Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh Semester B.Tech Degree Supplementary Examination June 2022 (2015 Scheme)

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 expression for sonic velocity in terms of the difference of specific heats and the ratio of specific heats of the medium. (10)

2 a) What is meant by mach angle? Derive it mathematically. (4)

b) Mach number and pressure at entry of a subsonic diffuser are 0.9 and 416.5 kPa. Determine the area ratio required and the pressure rise in the diffuser, if the Mach number at the exit of the diffuser is 0.2. Assume isentropic diffusion of air. (6)

3 a) Describe mathematically the effect of Mach Number on compressibility of flows. (6)

b) Explain the condition under which over expansion and under expansion occurs in isentropic flow through nozzles. (4)

4 The Mach number at inlet and exit of a supersonic diffuser are 2.5 bar and 1.2 respectively. The air inlet has a pressure of 80 kPa and -3°C. If the mass flow rate of the air is 120 kg/s, find i) stagnation pressure and temperature of air ii) exit area iii) static pressure and temperature of air at exit. (10)

PART B

Answer any three full questions, each carries 10 marks.

5 Derive an expression for Prandtl-Meyer relationship for a normal shock. Also represent Prandtl-Meyer relation in terms of reference Mach numbers downstream and upstream of shock. (10)

6 Air enters a convergent-divergent nozzle from a reservoir having a pressure and temperature of 200 kPa and 300 K respectively. The throat and exit areas of the nozzle are 1300 mm^2 and 2600 mm^2 respectively. If a standing shock wave occurs at an area of 1950 mm^2, find the pressure of air at the exit of the nozzle. Also find the increase in entropy for the flow across the nozzle. (10)

7 a) Compare the features of Fanno flow and Isothermal flow. (3)

b) At a section in Fanno flow, the Mach number is 0.7. The temperature and pressure of air at the section is 300 K and 1.5 bar. Find the Mach number, pressure and temperature at a section 25 m upstream of the section if the pipe is 50 mm diameter and average friction factor is 0.004. (7)

8 Air flows through an insulated circular pipe at a rate of 500 kg/min. The pressure, temperature and Mach number of air at entrance to the pipe are 0.35 MPa, 57°C and 0.16 respectively. The coefficient of friction for the pipe is assumed constant and its value is 0.005. If the Mach number at exit is 0.6 determine, i) diameter of the pipe ii) length of the pipe iii) pressure and temperature of air at the exit of the pipe iv) stagnation pressure loss v) entropy change (10)

PART C

Answer any four full questions, each carries 10 marks.

9 Condition of a gas ($\gamma = 1.3$, $c_p = 1.22$ kJ/kg K) at the entry of a constant area duct are; $M_1 = 0.28$, $T_{01} = 383$ K, $p_{01} = 4.965$ bar. If 627 kJ/kg of heat is supplied to the gas. Determine at the exit section, i) Mach number ii) pressure iii) temperature iv) stagnation pressure loss during heating (10)

10 Air fuel mixture enters a combustion chamber with an initial velocity of 205 m/s, pressure of 3.5 bar and a temperature of 454 K. The Mach number at the exit of the combustion chamber is 0.9. Taking $\gamma = 1.4$ and R = 287 J/kg K and calorific value of fuel a 42 MJ/kg, find i) entry Mach number ii) exit temperature and pressure iii) stagnation pressure loss iv) air fuel ratio required. (10)

11 a) Derive an expression for maximum heat transfer possible in Rayleigh flow. (7)

b) Explain the phenomenon of thermal choking during Rayleigh flow. (3)

12 a) Explain the working of a shock tube with the help of a sketch and mention its application. (5)

b) With a neat sketch explain the working of a Prandtl Pitot static probe. (5)

13 Explain the any two flow visualisation techniques used in compressible flow measurements with the help of sketches. (10)

14 a) With a neat sketch explain the working of open type and closed type wind tunnel (6)

b) Distinguish between constant current mode and constant temperature mode operation of hot wire anemometer. (4)

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