

Seat No.: _____

Enrolment No. _____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER-VII (NEW) - EXAMINATION – SUMMER 2018

Subject Code:2171914

Date:28/04/2018

Subject Name:Gas Dynamics(Department Elective - I)

Time:02.30 PM to 05.00 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) Define the following terms and write their units in the standard international system: (i) Stagnation velocity of sound, (ii) Crocco number, (iii) Stagnation Enthalpy. **03**

(b) Derive kinetic form of steady flow energy equation and prove; **04**

$$\frac{a^2}{\gamma - 1} + \frac{V^2}{2} = \frac{\gamma + 1}{2(\gamma - 1)} a^{*2} = \text{constant}$$

(c) Determine: (i) Velocity of sound in the jet, (ii) Stagnation temperature and stagnation enthalpy of the jet, (iii) Stagnation velocity of sound, (iv) Stagnation to static pressure ratio, (v) Critical speed of sound, (vi) Maximum isentropic speed, (vii) Crocco number, if the sonic velocity air jet has a temperature of 290 K. **07**

Q.2 (a) Define (1) Mach cone, (2) Mach angle and (3) Mach wave. **03**

(b) Derive the expression for the non-dimensional impulse function in the following form. **04**

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

(c) A reservoir whose temperature can be varied in a wide range of temperature receives air at a constant pressure of 1.5 bar. The air is expanded isentropically in a nozzle to an exit pressure of 1.015 bar. Determine (without using gas table) the values of the temperature to be maintained in the reservoir to produce the following velocities at the nozzle exit: (a) 100 m/s, (b) 250 m/s. **07**

What are the values of Mach numbers in the two cases?

OR

(c) A perfect gas flows through a flow passage with initial values of 2.45 bar, 26.5°C and 1.4 of pressure, temperature and Mach number respectively. If the Mach number at the exit is 2.5, determine for adiabatic flow of a perfect gas ($\gamma = 1.3$, $R = 0.469 \text{ kJ/kg K}$): (1) Stagnation temperature (2) temperature and velocity at the exit and, (3) the flow rate per square meter of the inlet cross section. **07**

Q.3 (a) List out general characteristics of the normal shock. **03**

(b) Explain the phenomenon of choking in isentropic flow. **04**

(c) Explain types of waves in compressible flow. **07**

OR

Q.3 (a) Derive expression for pressure ratio, temperature ratio and velocity ratio for the Fanno flow of a perfect gas. **03**

(b) Derive following equation of mass flow rate in terms of area ratio. **04**

$$\frac{\dot{m}\sqrt{T_0}}{Ap_0}\sqrt{\frac{R}{\gamma}} = \left(\frac{2}{\gamma+1}\right)^{\frac{(\gamma+1)}{2(\gamma-1)}}\frac{A^*}{A}$$

- (c) Derive following form of Prandtl-Meyer equation. $V_1V_2 = a^{*2}$ **07**
- Q.4** (a) Explain Mach number and its significance. **03**
- (b) Enlist assumptions that are made for Rayleigh flow. **04**
- (c) Write down the momentum equation for Fanno flow between two sections dx apart, in a constant area duct and explain the different terms. **07**

OR

- Q.4** (a) Differentiate between Fanno flow and Isothermal flow. **03**
- (b) Show that the upper branch of Fanno curve corresponds to subsonic flow and lower branch corresponds to subsonic flow. **04**
- (c) Explain Rayleigh line in Mollier diagram. **07**
- Q.5** (a) What is shock condensation? **03**
- (b) Prove that the Mach number at the maximum enthalpy point on the Rayleigh line is $1/\sqrt{\gamma}$. **04**
- (c) The velocity of a normal shock wave moving into stagnant air ($p = 1.0$ bar and $t = 17^\circ\text{C}$) is 500 m/s. If the area of cross section of the duct is constant, determine (a) pressure, (b) temperature, (c) velocity of air, (d) stagnation temperature and (e) the Mach number imparted upstream of the wave front. **07**

OR

- Q.5** (a) Show Rayleigh heating and Rayleigh cooling process on $h-s$ diagram. **03**
- (b) What is strength of shock wave? Explain. **04**
- (c) A gaseous mixture of air and fuel enters a ramjet combustion chamber with velocity 60 m/s, temperature 50°C and pressure 35 kPa. The heat of reaction of the mixture for the particular fuel-air ratio employed is 1160 kJ/kg. Find the condition of stream at the exit of combustion chamber, if the friction is neglected and the cross sectional area is assumed constant. Assume the properties of both reactants and products of combustion are the same as air. **07**

Isentropic Gas Table ($\gamma=1.4$)

M	T/T ₀	p/p ₀	ρ/ρ_0	A/A*	M*
0.16	0.99490	0.98228	0.98731	3.6727	0.17483
0.18	0.99356	0.97765	0.98398	3.2779	0.19654
0.56	0.94098	0.80822	0.85892	1.2403	0.59508
0.58	0.93696	0.79621	0.84977	1.2130	0.61500

Rayleigh Table ($\gamma=1.4$)

M	T/T*	p/p*	T ₀ /T ₀ *	p ₀ /p ₀ *
0.16	0.137429	2.316960	0.115110	1.246083
0.18	0.170779	2.295860	0.143238	1.240592
0.42	0.653456	1.924681	0.563758	1.147960
0.44	0.690255	1.888218	0.597485	1.139364

Normal Shock Table ($\gamma=1.4$)

M ₁	M ₂	p ₂ /p ₁	T ₂ /T ₁
1.46	0.715740	2.3202	1.293765
1.48	0.708290	2.3888	1.306948