

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

**2 0 1 8**

**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) Find the Cartesian component of a vector  $\vec{C}$  which is perpendicular to the vector  $\vec{A}$  and vector  $\vec{B}$ , where

$$\vec{A} = 2\hat{i} - \hat{j} + \hat{k} \quad \text{and} \quad \vec{B} = 3\hat{i} + 4\hat{j} - \hat{k} \quad 1$$

- (b) Define vector field in a region of space.  
Give an example of vector field. 1

2. (a) Give the vector diagram representation of  $\vec{A} \times \vec{B} = \vec{C}$  and  $\vec{B} \times \vec{A} = \vec{D}$ . Name a physical vector quantity which is the product of two vectors. 2
- (b) What is the physical significance of divergence of a vector? 2
- (c) Find the projection of vector  $\vec{A}$  on vector  $\vec{B}$ , where  $\vec{A} = 3\hat{i} + \hat{j} + 2\hat{k}$  and  $\vec{B} = \hat{i} - 3\hat{j} + 4\hat{k}$ . 2
- (d) A particle with position vector  $\vec{r} = \cos \omega t \hat{i} + \sin \omega t \hat{j}$  moves with a constant angular velocity  $\omega$ . The linear velocity  $\vec{v}$  of the particle is perpendicular to  $\vec{r}$ . Show that  $\vec{r} \times \vec{v}$  is a constant vector. 2

3. Answer any two questions : 5×2=10

(a) If  $\vec{V} = \vec{a} \cos \omega t + \vec{b} \sin \omega t$ , find that

$$\vec{V} \times \frac{d\vec{V}}{dt} = \omega(\vec{a} \times \vec{b})$$

Here  $\vec{a}$  and  $\vec{b}$  are two constant non-linear vectors and  $\omega$  is constant scalar.

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(b) If  $r = (x^2 + y^2 + z^2)^{1/2}$ , show that

$$\nabla^2 \left( \frac{1}{r} \right) = 0$$

(c) Show that gradient of any scalar field  $\phi(r)$  is irrotational and the curl of any vector field  $\vec{V}(r)$  is solenoidal.

GROUP—B

( **Mechanics** )

( Marks : 40 )

4. (a) What is fictitious force? Give an example of it. 1
- (b) Is the centre of mass frame of reference an inertial frame? Explain. 1
- (c) A particle is moving horizontally at the equator. What is the value of Coriolis force acting on it in local coordinate system? 1
- (d) What is the difference between laboratory frame of reference and centre of mass frame of reference? 1

- (e) When is a force field said to be conservative? Give an example of conservative force. 1
- (f) Can we have equipotential surfaces of the gravitational field of a point mass? What is the value of work done if a mass moves on an equipotential surface? 1
5. (a) Two particles of mass 2 kg each are moving with velocity  $(2\hat{i} + 4\hat{j})$  m/s and  $(5\hat{i} + 6\hat{j})$  m/s respectively. Find the kinetic energy of the system relative to centre of mass. 2
- (b) Show that force field given by  $\vec{F} = x^2 yz \hat{i} - xyz^2 \hat{k}$  is non-conservative. 2
6. Answer any two questions : 5×2=10
- (a) Show that whenever a body is acted upon by a number of forces such that the resultant is not zero, then the work done by the resultant force is equal to the change in the kinetic energy of the body.

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- (b) Calculate the moment of inertia of a thin hollow sphere about its diameter.
- (c) Find the centre of mass of a uniform solid hemisphere of radius  $a$ .

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

- (a) (i) Distinguish between inertial mass and gravitational mass.
- (ii) Obtain an expression for the gravitational potential and field due to a thin uniform spherical shell at an external point.
- (iii) The radius of the earth is  $6.637 \times 10^6$  m and its mean density is  $5.57 \times 10^3$  kg/m<sup>3</sup>. Calculate earth surface potential. Given  $G = 6.66 \times 10^{11}$  Nm<sup>2</sup> kg<sup>-2</sup>. 2+5+3=10
- (b) (i) What is the effect of Coriolis force on a particle falling freely under the action of gravity?

- (ii) Show that the angular accelerations of a particle in a fixed system and a rotating system are same. 5+5=10
- (c) (i) Give a schematic diagram of elastic collision of two particles in centre of mass frame and laboratory frame.
- (ii) Obtain a relation of scattering angles in these two frames of reference. 2+8=10
- (d) (i) Prove that a conservative force can be expressed as negative gradient of potential.
- (ii) Two particles of masses  $m_1$  and  $m_2$  separated by infinite distance apart, attract each other according to the law of gravitation. Considering the particles to be initially at rest, show that their velocity of approach

$$v = \sqrt{\frac{2G(m_1 + m_2)}{a}}$$

where  $a$  is final separation of the two masses.

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- (iii) Find the force field associated with the potential energy  $V = Ae^{\alpha(x+y+z)}$ , where  $A$  and  $\alpha$  are constants. 4+4+2=10

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