Seat No.: _____ Enrolment No._____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**ME - SEMESTER– I• EXAMINATION – WINTER 2014**

**Subject Code: 2711103 Date:09/01/ 2015**

**Subject Name: Advanced Fluid Mechanics**

**Time:02:30 p.m. to 05:00 p.m. 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 exact solution of Navier-Stoke equation and boundary conditions. Give your comments on exact solution of Navier-Stoke equation **07**

**(b)** Explain friction choking for Fanno flow **07**

**Q.2** **(a)** Define 1. Rotational and Irrotational flow, 2. Uniform and non-uniform flow, 3. Steady and unsteady flow, 4. Stream line and stream function, 5. Potential line and potential function, 6. Vorticity and circulation, 7. Ideal and real fluid. **07**

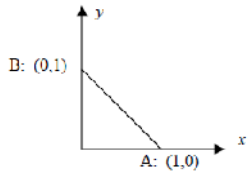
**(b)** Consider a 3D steady flow of an incompressible, Newtonian liquid with a velocity field given by: $u = axi + ayj - 2azk$ where *i, j, k* are unit vectors in x, y and z direction respectively. There are no body forces acting on the flow and the pressure at the origin is $p_0$. **07**

a. Show that the continuity equation is satisfied, b. Determine the pressure field.

c. Determine the vorticity field.

**OR**

**(b)** The velocity field for a planar, incompressible flow is given by: $u = 2(x^2 - y^2)i - 4xyj$ where *i,* and *j* are unit vectors in x and y direction respectively. a. Determine the stream function for this flow field if ɣ (0,0)=0. b. Determine the volumetric flow rate across the line AB shown in the figure. **07**




**Q.3** **(a)** Define boundary layer thickness, displacement thickness and momentum thickness for boundary layer flow. Show that drag on flat plate is related to momentum thickness **07**

**(b)** What is creeping flow? Write note on creeping flow **07**

**OR**

**Q.3** **(a)** Explain Exact Solution to Laminar Boundary Layer Flow over a Flat Plate with no Pressure Gradient **07**

**(b)** Write a short note on Transition to turbulence and transition process in boundary layer flow. **07**

**Q.4** **(a)** For turbulent flow explain law of the wall **07**

**(b)** Explain boundary layer solution using Falkner-Skan method **07**

**OR**

**Q.4** **(a)** Write note on characteristics nature of turbulent flow **07**

**(b)** Explain thermal boundary layer over flat plate **07**

**Q.5** **(a)** Show that for steady one dimensional isentropic flow through a duct **07**
$\frac{dA}{A}=\frac{dP}{\rho C^2}\left(1-M^2\right)$ and $\frac{dA}{A}=-\frac{dC}{C}\left(1-M^2\right)$. Hence give an analysis of these equations

**(b)** Using Governing equations derive Rankine-Hugoniot equations for a normal shock and show that a normal shock cannot compress the gas to a density more than six times the shock density of the upstream side of the shock **07**

**OR**

**Q.5** **(a)** **07**
For isentropic flow $\frac{A}{A^*}$ is given by $\frac{A}{A^*}=\frac{1}{M}\left[\frac{2}{\gamma+1}+\frac{\gamma-1}{\gamma+1}M^2\right]^{\gamma+1/2(\gamma-1)}$ and hence analyse the graph of $\frac{A_e}{A^*}$ *Vs* $M_e$.

**(b)** For a normal shock show that the product if upstream and downstream velocities is equal to the square of the critical velocity of the flow and hence show that $M_1^* M_2^* = 1$. **07**