Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. IST Semester–Remedial Examination – July- 2011

Subject code: 711103

Subject Name: Fluid Mechanics and Gas Dynamics

Date:11/07/2011 **Time: 10:30 am – 01:00 pm**

Total Marks: 60

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 **06**

(b) Differentiate between **06**

(i) Eulerian and Langrangian 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 **06**

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

(b) For an incompressible fluid the velocity components are **06**

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

Determine whether the continuity equation is satisfied.

OR

(b) Given that $u=-4ax\left(x^2-3y^2\right)$, $v=4ay\left(3x^2-y^2\right)$. Examine whether this velocity component represents a physically possible two- dimensional flow; if so whether the flow is rotational or irrotational? **06**

Q.3 **(a)** Verify whether the following functions are valid potential functions: $(i)\ \phi=A\left(x^2-y^2\right)$ $(ii)\ \phi=A\cos x$ **06**

(b) Define and explain briefly the following: **06**

(i) Velocity potential (ii) Stream function

OR

Q.3 **(a)** Show that a circle in ξ – 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. **06**

(b) A source of strength 10 m^2/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). **06**

Q.4 **(a)** Define the following terms: **06**

(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”? **06**

OR

Q.4 **(a)** Describe compressible flow through a convergent-divergent nozzle, How and where does the shock wave occur in the nozzle? **06**

(b) What is the critical pressure ratio for a compressible flow through a nozzle? On what factors does it depend? **06**

Q.5 **(a)** What do you mean by fundamental units and derived units? Give examples. **06**

(b) Using Buckingham's π-theorem, show that the velocity through a circular orifice is given by **06**

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

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. **06**

(b) For a normal shock wave in air Mach number is 2. If the atmospheric pressure and air density are 26.5 kN/m^2 and 0.413 kg/m^3 respectively, determine the flow conditions before and after the shock wave. Take γ = 1.4 **06**

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