CBCS SCHEME

USN | | | | | | | | | | 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, η = 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, $C_{\ell_{\delta_a}}$. Assume that the wing and aileron geometry are as:
$b/2 = 16.7$ m, $\lambda = 0.54$, $C_r = 7.2$ 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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