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

III B.Tech. II Semester Regular Examinations, April/May -2005
AIRCRAFT STABILITY AND CONTROL
(Aeronautical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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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.

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 $\frac{d\varepsilon}{d\alpha} =$ 0.5,tail efficiency $\eta_t = 0.9$,Aerodynamic centre at 0.24c ,$\left(\frac{dC_m}{dC_L}\right)_{Fus} = 0.083$,Elevator area ratio S_e/S_t =0.35 .Calculate the Stick fixed neutral point

3. How do hinge moments occur on a control surface? Explain it 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.

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 $\overline{V}$ =0.64,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, 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' .

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

6. Explain the Weather Cock stability of an airplane with illustrations. What is the contribution of wing, fuselage, power unit and empennage to this phenomenon? Make use of sketches and plots. Hence describe the stability criterion.

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.

8. The oscillatory mode from the lateral-directional stability quartic is given by $\lambda^2 + B\lambda + C = 0$, where B = 2.97 and C = 38.36.Obtain the characteristics of the oscillation and its simple analysis in terms of stability derivatives.

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 Set No.2

III B.Tech. II Semester Regular Examinations, April/May -2005
AIRCRAFT STABILITY AND CONTROL
(Aeronautical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks
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1. Make use of a detailed sketch and illustrate the existence and utility of different control surfaces on an airplane, clearly bringing about the necessity of the same. Describe with sketches / plots the forces and moments associated in this regard.

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 $\frac{d\varepsilon}{d\alpha}$ = 0.5tail efficiency $\eta_t = 0.9$,Aerodynamic centre at 0.24c , $\left(\frac{dC_m}{dC_L}\right)_{Fus}$ = 0.075,Elevator area ratio S_e/S_t =0.35 .Calculate the Stick fixed neutral point

3. Explain the terms 'floating tendency and restoring tendency' associated with a control surface. Describe the aerodynamic balancing of a control surface along with the desired objectives. Explain the use of shielded horn in this respect.

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, $N_0^{'}$.

5. Prove that an airplane with swept back wing 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.

6. Explain the Weather Cock stability of an airplane with illustrations. What is the contribution of wing, fuselage, power unit and empennage to this phenomenon? Make use of sketches and plots. Hence describe the stability criterion.

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 = 4 ,C = 10 ,D = 1.0 , E = 3.8 . 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.

8. Explain the aerodynamics of the recovery from spin. What are the geometrical modifications possible for improving spin resistance of an airplane?

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

III B.Tech. II Semester Regular Examinations, April/May -2005
AIRCRAFT STABILITY AND CONTROL
(Aeronautical Engineering)

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.

2. Consider the static longitudinal stability of an airplane with aft-tail location. Establish the useful relationship $\frac{d\delta_e}{dC_L} = -\frac{dC_m/C_L}{C_{m\delta}}$where δ_e is the elevator deflection and $C_{m\delta}$ is the elevator power.

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 **Trim tab**.

4. Develop the expression for stick force in unaccelerated flight given by $F_s = K\frac{1}{2}\rho V^2 \left[A + C_{h\delta t}\delta_t - C_L\left(\frac{dC_m}{dC_L}\right)_{free}\frac{C_{h\delta}}{C_{m\delta}}\right]$.Hence obtain the slope of stick force v/s speed curve and provide the nature of the gradient term.

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

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.

7. Consider an airplane in cruising flight at an altitude.It meets an upgust for about 20 seconds.Make use of sketches and plots to illustrate the after-gust behavior of the airplane's motion in support of your answer. Consider all possible options and explain the aerodynamics involved.

8. Explain the on-set of the problem of spin in airplane dynamics. Describe the important characteristics of spinning. Show the balance of forces and moments during spinning of airplane. Suggest the procedure of recovery from spinning.

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Code No: RR322101 **Set No.4**

III B.Tech. II Semester Regular Examinations, April/May -2005
AIRCRAFT STABILITY AND CONTROL
(Aeronautical Engineering)

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

Answer any FIVE Questions
All Questions carry equal marks

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1. Show with a sketch, different components of a conventional airplane. Hence describe the axis system associated with an airplane. Now explain the equilibrium of forces and moments acting on the airplane, illustrated with sketches and plots. How are these forces and moments controlled?

2. Derive the relationship between elevator angle required to trim a particular C_{Ltrim} .Present the relationship in the following form ; $\delta_{etrim} = \delta e0 + \frac{d\delta_e}{dC_L} C_{Ltrim}$.Provide explanation for each term.

3. How do hinge moments occur on a control surface? Explain it 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.

4. Derive the expression for stick force in unaccelerated flight given by $F_s = K\frac{1}{2}\rho V^2 \left[A + C_{h\delta t}\delta_t - C_L \left(\frac{dC_m}{dC_L}\right)_{free} \frac{C_{h\delta}}{C_{m\delta}} \right]$ .Plot the stick force v/s velocity curve and show that a stable airplane refuses to trim out with a nose-down tab for a given trim speed.

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

6. Sketch airplane configurations for weather cock stability for different values of $C_{n\psi}$ as below $C_{n\psi}$ =0 , $C_{n\psi} > 0$, $C_{n\psi} < 0$ .Describe each option with yourself as an airplane designer.

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

8. Describe the problem of autorotation in airplanes. Show that it results from aerodynamic and inertial moments and that it is a post-stall phenomenon.

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