Bengal Engineering and Science University, Shibpur
B. E. (Aero.) Part-II 4th Semester Final Examination, 2013
Fundamentals of Aerospace Engineering (AE 406)

Time: 3 Hrs. Full Marks: 70

Answer any five of the following questions

1. Show that the ratio of temperature at sonic condition to total temperaure at a point in a compressible flow of air is 0.833. 5

b) Derive Prandtl relation. 5

c) Show that total density decreases across a normal shock. 4

2. a) Show that velocity component along an oblique shock wave remains constant. 7
   b) Derive the expression θ-β-M across an oblique shock. 7

3. Derive the expressions for velocity and pressure distribution on the surface of a circular cylinder for a two dimensional inviscid incompressible flow around. 14

4. (a) Explain (i) hysteresis loop in strain hardening (ii) creep rate (iii) Miner's cumulative damage equation and its applicability.

   3x3=9

   (b) Discuss in brief, the principal aerodynamic forces appearing on a generic airplane during flight, with suitable schematic diagram(s).

   5

5. Show the major components of a generic aircraft in a typical sub-assembly breakdown sketch. Discuss the components in brief.

   5+9 = 14

6. (a) Sketch a typical C_m vs α plot and explain the condition for trim.

   3

   (b) The pitching moment coefficient curve from wing body tail combination of an airplane is given by the expression $C_{M,cg} = C_{M,ac_{wb}} + C_{L_{wb}}\left(h - h_{ac_{wb}}\right) - V_H C_{L,t}$,where the symbols have their usual meaning. Find the expression of $C_{M,cg}$ considering the effect of elevator deflection and derive the expression for elevator angle to trim. 7

(c) The NACA 64-412 airplane has an elevator added to the horizontal tail. The elevator control effectiveness $\left(\frac{\partial C_{L,t}}{\partial \delta_e}\right)$ is 0.04. Pitching moment coefficient at zero angle of attack $(C_{M,0})$ is 0.139. Slope of C_m vs α_a curve $\left(\frac{\partial C_{M,cg}}{\partial \alpha_a}\right)$ is given as -0.04 and tail volume ratio (V_H) is 0.5926. Calculate the elevator deflection angle necessary to trim the airplane at an angle of attack of 8^0 4

7. (a) State the difference between stick-free and stick-fixed longitudinal stability. 3

(b) Derive the expression for free elevator factor and explain the effect on this factor on stick-free static margin. 5

(c) The NACA 64-412 airplane has elevator control effectiveness $\left(\frac{\partial C_{L,t}}{\partial \delta_e}\right)$ is 0.04, lift slope of the tail (a_t) is 0.12 per degree, tail volume ratio (V_H) is 0.5926, tail setting angle (i_t) is 2^0, downwash angle when wing-body combination is at zero life (ε_0) is zero, $\frac{\partial \varepsilon}{\partial \alpha}$ is 0.42, lift slope of the wing body (a) is 0.09, location of aerodynamic center/chord length $(h_{ac,wb})$ is 0.24, location of center of gravity/chord length (h) is 0.26, the elevator hinge moment derivatives are $\left(\frac{\partial C_{he}}{\partial \alpha_t}\right)$ is -0.007, $\left(\frac{\partial C_{h_e}}{\partial \delta_e}\right)$ is -0.012. Assess the stick-free static margin of this configuration and compare it with stick-fixed static margin of the airplane. 6

8. (a) State the static stability criteria for directional stability and lateral stability of an airplane. 4

(b) Derive the expression for airplane yaw moment coefficient (C_n) in terms of vertical tail volume ratio, ratio of dynamic pressures at rudder and wing, rudder control effectiveness and rudder deflection. 5

(c) What is dihedral effect? Explain this effect by drawing suitable velocity triangle for dihedral wings. 5