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.**

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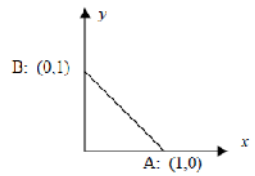
|---|---|---|---|
| **Q.1** | **(a)** | Explain exact solution of Navier-Stoke equation and boundary conditions. Give your comments on exact solution of Navier-Stoke equation | **07** |
| | **(b)** | Explain friction choking for Fanno flow | **07** |
| **Q.2** | **(a)** | Define 1. Rotational and Irrotational 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 $p_0$. a. Show that the continuity equation is satisfied, b. Determine the pressure field. c. Determine the vorticity field. | **07** |
| | | **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** |

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| **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** |

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| **Q.4** | **(a)** | For turbulent flow explain law of the wall | **07** |
| | **(b)** | Explain boundary layer solution using Falkner-Skan method | **07** |

**OR**

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|---|---|---|---|
| **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 $\frac{dA}{A}=\frac{dP}{\rho C^2}\left(1-M^2\right)$ and $\frac{dA}{A}=-\frac{dC}{C}\left(1-M^2\right)$. Hence give an analysis of these equations | **07** |
| | **(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**

| | | | |
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| **Q.5** | **(a)** | 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* $M_e$. | **07** |
| | **(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** |