C 21463 (Pages : 3) Name.....

Reg. No.....

EIGHTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION APRIL 2017

ME 09 802—COMPRESSIBLE FLUID FLOW

(2009 Admissions)

Time : Three Hours Maximum : 70 Marks

Use of Gas table is permitted.

Part A

Answer **all** *questions.*
Each question carries 2 *marks.*

1. Define zone of action and zone of silence.
2. Determine the velocity of sound in air at 35°C. What should be the minimum temperature of air if it has to be hypersonic when it has a velocity of 1500 m/s ?
3. The pressure, temperature and Mach number of the gas at exit are 2 bar, 1200°C and 0.7 respectively. The ratio of stagnation temperature at exit to entry is 3.85. Calculate pressure and temperature of the gas at entry.
4. A circular duct passes 8.25 kg/s. of air at an exit Mach number of 0.5. The entry pressure and temperature is 3.5 bar and 38°C respectively and coefficient of friction is 0.005. If the Mach number at entry is 0.15, determine diameter of the duct.
5. Show the normal shock in *h-s* diagram with the help of Rayleigh line and Fanno line.

(5 × 2 = 10 marks)

Part B

Answer any **four** *questions.*
Each question carries 5 *marks.*

6. Air enters a straight axisymmetric duct at 300 K, 3.45 bar and 150 m/s and leaves it at 277 K, 2.058 bar and 260 m/s. the area of cross-section at entry is 500 cm^2. Assuming adiabatic flow, determine stagnation temperature, maximum velocity, mass flow rate and area of cross-section at exit.
7. Derive an expression for the mass flow rate in flow through a convergent divergent nozzle in terms of pressure ratio and inlet conditions of the gas.
8. The pressure, temperature and Mach number of the gas at exit are 2 bar, 1200°C and 0.7 respectively. The ratio of stagnation temperature at exit to entry is 3.85. Calculate pressure and temperature of the gas at entry.

Turn over

9. A circular duct passes 8.25 kg/s. of air at an exit Mach number of 0.5. The entry pressure and temperature is 3.5 bar and 38°C respectively and coefficient of friction is 0.005. If the Mach number at entry is 0.15, determine diameter of the duct.

10. Shock waves cannot develop in subsonic flow ? Why ?

11. Briefly discuss about strength of normal shock wave.

(4 × 5 = 20 marks)

Part C

Answer **all** *questions.*

12. (a) An aircraft is flying at an altitude of 11,000 metres, at 800 km/hr. The air is reversibly compressed in an inlet diffuser. The inlet temperature is 216.65 K and pressure is 0.226 bar. If the Mach number at the exit of the diffuser is 0.35, calculate the following :—

(i) Entry Mach number.

(ii) Velocity, pressure and temperature of air at the diffuser exit.

Or

(b) Show that for a compressible fluid flow :

$$M^{*2} = \frac{\left[\frac{\gamma+1}{2}\right] M^2}{1 + \frac{\gamma-1}{2} M^2}.$$

13. (a) In a supersonic nozzle air expands from p_0 = 24 bar and T_0 = 1000 K to an exit pressure of 4.3 bar. If the exit area of the nozzle is 110 cm^2, calculate the following :—

(i) Throat area.

(ii) Pressure and temperature at the throat.

(iii) Temperature at exit.

(iv) Mass flow rate.

(v) Exit velocity as fraction of the maximum attainable velocity.

Or

(b) Derive an expression for the mass flow rate in flow through a convergent-divergent nozzle in terms of pressure ratio and inlet conditions of the gas.

14. (a) Prove that for Reyleigh flow the static pressure ratio :

$$\frac{p_2}{p_1} = \frac{1 + \gamma M_1^2}{1 = \gamma M_2^2}.$$

Or

(b) A circular duct passes 8.25 kg/s. of air at an exit Mach number of 0.5. The entry pressure and temperature are 3.5 bar and 38°C respectively and co-efficient of friction is 0.005. If the Mach number at entry is 0.15, determine :

(a) Diameter of the duct.

(b) Length of the duct.

(c) Pressure and temperature at the exit.

(d) Stagnation pressure loss.

15. (a) The following data refer to compressible fluid flow in a convergent-divergent nozzle.

Throat area = 2.4 cm^2, exit area = 5 cm^2, stagnation pressure = 7 bar, stagnation temperature = 100°C. Normal shock occurs at a section where the cross-sectional area is 3.4 cm^2. Taking the flow as isentropic before and after the shock. Determine (a) The properties of the fluid just after the shock ; (b) Exit Mach number ; and (c) Properties of the fluid at exit.

Or

(b) Prove for a compressible fluid flow

$$M_y^2 = \frac{\frac{2}{\gamma - 1} + M_x^2}{\frac{2\gamma}{\gamma - 1} M_x^2 - 1}.$$

(4 × 10 = 40 marks)