Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI (NEW) EXAMINATION – SUMMER 2024

Subject Code:3161912 Date:20-05-2024

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: **03**

1. Isentropic flow
2. Bulk modulus (K)
3. Mach number

(b) Air at 200 kPa flows at a velocity of 50 m/s. Determine the Mach number at a point where its density is 2.9 kg/m^3. **04**

(c) Explain Mach waves, Mach cone and Mach angle for different types of sonic flows with neat diagrams. **07**

Q.2 **(a)** Sketch *T*-*S* and *h*-*S* diagrams for nozzles with adiabatic and isentropic flow processes and define nozzle efficiency. **03**

(b) Explain the effect of varied back pressure in a convergent-divergent nozzle under isentropic flow conditions with neat sketches. **04**

(c) Develop the following equation for one-dimensional isentropic flow and demonstrate the maximum discharge condition. **07**

$$\frac{m}{A}=\sqrt{\frac{\gamma}{RT_0}}\times p_0\times\frac{M}{\left[1+\left(\frac{\gamma-1}{2}\right)M^2\right]^{\frac{(\gamma+1)}{2(\gamma-1)}}}$$

OR

(c) Air is discharged from a reservoir at p_0 = 6.91 and T_0 = 325°C through a nozzle to an exit pressure of 0.98 bar. If the flow rate is 3600 kg/hr., determine for isentropic flow: **07**

1. Throat area, pressure, and velocity
2. Exit area, Mach number
3. Maximum velocity.

Use the following properties for isentropic flow process:

M	p/p_0	T/T_0	ρ/ρ_0	A/A^*	M^*
1.00	0.5283	0.8333	0.6287	1.000	1.000
1.92	0.1447	0.5756	0.2514	1.580	1.5909
1.93	0.1425	0.5731	0.2486	1.593	1.6005
1.94	0.1403	0.5705	0.2459	1.606	1.6052

Q.3 **(a)** State the governing equations which satisfy the state before and after a normal shock. **03**

(b) The state of a gas (γ = 1.3, R = 469 J/kgK) upstream of a normal shock wave is given by the following data: M_x = 2.5, p_x = 2 bar, T_x = 275 K. Calculate the Mach number and static pressure of the gas downstream of the shock. **04**

(c) Define the Rankine-Hugoniot relation. Develop the following equation. **07**

$$\frac{P_y}{P_x} = \frac{\frac{\rho_y}{\rho_x}\left(\frac{\gamma+1}{\gamma-1}\right)-1}{\left(\frac{\gamma+1}{\gamma-1}\right)-\frac{\rho_y}{\rho_x}}$$

OR

Q.3 **(a)** Define a shock wave and differentiate between normal shock and oblique shock. **03**

(b) Explain the function of a supersonic diffuser with a neat sketch. **04**

(c) Explain the Supersonic pitot tube. **07**

Q.4 **(a)** Define Fanno flow. List out assumptions in Fanno flow. **03**

(b) Derive following equation for Fanno flow. **04**

$$\frac{dT}{T}+\left(\frac{\gamma-1}{2}\right)M^2\frac{dC^2}{C^2}=0$$

(c) The air with Mach number 0.3, stagnation pressure 6 bar and stagnation temperature 350 K enters into a thermally insulated duct of constant diameter 10 cm. If the duct operates under choking condition, determine the length of duct, flow parameters at duct exit and mass flow rate. Take the mean friction co-efficient for the duct as 0.004. **07**

Use the following properties for Fanno flow process:

M	p/p^*	$C/C^*=\rho/\rho^*$	T/T^*	p_0/p_0^*	F/F^*	$\frac{4\bar{f}L_{max}}{D}$
0.3	3.619	0.3257	1.178	2.035	1.698	5.299
0.4	2.696	0.4310	1.163	1.590	1.375	2.308
1.0	1.000	1.0000	1.000	1.000	1.000	1.000
1.2	0.804	1.1580	0.932	1.030	1.011	0.0336

OR

Q.4 **(a)** Write governing equations for the Fanno flow process and show its plot on the (*h*-*s*) diagram. **03**

(b) Derive expression for the pressure ratio and impulse function ratio for the Fanno flow of a perfect gas. **04**

(c) Show that the upper and lower branches of a Fanno curve represent subsonic and supersonic flows respectively. How would the state of a gas change from the supersonic to subsonic branch. **07**

Q.5 **(a)** Write continuity and momentum equations for the Rayleigh flow process and show its plot on the (*h*-*s*) diagram. **03**

(b) Explain applications of wind tunnel. **04**

(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**

OR

Q.5 **(a)** Define Rayleigh flow. List out assumptions in Rayleigh flow. **03**

(b) Differentiate between open and closed-circuit wind tunnels. **04**

(c) Explain the expansion and compression both adiabatically and isentropically with the help of T-s and P-V diagrams. **07**

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