

2017

PHYSICS

(Major)

Paper : 1.1

Full Marks : 60

Time : 3 hours

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

GROUP—A

(**Mathematical Methods**)

(Marks : 20)

1. (a) $\phi(r)$ is a scalar field. State whether the end result of $\nabla^2\{\vec{\nabla}\phi(r)\}$ is a scalar or vector. 1
- (b) When a physical quantity is said to have an odd parity? 1
2. (a) What is solenoidal vector? Give an example of it. 2

(b) Prove that $\nabla \cdot \hat{r} = \frac{2}{r}$, where \hat{r} is a unit vector along \vec{r} . 2

(c) Show that $\vec{A} = 3\hat{i} - 2\hat{j} + \hat{k}$, $\vec{B} = \hat{i} + 3\hat{j} + 5\hat{k}$ and $\vec{C} = 2\hat{i} + \hat{j} - 4\hat{k}$ form a right-angled triangle.

(d) Some scalar field is given by

$$\phi(r) = r^2 = x^2 + y^2 + z^2$$

Show that $\vec{\nabla} \cdot \vec{r}$ is a unit vector. 2

3. Answer any two questions :

5×2=10

(a) Show that the curl of the linear velocity of a particle of a rigid body is equal to twice the angular velocity.

(b) Determine constant C such that the vector

$$\vec{A} = (x + 3y)\hat{i} + (y - 2z)\hat{j} + (x + Cz)\hat{k}$$

is solenoidal.

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

$$\vec{A} \times \vec{B} \times \vec{C} = \vec{B}(\vec{A} \cdot \vec{C}) - \vec{C}(\vec{A} \cdot \vec{B})$$

GROUP—B

(**Mechanics**)

(Marks : 40)

4. (a) Is the frame of reference fixed to the earth an inertial frame? What is the nature of the space required for an inertial frame? 1
- (b) What is rotational analogue of the mass of a body? Is it a vector quantity? 1
- (c) Why is centre of mass frame called zero momentum force? 1
- (d) A force \vec{F} acts on a body and changes its position from A to B along a path r such that $\int \vec{F} \cdot d\vec{r} = 0$. What is the nature of the force? 1
- (e) The negative of work done by the conservative internal force on a system equals the change in
- (i) total energy
 - (ii) kinetic energy
 - (iii) potential energy
 - (iv) None of the above
- Which is correct? 1
- (f) Define scalar field and vector field in space. 1

5. (a) Show that gravitational force is a conservative force. 2

(b) Calculate the moment of inertia of solid circular cylinder of radius 20 cm and length 10 cm about its own axis. Density of the material 9 gm/cc. 2

6. Answer any *two* questions : 5×2=10

(a) Obtain an expression for gravitational field due to a uniform solid sphere of mass M and radius R at a distance l from the centre.

(b) Show the centre of suspension and centre of oscillation of a compound pendulum are reversible.

(c) How can you identify a solid sphere from a hollow sphere of same mass and radius? If both spheres are allowed to roll down on an inclined plane, which one will reach the ground faster?

7. Answer any *two* questions : 10×2=20

(a) Show mathematically that Coriolis force and centrifugal force are produced as a result of earth rotation.

Discuss why cyclones are not formed at the equator. 7+3=10

(b) (i) Consider a system of three particles of masses m_1 , m_2 and m_3 located at positions \vec{r}_1 , \vec{r}_2 and \vec{r}_3 at time t . How do you define centre of mass? Obtain the velocity of the centre of mass.

(ii) Show that the velocity of the centre of mass of a system remains constant if no external force is applied to it. (4+1)+5=10

(c) (i) Establish work-energy theorem.

(ii) The position of a moving particle at an instant is given by

$$\vec{r} = \hat{i} a \cos \theta + \hat{j} a \sin \theta$$

Show that the force acting on the particle is conservative. 5+5=10

(d) (i) Show that the relationship between the angular momentum relative to centre of mass frame of reference of a system of particles and the angular momentum relative to laboratory frame is

$$\vec{L} = \vec{L}_{CM} + \vec{r}_{CM} \times \vec{P}$$

(6)

- (ii) A particle moves from a point $\vec{r}_1 = (2\hat{i} + 3\hat{j})m$ to another point $\vec{r}_2 = (3\hat{i} + 2\hat{j})n$ during which a certain force $\vec{F} = (5\hat{i} + 5\hat{j})N$ acts on it. Find the work done by the force on the particle during this displacement.

6+4=10
