FYUG Even Semester Exam., 2026

MATHEMATICS

(6th Semester)

Paper Code : MTMDSC-352T

(Hydrodynamics)

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions.

UNIT—I

1. Answer any *two* of the following questions : 2×2=4

(a) Define real and ideal fluids, and give example of both.

(b) Name the methods of describing fluid motion.

(c) Write the components of acceleration of a fluid particle in cylindrical coordinates.

Scanned with OKEN Scanner

2. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] :

(a) The velocity components for a two-dimensional fluid system can be given in the Eulerian system by

$$u = 2x + 2y + 3t,\ v = x + y + \frac{1}{2}t$$

Find the displacement of a fluid particle in Lagrangian system. 8

(b) Write the components of acceleration of a fluid particle in Cartesian coordinates. 2

(c) Establish the relation

$$\frac{D}{Dt} \equiv \frac{\partial}{\partial t} + \vec{q} \cdot \vec{\nabla}$$

What do you mean by material and convective derivatives? 6+2=8

(d) Determine the component of acceleration of a fluid particle in *X*-direction from the flow field

$$\vec{q} = (Axy^2t)\hat{i} + (Bx^2yt)\hat{j} + (Cxyz)\hat{k}$$ 2

UNIT—II

3. Answer any *two* of the following questions : 2×2=4

(a) Define steady and unsteady flow.

(b) What do you mean by rotational and irrotational flow?

(c) Write the difference between streamlines and pathlines.

4. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] :

(a) Find the path lines when the velocity field is given by

$$u = \frac{x}{1+t},\ v = y,\ w = 0$$ 4

(b) If the motion is specified by

$$\vec{q} = \frac{k^2(x\hat{j} - y\hat{i})}{x^2 + y^2}\quad (k = \text{constant})$$

test whether the motion is of potential kind and if so determine the velocity potential. 6

(c) If velocity distribution is

$$\vec{q} = (Ax^2yt)\hat{i} + (By^2zt)\hat{j} + (Czt^2)\hat{k}$$

then find the vorticity components. 4

(d) The velocity components of a possible liquid motion are given by

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

Is this motion irrotational? 6

Scanned with OKEN Scanner

UNIT—III

5. Answer any *two* of the following questions : 2×2=4

(a) Give the physical significance of the equation of continuity.

(b) Write the equation of continuity in *(i)* Cartesian coordinates and *(ii)* cylindrical coordinates.

(c) Show that flow is possible, if velocity components of an incompressible flow are $u = x^2 - y^2$, $v = z^2 - y^2$, $w = 2z(y - x)$.

6. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] :

(a) Deduce the equation of continuity in the form

$$\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot (\rho \vec{q}) = 0$$ 7

(b) Derive the equation of continuity by Lagrangian method. 3

(c) A mass of fluid is in motion so that the lines of motion lie on the surface of coaxial cylinders. Show that the equation of continuity is

$$\frac{\partial \rho}{\partial t} + \frac{1}{r}\frac{\partial}{\partial \theta}(\rho u) + \frac{\partial}{\partial z}(\rho v) = 0$$ 7

(d) If the velocity components of a two-dimensional liquid be given by

$$u = \frac{ax - by}{x^2 + y^2}, \quad v = \frac{ay + bx}{x^2 + y^2}$$

verify the equation of continuity. 3

UNIT—IV

7. Answer any *two* of the following questions : 2×2=4

(a) Write Euler's equation of motion in Cartesian coordinates.

(b) State the principles of linear and angular momentum for fluid motion.

(c) Write the statement of energy equation for incompressible fluid.

8. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] :

(a) Derive the equation of motion in the form

$$\frac{D\vec{q}}{Dt} = \vec{F} - \frac{1}{\rho}\vec{\nabla} p$$

symbols having their usual meanings. 7

(b) From Euler's equation of motion, deduce the equation

$$\frac{\partial \vec{q}}{\partial t} - \vec{q} \times \text{curl } \vec{q} = \vec{F} - \frac{1}{\rho}\vec{\nabla} p - \frac{1}{2}\vec{\nabla} q^2$$ 3

Scanned with OKEN Scanner

(c) What do you mean by conservative force? 2

(d) Write Lamb's hydrodynamical equation and derive it. 8

UNIT—V

9. Answer any *two* of the following questions : 2×2=4

(a) State Euler's momentum theorem.

(b) What do you mean by d'Alembert's paradox?

(c) Define stream function.

10. Answer *either* [*(a)* and *(b)*] *or* [*(c)* and *(d)*] :

(a) State and prove Bernoulli's theorem. 7

(b) Show that stream function satisfies Laplace's equation. 3

(c) Explain the physical significance of stream function. 3

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

★ ★ ★

Scanned with OKEN Scanner