Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI (NEW) EXAMINATION – SUMMER 2022

Subject Code:3161912 Date:06/06/2022

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. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Define the following terms: 1. Gas dynamics 2. Mach number 3. Critical and maximum velocity.	**03**
	(b)	Explain bulk modulus of elasticity and derive its equation for isothermal process.	**04**
	(c)	Derive the following from one dimensional steady flow energy equation: $\frac{a^2}{(\gamma-1)}+\frac{1}{2}C^2=\frac{1}{2}C_{max}{}^2=\frac{1}{2}a^{*2}(\frac{\gamma+1}{\gamma-1})$	**07**
Q.2	**(a)**	Explain the phenomenon of choking in isentropic flow.	**03**
	(b)	State and explain the practical application of wind tunnel.	**04**
	(c)	Air expands isentropically from 20 bar and 100°C to 12 bar. Determine the temperature and density at the final state. Also find the ratio if initial to final acoustic velocity.	**07**
		OR	
	(c)	Derive the following equation for one dimensional isentropic flow and draw the shape of nozzle and diffuser for subsonic, sonic and supersonic flow. $\frac{dA}{A}=\frac{dP}{\rho c^2}(1-M^2)$	**07**
Q.3	**(a)**	Explain"shock condensation".	**03**
	(b)	Write a short on Supersonic pitot tube.	**04**
	(c)	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. **Normal Shocks Tables (γ=1.4):**	**07**

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

OR

Q.3	**(a)**	Write three governing equations which satisfy the state before and after a normal shock.	**03**
	(b)	Write general characteristic of normal shock.	**04**
	(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**

Q.4 **(a)** What is Fanno flow? Write governing equations for Fanno flow. **03**

(b) From the adiabatic energy equation prove that irrespective of entry condition of flow limiting condition at exit for Fanno flow is when M=1. **04**

(c) Air enters a pipe of diameter 10 cm at M = 2.5. Find the i. the length of the pipe, if air leaves the pipe at M = 1.5. ii. the length of the pipe, if air leaves the pipe at M = 1.0. Assume f = 0.003. **07**

M	p/p^*	T/T^*	p_0/p_0^*	$4\bar{f}L/D$
1	1	1	1	0
1.5	0.606478	0.827586	1.176167	0.136050
2.5	0.292119	0.533333	2.636719	0.431977

OR

Q.4 **(a)** State assumptions made in deriving equations for Fanno flow. State two engineering fluid flow conditions which can be analyzed as Fanno flow. **03**

(b) Derive expression for pressure ratio, temperature ratio and velocity ratio for the Fanno flow of a perfect gas. **04**

(c) 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**

Q.5 **(a)** State the four assumptions of Rayleigh flow. **03**

(b) What is critical state? Calculate the ratio of stagnation pressure to the critical pressure for monoatomic gas. **04**

(c) 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**

OR

Q.5 **(a)** Define following : **03**

1. Maximum fluid velocity
2. Critical velocity of sound
3. Hypersonic flow.

(b) For an isentropic flow, prove that: **04**

$$\frac{dA}{A} = (M^2 - 1)\frac{dV}{V}$$

(c) Air at Mach number 1.5, pressure 300 kN/m^2, static temperature 288K, stagnation temperature 418K, is brought to sonic velocity in a frictionless constant area duct through which heat transfer occurs. Determine the final pressure, final temperature and heat added during the process. **07**

M	T/T^*	p/p^*	T_0/T_0^*	p_0/p_0^*
1.5	0.753	0.578	0.909	1.121

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