Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – WINTER 2012

Subject code: 711103N **Date: 12/01/2013**

Subject Name: Fluid Mechanics and Gas Dynamics

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. **Usual notations are used**

Q.1 (a) Derive the Euler's equation of motion. **07**

(b) Determine the components of rotation for the following velocity field pertaining to the flow of an incompressible fluid $u = Cyz$; $v = Czx$; $w = Cxy$ where $C = \text{constant}$. State whether the flow is rotational or irrotational? **07**

Q.2 (a) Derive continuity equation in cylindrical polar co-ordinates for a two dimensional fluid flow with usual notations. **07**

(b) Distinguish between path lines, stream lines and streak lines. **07**

OR

(b) In an incompressible flow, the velocity vector is given by **07**

$V = (6xt + yz^2)i + (3t + xy^2)j + (xy - 2xyz - 6tz)k$

(i) Verify whether the continuity equation is satisfied.

(ii) Determine the acceleration vector at point $L(2,2,2)$ at $t = 2.0$

Q.3 (a) If the velocity field is given by $u = (16x - 8x)$, $v = (8y - 7x)$ find the circulation around the closed curve defined by $x = 4,\ y = 2,\ and\ x = 8,\ y = 8.$ **07**

(b) For the following stream functions calculate velocity at a point (1,2) **07**

$(i)\ \psi = 3xy \quad (ii)\ y = 3x^2y - y^3$

OR

Q.3 (a) Derive the Navier-Stokes equation for viscous compressible fluid with constant viscosity **07**

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

(b) 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. **07**

Q.4 (a) Obtain following equations of Rankine-Hugoniot equations. **07**

$$(i)\ \frac{p_2}{p_1} = \frac{\left(\frac{\gamma+1}{\gamma-1}\right)\frac{\rho_2}{\rho_1} - 1}{\left(\frac{\gamma+1}{\gamma-1}\right) - \frac{\rho_2}{\rho_1}} \quad (ii)\ \frac{\rho_2}{\rho_1} = \frac{1 + \left(\frac{\gamma+1}{\gamma-1}\right)\frac{p_2}{p_1}}{\left(\frac{\gamma+1}{\gamma-1}\right) + \frac{p_2}{p_1}}$$

(b) Describe compressible flow through a convergent-divergent nozzle. How and where does the shock wave occur in the nozzle? **07**

OR

Q.4 (a) What is Mach number? Why is this parameter so important for the study of flow of compressible fluids? **07**

Q.4 (b) Define the following terms: **07**

(i) Subsonic flow (ii) Sonic flow (iii) Supersonic flow (iv) Mach cone
(v) stagnation pressure (vi) silence zone (vii) shock strength.

Q.5 (a) What are repeating variables? How are these selected by dimensional analysis? **07**

(b) Enumerate different laws on which models are designed for dynamic similarity. Where are they used? **07**

OR

Q.5 (a) By dimensional analysis, show that the discharge Q of a centrifugal pump is given by **07**

$$Q = ND^3\phi\left(\frac{gH}{N^2D^2}, \frac{\mu}{\rho ND^2}\right)$$

Where,

$\rho =$ mass density of fluid,

$N =$ speed of the pump,

$D =$ diameter of the impeller,

$H =$ manometric head and

$\mu =$ viscosity of fluid

(b) An oil of specific gravity 0.92 and viscosity 0.003 Ns/m^2 is to be transported at the rate of 2500 litres/sec. through a 1.2 m diameter pipe. Tests were conducted on a 0.12 m diameter pipe using water at 20°C. if the viscosity of water at 20°C is 0.001 Ns/m^2 find : (i) velocity of flow in the model (ii) Rate of flow in the model. **07**

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