Dept.

Total number of printed pages–7

3 (Sem–1/CBCS) PHY HC 1

2025

PHYSICS

(Honours)

Paper : PHY–HC–1016

(Mathematical Physics–I)

Full Marks : 60

Time : Three hours

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

1. Answer the following questions : 1×7=7

   (a) Write the difference between Systematic error and Random error.

   (b) Define Dirac delta function.

(c) What are the coordinate surfaces in orthogonal curvilinear coordinates ?

(d) Determine the order and degree of the differential equation

$$\left(\frac{d^2y}{dx^2}\right)+x^2\left(\frac{dy}{dx}\right)^2=0$$

(e) Find the Laplacian of the scalar field $\phi = xy^2z^3$.

(f) If $\vec{R}(u)=\frac{d}{du}\vec{S}(u)$, find $\int_a^b \vec{R}(u)\,du$.

(g) What is the geometrical interpretation of the scalar triple product of three vectors ?

2. Answer ***any four*** of the following questions : 2×4=8

(a) State the transformation relation between the spherical polar co-ordinates (r, θ, ϕ) and Cartesian co-ordinates (x, y, z). Obtain the volume elements in spherical polar co-ordinate.

(b) Solve the differential equation

$$xy\,(y+1)\,dy=\left(x^2+1\right)dx.$$

(c) Show that $\iint_S \vec{A}.\hat{n}\,dS$, over any closed surface S is equal to $\iint_R \vec{A}.\hat{n}\,\frac{dx\,dy}{|\hat{n}\,.\,\hat{k}|}$, where R is the projection of S on xy-plane.

(d) Prove that, the vector $\vec{A}=3y^4z^2\hat{i}+4x^3z^2\hat{j}-3x^2y^2\hat{k}$ is solenoidal.

(e) If $\vec{A}(t)$ has a constant magnitude, then show that $\frac{d\vec{A}}{dt}$ is perpendicular to $\vec{A}$.

3. Answer **any three** of the following questions : 5×3=15

(a) Express $\nabla^2\psi$ in orthogonal curvilinear coordinates.

(b) Test the Exactness of the differential equation

$$\left(5x^4+3x^2y^2-2xy^3\right)dx+\left(2x^3y-3x^2y^2-5y^4\right)dy=0$$

and then solve it.

(c) If $\vec{A}$ is a vector, prove that

$$\vec{\nabla}\times\left(\vec{\nabla}\times\vec{A}\right)=\vec{\nabla}\left(\vec{\nabla}.\vec{A}\right)-\nabla^2\vec{A}.$$

(d) How will you define divergence and curl of a vector $\vec{V}$? Evaluate $\vec{\nabla}.\vec{r}$ and $\vec{\nabla}\times\vec{r}$.

4. Answer **any three** of the following questions : 10×3=30

(a) (i) Prove the expression

$\int_{-\infty}^{+\infty}\delta(x)dx=1$ where $\delta(x)=0$ if $x\neq 0$ and $\delta(x)=\infty$ if $x=0$. 5

(ii) Given the three vectors

$$\vec{A}=\hat{i}+2\hat{j}-\hat{k}$$
$$\vec{B}=\hat{j}+\hat{k}$$
$$\vec{C}=\hat{i}-\hat{j}$$

Evaluate $\vec{A}\times\left(\vec{B}\times\vec{C}\right)$ and show that

$$\vec{A}\times\left(\vec{B}\times\vec{C}\right)=\vec{B}\left(\vec{A}.\vec{C}\right)-\vec{C}\left(\vec{A}.\vec{B}\right)$$

2+3=5

(b) (i) Prove that spherical polar coordinate system is orthogonal. 6