Question Paper Code : 51028

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2014.

Fifth Semester

Aeronautical Engineering

AE 2303/AE 1303/AE 53/10122 AE 503 — AERODYNAMICS – II

(Regulation 2008/2010)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write down the energy equation as applied to a control volume in fluid flow and brief the terms involved.

2. Define chocked flow with a suitable example.

3. What are the properties of a gas flow after it passes through a normal shock?

4. Why are the angle of incidence and reflected shock wave not equal?

5. A gas enters a constant area pipe at a subsonic Mach number and the flow is adiabatic. If friction is present, describe the flow if the pipe has length greater than the critical length.

6. Define characteristic line.

7. How do the solutions to small disturbance equations differ for subsonic and supersonic flows?

8. Sketch the pressure distribution on a flat plate at a small angle of attack for subsonic and supersonic flows and describe the differences.

9. Define transonic area rule.

10. State the meaning of shock induced separation.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Derive an expression for Mach number in a subsonic, isentropic flow in terms of the ratio of Stagnation pressure to static pressure. (8)

(ii) A pitot static tube is used to measure the velocity of air in subsonic isentropic flow. The free stream static pressure is 96 kPa and the free stream temperature's 300 K. The stagnation pressure is measured as 130 kPa. Determine the air velocity assuming the flow is compressible and also assuming the flow to be incompressible. (8)

Or

(b) (i) Show that the mass flow rate per unit area in a duct with isentropic flow is a maximum. Where the Mach number is unity? (8)

(ii) Air is expanded isentropically in a nozzle from stagnation pressure of 20 bar and stagnation temperature of 473K. At a point the static pressure is 2 bar and the mass flow rate is 5 kg/s. Determine the cross sectional area, Mach number and throat area of the nozzle. (8)

12. (a) (i) Derive Prandtl's relation for a normal shock. (8)

(ii) Air is expanded isentropically from a reservoir in which the pressure is 1000 kPa and the temperature is 303 K until the pressure has dropped to 25 kPa. A normal shock occurs at this point. Find the static pressure, static temperature and stagnation pressure after the shock. (8)

Or

(b) (i) Derive the Rankine-Hugoniot relation connecting the pressure ratio across the shock with the density ratio across the shock. (8)

(ii) A normal shock wave propagates down a constant area duct into stagnant air at a pressure of 100 kPa and a temperature of 300 K. If the pressure ratio across the shock wave is 3, find the Shock speed, and the velocity of air behind the shock. (8)

13. (a) (i) Show that the upper branch of Fanno curve represents subsonic flow and the lower branch represents supersonic flow. (6)

(ii) Air flows under adiabatic conditions through a pipe of diameter 0.15 m. At the inlet the Mach number is 0.1, the pressure is 70 kPa, and the temperature is 308K. The mean friction factor is 0.005. If the exit Mach number is 0.8, calculate the length of the pipe, the exit temperature and the exit pressure. (10)

Or

(b) (i) Show that the point of maximum entropy on the Rayleigh line represents the point where the Mach number is unity. (6)

(ii) Air enters a constant area combustion chamber with a Mach number of 0.2 and stagnation temperature of 393 K. What is the amount of heat to be added to unit mass of air for the Mach number to be 0.7 at the exit? Also calculate the maximum amount heat that can be added to unit mass of air. (10)

14. (a) (i) Using linearized subsonic potential equation, derive an expression for the coefficient of pressure over a thin body at a small angle of attack. (8)

(ii) A thin flat plate is kept at angle of attack of 4 degrees in a uniform subsonic stream of Mach number 0.6. The coefficient of pressure at mid chord in incompressible flow is given as $C_p = -0.07$. Determine the pressure coefficient at the same point for Mach number 0.6. (8)

Or

(b) (i) A supersonic parallel stream with velocity V undergoes a small turn $d\theta$ from its initial direction which is accompanied by a small change in velocity dV. If the change takes place under isentropic condition, derive a relation connecting dV and $d\theta$. (8)

(ii) A flat plate of chord 1 m is kept at a small angle of 3 degrees in a parallel supersonic stream of Mach number 2.5. The free stream static pressure is 100 kpa, and the temperature is 280 K. Determine the static pressure on the upper side of the flat plate. (8)

15. (a) (i) Derive an expression for the pressure coefficient Cp in a supersonic flow if the disturbance velocity is small. (8)

(ii) A thin flat plate is kept at an angle of attack of 5 deg. in a supersonic stream of Mach number 2.0. Determine the pressure on the upper and lower surfaces and hence the lift and drag coefficients for the flat plate. (8)

Or

(b) (i) Explain what is meant by shock expansion method with a suitable example. (8)

(ii) A flat plate is kept at an angle of attack of 5 degrees in a supersonic parallel stream of Mach number 2.5. The free stream static pressure is 100 kPa and static temperature is 300 K. Determine the lift and drag coefficients using shock expansion method. (8)