Seat No.: ________ **Enrolment No.___________**

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII (NEW) - EXAMINATION – SUMMER 2017

Subject Code: 2171914 **Date: 29/04/2017**

Subject Name: Gas Dynamics(Department Elective - I)

Time: 02.30 PM to 05.00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Use of Gas Table is permitted.**
3. **Make suitable assumptions wherever necessary.**
4. **Figures to the right indicate full marks.**

Q.1 **(a)** What is effect of compressibility on Mach number? Prove for $\gamma = 1.4$ **07**

$$\frac{p_0 - p}{\frac{1}{2}\rho c^2} = 1 + \frac{1}{4}M^2 + \frac{1}{40}M^4 + \ldots\ldots\ldots\ldots$$

(b) Prove that the mass flow parameter for an air as a perfect gas is given by following expressions **07**

$$\frac{\dot{m}_{\max}\sqrt{T_0}}{AP_0} = 0.0404$$

Q.2 **(a)** Derive following equation for area ratio as function of Mach number : **07**

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

(b) Air (Cp=1.045 kJ/kg K, γ=1.35) at $P_1=3.5\times10^5$ N/m^2 and T_1=505 K flows with a velocity of 202 m/s in a 30 cm diameter duct. Calculate (a) Mass flow rate (b) Stagnation temperature (c) Mach number (d) Stagnation pressure values .Assuming the flow as compressible and incompressible. **07**

OR

(b) Derive the following from one dimensional steady flow energy equation and also explain various regions of flow based on it : **07**

$$\frac{a^2}{\gamma-1} + \frac{1}{2}C^2 = \frac{1}{2}C^2_{\max} = H_o$$

Q.3 **(a)** Derive the equation of static pressure ratio across the normal shock **07**

$$\frac{p_y}{p_x} = \frac{2\gamma}{\gamma-1}M_x^2 - \frac{\gamma-1}{\gamma+1}$$

(b) Starting from the energy equation for flow through a normal shock, obtain the Prandtl - Mayer relation : **07**

$$M_x^* \, M_y^* = 1$$

OR

Q.3 **(a)** Explain the behavior of a convergent nozzle under isentropic flow conditions with variation in back pressure. **07**

(b) Show that the Mach number downstream of the normal shock wave is **07**

$$M_y^2 = \frac{\frac{2}{\gamma-1}+M_x^2}{\frac{2\gamma}{\gamma-1}M_x^2-1}$$

Q.4 **(a)** A gas ([redacted], R=0.287 kJ/kg.K) at p_1 =1.0 bar, T_1 =400 K enters a 30 cm diameter duct at a Mach number of 2.0. A normal shock occurs at a Mach number of 1.5 and the exit Mach number is 1.0. If the mean value of the friction factor is 0.003 determine : **07**

(a) Length of the duct upstream and downstream of the shock wave,

(b) Mass flow rate of the gas ,and

(c) Change of entropy upstream of the shock, across the shock and downstream of the shock

(For isentropic flow[redacted] , M=2.0 , p_1/p_{01}=0.131, T_1/T_{01}=0.625)

(For normal shock [redacted], M_x=1.5, M_y= 0.69[redacted], p_x/p_y = 2.413 , T_y/T_x =1.247, p_{0y}/p_{0x} = 0.926)

Fanno flow table for[redacted]

M	p/p*	T/T*	P0/p0*	[redacted]
2	0.424	0.719	1.773	0.357
1.5	0.618	0.860	1.189	0.156
0.7	1.479	1.071	1.097	0.231

(b) Prove that Mach numbers at the maximum enthalpy and maximum entropy points on the Rayleigh line are $1/\sqrt{\gamma}$ and 1.0 respectively. Show the h = constant and s = constant lines at these points on the Rayleigh line on the h-s and p-v planes. **07**

OR

Q.4 **(a)** Explain the isothermal flow process with friction with T-s diagram. **07**

(b) Derive the Area- Velocity relation and draw the shape of nozzle and diffuser for subsonic, sonic and supersonic flow . **07**

Q.5 **(a)** Show that the upper and lower branches of a fanno curve represent sub-sonic and supersonic flows respectively. Prove that at a maximum entropy point Mach number is unity and processes approach this point. **07**

(b) Obtain an equation representing the Rayleigh line. Draw Rayleigh lines on h-s and p-v planes for two different values of mass flux. Derive the equation of slope for Rayleigh line for p-v plane. **07**

OR

Q.5 **(a)** A Conical diffuser has entry and exit diameter 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. Assume : Isentropic flow - γ = 1.4, C_p = 1.00 KJ/Kg.K Determine: (a) the exit pressure (b) the exit velocity and (c) the force exerted on diffuser walls. **07**

(b) Make a sketch of pressure pulse pattern when a point source of disturbance moves at subsonic, sonic and supersonic speed. Show the zone of action in each case. **07**

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