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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 $\vec{U} = (t^2 + 5t)\,i + (y^2 - z^2 - 1)\,j - (y^2 + 2yz)\,k$, 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/Joukowsky transformation. 5

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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, δ 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 $H = \frac{\delta^*}{\theta}$. 8

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 ? 3

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. 7

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