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10AE73

Seventh Semester B.E. Degree Examination, Dec.2016/Jan.2017
Aircraft Stability and Control

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Derive expression for wing contribution, $\left(\frac{dC_m}{dC_L}\right)_w$ for the longitudinal static stability of an airplane and discuss the significance of C.G. position with respect to the wing aerodynamic center. **(10 Marks)**

b. The wing-fuselage pitching moment characteristics of a high-wing, single-engine, general aviation airplane follow, along with pertinent geometric data: $C_{m_{cg_{wf}}} = -0.05 - 0.0035\alpha$

where α is the fuselage reference line angle of attack in degrees and wf means wing fuselage.

$S_w = 178\ m^2$; $x_{cg}/c = 0.1$; $b_w = 35.9\ m$; $AR_w = 7.3$; $\bar{C}_w = 5m$; $C_{L_{\alpha_{wf}}} = 0.07/deg$;

$j_w = 2^\circ$; $C_{L_{\alpha=0}} = 0.26$

Estimate the horizontal tail area and tail incidence angle, i_t, so that the complete airplane has the following pitching moment characteristics:

$C_{m_{cg_{wft}}} = 0.15 - 0.025\alpha$

where α is in degrees and wft is the wing-fuselage-horizontal tail contribution. Assume the following with regard to the horizontal tail: $l_t = 14.75\ m$; $\eta = 1$, $AR_t = 4.85$; $C_{L_{\alpha_t}} = 0.073/deg$. **(10 Marks)**

2 a. Define stick fixed neutral points and static margin. Write down the expression for stick fixed neutral point and discuss the effect of CG shift on pitching moment. **(10 Marks)**

b. Derive the expression for elevator control power ; $C_{m_{\delta_e}} = -V_H \eta C_{L_{\alpha_t}} \tau$ **(10 Marks)**

3 a. Obtain the expression for $(\delta_e)_{free}$ elevator deflection condition for stick-free condition. **(08 Marks)**

b. How Hinge moment parameters can be estimated? **(06 Marks)**

c. Write short notes on stick force gradient. **(06 Marks)**

4 a. Define static directional stability of an airplane and explain the criteria with the relevant equations and graphs. **(06 Marks)**

b. Briefly explain the requirements for directional control and obtain the expression for rudder control effectiveness, $C_{n_{\delta_r}}$. **(10 Marks)**

c. What is meant by 'Rudder lock' and the 'Dorsal fin'? **(04 Marks)**

PART – B

5 a. Explain the aileron control forces during maneuvers and derive the expression for stick force requirement in the form,

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

b. Obtain the relation for lateral control power, $C_{l_{\delta a}}$. **(06 Marks)**

c. Explain the various methods of aileron balancing. **(04 Marks)**

6 a. Show that the propulsive forces and gravitational forces can create moments with clear sketches with all components with equations of motion. **(10 Marks)**

b. Define longitudinal dynamic stability and briefly describe the following with relevant sketches of Phugoid motion and short period motion. **(10 Marks)**

7 a. Obtain the derivatives due to the change in forward speed. **(10 Marks)**

b. Obtain the derivatives due to the time rate of change of the Angle of attack. **(10 Marks)**

8 Write short notes on the following:

a. Routh's criteria.

b. Effect of wind shear.

c. Flying qualities in pitch.

d. Cooper-Harper scale. **(20 Marks)**

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