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10AE73

Seventh Semester B.E. Degree Examination, Aug./Sept. 2020
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. Explain longitudinal static stability. **(06 Marks)**

b. Briefly explain Fuselage contribution to static stability using Multhopp's method. **(10 Marks)**

c. For a given body combination, the aerodynamic centre lies 0.05 Chord ahead of C.G. The moment coefficient about the aerodynamic centre is -0.016. If the lift co-efficient is 0.45. calculate the moment coefficient about C.G. **(04 Marks)**

2 a. Derive an expression for elevator angle verses equilibrium lift coefficient. **(10 Marks)**

b. Given the general aviation airplane with the following configuration details:

$W = 2750$ kg, $V = 176$ m/s, $X_{cg} = 0.295\ \bar{c}$, $S = 184\ m^2$, $b = 33.4$ m,
$\ell t = 16$ m, $\bar{c} = 5.7$ m, $S_t = 43\ m^2$, $\eta = 1.0$, $C_{L_{\alpha_t}} = 3.91\ rad^{-1}$.

Assume that the pitching moment curve for the landing configuration for the forward most C.G. position is as follows: $C_{m_{cg}} = -0.20 - 0.035\alpha$ where α is in degrees. Estimate the flop effectiveness parameter and the size of the elevator to trim the airplane at the landing angle of attack of 10°, using Fig.Q2(b). Assume that the elevator angle is constrained to +20° and –25°.

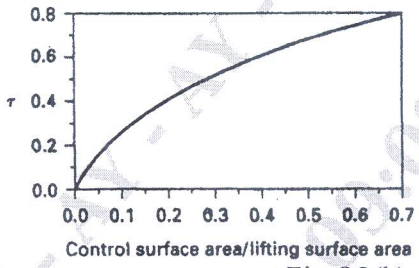

Fig.Q2(b) **(10 Marks)**

3 a. Briefly explain Hinge moment parameters and trim tabs. **(10 Marks)**

b. Derive an expression for stick-free neutral point with necessary graphs and compare it with stick-fixed neutral point. **(10 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. $S_W = 16m^2$, $X_{cg/c} = 0.12$, $b_w = 10.5$m, $AR_w = 7.4$ $\bar{C}_w = 1.6$m, $C_{L_{\alpha wf}} = 0.072$/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: $l_t = 4.5$m, $\eta = 0.98$, $AR_t = 4.76$, $C_{L_{\alpha t}} = 0.069$/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. Starting with x-force equation, use the small disturbance theory to determine the linearized force equation. Assume a steady level flight for the Reference flight conditions. **(10 Marks)**

b. Derive the equation for motion of a Rigid body. **(10 Marks)**

7 a. Show that the coefficient C_{mu} depends on the mach number but also is affected by elastic properties of air frame. **(10 Marks)**

b. Obtain derivatives due to the pitching velocity. **(10 Marks)**

8 a. Determine whether the characteristic equation given below have stable or unstable roots.

i) $2\lambda^3 + 4\lambda^2 + 4\lambda + 12 = 0$

ii) $A\lambda^4 + B\lambda^3 + C\lambda^2 + D\lambda + E = 0$, where A, B, C, D and E are the functions of the longitudinal stability derivatives. **(06 Marks)**

b. Explain cooper – Harper scale. **(07 Marks)**

c. Briefly explain Phugoid response and short period response with neat diagram. **(07 Marks)**

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