

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 cm². Assume, $\gamma=1.4$, $R=287.43$ 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 ($\gamma=1.4$, $C_p=1.0$ 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, $\gamma=1.4$ and $C_p=1.000$ KJ/kg K. **07**

Isentropic flow gas table ($\gamma=1.4$):

M	M*	T/T ₀	p/p ₀	A/A*	F/F*	A _p /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**

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

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

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

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, $\gamma=1.4$ and $R=287$ J/kg K. **07**

Isentropic flow gas table ($\gamma=1.4$) :

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 ($\gamma=1.4$)

M	p/p*	T/T*	p ₀ /p ₀ *	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 $\gamma=1.4$ 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 ($\gamma=1.4$):

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 ($\gamma=1.4$):

M	p/p*	p ₀ /p ₀ *	T/T*	T ₀ /T ₀ *	$c/c^* = \rho^*/\rho$
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
