

**3 (Sem-1) PHY M 1**

**2 0 1 7**

**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

( 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. 2

(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

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