Seat No.: _____ Enrolment No.______

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Regular Examination January / February 2011

Subject code:712103N

Subject Name: Fluid Mechanics & Gas Dynamics

Date: 02 /02 /2011 **Time: 02.30 pm – 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.**
4. **Use of Gas Tables is permitted.**

Q.1 **(a)** Explain the variations in flow parameters for the Fanno Flow Process. Also show that the stagnation pressure always decreases in Fanno Flow Process. Also represent graphically the variation of stagnation pressure on enthalpy-entropy diagram. **07**

(b) 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. Also find the new inlet conditions required to maintain the same continuous mass flow rate; when the duct length is increased by 45% of the value determine above. Take mean friction co-efficient for the duct as 0.004. **07**

Q.2 **(a)** It is desired to heat the air flowing in a constant diameter combustion chamber of negligible wall friction. Stating governing equation for this flow and illustrating on p-v and h-s planes, show that maximum temperature of stream is attained at $M=\frac{1}{\sqrt{\gamma}}$. **07**

(b) Justify the variation of static temperature during heating of subsonic flow in a Rayleigh flow process. Also calculate, for a given Rayleigh flow, the maximum heat transfer rate in non-dimensional form, when initial Mach number is (i) 0.5 and (ii) 2.0 **07**

OR

(b) The stream of air with Mach number 0.5, static temperature 350 K and static pressure 5 bar enters into a combustor of constant area and negligible wall friction. Estimate the maximum amount of fuel of calorific value 42 MJ/kg that can be burnt per kg of air flow. Determine also the flow parameter at exit of combustor. **07**

What should be the change in flow parameter at inlet of combustor, if the fuel injection is to be doubled per kg of air ? The properties of air and gas may be assumed to be the same.

Q.3 **(a)** Establish the general expression for mass flow rate through convergent-divergent passage and show that for maximum mass flow rate through the passage, the flow condition at the throat should be sonic. Prove also that for maximum mass flow rate through the passage, $\frac{\dot{m}\sqrt{T_0}}{A^* P_0}$=constant. **07**

(b) A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s. Determine: **07**
(i)exit pressure (ii)exit velocity (iii) force exerted on diffuser walls.
Assume isentropic flow, γ =1.4, Cp=1.005 KJ/kg-K for the air.

OR

Q.3 (a) Write the four basic equations which satisfy the state points before and after a normal shock wave. Using the above equations, prove that at the maximum entropy point on the enthalpy-entropy diagram, the Mach number is unity. **07**

(b) If the air flowing through the convergent-divergent nozzle experiences a normal shock wave at the nozzle exit plane. Determine the following after the shock: (i) the stagnation pressure, static pressure, static temperature and static density; (ii) the entropy change across the shock; (iii) the exit velocity and (iv) the mass flow rate through the nozzle. Assume steady, one dimensional, and isentropic flow with γ =1.4 from the nozzle inlet to the shock location. **07**

Q.4 (a) Derive the continuity equation in Cartesian co-ordinates for multi- dimensional fluid flow with usual notations. **07**

(b) Show that the power P developed in a water turbine can be expressed as: **07**

$$P = \rho N^3 D^5 \phi \left[\frac{D}{B}, \frac{\rho D^2 N}{\mu}, \frac{ND}{\sqrt{gH}} \right]$$

Where D and B are the diameter and width of runner, N is the speed in revolutions per minute, H is the operating head, μ and ρ are respective coefficient of dynamic viscosity and mass density of the liquid.

OR

Q.4 (a) Explain Source flow, Sink flow and Doublet with figures. **07**

(b) The lift force F_L on an aerofoil depends upon the mass density 'ρ' of the medium, velocity of the flow 'V', a characteristic length 'l', viscosity 'μ' and angle of attack 'α'. Obtain an expression for the lift force. **07**

Q.5 (a) What is an aerofoil? Define Drag and Lift co-efficient in reference of aerofoil. Also explain the variation in the value of the coefficient of lift and the coefficient of drag of an aerofoil with angle of incidence. **07**

(b) Show that for steady one dimensional isentropic compressible flow through a duct $\frac{dA}{A} = \frac{dp}{\rho C^2}\left(1 - M^2\right)$ and explain its implication in design of nozzles and diffusers. **07**

OR

Q.5 (a) Explain the propagation of disturbances in compressible fluid with neat sketch. **07**

(b) Derive the following, from one dimensional steady flow energy equation. **07**

$$\frac{a^2}{\gamma - 1} + \frac{1}{2}C^2 = \frac{1}{2}(C\max)^2 = h_0$$

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