Seat No.: _____ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER– VII (New) EXAMINATION – WINTER 2019

Subject Code: 2171914 **Date: 23/11/2019**

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.**
4. **Use of Gas Table is permitted.**

			MARKS
Q.1	**(a)**	Define the following terms: (1) Stagnation pressure (2) Critical and maximum velocity (3) Stagnation velocity of sound.	**03**
	(b)	Write a short on reference velocities.	**04**
	(c)	In a supersonic diffuser, the air flows at the rate of 100 kg/s at 0.7 bar and 260 K static conditions, enters at Mach number 2.6 and at exit its Mach number is 1.3. Determine: 1) stagnation pressure and temperature at inlet, 2) velocity of air at inlet, 3) area at throat and exit, 4) static pressure and temperature at exit, 5) velocity of air exit.	**07**

M	T/T_0	P/P_0	A/A^*	ρ/ρ_0
1.3	0.7474	0.3609	1.066	0.4829
2.6	0.4252	0.0501	2.896	0.1179

Q.2	**(a)**	Explain the expansion and compression adiabatically with help of T-S and P-V diagrams.	**03**
	(b)	Derive the following relationship for an isentropic flow.	**04**

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

	(c)	Explain how does a shock wave develop in the diverging section of a supersonic nozzle? How does this wave move towards the exit?	**07**

OR

	(c)	Prove that the mass flow parameter is given by following expressions.	**07**

$$\frac{m\sqrt{To}}{APo} = \sqrt{\frac{2y}{R(y-1)}\left\{\left(\frac{p}{po}\right)^{\frac{2}{y}} - \left(\frac{p}{po}\right)^{\frac{y+1}{y}}\right\}}$$

Q.3 **(a)** Write a short on Supersonic Diffusers. **03**

(b) Derive the equation of static pressure ratio across the normal shock: **04**

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

(c) Starting from the energy equation for flow through a normal shock, obtain the Prandtl Mayer relation in terms of mach number. **07**

OR

Q.3 **(a)** Write a short on Supersonic pitot tube. **03**

(b) Derive the following relations for flow through a normal shock: **04**

$$M_y^2 = \frac{\left(\frac{2}{\gamma-1}\right) + M_x^2}{\left(\frac{2\gamma}{\gamma-1}\right)M_x^2 - 1}$$

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

Q.4 **(a)** Draw the Fanno curve on h-s diagram and discuss the effect of friction in case of supersonic flow. **03**

(b) Air flows at a pressure of 101 kPa and temperature of 27 ºC into a 462 cm long tube of 4 cm diameter. The tube is perfectly insulated. Determine the maximum mass flow rate and exit pressure to produce this flow. Take f = 0.005. **04**

M	P/P*	T/T*	$4fL_{max}/D$
0.3	3.619	1.178	5.299
0.35	3.0922	1.1713	3.4691
0.4	2.696	1.163	2.31
0.5	2.1381	1.11429	1.06908

(c) Derive 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**

OR

Q.4 **(a)** Define Fanno flow process and state its governing equations. **03**

(b) Derive the following equation for one dimensional isentropic flow. **04**

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

(c) Air at the rate of 33.68 m^3/s leaves at 150 kPa and 293 K while flowing in pipe of 0.5 m dia. The length of pipe is 60 m. Take f = 0.005. **07**

Determine the following:

1) Mach number at exit.
2) The inlet pressure and temperature.
3) Maximum length of pipe that can be used.

M	P/P*	T/T*	$4fL_{max}/D$
0.3	3.619	1.178	5.299
0.35	3.0922	1.1713	3.4691
0.4	2.696	1.163	2.31
0.5	2.1381	1.11429	1.06908

Q.5 **(a)** What is Rayleigh flow? Give two practical examples. **03**

(b) Explain the mechanism of energy conversion when a subsonic flow is heated in Rayleigh flow. **04**

(c) Air enters a constant area duct at pressure, temperature and Mach number 100 kPa, 280 K, and 2.5 respectively. Heat is transferred to the duct such that exit Mach number equal to 1.2. Find: 1) Heat transferred per kgof air. 2) Pressure and temperature at the exit. 3) Maximum amount of heat that can be transferred. **07**

M	P/P*	T/T*	T_0/T_0*
1.2	0.79576	0.91185	0.97872
2.5	0.24616	0.3787	0.71005

OR

Q.5 **(a)** Write the conditions Under which the assumption of Rayleigh flow is not valid in a heat exchanger? **03**

(b) Derive the following expressions in Rayleigh line flow. **04**

$$\frac{T_2}{T_1} = \left(\frac{M_2}{M_1}\right)^2 \left(\frac{1+\gamma M_1^2}{1+\gamma M_2^2}\right)^2$$

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

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