CBCS SCHEME

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17AE73

Seventh Semester B.E. Degree Examination, Jan./Feb.2021
Aircraft Stability & Control

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. The wing fuselage pitching moment characteristics of a high-wing, single-engine, general aviation airplane follow, along with pertinent geometric data : $Cm_{cg_{wf}} = -0.05 - 0.0035\alpha$ where α is the fuselage reference line angle of attack in degrees and wf means wing fuse lage.

$S_w = 178\ m^2$, $\frac{x_{cg}}{C} = 0.1$, $b_w = 35.9\ m$, $AR_W = 7.3$, $\tau_W = 5\ m$, $C_{L_{\alpha_{wf}}} = 0.07/deg$, $i_w = 2.0^\circ$, $C_{L_{\alpha=0}} = 0.26$.

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 tail contribution. Assume $\ell_t = 14.75\ m$, $\eta = 1$, $AR_t = 4.85$, $C_{L_{\alpha_t}} = 0.073/deg$. **(10 Marks)**

b. Derive expression for wing contribution for the longitudinal static stability of an airplane. **(10 Marks)**

OR

2 a. Derive the expression for elevator control power. **(10 Marks)**

b. At its forward most center of gravity position is as follows : $C_{m_{cg}} = -0.20 - 0.035\alpha$, where α is in degrees. Estimate the size of the elevator to trim the airplane at the landing angle of attack of 10° and Flop effectiveness parameter. Assume that the elevator angle is constrained to +20° and −25°. $\ell_t = 16\ m$, $S_t = 43\ m^2$, $S = 184\ m^2$, $C = 5.7\ m$, $C_{L_{\alpha_t}} = 3.91\ rad^{-1}$, $\eta = 1$

τ	0.24	0.32	0.49	0.58	0.62
S_C / S_t	0.1	0.2	0.3	0.4	0.5

(10 Marks)

Module-2

3 a. With a help of diagram and expression, explain the control surface floating characteristics and aerodynamic balance. **(10 Marks)**

b. Derive the equation for stick-free neutral point. **(10 Marks)**

OR

4 a. Briefly explain the requirements for direction control and obtain the expression for rudder control effectiveness. **(10 Marks)**

b. Obtain an expression for stick force gradient $\frac{dF}{dV} = K\rho V\left(A + Ch_{\delta_t}\delta_t\right)$ **(10 Marks)**

Module-3

5 a. Explain the effect of wing sweep, flaps and power on dihedral effect. **(10 Marks)**

b. 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, $\lambda = 0.54$, $C_r = 7.2$m, $C_t = 3.9$ m, $y_1 = 11.1$ m, $y_2 = 16$m, $S = 184$ m^2, $C_{L_{\alpha_\omega}} = 4.44/\text{rad}$. $C_{a/c} = 0.18$m, $\tau = 0.36$.

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

c. Explain Dihedral effect. **(04 Marks)**

OR

6 a. Write short notes on Aileron reversal and Adverse yaw effect. **(10 Marks)**

b. Obtain the relation for Lateral Control Power. **(10 Marks)**

Module-4

7 a. Derive equation of motion of rigid body. **(10 Marks)**

b. Explain Aerodynamic force and moment representation. **(10 Marks)**

OR

8 a. Derive an expression for change in forward velocity. **(10 Marks)**

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

Module-5

9 a. Examine the two potential cases where the Routh method breaks down. The two characteristic equations are as follows:

(i) $\lambda^5 + \lambda^4 + 3\lambda^3 + 3\lambda^2 + 4\lambda + 6 = 0$

(ii) $\lambda^6 + 3\lambda^5 + 6\lambda^4 + 12\lambda^3 + 11\lambda^2 + 9\lambda + 6 = 0$ **(10 Marks)**

b. Explain Dutch roll and Spiral Instability with relevant sketches. **(10 Marks)**

OR

10 Write short notes on:

a. Wind shear.

b. Flying qualities.

c. Cooper-Harper scale.

d. Auto-rotation and spin. **(20 Marks)**

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