Seat No.: ________ Enrolment No.

GUJARAT TECHNOLOGICAL UNIVERSITY

BE- SEMESTER–VII (NEW) EXAMINATION – WINTER 2020

Subject Code:2171914 **Date:19/01/2021**

Subject Name:Gas Dynamics

Time:10:30 AM TO 12:30 PM **Total Marks: 56**

Instructions:

1. **Attempt any FOUR questions out of EIGHT 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 following : **03**
1) Crocco number
2) Mach number
3) Stagnation enthalpy

(b) Define bulk modulus of elasticity and derive its equation for isothermal process. **04**

(c) Define M*. Derive following relation: **07**

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

Calculate its maximum value for diatomic gas.

Q.2 **(a)** Compare adiabatic expansion and isentropic expansion processes on T→S diagram. **03**

(b) An air jet at 400K has sonic velocity. Calculate **04**
1) velocity of sound at the stagnation condition and
2) Maximum possible velocity of jet

Take : R = 287J/kg-K and γ = 1.4.

(c) From the continuity equation, derive the equation for non-dimensional mass flow rate in terms of pressure ratio of static and stagnation pressure. **07**

Non-dimensional mass flow rate = $\frac{\dot{m}\sqrt{T_0}}{A^* P_0}\sqrt{\frac{R}{\gamma}}$

Q.3 **(a)** What is shock strength?.Write the equation which represents shock strength in terms of upstream Mach number. **03**

(b) A gas at a Mach number of 1.8, pressure 0.8 bar and temperature 373K passes through a normal shock wave. Determine density after the shock. Compare its value in an isentropic compression through same pressure ratio. **04**
Take : R = 287J/kg-K and γ = 1.4.

(c) Starting from energy equation prove that, **07**
$M_1^* * M_2^* = 1$.
Where upstream and downstream reference Mach numbers for normal shock are represented by M_1^* and M_2^* respectively.

Q.4 **(a)** What is shock? Represent normal shock on h→s diagram aalng with Rayleigh and Fanno curve. **03**

(b) Condition of gas at upstream side of shock: **04**
M = 2.5, p = 2 bar and T = 275K.

Calculate temperature, pressure and velocity of gas at downstream side.
Take : R = 287J/kg-K and γ = 1.4.

(c) From the energy equation, derive the following relation for the normal shock **07**

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

Where upstream and downstream reference Mach numbers for normal shock are represented by M_x^* and M^*_y respectively.

Q.5 **(a)** What is Fanno flow? State assumptions related to Fanno flow process. **03**

(b) Prove that at maximum entropy point on Fanno curve is where Mach number is unity and all processes approach this point. **04**

(c) A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry condition of air is 3.45 bar and 311K. Co-efficient of friction of duct is 0.005. If entry Mach number is 0.15 determine: **07**

1) Length of duct
2) Diameter of duct
3) Exit pressure and temperature of air.

Q.6 **(a)** Differentiate : Fanno flow and Isothermal flow. **03**

(b) Write governing describing Fanno curve. Draw three different Fanno curve on T→S diagram for three different mass densities. **04**

(c) Air at stagnation pressure 10 bar , stagnation temperature 400K and M = 3 is supplied to a 50mm diameter pipe. The friction factor for the pipe surface is 0.002. If exit Mach number is 1, calculate : **07**

1) The length of pipe
2) Velocity of sound at entry
3) Mass flow rate.
4)

Q.7 **(a)** What is critical state? Calculate the ratio of stagnation pressure to the critical pressure for monoatomic gas. **03**

(b) State the four assumptions of Rayleigh flow as well as write two applications where Rayleigh flow analysis is applicable. **04**

(c) A combustion chamber in a gas turbine plant receives air at 350K, 0.55bar and 75 m/s. The air-fuel ratio is 29 and calorific value of fuel is 41.87MJ/kg. For the gas determine : **07**

1) Initial and final Mach number
2) Final temperature and pressure of the gas.

Take : R = 287J/kg-K and γ = 1.4.

Q.8 **(a)** Write the equation of A/A^* and draw the graph of $(A/A^*) \rightarrow M$. **03**

(b) Write momentum equation for Rayleigh flow. Plot Rayleigh curve on p→v diagram and find : $\left(\frac{dp}{dv}\right)_R$ for Rayleigh line. **04**

(c) Write momentum equation for Rayleigh flow and from that derive equations for (F/F^*) , (p/p^*) and (p_0/p_0^*)
Where F represents impulse function. **07**

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