Seat No.: _____ *Enrolment No._____*

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – I • EXAMINATION – SUMMER • 2014

Subject code: 711103N **Date: 19-06-2014**

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.**

Q.1 **(a)** Explain the term: (i) Path line, (ii) Streak line, (iii) Stream line, (iv) Stream tube, (v) Laminar flow (vi) Turbulent flow, and (vii) Steady flow. **07**

(b) Define the equation of continuity. Obtain an expression for continuity equation for a three dimensional flow. **07**

Q.2 **(a)** Explain uniform flow with source and sink. Obtain expressions for stream and velocity potential functions. **07**

(b) Explain doublet, define the strength of the doublet and distinguish between a source and a sink. **07**

OR

(b) Sketch and describe the flow pattern of an ideal fluid flow past a cylinder with circulation. **07**

Q.3 **(a)** Define rotational and irrotational flow. The stream function and velocity potential for a flow are given by: $\Psi = 2xy$, $\phi = x^2 - y^2$, Show that the conditions of continuity and irrotational flow are satisfied. **07**

(b) A fluid flow field is given by $V = x^2 yi + y^2 zj - \left(2xyz + yz^2\right)k$. Prove that it is a case of possible steady incompressible fluid flow. Calculate the velocity and acceleration at the point (2, 1, 3). **07**

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. Also determine the magnitude of circulation required to satisfy the Kutta condition. **07**

Q.4 **(a)** Explain the following: (i) Mach angle (ii) Mach cone (iii) Mach wave (iv) Zone of action (v) Zone of silence (vi) stagnation pressure (vii) critical velocity **07**

(b) Explain the different types of hydraulic similarities that must exist between a prototype and its model. **07**

OR

Q.4 **(a)** Define stagnation temperature and critical temperature of a gas. Also derive the equation $\frac{T^*}{T} = \left(\frac{2}{\gamma + 1}\right)$ with usual notations. **07**

(b) Define Static and Stagnation enthalpies. **07**

Also prove that $h_o = h\left[1+\left(\frac{\gamma-1}{2}\right)M^2\right]$ with usual notations.

Q.5 **(a)** Describe the behaviour of flow in convergent-divergent nozzle when it is operated at (i) the design pressure ratio (ii) Pressure ratio higher than the design value. (iii) Pressure ratio lower then design value. **07**

(b) Show upper and lower branch of Fanno curve represent subsonic and supersonic flows respectively. Prove that at the maximum entropy point Mach number is unity. **07**

OR

Q.5 **(a)** For a Rayleigh flow obtain an expression for the value of maximum possible heat transfer in terms of Mach number. **07**

(b) Derive the Rankine-Hugoniot equations for normal shock waves. **07**

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