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B.Sc. 6th Semester Examination, July-2021

MATHEMATICS (HONS)

Paper-BHM-365

(Fluid Dynamics)

*Time : **Three** Hours]* *[Maximum Marks : **60***

Before answering the questions, candidates should ensure that they have been supplied the correct and complete question paper. No complaint in this regard, will be entertained after examination.

Note :- Attempt *five* questions in all, selecting *one* question from each Section. Q. No. **9** is compulsory. All questions carry equal marks.

Section–I

1. (a) The velocities at a point in a fluid in the Eulerian system are given by $u = x + y + z + t$, $v = 2(x + y + z) + t$, $w = 3(x + y + z) + t$, obtain the displacements of a fluid particle in the Lagrangian system.

(b) The velocity field at a point in fluid is given by $\vec{q} = \left(\frac{x}{1+t}, y, 0\right)$. Find the streamlines, pathlines and streaklines.

2. (a) Derive equation of continuity in cylindrical co-ordinates.

(b) Show that :

$$u = \frac{-2xyz}{(x^2+y^2)^2}, \quad v = \frac{(x^2-y^2)z}{(x^2+y^2)^2}, \quad w = \frac{y}{x^2+y^2}$$

are the possible velocity components of a liquid motion. Is this motion irrotational ?

Section–II

3. (a) Components of acceleration in spherical polar co-ordinates (r, θ, ϕ) with velocity components (V_r, V_θ, V_ϕ).

(b) Homogeneous liquid is in motion in a vertical plane, within a curved tube of uniform small bore, under the action of gravity. Calculate period of oscillation.

4. (a) Obtain Bernoulli's equation for steady motion.

(b) In a two dimensional incompressible flow, the fluid velocity components are given by $u = x - 4y$ and $v = -y - 4x$. Show that velocity potential exists and determine its form as well as stream function.

Section–III

5. (a) State and prove Kelvin's minimum energy theorem.

(b) Show that there cannot be two different forms of irrotational motion for a given confined mass of incompressible inviscid liquid whose boundaries are subject to the given impulses.

6. (a) Determine velocity potential due to a three dimensional doublet.

(b) Discuss motion of a sphere through an infinite mass of a liquid at rest at infinity.

Section–IV

7. (a) The velocity potential function for a two dimensional flow is $\phi = x(2y - 1)$. At a point $\rho(4, 5)$ determine :

(i) The velocity stream

(ii) The value of function

(b) State and prove Milne-Thomson circle theorem.

8. (a) Find the image of a line doublet in a circle.

(b) An infinite cylinder of radius a and density σ is surrounded by a fixed concentric cylinder of radius b and the intervening space is filled with liquid of density ρ. Prove that the impulse per unit length necessary to start the inner cylinder with velocity V is :

$$\frac{\pi^2}{b^2 - a^2}\left[(\sigma + \rho)\, b^2 - (\sigma - \rho)\, a^2\right] V$$

Section–V

9. (a) Write short note on sinks and doublets.

(b) Give examples of irrotational and rotational flows.

(c) Define Lagrange's stream function.

(d) Define term–impulsive motion.

(e) Discuss significance of the equation of continuity.

(f) State Blasius theorem.