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Sl. No.

M.Sc. IV Semester Degree Examination, October - 2023

MATHEMATICS

Advanced Fluid Mechanics

(NEP)

Time : 3 Hours Maximum Marks : 70

Note : *Answer* ***any five*** *questions with question No.* ***1*** *is* ***compulsory****.*

1. (a) Explain Stoke's law of viscosity and hence derive the relation between stress and rate of strain components. **8+6**

(b) The state of stress at a point is given by the stress tensor $\sigma_{ij} = \begin{bmatrix} \sigma & a\sigma & b\sigma \\ a\sigma & \sigma & c\sigma \\ b\sigma & c\sigma & \sigma \end{bmatrix}$.

Where a, b, c are constants and σ is some stress value. Determine the constants a, b and c. So that the stress vector on the octahedral plane. $n = \left(\frac{1}{\sqrt{3}} i + \frac{1}{\sqrt{3}} j + \frac{1}{\sqrt{3}} k \right)$ vanishes.

2. Define the law of conservation of momentum and derive the Navier - Stroke equation in the form $\rho\left[\frac{\partial \vec{q}}{\partial t} + \left(\vec{q} \cdot \nabla\right)\vec{q}\right] = -\nabla p + \rho \vec{g} + \mu \nabla^2 \vec{q}$. **14**

3. (a) State and prove Buckingham-π theorem. **7+7**

(b) Define the similarity of two flows and also explain the physical significance of the following non-dimensional parameter.

(i) Reynold's number

(ii) Mach number

(iii) Prandtl number

4. Define the plane Poiseuille flow. For such a flow obtain the velocity distribution, average velocity, maximum velocity, mass flow rate and skin friction. **14**

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5. (a) Define : **7+7**

(i) Displacement thickness

(ii) Momentum thickness

(iii) Energy thickness,

Show that :

(i) $\int_0^{\delta}\left(\frac{u}{v}\right)dy = \delta - \delta_1$

(ii) $\int_0^{\delta}\left(\frac{u}{v}\right)^2 dy = \delta - \delta_1 - \delta_2$

(iii) $\int_0^{\delta}\left(\frac{u}{v}\right)^3 dy = \delta - \delta_1 - \delta_3$

(b) Discuss the Blasius equation for boundary layer on a flat plate and calculate the coeffecient of skin friction.

6. (a) Define Circulation. Show that $\frac{d\Gamma}{dt} = V\nabla^2 T$. **7+7**

(b) Define Reynold's number and indicate it's significance.

7. (a) Discuss the velocity distribution in the case of the Hagen-Poiseuille flow of a viscous incompressible fluid. **7+7**

(b) Derive the two-dimensional thermal boundary layer equations for flow over a flat plate using the order of magnitude approach.

8. (a) Show that the time rate of change of circulation in a closed circuit, drawn in a viscous incompressible fluid under the action of conservative forces, moving with fluid depends only on the kinematic viscosity and the space rate of change of vorticity components at the contour. **5+5+4**

(b) Find the velocity distribution for plane Couette flow of a viscous incompressible fluid.

(c) Find Displacement thickness and Momentum thickness for the velocity distribution in the boundary layer given by, $\frac{u}{v} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$.

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