Code No: RR322101 **Set No. 1**

III B.Tech II Semester Supplementary Examinations,
November/December 2005
AIRCRAFT STABILITY AND CONTROL
(Common to Aeronautical Engineering and Aeronautical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. The axis system associated with an airplane may be depicted with a sketch. Now explain the equilibrium of forces and moments acting on the airplane, illustrated with sketches and plots. How are these forces and moments controlled? [16]

2. The geometrical and aerodynamic characteristics of a glider are given as follows; Wing AR=8(NACA 23012, a_0 = 0.104,α_{0L} = -1.2),Hor.Tail AR = 4 (NACA 0009.a0 = 0.110), Tail volume ratio $\overline{V}$ =0.64 ,rate of change of down wash $\frac{d\varepsilon}{d\alpha}$ = 0.5,tail efficiency $\eta_t = 0.9$,Aerodynamic centre at 0.24c , $\left(\frac{dC_m}{dC_L}\right)_{Fus} = 0.08$,Elevator area ratio S_e/S_t =0.35 .Calculate the Stick fixed neutral point [16]

3. Describe with sketches /plots the occurrence of hinge moments on the horizontal tail from the pressure distribution due to angle of attack α and the deflections $\delta_e and \delta_t$ from elevator and tab. Hence define the terms floating tendency and restoring tendency. Describe ways and means to alleviate or control these hinge moments. [16]

4. Show that an expression for the difference between stick-fixed and stick-free neutral points is given as follows
$N_0 - N_0' = \frac{a_t\,\overline{V}\,\eta\,C_{h\alpha}}{a_w\,C_{h\delta}}\tau\left(1 - \frac{d\varepsilon}{d\alpha}\right)$ with usual notations. [16]

5. Establish with sketches and plots that the wing sweep-back ($+\Lambda$) produces positive dihedral effect i.e $-C_{l'\beta}$. [16]

6. Explain the conditions under which $C_{n\beta}$ is equal to negative of $C_{n\psi}$. Hence bring out the requirement of dorsal fin from the contribution of vertical tail-fuselage combination. [16]

7. The characteristic equation of dynamic longitudinal stability of an airplane was obtained as below; $A\lambda^4 + B\lambda^3 + C\lambda^2 + D\lambda + E = 0$, where A = 1 ,B = 10 ,C = 100 ,D = 600 , E = 2000 . Work out the period, $N_{1/2}$ and $t_{1/2}$of the phugoid oscillations.Provide the basis of your recognizing the oscillation to be as such. [16]

8. The characteristic equation of lateral dynamic stability is ; $A\lambda^4 + B\lambda^3 + C\lambda^2 + D\lambda + E = 0$, where A = 1, B = 9.417 , C = 13.982 , D = 48.102 and E = 0.0425 .Extract the roots of this equation by an approximate technique and comment on the stability of the modes of airplane motion. Work out the details of the motions of airplane. [16]

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1. Explain the terms static and dynamic stability associated with an airplane. Is the stability part of the airplane design and operation? Does the pilot apply control in this respect? Please illustrate. [16]

2. The geometrical and aerodynamic characteristics of a glider are given as follows; Wing AR=8(NACA 23012, a_0 = 0.104,α_{0L} = -1.2),Hor.Tail AR = 4 (NACA 0009.a0 = 0.110), Tail volume ratio $\overline{V}$=0.63 ,rate of change of down wash $\frac{d\varepsilon}{d\alpha}$ = 0.5,tail efficiency $\eta_t = 0.9$,Aerodynamic centre at 0.24c ,$\left(\frac{dC_m}{dC_L}\right)_{Fus} = 0.08$,Elevator area ratio S_e/S_t =0.35 .Calculate the Stick fixed neutral point [16]

3. Make use of sketches /plots to explain the term 'hinge moments' on the horizontal tail from the pressure distribution due to angle of attack α and the deflections δ_e and δ_t from elevator and tab. Hence define the terms 'floating tendency and restoring tendency'. Describe ways and means to alleviate or control these hinge moments. [16]

