Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), DECEMBER 2019

Course Code: ME409

Course Name: COMPRESSIBLE FLUID FLOW

Max. Marks: 100 Duration: 3 Hours

Use of Gas Tables permitted. Assume suitable values for missing data.

PART A

Answer any three full questions, each carries 10 marks. Marks

1 Derive the conservation of mass equation for compressible flow through a control volume. (10)

2 (a) Derive an expression for stagnation temperature in terms of Mach number for compressible fluid flow. (4)

(b) A supersonic fighter plane flies at an altitude of 5000 m. The Mach number of the fighter plane is 3.0. Estimate the time taken by an observer on the ground to hear the sonic boom after the plane passes directly over his head. Take the average temperature at 5000 m altitude as 10°C. Also determine the speed of the aircraft. (6)

3 a) Derive an expression for area ratio in terms of Mach number for isentropic flow. Explain graphically the variation of area ratio with Mach number. (6)

b) Derive the condition at which flow become choked in isentropic flow? (4)

4 An air nozzle is to be designed for an exit Mach number of 2.5. Conditions of the air available in the reservoir are 800 kPa, 523 K. Estimate i) pressure ii) temperature iii) velocity of flow iv) area, at throat and exit of the nozzle. Mass flow rate through the nozzle is 12000 kg/hr. (10)

PART B

Answer any three full questions, each carries 10 marks.

5 a) Define shock strength. (2)

b) Derive an expression for Mach number downstream of a normal shock. (8)

6 The ratio of exit to entry area in a subsonic diffuser is 3.5. The Mach number of a jet of air approaching the diffuser is 2.18. Stagnation pressure of the jet is 1 bar and its static temperature is 300 K. There is a standing normal shock wave just outside the diffuser entry. The flow in the diffuser is isentropic. Determine pressure, temperature and Mach number at the exit of the diffuser. Also find the (10)

loss in stagnation pressure of the jet as it passes through the diffuser.

7 a) Explain the phenomenon of choking in Fanno flow. (3)

b) Prove that M = 1.0 is the limiting condition for Fanno flow. (5)

c) Explain the significance of critical length in Fanno flow (2)

8 Air at pressure 1 bar and 400 K enters a 30 cm diameter duct with a Mach number of 2.0. A normal shock occurs at a Mach number of 1.5 and the exit Mach number is 1.0. If the mean value of friction factor is 0.003, determine (10)

i) length of the duct upstream and downstream of the shock wave

ii) mass flow rate of air

iii) entropy change across the shock and downstream of the shock.

PART C

Answer any four full questions, each carries 10 marks.

9 Data for entry of air at a constant area duct are $p_1 = 0.345$ bar, $T_1 = 314$ K, $c_1 =$ 64 m/s. If 627 kJ/kg if heat is added to the gas in the duct between entry and exit sections, determine at the exit a) pressure b) temperature c) Mach number d) velocity of gas. How much heat is required to accelerate air from initial condition to sonic condition? (10)

10 The stagnation temperature of air in a combustion chamber is increased 3.5 times its initial value. If the air at entry is at 5 bar and 105 °C and a Mach number of 0.25, determine i) Mach number, pressure and temperature at exit ii) stagnation pressure loss iii) heat supplied per kg of air (10)

11 Prove that the Mach numbers at the maximum enthalpy and maximum entropy points on the Rayleigh line are $1/\sqrt{\gamma}$ and 1.0 repectively. (10)

12 a) Explain the working of a constant current hot wire anemometer used for flow velocity measurement. (4)

b) Explain Schlieren method of flow visualisation used in compressible flow. (6)

13 a) Explain in detail the working of a closed type wind tunnel with the help of a sketch. (6)

b) Explain with the help of sketches how yaw angle is eliminated in a Kiel probe. (4)

14 a) With a neat sketch explain the working of stagnation temperature probe. (6)

b) Explain how Prandtl Pitot probe simultaneously measure static and stagnation pressure. (4)

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