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MT-602

Viscous Fluid Dynamics-I

MA/MSC Mathematics (MAMT/MSCMT)

3rd Semester Examination, 2023 (June)

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. Show that for each state of stress at a point, there exists at least one set of three mutually perpendicular principal directions.

2. Show that the vorticity vector Ω of an incompressible viscous fluid moving under no external forces satisfies the differential equation $\frac{D\Omega}{Dt} = (\Omega.\nabla)q + v\nabla^2\Omega$ where v is the kinematic of viscosity.

3. Show that in the dynamics of compressible fluids, there are only five independent dimensionless groups.

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

5. Discuss unsteady flow of a viscous incompressible fluid due to an oscillating plane wall.

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. Let the stress tensor at a point in the fluid be $\begin{bmatrix} 5 & 2 & 2 \\ 2 & 2 & 1 \\ 2 & 1 & 2 \end{bmatrix}$.

Obtain the principal stresses.

2. Show that the two principal directions corresponding to any two distinct principal stresses are orthogonal.

3. The resistance force R of a supersonic plane during flight can be considered as dependent upon the length of the aircraft l, velocity V, air velocity μ, air density ρ and bulk modulus of air K. Find an expression for R.

4. Define and give the physical importance of the followings: Grashoff Number, Eckert Number, Reynold's Number, Brinkman Number.

5. Derive the velocity distribution in plane poiseuille flow.

6. Write short notes on :

(a) Limitations of the Navier-Stokes equations.

(b) Exact Solutions of the Navier-Stokes equations.

7. What type of the motion do the following velocity components constitute?

$u = a + by - cz$; $v = d - bx + ez$; $w = f + cx - ey$;

where a, b, c, d, e, f are arbitrary constants.

8. Write Navier-Stokes equations in cartesian co-ordinates. Simplify these equations when the fluid is incompressible and viscous effects are negligible.