4. The geometrical and aerodynamic characteristics of a glider are given as follows; Wing AR=8(NACA 23012, $a_0 = 0.104$,α_{0L} = -1.2),Hor.Tail AR = 4 (NACA 0009. $a_0 = 0.110$ per degree), Tail volume ratio $\overline{V}$ =0.6 ,rate of change of down wash $\frac{d\varepsilon}{d\alpha}$ = 0.5,tail efficiency $\eta_t = 0.9$,Aerodynamic centre at 0.24c, $\left(\frac{dC_m}{dC_L}\right)_{Fus} = 0.08$,Elevator area ratio S_e/S_t =0.35, floating tendency $C_{h\alpha} = -0.003$, restoring tendency$C_{h\delta}$ = -0.0055, Residual hinge moments $C_{h0} = 0$. Calculate the Stick free neutral point, N_0' . [16]

5. Prove that an airplane with swept back wing($+\Lambda$) produces left rolling moments when it meets right side-slip i.e. it produces positive dihedral effect i.e $-C_{l'\beta}$. Make use of sketches and plots in this respect. [16]

6. If the rudder angle δ_r required to produce sideslip ψ is given by $\delta_r = \frac{d\delta_r}{d\psi}\psi$, then obtain the expression for $\frac{dPF}{d\psi}$, the gradient of pedal force v/s sideslip. [16]

7. The characteristic equation of dynamic longitudinal stability of an airplane was obtained as below; $A\lambda^4 + B\lambda^3 + C\lambda^2 + D\lambda + E = 0$, where A = 1 ,B = 10 ,C = 100 ,D = 600 , E = 2000 . Work out the period, $N_{1/2}$ and $t_{1/2}$of the phugoid oscillations.Provide the basis of your recognizing the oscillation to be as such. [16]

8. Describe the phenomenon of spinning of an airplane. What are its characteristics? Make use of figures to explain the balance of forces. [16]

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Code No: RR322101 **Set No. 3**

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Establish that the terms static and dynamic stabilities are associated with an airplane. Is the stability part of the airplane design and operation? Does the pilot apply control in this respect? Please illustrate. [16]

2. The geometrical and aerodynamic characteristics of a glider are given as follows; Wing AR=8(NACA 23012, a_0 = 0.104),α_{0L} = -1.2),Hor.Tail AR = 4 (NACA 0009.a0 = 0.110), Tail volume ratio $\overline{V}$ =0.6 ,rate of change of down wash 2.$\frac{d\varepsilon}{d\alpha}$ = 0.5, tail efficiency η_t = 0.9,Aerodynamic centre at 0.24c , $\left(\frac{dC_m}{dC_L}\right)_{Fus}$ = 0.08 Elevator area ratio S_e/S_t= 0.35.Calculate the Stick fixed neutral point. [16]

3. Define the terms 'floating tendency and restoring tendency'. What is floating of a control surface? Describe ways and means to alleviate or control these hinge moments by an arrangement known **Internal Balance**. [16]

4. The geometrical and aerodynamic characteristics of a glider are given as follows; Wing AR=8(NACA 23012, a_0 = 0.104,α_{0L} = -1.2),Hor.Tail AR = 4 (NACA 0009. a_0 = 0.110 per degree), Tail volume ratio $\overline{V}$ =0.6,rate of change of down wash $\frac{d\varepsilon}{d\alpha}$ = 0.5,tail efficiency η_t = 0.9 ,Aerodynamic centre at 0.24c, $\left(\frac{dC_m}{dC_L}\right)_{Fus}$ = 0.08,Elevator area ratio S_e/S_t =0.36, floating tendency $C_{h\alpha} = -0.003$, restoring tendency$C_{h\delta}$ = -0.0055, Residual hinge moments $C_{h0} = 0$. Calculate the Stick free neutral point, $N_0^{'}$. [16]

