Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII(NEW) • EXAMINATION – WINTER 2016

Subject Code:2171914 **Date:18/11/2016**

Subject Name:Gas Dynamics(Department Elective - I)

Time:10.30 AM to 1.00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive the following from one dimensional steady flow energy equation **07**

$$\frac{a^2}{(\gamma-1)}+\frac{1}{2}C^2=\frac{1}{2}C_{max}{}^2=\frac{1}{2}a^{*2}\left(\frac{\gamma+1}{\gamma-1}\right)$$

(b) Air enters a straight axisymmetric duct at 350 K, 4 bar and 180 m/s and leaves it at 300 K, 2.89 bar and 280 m/s. The area of cross section at entry is 444 cm^2. Assume, γ=1.4, R=287.43 J/kg K and adiabatic flow. Determine, (*i*) Stagnation temperature, (*ii*) Maximum velocity, (*iii*) Mass flow rate and (*iv*) Area of cross section at exit. **07**

Q.2 **(a)** Derive the following equation for one dimensional isentropic flow and draw the shape of nozzle and diffuser for subsonic, sonic and supersonic flow **07**

$$\frac{dA}{A}=\frac{dP}{\rho c^2}(1-M^2)$$

(b) The pressure, velocity and temperature of air (γ=1.4, C_p=1.0 KJ/kg K) at the entry of a nozzle are 2 bar, 145 m/s and 330 K; the exit pressure is 1.5 bar. Determine for isentropic flow, (*i*) The mach number at entry and exit and (*ii*) The flow rate and maximum possible flow rate without using gas table. **07**

OR

(b) A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s respectively. Determine,(*i*) The exit pressure, (*ii*) The exit velocity and (*iii*) The force exerted on diffuser walls. Assume, γ=1.4 and C_p=1.000 KJ/kg K. **07**

Isentropic flow gas table (γ=1.4):

M	M^*	T/T_0	p/p_0	A/A^*	F/F^*	Ap/A^*p_0
0.1	0.1094	0.998	0.993	5.822	4.624	5.781
0.107	0.1098	0.991	0.992	5.360	4.300	5.724
0.488	0.534	0.952	0.843	1.340	1.203	1.129

Q.3 **(a)** Starting from the energy equation for flow through a normal shock, obtain the following relations: **07**

$$C_x.C_y=a^{*2}\ and\ M_x^*.M_y^*=1$$

(b) The state of gas (γ=1.3, R=0.469 KJ/kg K) upstream of a normal shock wave is given by, **07**

$M_x=2.5\,,p_x=2\ bar, T_x=275\ K$

Calculate the Mach number, pressure, temperature and velocity of the gas downstream of the shock without using gas table.

OR

Q.3 **(a)** Derive the following relations for flow through a normal shock: **07**

$$(i)\ M_y^2 = \frac{\left(\frac{2}{\gamma-1}\right) + M_x^2}{\left(\frac{2\gamma}{\gamma-1}\right) M_x^2 - 1} \quad (ii)\ \frac{P_y}{P_x} = \frac{2\gamma}{\gamma+1} M_x^2 - \frac{\gamma-1}{\gamma+1}$$

(b) Derive the expression for the pressure ratio across normal shock in terms of density ratio. **07**

Q.4 **(a)** Obtain an expression for change in entropy as a function of stagnation pressure ratio for Fanno flow process. **07**

(b) Derive the following relationship for an isentropic flow. **07**

$$\frac{A}{A^*} = \frac{1}{M}\left(\frac{2}{\gamma+1} + \frac{\gamma-1}{\gamma+1} M^2\right)^{\frac{\gamma+1}{2(\gamma-1)}}$$

OR

Q.4 **(a)** Draw the Fanno curve on h-s diagram and discuss the effect of friction in case of subsonic and supersonic flow. What is the limiting value of Mach number? **07**

(b) A circular duct passes 9 kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature are 3.45 bar and 311 K respectively, and the coefficient of friction is 0.005. If the Mach number at entry is 0.15, Determine, (*i*) The diameter of the duct, (*ii*) Length of the duct, (*iii*) Pressure and temperature at exit and (*iv*)Stagnation pressure loss. Assume, γ=1.4 and *R*=287 J/kg K. **07**

Isentropic flow gas table (γ=1.4) :

M	M^*	T/T_0	p/p_0	A/A^*	F/F^*	Ap/A^*p_0
0.15	0.1640	0.996	0.984	3.910	3.312	3.849

Fanno flow gas table (γ=1.4)

M	p/p^*	T/T^*	p_o/p_o^*	c/c^*	$4\bar{f}L_{max}/D$
0.15	7.319	1.1945	3.928	0.164	28.354
0.50	2.138	1.143	1.340	0.534	1.069

Q.5 **(a)** Show that the mach number at the maximum enthalpy and maximum entropy points on the Rayleigh line are $1/\sqrt{\gamma}$ and 1.0 respectively. **07**

(b) A combustion chamber in a gas turbine plant receives air at 350 K, 0.55 bar and 75 m/s respectively. The stagnation enthalpy rise due to combustion of one kg of fuel is 1395.67 kJ/kg of air fuel mixture. Taking γ=1.4 and R=287 J/kg K for the gas determine: (*i*) The initial and final mach numbers, (*ii*) Final pressure, velocity and temperature of gas and (*iii*) Stagnation pressure loss in the combustion chamber. **07**

Isentropic Gas Table (γ=1.4):

M	M^*	T/T_0	p/p_0	A/A^*	F/F^*	Ap/A^*p_0
0.2	0.218	0.992	0.973	2.964	2.400	2.882

Rayleigh Table (γ=1.4):

M	p/p^*	p_o/p_o^*	T/T^*	T_o/T_o^*	$c/c^* = \rho^*/\rho$
0.2	2.273	1.235	0.207	0.174	0.091
0.64	1.525	1.061	0.953	0.859	0.625

OR

Q.5 **(a)** Derive the following expressions in Rayleigh line flow. **07**

$$(i)\ \frac{p_2}{p_1} = \left(\frac{1+\gamma M_1^2}{1+\gamma M_2^2}\right) \quad (ii)\ \frac{T_2}{T_1} = \left(\frac{M_2}{M_1}\right)^2 \left(\frac{1+\gamma M_1^2}{1+\gamma M_2^2}\right)^2$$

(b) Define the following terms with neat sketch: **07**

(*i*) Mach cone (*ii*) Mach angle (*iii*) Zone of action (iv) Zone of silence

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