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10AE73

Seventh Semester B.E. Degree Examination, Dec.2018/Jan.2019
Aircraft Stability and Control

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Using a neat sketch of the forces and moments acting on an airplane in the plane of symmetry, derive, in terms of aerodynamic coefficients,
   i) Total pitching moment equation ($C_{m_{cg}}$)
   ii) Stability equation ($d C_m / d C_L$). **(10 Marks)**

b. The rectangular wing of an airplane has the following parameters: AR = 6, S = 600Sq ft, $X_{ac} = 0.24\,\overline{C}$, and ($C_{m_{ac}}$) = -0.088. If the wing is balanced so that the CG lies on the wing chard but 6 inches ahead of the a.c calculate the lift coefficient for which the wing would be in equilibrium ($C_{m_{cg}} = 0$). Is the lift coefficient useful? Is the equilibrium statically stable? Calculate the position of the CG for equilibrium at $C_L = 0.4$. Is the equilibrium statically stable? **(10 Marks)**

2 a. Define stick – fixed neutral point and static margin. Derive an expression for stick – fixed neutral point (N_o) and discuss the effect of CG shift on pitching moment. **(10 Marks)**

b. Define elevator control power ($C_{m_{\delta_e}}$) and derive an expression for it. **(10 Marks)**

3 a. Briefly discuss elevator hinge moment parameters and trim tab, with suitable sketches and equations. **(06 Marks)**

b. Derive an equation for elevator stick force (F_s) and stick force gradient ($d F_s/dv$) in terms of hinge moment parameters. **(10 Marks)**

c. The hinge moment parameters of an assumed elevator control are as follows :
$C_{h_\alpha} = -0.006$, $C_{h_\delta} = -0.010$, $C_{h_o} = 0$
Plot curves of elevator hinge moment coefficient, C_{h_e}, versus elevator deflection, δ_e, for the following angles of attack :
$\alpha = -15°, -10°, -5°, 0°, 5°, 10°, 15°$
Carry this plots for $\delta_e = -30°$ and $\delta_e = +30°$. **(04 Marks)**

4 a. Define sideslip angle (β) and leaving or yaw angle (ψ) and illustrate them with suitable sketches for symmetric flight path and asymmetric flight path. Discuss the static directional stability criteria with a neat sketch. **(06 Marks)**

b. Define rudder control power ($C_{n_{\delta r}}$) and derive an equation for it. **(06 Marks)**

c. Briefly discuss Rudder Lock and Dorsal Fin. **(08 Marks)**

PART – B

5 a. Define Dihedral angle and Dihedral Effect with suitable sketches. **(04 Marks)**

b. Discuss, with relevant equations, the contribution of wing, vertical trail, wing fuselage interference, and wing – vertical tail interference to the dihedral effect. Write the equation for the dihedral effect of the complete airplane. **(06 Marks)**

c. With the help of a neat sketch, how roll control is achieved using the ailerons. Derive an expression for the aileron control forces, during rolling maneuver, in the form.

$$F_a = -qS_aC_aGC_{h\delta}\delta_a\left[1-2n\frac{C_{h\alpha}}{C_{h\delta}}\right]$$ **(10 Marks)**

6 a. Define dynamic longitudinal stability. Discuss with suitable sketches the phugoid and short period modes of motion. **(06 Marks)**

b. Derive an equation for the pure pitching motion of an airplane and discuss the angle of attack time history for various damping ratios. **(10 Marks)**

c. Discuss the time to half ($T_{½}$) and the time is double (T_2) with relevant sketches and equations. **(04 Marks)**

7 a. Obtain the derivatives due to the pitching velocity : C_{m_q} and C_{z_q} **(10 Marks)**

b. Obtain the derivatives due to rolling rate : C_{ℓ_p} and C_{n_p} **(10 Marks)**

8 a. Briefly discuss the Spiral, Roll and Dutch Roll motions of an airplane with neat sketches. **(06 Marks)**

b. Define Handling Qualities and Cooper – Harper rating scale. **(04 Marks)**

c. Draw a neat flow chart of the Cooper – Harper rating scale, and discuss how a pilot assigns Level 1, Level 2 and Level 3 handling qualities levels for an airplane performing a specified task using the rating scale. **(10 Marks)**

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