Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION(S), MAY 2019

Course Code: ME409

Course Name: COMPRESSIBLE FLUID FLOW

Max. Marks: 100 Duration: 3 Hours

Use of Gas Tables Permitted, Assume suitable value for missing data

PART A

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

1 a) What is Mach angle? Derive an expression for Mach angle in terms of Mach number. (4)

b) A perfect gas having C_p = 1017.4 J/kg and molecular weight 28.97 flows adiabatically in a converging passage with a mass flow rate if 29.18kg/s. At a particular location, M = 0.6, T = 550K and p = 0.2 MPa. Calculate the area of cross section of the duct at the location. (6)

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

3 Derive an expression for mass flux in terms of Mach number for an isentropic flow. From the expression for mass flux determine the condition for maximum mass flux. (10)

4 A supersonic nozzle expands air from p_o = 25 bar and T_o = 1050 K to an exit pressure of 4.35 bar; the exit area of the nozzle is 100 cm^2. Determine (a) throat area (b) pressure and temperature at the throat (c) temperature at exit (d) exit velocity as fraction of the maximum attainable velocity and (e) mass flow rate (10)

PART B

Answer any three full questions, each carries 10 marks.

5 a) What do you meant by shock strength? (3)

b) Explain why shock is impossible in subsonic flow. (3)

c) What is an expansion fan? How does it occur in supersonic flow? (4)

6 A convergent divergent nozzle has an exit to throat area ratio of 3.0. The stagnation properties of air at inlet are 700 kN/m^2 and 90 °C. The throat area is 10 cm^2. Due to its operation at off design condition a plane normal shock is seen to stand at the section where M = 2. Determine the Mach number, static pressure and static temperature at the exit of the nozzle. Assume isentropic flow before (10)

and after the shock.

7 a) Explain the phenomenon of frictional chocking. (3)

b) A convergent-divergent nozzle is provided with a pipe of constant cross section at its exit. The exit diameter of nozzle and that of pipe is 40 cm. The mean coefficient of friction for the pipe is 0.0025. Stagnation pressure and temperature of air at the nozzle entry are 12 bar and 600 K. The flow is isentropic in the nozzle and adiabatic in the pipe. The Mach number at the entry and exit of the pipe are 1.8 and 1.0 respectively. Determine i) length of pipe, ii) diameter of the nozzle throat and iii) pressure and temperature at the pipe exit. (7)

8 a) Differentiate between Fanno flow and Isothermal flow. What is the limit for continuous subsonic isothermal flow through a constant area duct. (4)

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 3.45 bar and 38°C respectively and the mean coefficient of friction 0.005. If the Mach number at the entry is 0.15, determine i) diameter of the duct, ii) length of duct, iii) pressure and temperature at exit and iv) stagnation pressure loss. (6)

PART C

Answer any four full questions, each carries 10 marks.

9 A combustion chamber in a gas-turbine plant receives air at 300 K, 55 kPa and 60 m/s. The fuel air ratio is 29 and the calorific value of the fuel is 42MJ/kg. Assuming γ=1.4, R=0.287 kJ/kg K for the gas, determine *(i)* Mach numbers at inlet and exit. *(ii)* pressure, temperature and velocity of the gas at exit of combustion chamber. *(iii)* percentage loss in stagnation pressure. (10)

10 Air-fuel mixture enters a combustion chamber with a initial velocity of 150m/s, pressure of 4 bar and temperature of 410K. The mach number at the exit of the combustion chamber is 0.8. Taking γ=1.3, C_p=1.144kJ/kgK and calorific value of fuel = 43 MJ/kg, find *(i)* entry Mach no. *(ii)* exit temperature and pressure *(iii)*stagnation pressure loss and *(iv)* air-fuel ratio required. (10)

11 Derive an expression for the maximum possible Heat addition (Q_{max}) in terms of Mach number, gamma and temperature for a Rayleigh flow. Explain the phenomenon of thermal choking. (10)

12 a) With the help of neat sketch explain the working of a shock tube. (4)

b) With a neat sketch show the working of a Open type and Closed type wind tunnel clearly labelling the different parts (6)

13 a) Draw the bridge circuit of a constant current hot wire anemometer and explain the working principle. (4)

b) With a neat sketch show the working principle of Shadowgraph and Schlieren techniques (6)

14 a) Draw the bridge circuit of a constant temperature hot wire anemometer and explain the working principle. (4)

b) What is the advantage of using a Kiel probe over a Pitot tube. How is the yaw sensitivity of the Kiel probe compared to the Pitot tube. (6)

****