

GUJARAT TECHNOLOGICAL UNIVERSITY**M. E. IST Semester–Remedial Examination – July- 2011****Subject code: 711103N****Subject Name: Fluid Mechanics and Gas Dynamics****Date: 11/07/2011****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. Usual notations are used

- Q.1** (a) Derive the continuity equation in Cartesian coordinates **07**
 (b) Differentiate between **07**
 (i) Eulerian and Lagrangian methods of representing fluid flow.
 (ii) The rotational and irrotational flows

- Q.2** (a) Derive the Navier-Stokes equation for viscous compressible fluid with constant viscosity **07**

$$\rho \frac{D\bar{q}}{Dt} = \rho \bar{X} - \nabla p + \mu \nabla^2 \bar{q} + \frac{\mu}{3} \nabla (\nabla \cdot \bar{q})$$

- (b) For an incompressible fluid the velocity components are **07**

$$u = x^3 - y^3 - z^3, v = y^3 - z^3, w = -3x^2z - 3y^2z + \frac{z^3}{3}$$

Determine whether the continuity equation is satisfied.

OR

- (b) Given that $u = -4ax(x^2 - 3y^2)$, $v = 4ay(3x^2 - y^2)$. Examine whether this velocity component represents a physically possible two-dimensional flow; if so whether the flow is rotational or irrotational? **07**

- Q.3** (a) Verify whether the following functions are valid potential functions: **07**
 (i) $\phi = A(x^2 - y^2)$ (ii) $\phi = A \cos x$

- (b) Define and explain briefly the following: **07**
 (i) Velocity potential (ii) Stream function

OR

- Q.3** (a) Show that a circle in $\xi - \eta$ plane displaced from the origin is mapped to an aerofoil in the physical z -plane via the Joukowski transformation. Also determine the magnitude of circulation required to satisfy the Kutta condition. **07**

- (b) A source of strength $10 \text{ m}^2/\text{s}$ at $(1, 0)$ and a sink of the same strength at $(-1, 0)$ are combined with a uniform flow of 25 m/s in the negative x -direction. Determine the size of Rankine body formed by the flow and the difference in pressure between a point far upstream in the uniform flow and the point $(1, 1)$. **07**

- Q.4** (a) Define the following terms: **07**
 (i) Subsonic flow (ii) Sonic flow (iii) Supersonic flow (iv) Mach cone

- (b) How is a shock wave produced in a compressible fluid? What do you mean by the term "Shock strength"? **07**

OR

- Q.4 (a)** Describe compressible flow through a convergent-divergent nozzle, How and where does the shock wave occur in the nozzle? **07**
- (b)** What is the critical pressure ratio for a compressible flow through a nozzle? On what factors does it depend? **07**

- Q.5 (a)** What do you mean by fundamental units and derived units? Give examples. **07**
- (b)** Using Buckingham's π -theorem, show that the velocity through a circular orifice is given by **07**

$$V = \sqrt{2gH} \phi \left[\frac{D}{H}, \frac{\mu}{\rho V H} \right]$$

where,

H=Head causing flow, D= Diameter of the orifice, μ = Coefficient of viscosity,
 ρ = Mass density, and g = Acceleration due to gravity.

OR

- Q.5 (a)** Derive the Rankine-Hugoniot equations for normal shock waves. **07**
- (b)** For a normal shock wave in air Mach number is 2. If the atmospheric pressure and air density are 26.5 kN/m² and 0.413 kg/m³ respectively, determine the flow conditions before and after the shock wave. Take $\gamma = 1.4$ **07**
