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PHYSICS

(Major)

Paper : 1.1

Full Marks : 60

Time : 2½ hours

The figures in the margin indicate full marks
for the questions

GROUP—A

(Mathematical Methods)

(*Marks* : 20)

1. (a) How do you define the direction of angular momentum? Why is the Higgs particle termed as Higgs scalar not Higgs vector?   1+1=2

   (b) Give the vector diagram representation of $\vec{A} \times \vec{B} = \vec{C}$ and $\vec{B} \times \vec{A} = \vec{D}$. Name a vector physical quantity which is the product of two vectors.   1+1=2

(Turn Over)

(c) The electric field intensity $\vec{X}$ at any point is in the direction of the maximum rate of decrease of potential ϕ. Express it in the mathematical form. Give the mathematical expression of the divergence of a vector over the surface of a unit volume element surrounding a point in a vector field. $1+1=2$

(d) Is the direction of a vector an absolute concept? Explain using the idea of derivative of a vector. $1+1=2$

(e) The Euclidean space cannot be considered as a vector space. Why? Show how you get a scalar field from a vector field. $1+1=2$

2. (a) Show that the gradient of any scalar field $\phi(r)$ is irrotational and the curl of any vector field $\vec{V}(r)$ is solenoidal. 4

(b) Prove that

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

If $\vec{A}$ and $\vec{B}$ are irrotational, show that $\vec{A} \times \vec{B}$ is solenoidal. 6

Or

(c) (i) Let $\vec{r}(t)$ be a vector of fixed magnitude. Show that $\dfrac{d\vec{r}(t)}{dt}$ is perpendicular to $\vec{r}(t)$.

(ii) If $\vec{v}(t)$ is a time-dependent vector, show that

$$\vec{v} \cdot \frac{d\vec{v}}{dt} = v \frac{dv}{dt}$$

where v is the magnitude. How is this relation relevant in connection with the motion of a particle in a circular orbit? Explain. $2+(3+1)=6$

GROUP—B

(**Mechanics**)

(*Marks* : 40)

3. (a) What is integral of the equation of motion? 1

(b) Can you state the relevance of rotating frame of reference with 'Mars Orbital Mission' of India? 1

(c) Give the hint that Tsunami can change the time duration of day and night. 1

(d) Which is the weakest interaction of all interactions known in nature? 1

(e) Centre of mass frame is also an inertial frame but all inertial frames cannot be considered as centre of mass frame to investigate a particular physical system. Why? 1

(f) What is the meaning of the statement that there is no absolute velocity? Explain whether the momentum is a frame-dependent quantity or not. 1

4. (a) Show that the moment of inertia of the body about an axis is numerically equal to the torque producing unit angular acceleration about the same axis. 2

(b) Show that the gravitational force is conservative. 2

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

(a) Calculate the centre of mass of semicircular arc and semicircular disc.

(b) Derive an expression for the gravitational field inside a sphere of radius R when the mass density at a point is $\rho = a + br^2$ where r is the distance of the point from the centre of the sphere, a and b are two constants.

(c) Find out the mathematical expression of moment of inertia of a spherical shell about a diameter as axis.

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

(a) What is Galilean transformation equation? Is it relevant to non-inertial frame of reference? Explain. Derive the equation of motion in a rotating frame of reference. 1+1+8=10

(b) Give the theory of the compound pendulum and show that the centres of suspension and oscillation are reversible. Derive the condition for minimum time period. 3+4+3=10

(c) Establish the relations between scattering angles in Lab and CM frames. Considering the elastic collision, show that

$$\tan \theta_1 = \frac{\sin \theta_c}{\cos \theta_c + \dfrac{m_1}{m_2}}$$

where the symbols carry usual meanings. 8+2=10

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