Question Paper Code : P 1016

Time : Three hours   Maximum : 100 marks

(Gas Tables Permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define isentropic compressibility.

2. Distinguish between thermally perfect gas and calorically perfect gas.

3. Define characteristic Mach number and what is the maximum value of it?

4. State the importance of Rayleigh supersonic Pitot formula.

5. What do you meant by Mach reflection?

6. Distinguish between Mach lines and compression waves.

7. What is the effect of sweep back on compressibility?

8. Define wave drag.

9. Sketch the different types of supersonic profiles.

10. What is the special feature of a transonic test section?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Air at 30°C and 101 kPa is drawn through a convergent-divergent nozzle which discharges into a large vacuum tank. Determine the conditions upstream and downstream of a normal shock which is located at the nozzle exit. The nozzle throat and exit have areas of 0.025 m² and 0.0724 m², respectively.   (8)

(ii) Show that the maximum mass flow rate in terms of P_0, T_0 and A_{th} for isentropic flow of a perfect gas through a nozzle is given by

$$\dot{m}_{max} = A_{th}\sqrt{\frac{\gamma}{RT_0}}P_0\left(\frac{2}{\gamma+1}\right)^{\left(\frac{\gamma+1}{2(\gamma-1)}\right)}$$ where γ, is the ratio of specific

heats and R is the gas constant. (8)

Or

(b) (i) Explain the term choking in a C-D nozzle and the flow conditions leading to the same. Hence describe with illustrations

(1) an under-expanded,

(2) correctly expanded and

(3) over-expanded nozzle. (8)

(ii) Derive Hugoniot equation. (8)

12. (a) (i) A normal shock moves in a constant area tube. In the region ahead of the shock, $V_1 = 100$ m/s, $T_1 = 30°C$ and $P_1 = 0.7$ atm. The shock speed with respect to a fixed co-ordinate system is 600 m/s. Find the fluid properties in the region aft of the moving normal shock. (8)

(ii) Explain with sketches and plots

(1) Shock waves and Mach waves and (4)

(2) Strong and weak shock waves. (4)

Or

(b) (i) A supersonic stream of air at M = 3 and 1 atm passes through a sudden convex and then a sudden concave corner of turning angle 15° each. Determine Mach number and pressure of flow downstream of the concave corner. (8)

(ii) An uniform supersonic flow of air at Mach 3.0 and $P_1 = 0.05$ atm passes over a cone of semi-vertex angle 8° kept in line with the flow. Determine the shock angle and the static pressure at the cone surface, just behind the shock. (8)

13. (a) (i) Show that for weak oblique shocks the strength of the wave is proportional to the deflection angle. (8)

(ii) A Mach 2 air stream passes over a 10° compression corner. The oblique shock from the corner is reflected from a flat wall which is parallel to the freestream, as shown in Fig. 1. Compute the angle of the reflected shock wave relative to the flat wall and the Mach number downstream of the reflected shock. (8)
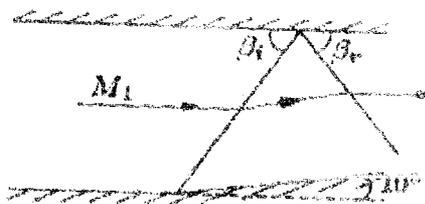

Fig.1 (For Problem 13(a) (ii))

Or

(b) (i) Derive the relations to obtain C_L and C_D for a two-dimensional wing having cross section of thin double wedge at small angle of attack. State all the assumptions. (8)

(ii) A wing having double wedge section has the maximum thickness of 20% of chord. The top surface is flattened symmetrically from center. If the length of the flat surface is 50% of chord, what change in lift and drag is expected due to this change in shape at freestream Mach number of 2 and angle of attack of 2 degree. (8)

14. (a) (i) Based on small perturbation theory, derive the linearized velocity potential equation for compressible flows. (10)

(ii) Based on the above equation establish the Prandtl-Glauert rule. (6)

Or

(b) (i) Consider an infinitely thin flat plate at a 5° angle of attack in a Mach 2.6 freestream. Calculate the lift and drag coefficients using shock expansion theory. (10)

(ii) Write a brief note on critical Mach number and drag divergence Mach number. (6)

15. (a) (i) Explain the working principle of shock tube with a neat sketch and list its uses. (8)

(ii) Draw the sketch of Mach-Zehnder interferometer and explain the formation of dark and bright fringes in the interferometer. (8)

Or

(b) (i) What are the different optical methods of flow exploration? Explain with suitable diagram the Schlieren system. (10)

(ii) Discuss transonic area rule and supercritical airfoil. (6)