Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – SUMMER • 2013

Subject code: 711103N **Date: 13-06-2013**

Subject Name: Fluid Mechanics and Gas Dynamics

Time: 10.30 am – 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.**
5. **Usual notations are used.**

Q.1 **(a)** What is chocked flow in nozzle? Derive maximum mass flow equation **07**

$$\frac{\dot{m}_{\max}\sqrt{T_0}}{A^* P_0}\sqrt{\frac{R}{\gamma}} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}}$$

(b) Air is discharged from a reservoir at P_0=6.91 bar and T_0=325^{0}C through a nozzle to an exit pressure 0.98 bar. If the flow rate is 3600 kg/hr determine for isentropic flow (i) Throat area, pressure and velocity (ii) exit area, Mach number and (iii) maximum velocity. **07**

Q.2 **(a)** Define geometric, kinematic and dynamic similarities. Explain how the condition of dynamic similarity of a hydraulic model is satisfied in actual practice. **07**

(b) What do you understand by stagnation state of fluid? Derive following equation and show various region of flow on a-c diagram. **07**

$$\frac{a^2}{\gamma-1}+\frac{1}{2}c^2 = \frac{1}{2}c^2{}_{\max} = \frac{a_0{}^2}{\gamma-1} = h_0$$

OR

(b) Show that the resistance F to the motion of a sphere of diameter D moving with a uniform velocity V through a real fluid of density ρ and viscosity ε is given by: **07**

$$F = \rho D^2 V^2 f\left(\frac{\mu}{VD\rho}\right)$$

Q.3 **(a)** Show that the upper and lower branches of a Fanno curve represent subsonic and supersonic flows respectively. Prove that at the maximum entropy point Mach number is unity and all processes approach this point. **07**

(b) A long pipe of 25.4 mm diameter has a mean coefficient of friction of 0.003. Air enters the pipe at a Mach number of 2.5, stagnation temperature 310 K and static pressure 0.507 bar. Determine for a section at which the Mach number reaches 1.2, (i) static pressure and temperature (ii) stagnation pressure and temperature (iii) velocity of air (iv) distance of this section from the inlet (v) mass flow rate of air. **07**

OR

Q.3 **(a)** Prove that the algebraic addition of the stream functions of individual flow fields gives the stream function of the combined flow field. **07**

(b) Explain source and sink with necessary diagrams. **07**

Q.4 **(a)** Obtain an equation representing the Rayleigh line. Draw Rayleigh lines on the h-s and p-v planes for two different values of the mass flux. **07**

(b) The conditions of a gas in a combustor at entry are: p_1=0.343 bar, T_1=310 K, c_1=60 m/s; Determine the Mach number, pressure, temperature and velocity at the exit, if the increase in stagnation enthalpy of the gas between entry and exit is 1172.5 kJ/kg. Take c_p=1.005 kJ/kg K, ɔ=1.4. **07**

OR

Q.4 **(a)** (a)Define circulation and velocity **07**
(b)Show that the line integral between two points in a flow field is independent of the path for irrotational flow.

(b) Write down the Navier-Stocks equations of motion for three-dimensional, unsteady, compressible and viscous flow with body and pressure forces. **07**

Q.5 **(a)** Starting from the energy equation for flow through a normal shock obtain the following relations: $c_x c_y = a^{*2}$ & $M_x^* M_y^* = 1$ **07**

(b) A jet of air at 275 K and 0.69 bar has an initial Mach number of 2.0. If it passes through a normal shock wave. Determine (i) Mach number (ii) pressure (iii) temperature (iv) density (v) speed of sound and (vi) jet velocity at downstream of the shock. **07**

OR

Q.5 **(a)** Define the following terms for an aerofoil with figure: **07**
(1) Drag force (2) Chord length (3) Angle of attack (4) Span

(b) Explain flow past an inclined Joukowski aerofoil. **07**

****