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M.Sc. II Semester Degree Examination, September/October - 2022

MATHEMATICS

21MAT2C8L DSC8 : Fluid Mechanics

Time : 3 Hours   Maximum Marks : 70

Note : *Answer **any five** of the following questions with question No.**1 (Q1)** is **Compulsory**, Each question carries **equal** marks.*

1. (a) Define : **8**

(i) Viscous fluid and inviscid fluid

(ii) Newtonian and non-newtonian fluid

(iii) Dynamic viscosity and kinematic viscosity

(iv) Uniform and non-uniform flow

(b) Derive the relation $\frac{D}{Dt}=\frac{\partial}{\partial t}+\left(\vec{q}\,\nabla\right)$ where $\vec{q}$ = (u,v,w) **6**

2. (a) Derive equation of motion under impulsive force and prove that impuls satisfy the laplace equation. **7**

(b) The velocity field at a point in fluid is given as $q=\left(x/t,\ y,\ 0\right)$. Obtain path line and streak lines. **7**

3. (a) State and prove Bernoulli's theorem for a steady inviscid flow in a conservative field of force and discuss the nature of the constant. **7**

(b) An infinite mass of fluid is acted on by a force $\frac{\mu}{r^{3/2}}$ per unit mass directed to the origin. If initially the fluid is at rest and there is a cavity in the form of the sphere r=C in it. Show that the cavity will be filled up after an interval of time $\left(\frac{2}{5\mu}\right)^{\frac{1}{2}}\cdot C^{\frac{5}{4}}$. **7**

4. (a) Define stream function. Write physical significance of stream function. **7**

(b) Derive Cauchy - Riemann equations in cartesian and polar forms. **7**

5. (a) Define sources and sinks. And explain their utility in hydrodynamics. **7**

(b) State and prove Kelvin's circulation theorem. **7**

6. (a) A sphere of radius 'a' is surrounded by infinite liquid of density ρ, the pressure at infinity being π. Thus sphere is suddenly annihilated. Show that the pressure at a distance 'r' from the centre immediately falls to $\pi\left(1-\frac{a}{r}\right)$. **10**

Show further that, if the liquid is brought to rest by impinging on a concentric sphere of radius $\left(a/2\right)$, the impulsive pressure sustained by the surface of this sphere is $\left[\frac{7\pi\rho^2}{6}\right]^{\frac{1}{2}}$.

(b) Find the trajectory of a free jet. Also, find the velocity at an arbitrary point of the jet. **4**

7. (a) Show that the stream function φ and the velocity potential ϕ for a two-dimensional irrotational motion satisfy Laplace equation. **7**

(b) A space is bounded by an ideal fixed surface S drawn in a homogeneous incompressible fluid. Satisfying the conditions for the continued existence of a velocity potential ϕ under conservative forces. Prove that the rate per unit time at which energy flows across S into the space bounded by S is **7**

$$-\rho \iint \frac{\partial \phi}{\partial t} \cdot \frac{\partial \phi}{\partial n} \cdot ds$$

Where ρ is the density and δn an element of the normal to δs drawn into the space considered.

8. (a) Show that the family of curves $\phi(x, y) = C_1$ and $\psi(x, y) = C_2$, C_1, C_2 being constants, cut orthogonally at their points of intersection. **5**

(b) The velocity in the flow field is given by : **5**

$q = i\ (Az - By) + j(Bx - Cz\ ) + K(Cy - Ax)$

Where A, B, C are non-zero constants.

Determine the equation of the vortex lines.

(c) Write advantages of images in fluid dynamics. **4**

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