Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VIII • EXAMINATION – SUMMER 2014

Subject Code: 181906 **Date: 27-05-2014**

Subject Name: Gas Dynamics

Time: 10:30 am TO 01:00 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**

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

(b) Define Fanno flow process and state its governing equations. Using them obtain the equation for Fanno flow and show its plot on h-s diagram. **07**

Q.2 **(a)** Prove that the mass flow parameter for an air as a perfect gas is given by following expressions. **07**

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

(b) For air at a stagnation temperature of 1000 K, find (i) Maximum attainable velocity (ii) Static temperature and velocity for a Mach number of 0.8 (iii) the Mach number and velocity for a static temperature of 800 K (iv) the Mach number and static temperature for a velocity of 1000 m/s. **07**

OR

(b) The pressure, velocity and temperature of air at entry to a nozzle are 200 kPa, 145 m/s and 330 K. The exit pressure is 150 kPa. What is the shape of the nozzle? Determine the Mach number at entry and exit, the flow rate per unit area at inlet, assuming the flow to be isentropic. Take γ=1.4 for the air. Use isentropic flow table given at end of paper. **07**

Q.3 **(a)** Derive the expression for the pressure ratio across normal shock in terms of density ratio. **07**

(b) Air flows through an insulated circular pipe at a rate of 495 kg/minute. The pressure, temperature and Mach number of air at entrance to the pipe are 0.3 MPa, 27^{o}C and 0.15 respectively. The coefficient of friction for the pipe is assumed constant and its value is 0.005. If the Mach number at exit is 0.5, determine (i) the diameter of the pipe (ii) the length of the pipe (iii) pressure and temperature of air at the exit of the pipe. **07**

Take γ=1.4 for the air.

#Fanno Flow Tables (γ=1.4):

M	T/T^*	P/P^*	$4fL_{max}/D$
0.14	1.195314	7.809317	32.51131
0.16	1.193887	6.829072	24.19783
0.50	1.142857	2.138090	1.069060

OR

Q.3 **(a)** Obtain an expression for change in entropy as a function of stagnation pressure ratio for Fanno flow process. Hence show that stagnation pressure always decreases in the process. **07**

(b) A compression shock occurs in a divergent air flow passage. On the upstream side of the shock, the velocity of air is 400 m/s and the pressure and temperature are 0.2 MPa and 35°C respectively. Determine (i) Mach number and air velocity on the downstream side of the shock (ii) change in entropy per unit mass of air as a result of shock. Take γ=1.4 for the air. **07**

 # Normal Shocks Tables (γ=1.4):

M_x	M_y	P_y/P_x	T_y/T_x	P_{0y}/P_{0x}
1.14	0.822	1.3495	1.0903	0.997

Q.4 (a) Prove that Mach number at the maximum enthalpy and maximum entropy point on Rayleigh line are $\frac{1}{\sqrt{\gamma}}$ and 1.0 respectively **07**

(b) The pressure, temperature and velocity of a gas at entry of the combuster are 0.343 bar, 310 K and 60 m/s. Determine the Mach number, pressure, temperature and velocity at the exit if the increase in stagnation enthalpy of the gas between entry and exit is1172.5 kJ/kg. Take Cp=1.005 kJ/kg-K, γ=1.4. **07**

#Rayleigh Flow Tables (γ=1.4):

M	T/T^*	P/P^*	T_0/T_0^*	c/c*
0.16	0.137	2.317	0.115	0.0593
0.18	0.1708	2.296	0.143	0.0744
0.45	0.7075	1.870	0.612	0.378

OR

Q.4 (a) Derive the following relations for one dimensional isentropic flow. **07**

(i) $\frac{dA}{A} = \frac{dp}{\rho c^2}(1 - M^2)$ (ii) $\frac{p^*}{p} = \left(\frac{2}{\gamma+1} + \frac{\gamma-1}{\gamma+1}M^2\right)^{\frac{\gamma}{\gamma-1}}$

(b) Derive the equation of maximum non-dimensional heat transfer rate in Rayleigh flow process. Also obtain the value of supersonic mach number for the same maximum heat transfer. **07**

Q.5 (a) State and explain the practical applications of wind tunnel. **07**

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

(a) Mach cone (b) Mach angle (c) zone of action (d) zone of silence

OR

Q.5 (a) Starting from the energy equation for flow through a normal shock obtain the following relations: **07**

$M_x^* M_y^* = 1$

(b) Explain the mechanism of energy conversion for Reyleigh flow with neat sketch when **07**

(a) a subsonic flow is heated.

(b)When a supersonic flow is cooled.

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 # Isentropic Flow Tables (γ=1.4):

M	T/T_0	P/P_0
0.16	0.99490	0.98228
0.18	0.99356	0.97765
0.40	0.96899	0.89562
0.76	0.89644	0.68207
0.78	0.89152	0.66905