CBCS SCHEME

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15AE73

Seventh Semester B.E. Degree Examination, Aug./Sept.2020

Aircraft Stability and Control

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Briefly explain Fuselage contribution to stability using Multhopp's method. **(08 Marks)**

b. A wing-body model is tested in a subsonic wind tunnel. The lift is found to be zero at a geometric angle of attack $\alpha = -1.5°$. At $\alpha = 5°$, the lift coefficient is measured as 0.52. Also, at $\alpha = 1.0°$ and 7.88°, the moment coefficients about the center of gravity are measured as –0.01 and 0.05, respectively. The center of gravity is located at 0.35C. Calculate the location of the aerodynamic center and the value of $C_{m_{ac_{\omega b}}}$. **(08 Marks)**

OR

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

b. For the given general aviation airplane, its forward most center of gravity position is as follows: $C_{m_{cg}} = -0.20 - 0.035\alpha$ where α is in degrees. Estimate flap effectiveness parameter of the airplane at the landing angle of attack of 10°. Assume that the elevator angle is constrained to +20° and –25°.

Reference geometry: S = 184 m^2, S_H = 43 m^2, $C_{L_{\alpha_t}}$ = 3.9 per rad, b = 33.4 m, ℓ_t = 16 m, c = 5.7 m, $\eta = 1$. **(06 Marks)**

Module-2

3 a. How Hinge Moment parameters can be estimated? **(06 Marks)**

b. Derive an expression for stick-free neutral point with necessary graph and compare it with stick-fixed neutral point. **(10 Marks)**

OR

4 a. Obtain an expression for stick force gradients, $\frac{dF}{dV} = K_\rho V(A + {}_{h_{\delta_t}}\ \delta_t)$. **(10 Marks)**

b. Write a short note on Weather Cocking effect. **(06 Marks)**

Module-3

5 a. Obtain a relationship to rate of roll for a given stick force varies inversely with the density of the air and with the velocity, V and also inversely with the span to the fourth power. **(10 Marks)**

b. Explain Dihedral effect. **(06 Marks)**

OR

6 a. For the NAVION airplane, estimate the roll control power, $C_{l_{\delta_a}}$. Assume that the wing and aileron geometry are as:
b/2 = 16.7 m, λ = 0.54, C_r = 7.2 m, C_t = 3.9 m, y_1 = 11.1 m, y_2 = 16 m, s = 184 m^2, $C_{L_{\alpha_\omega}} = 4.44/\text{rad}$, $\tau = 0.36$.

Take for tapered wing; $C = C_r = \left[1+\left(\frac{\lambda-1}{b/2}\right)y\right]$ **(06 Marks)**

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

Module-4

7 a. Briefly explain gravitational and thrust force. **(08 Marks)**

b. 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. **(08 Marks)**

OR

8 a. Derive an expression for change in forward velocity. **(08 Marks)**

b. Obtain the derivatives due to the time rate of change of the angle of attack. **(08 Marks)**

Module-5

9 a. Determine whether the characteristic equations given below have stable or unstable roots:
i) $\lambda^3 + 6\lambda^2 + 12\lambda + 8 = 0$
ii) $2\lambda^3 + 4\lambda^2 + 4\lambda + 12 = 0$ **(08 Marks)**

b. Briefly explain Dutch roll and spiral instability with relevant sketches. **(08 Marks)**

OR

10 Write short notes on:
a. Wind shear
b. Flying qualities
c. Cooper-Harper scale
d. Auto-rotation and spin **(16 Marks)**

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