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10AE73

# Seventh Semester B.E. Degree Examination, July/August 2021

## Aircraft Stability and Control

Time: 3 hrs. Max. Marks:100

***Note: Answer any FIVE full questions.***



1 a. Define longitudinal static stability and derive an expression for tail contribution ($C_{M\alpha_t}$) for the static longitudinal stability of an airplane. **(10 Marks)**

b. For the given general aviation airplane data, determine the contribution of the wing and tail to the $C_m$ versus $\alpha$ curve. Assume standard sea-level atmospheric conditions W = 2750 N, V = 176 M/S, $X_{cg} = 0.295\ \bar{C}$

| Wing airfoil characteristics | Tail Airfoil section |
|---|---|
| $C_{M_{ac}} = 0.116$<br>$C_{l_\alpha} = 0.097/\text{deg}$<br>$\alpha_{O_L} = -5°$<br>$X_{ac} = 0.25\,\bar{C}$<br>$i_w = 1.0°$ | $C_{l_\alpha} = 0.01/\text{deg}$<br>$C_{M_{ac}} = 0.0$<br>$i_t = -1.0°$<br>$C_{L\alpha_t} = 3.91\ \text{rad}^{-1}$ |

Reference geometry: S = 184 $m^2$, $S_H$ = 43 $m^2$ = $S_t$, b = 33.4 m, $l_t$ = 16 m, $\bar{C}$ = 5.7 m, $\eta$ = 1. **(10 Marks)**

2 a. Derive an expression for elevator angle to trim and with the help of pitching moment curves. How elevator angle to trim can be obtained? **(10 Marks)**

b. Explain the effect of elevator required for landing and restriction of forward limit of C.G. range. **(10 Marks)**

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

b. Derive an expression for stick force gradients in unaccelerated flight and also obtain the expression for the slope of the stick force versus speed curve. **(10 Marks)**

4 a. Obtain an expression for rudder control effectiveness. **(06 Marks)**

b. Explain the contribution of aircraft components to directional stability. **(06 Marks)**

c. Obtain an expression for the stability contribution of the virtual tail with a free rudder. **(08 Marks)**

5 a. For the following data of 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 $m^2$, $C_{L\alpha_w}$ = 4.44/rad, $\tau$ = 0.36. consider for a tapered wing the chord can be expressed as a function of y by the following relationship

$$C = C_r\left[1 + \left(\frac{\lambda - 1}{b/2}\right)y\right]$$ **(10 Marks)**

b. Describe the coupling between rolling and yawing moments. **(10 Marks)**

6 a. Develop the equations of longitudinal motion for airplane pure pitching condition. **(12 Marks)**
b. Write short notes on orientation and position of the airplane. **(08 Marks)**

7 a. Obtain the derivatives due to the pitching velocity. **(10 Marks)**
b. Obtain the derivatives due to the rolling rate. **(10 Marks)**

8 Write short notes on the following:
a. Effect of wind shear
b. Flying qualities in pitch
c. Spiral, rolling and dutch roll mode
d. Roll-Pitch-Yaw inertial coupling **(20 Marks)**

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