5. An airplane with positive dihedral develops left rolling moments when it meets right side slip. Prove that $C_{l'\beta} = -\frac{2\Gamma}{57.3}\frac{dC_L}{d\beta}\frac{\overline{y}}{b}\frac{S_\Gamma}{S}$,with standard notations. [16]

6. Consider the contribution of vertical tail to weather cock stability and prove from fundamental considerations that $(C_{n\beta})_{tail} = \frac{dC_N}{d\alpha_t}\frac{q_t S_t l}{qSb}$ .Show that it is possible to enhance the directional characteristics of a vertical tail-fuselage combination by the incorporation of a dorsal fin. [16]

7. The phugoid oscillations of the airplane are treated as a result of the exchange of airplane's kinetic energy and potential energy which may be considered in the form of the motion of airplane given by $m\ddot{Z}+(W-L)=0, where L \propto V^2 and W \propto V_0^2$ .L is the instantaneous value of the lift. Show that the time period of the oscillations is given by $T = \sqrt{2}\pi\frac{V_0}{g}$. [16]

8. The characteristic equation of lateral dynamic stability is ; $A\lambda^4 + B\lambda^3 + C\lambda^2 + D\lambda + E = 0$, where A = 1, B = 14.5 , C = 69.4 , D = 40 and E = -74.8 .Extract the

roots of this equation by an approximate technique and comment on the stability of the modes of airplane motion. Work out the details of the motions of airplane. [16]

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1. The axis system associated with an airplane may be shown with a sketch. Now explain the equilibrium of forces and moments acting on the airplane, illustrated with sketches and plots. How are these forces and moments controlled? [16]

2. Explain the mechanism on elevator required for landing of an airplane and that it is given by
$x_{cgfwd} = x_{ac} - \frac{C_{m\delta}}{C_{L\max}}\left[\delta_{e\max} + \frac{(\alpha_w - \varepsilon - i_w + i_t)}{\tau} + \frac{C_{mac}+C_{mFus}+C_{mp}}{C_{m\delta}}\right]$.
Hence show that the rearward shift of the limiting forward c.g location is given by $(\Delta x_{cg})_{fwd} = \Delta\delta_{eg-0}\frac{C_{m\delta}}{C_{L\max}}$. [16]

3. Define the terms 'floating tendency and restoring tendency'. What is floating of a control surface? Describe ways and means to alleviate or control these hinge moments by an arrangement known as **Beveled Trailing Edge**. [16]

4. The geometrical and aerodynamic characteristics of a glider are given as follows; Wing AR=8(NACA 23012, $a_0 = 0.104$,α_{0L} = -1.2),Hor.Tail AR = 4 (NACA 0009. $a_0 = 0.110$ per degree), Tail volume ratio $\overline{V}$ =0.6,rate of change of down wash $\frac{d\varepsilon}{d\alpha} = 0.5$,tail efficiency $\eta_t = 0.9$,Aerodynamic centre at 0.24c, $\left(\frac{dC_m}{dC_L}\right)_{Fus} = 0.085$,Elevator area ratio S_e/S_t =0.35, floating tendency $C_{h\alpha} = -0.003$, restoring tendency$C_{h\delta} = -0.0055$, Residual hinge moments $C_{h0} = 0$. Calculate the Stick free neutral point, N_0' . [16]

5. Establish that $C_{l'\beta} = -\frac{2\Gamma}{57.3}\frac{dC_L}{d\beta}\frac{\overline{y}}{b}\frac{S_\Gamma}{S}$ holds for an airplane with dihedral when a right side-slip produces left rolling moments (with standard notations) . [16]

6. Illustrate with a sketch that positive static directional stability of airplane is termed Weather Cock stability. Describe the directional characteristics of the vertical tail and show that only vertical tail contributes to positive stability. [16]

7. Obtain expressions for $C_{m\delta}, C_{md\delta}, C_{md\alpha} and C_{md\theta}$.Explain the significance and role of these stability derivatives in the longitudinal dynamics of airplane. [16]

8. Describe the phenomenon of spinning of an airplane. What are its characteristics? Make use of figures to explain the balance of forces. [16]

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