Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh semester B.Tech examinations (S), September 2020

Course Code: ME409

Course Name: COMPRESSIBLE FLUID FLOW

Max. Marks: 100 Duration: 3 Hours

Use of Gas table is permitted. Assume suitable value for missing data

PART A

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

1 a) Derive an expression for sonic velocity in medium in terms of the ratio of specific heats and difference of specific heats of the medium. (4)

b) Show that for air at sonic flow condition, the deviation between the compressible and incompressible flow values of the pressure coefficient of a perfect gas is about 27.5 percent. (6)

2 a) A Schlieren photograph showing a wave front by a bullet moving in air gave a Mach angle of 40^0. Find the speed of the bullet if the pressure and temperature of atmosphere are 0.95 bar and 2^0C. (4)

b) Derive steady flow adiabatic ellipse equation. Represent various flow regimes on steady flow adiabatic ellipse. (6)

3 a) Find the maximum value of mass flow parameter $\frac{m\sqrt{T_o}}{A^* p_o}$ for (i) air (ii) carbon dioxide at 273 K. (4)

b) Derive the relation for one-dimensional isentropic flow $\frac{dA}{A} = \frac{dp}{\rho c^2}\left(1 - M^2\right)$ (6)

4 A gas is isentropically expanded from a pressure of 10 bar and temperature of 525 ^{0}C in a nozzle to a pressure of 7.6 bar. If the rate of flow of the gas is 1.5 kg/s determine (10)

i) pressure, temperature and velocity at the nozzle throat and exit

ii) maximum possible velocity attainable by the gas

iii) throat area

Take $\gamma = 1.3$ and R = 0.464 kJ/kgK

PART B

Answer any three full questions, each carries 10 marks.

5	a)	Explain two situations where a normal shock wave is formed.	(4)
	b)	Prove that a normal shock wave formation is impossible in subsonic region of a flow.	(6)
6	a)	Explain the formation of oblique shock wave in a concave corner and expansion fan in convex corner.	(4)
	b)	A stationary normal shock occurs in an air stream when the pressure, temperature and Mach number are 80 kPa, 100 ^{0}C and 1.8 respectively. Determine its density after the shock. Compare this value in an isentropic compression through the same pressure ratio.	(6)
7	a)	Differentiate between Fanno flow and isothermal flow. Give one practical example for Fanno flow and isothermal flow.	(4)
	b)	Derive the equation of a Fanno curve. Prove that at the maximum entropy point Mach number is unity.	(6)
8	a)	Air enters, a long circular duct of diameter 12.5 cm and mean coefficient of friction 0.0045, at a Mach number of 0.5, pressure 3 bar and temperature 312 K. If the flow is adiabatic throughout the duct, determine i) the length of the pipe required to change the Mach number to 0.7 ii) pressure and temperature of air at M=0.7 iii) the length of the pipe required to attain limiting Mach number iv) pressure, temperature and Mach number at the limiting condition	(10)

PART C

Answer any four full questions, each carries 10 marks.

9	a)	What is Rayleigh flow? Explain Rayleigh flow with one practical case.	(3)
	b)	What are the assumptions made in deriving equation for Rayleigh flow? Derive an equation describing a Rayleigh curve. Show that at maximum entropy point the flow is sonic.	(6)
10		A combustion chamber in a gas turbine plant receives air at 350 K, 0.55 bar and 75 m/s. The air-fuel ratio is 29 and the calorific value of fuel is 41.87 MJ/kg. Determine i) initial and final Mach numbers ii) final pressure, temperature and velocity of gas iii) percentage of stagnation pressure loss in the combustion chamber iv) maximum stagnation temperature attainable	(10)
11		The data at inlet to a ramjet engine combustion chamber employing a	(10)

hydrocarbon fuel are as follows: velocity of air-fuel mixture = 73 m/s, static temperature = 333 K, static pressure = 0.55 bar. The heat of reaction of the fuel-air mixture is 1400 kJ/kg. Assuming that the working fluid has the same thermodynamic properties as air before and after combustion, calculate

i) the lost in stagnation pressure due to heat addition

ii) the maximum heat of reaction for which flow with the specified initial conditions can be maintained.

12 a) When does a shadowgraph preferred over a Schlieren system in studying density effects? Mention the difference in principle of the two instruments. (4)

b) With the help of a neat sketch explain the working of an interferometer. (6)

13 Explain the working of a shock tube with neat sketch. (10)

14 Describe with the aid of a schematic diagram the working of a closed circuit supersonic wind tunnel. (10)

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