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MT-602

Viscous Fluid Dynamics-I

MA/MSC Mathematics (MAMT/MSCMT)

3rd Semester Examination, 2022 (Dec.)

Time : 2 Hours] **[Max. Marks : 35**

Note : This paper is of Thirty Five (35) marks divided into two (02) Sections A and B. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION–A

(Long Answer Type Questions)

Note : Section 'A' contains Five (05) long answer type questions of Nine and Half (9½) marks each. Learners are required to answer any Two (02) questions only. (2×9½=19)

1. Given a velocity field with components $u = cx + 2\omega_0 y + u_0$, $v = cy + v_0$, $w = -2cz + \omega_0$, where c, u_0, v_0 and ω_0 are constants. With the above velocity components at a point P(x,y,z), determine the velocity components at a neighbouring point Q$(x + dx, y + dy, z + dz)$ and determine the different types of motion which are involved.

2. Prove that the vorticity $\vec{\pi}$ satisfy the differential equation

$$\frac{D\vec{\pi}}{Dt} = (\vec{\pi} \cdot \nabla)\vec{q} + v\nabla^2(\vec{\pi}).$$

3. State and prove the Navier-Stokes equations of motion for a viscous fluid compressible fluid.

4. Define Reynold's number and indicates its significance.

5. State and prove the equation of continuity in Cartesian coordinates.

SECTION–B

(Short Answer Type Questions)

Note : Section 'B' contains Eight (08) short answer type questions of Four (04) marks each. Learners are required to answer any Four (04) questions only. (4×4=16)

1. The stress tensor at a point P is given by $\sigma_{ij} = \begin{pmatrix} 7 & 0 & -2 \\ 0 & 5 & 0 \\ +2 & 0 & 4 \end{pmatrix}$. Determine the stress vector on the plane at P whose unit normal is $n = \frac{2}{3}i - \frac{2}{3}j + \frac{1}{3}k$.

2. Consider the rectangular flow $q = \{0, 0, \phi\{x_1, x_2)\}$ of an isotropic incompressible fluid, show that strain rate tensor has non-zero component.

3. Explain the terms: Froude number, Mach number, Prandtl number and Peclet number.

4. Show by means of dimensional analysis that the thrust T of screw propeller is given by $T = pd^2V^2\phi\left(\frac{V d\rho}{\mu}, \frac{dn}{V}\right)$, where ρ is the fluid density, μ its viscosity, d is the diameter of propeller, V is speed of advance and n is the revolution per second.

5. Obtain the viscous stress in the flow between two concentric rotating cylinder when the inner cylinder being at rest. Also find the torque.

6. Volocity field at points is given by $1 + 2y - 3z$, $4 - 2x + 5z$, $6 + 3x - 5y$. Show that it represent a rigid body motion.

7. Discuss the flow of an incompressible viscous fluid between two rotating concentric cylinders.

8. State and prove the Buckingham π-theorem.
