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 $C =$ 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**

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

(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,

ρ = mass density of fluid,

N = speed of the pump,

D = diameter of the impeller,

H = manometric head and

μ = 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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