Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E Sem-I Examination January 2010

Subject code: 712103

Subject Name: Fluid Mechanics & Gas Dynamics

Date: 25 / 01 / 2010 **Time: 12.00 – 2.30 pm**

Total Marks: 60

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**

Q.1 **(a)** Derive the momentum equation for compressible fluid flow under steady state conditions. **06**

(b) Write a note on reference velocities. **06**

Q.2 **(a)** Explain propagation of disturbance in incompressible, subsonic, sonic and supersonic flow. Define Mach cone and Mach angle. **06**

(b) Air is accelerated isentropically from 100 m/s to 400 m/s in a nozzle. If the temperature at the initial state is 400 K and the Mach number at the final state is 1.5, determine **06**

(i) the initial mach number and (ii) the final temperature

OR

(b) Air flows in a duct at the rate of 2 kg/s. At entry the conditions of air are 5 bar, 400 K and 150 m/s while the air leaves the duct at 2 bar pressure. Find the temperature, velocity and area of duct at exit of duct. Assume C_p= 1050 J/kg K, R = 300 J/kg K, γ = 1.4. **06**

Q.3 **(a)** Explain source, sink and doublet with the help of neat sketches. **06**

(b) A stream function in a two dimensional flow is ψ = 2xy. Show that flow is irrotational and determine the corresponding velocity potential φ. **06**

OR

Q.3 **(a)** Derive Kutta-Joukowski equation for lift of a cylinder. **06**

(b) Derive Navier-Stokes equation of motion. **06**

Q.4 **(a)** Draw Fanno line on h-s diagram and discuss the effect of friction in subsonic and supersonic flows. **06**

(b) Air flows at a pressure of 101 kPa and 300 K into a 4.62 m long tube of 0.04 m diameter. The tube is perfectly insulated. Considering an average friction factor of 0.005 for the tube, determine the maximum mass flow rate and the exit pressure to produce this flow. **06**

OR

Q.4 **(a)** Sketch Rayleigh line on h-s diagram and explain significance of it. **06**

(b) Starting from the energy equation for flow through a normal shock obtain the following relations : **06**

$C_x C_y = a^{*2}$

$M^*_x M^*_y = 1$

Q.5 **(a)** A supersonic diffuser for air ($\gamma = 1.4$) has an area ratio of 0.416 with an inlet Mach number of 2.4 (design value). Determine the exit Mach number and the design value of the pressure ratio across the diffuser for isentropic flow. At an off-design value of the inlet Mach number (2.7) a normal shock occurs inside the diffuser. Determine the upstream Mach number and area ratio at the section where the shock occurs. **06**

(b) Write a note on moving shock waves. **06**

OR

Q.5 **(a)** Using Buckingham's π Theorem show that the thrust F of a propeller having diameter d, moving with a velocity V in a fluid of viscosity μ and density ρ, rotating at a speed of N is expressed as **06**

$F = \rho V^2 d^2 \; f [N d / V, \; \rho V d / \mu]$

(b) Define the following dimensionless numbers and state its applications: **06**

(i) Froude's number, (ii) Reynold's number and (iii) Weber's number

****