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A – 1052

Reg. No. : .....

Name : .....

First Semester M.Tech. Degree Examination, April 2016  
(2013 Scheme)

MECHANICAL ENGINEERING

Stream : Thermal Engineering

MTC 1003 : Incompressible and Compressible Flow

Time : 3 Hours

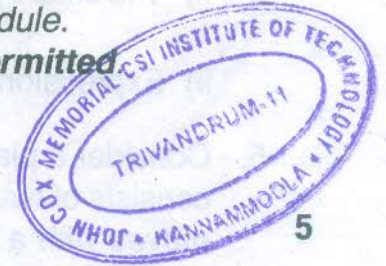
Max. Marks : 60

**Instructions :** i) Answer **any two** questions from **each** Module.

ii) **Use** of approved charts and tables are **permitted**.

MODULE – I

1. a) Derive vorticity transport equation in two dimensions. 5
- b) Given the velocity field  $\vec{U} = (t^2 + 5t)\mathbf{i} + (y^2 - z^2 - 1)\mathbf{j} - (y^2 + 2yz)\mathbf{k}$ , compute at  $t = 2$  and  $\vec{X} = (3, 2, 4)$ :
- a) The total acceleration. 2
- b) The rate of expansion (i.e. dilation). 2
- c) The vorticity. 1
2. a) Write down the Navier-Stokes equation in vector and Cartesian tensor forms. Explain the significance of each term. What are the assumptions used in deriving the Navier-Stokes equation? 4
- b) Consider the flow due to a vortex of strength  $K$  at the origin. Evaluate the circulation about the clockwise path from  $(r, \theta) = (a, 0)$  to  $(2a, 0)$  to  $(2a, 3\pi/2)$  to  $(a, 3\pi/2)$  and back to  $(a, 0)$ . Interpret the result. 4
- c) What is Stoke's hypothesis? What is its implication? 2
3. a) Obtain the expression for stream function and velocity field for a combination of a sink and a potential vortex. 5
- b) Obtain the expression for potential flow past a rotating circular cylinder by method of superposition/Joukowski transformation. 5



P.T.O.



## MODULE – II

4. The velocity distribution in the laminar boundary layer over a flat plate along which the pressure gradient is zero is given by  $\frac{u}{U} = f(y) = \text{Sin}\left(\frac{\pi y}{\delta}\right)$  where  $u$  is the velocity at a distance  $y$  from the wall,  $\delta$  is the boundary layer thickness and  $U$  is the free stream velocity at the edge of the boundary layer  $y = \delta$ . Determine :

i) The shape parameter  $H = \frac{\delta^*}{\theta}$ .

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- ii) Expression for local wall shear stress.

2

5. Consider a plane Couette flow with an applied pressure gradient. The system consists of two large parallel plates kept at a distance 'h' apart. The lower plate moves with a speed  $U_1$  towards the left, while the upper plate moves with a speed  $U_2$  towards the right. Assume that the flow is steady and incompressible. Choose a co-ordinate system such that  $y = 0$  corresponds the lower plate. Determine :

- a) The velocity profile.

4

- b) The volume flow rate per unit width and

3

- c) The shear stress at the lower and upper walls.

3

6. a) Explain mixing length and Boussinesq hypothesis.

3

- b) What are the characteristics of a typical turbulent flow ?

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- c) Explain with neat sketch, the working of a constant temperature hot wire anemometer for velocity measurements.

4

## MODULE – III

7. a) Derive the equations governing the flow of compressible fluid in two dimensions.

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- b) What is the significance of influence coefficients in compressible flow analysis ?

3





- 8. a) What are the main driving potentials considered for a generalized one-dimensional flow analysis ? 3
- b) Obtain a differential equation for Mach number if area change and mass flow rate changes are the driving potentials. 3
- c) Derive the expression for conservation of energy for a steady one dimensional compressible flow with mass addition. 4
  
- 9. Write short notes on :
  - i) Characteristics and features of hypersonic flow. 3
  - ii) Influence coefficients. 3
  - iii) Method of solution of 2-D compressible flows. 4



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