0.01 and 0.05 respectively. If the c.g. is located at $0.35\,\bar{C}$, calculate the location of aerodynamic center and C_{macf}. **(06 Marks)**

3 a. Explain the longitudinal stability control, trim condition and trim tabs. **(06 Marks)**

b. Explain the effect of jet engine on stability by showing, $C_{ml} = \frac{T_j Z_j}{W\bar{C}}$, explain the design parameter while installing an airframe; comment. **(08 Marks)**

c. Explain the effect of elevator required during landing for a fixed wing, tail mounted engines. **(06 Marks)**

4 a. Discuss the relation between stick free, wing moment with relevant equations. **(08 Marks)**

b. The wing fuselage pitching moment characteristics of a high wing experimental, single engined aircraft of NAL (R and D):

$C_{mcgwf} = -0.06 - 0.039\alpha$, when α is with respect to FRL AOA is degrees, 'wf' represents wing fuselage. $S_W = 16m^2$, $X_{cg/c} = 0.12$, $b_w = 10.5m$, $AR_w = 7.4$ $\bar{C}_w = 1.6m$, $C_{L_{awf}} = 0.072/deg$, $l_w = 2.3°$ $C_{L\alpha} = 0.28$ (for $\alpha = 0$). Estimate the horizontal tail arc and tail incidence angle, if so that the complete airplane has the following pitching moment characteristics.

$C_{mcgwft} = 0.17 - 0.023\alpha$, where α is in degrees and 'wft' represent the wing-fuselage-horizontal tail contribution. Assume the following: $l_t = 4.5m$, $\eta = 0.98$, $AR_t = 4.76$, $C_{L_{at}} = 0.069/deg$.

As an aerodynamist provide your comments on design parameters for tail plane location and geometry for longitudinal control for the airplane. **(12 Marks)**

PART – B

5 a. What do you understand by roll stability? Explain with sketches the dihedral and wing location (high and low) on fuselage effects. **(10 Marks)**

b. How do you obtain roll control through aileron and spoilers, obtain an expression for roll control power, $C_{l\sigma a}$? **(10 Marks)**

6 a. Explain the dynamic longitudinal stability with different modes and provide short notes on Phugoid and short period motion. **(12 Marks)**

b. Show that the propulsive forces and gravitational forces can create moments with clear sketches with all components with equations of motion. **(08 Marks)**

7 a. Show that coefficient C_{mu} depends on the Mach No but also is affected by elastic properties of airframe. **(10 Marks)**

b. Obtain the derivative due to time rate of change of AOA, $C_{m\dot{\alpha}} = 2C_{L_{\alpha_t}} \eta V_H \frac{l_t}{\bar{c}} \cdot \frac{d\epsilon}{d\alpha}$, explain and comment. **(10 Marks)**

8 Write short notes on the following (any four):

a. Canarol control.
b. Wing rock.
c. Dutch roll.
d. Spiral approximation.
e. Roll control reversal. **(20 Marks)**

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