2023

(Held in 2024)

PHYSICS

Paper : PHYMIN1014

(Mechanics)

Full Marks : 50

Pass Marks : 20

Time : 2 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×5=5

(a) If $|\vec{A}+\vec{B}|=|\vec{A}-\vec{B}|$, then the angle between $\vec{A}$ and $\vec{B}$ is

(i) 0°

(ii) 30°

(iii) 60°

(iv) 90°

(b) The law of conservation of linear momentum is the consequence of

(i) homogeneity of space

(ii) isotropy of space

(iii) homogeneity of space and time

(iv) homogeneity of time

(c) The torque of a force $\vec{F} = -3\hat{i} + \hat{j} + 5\hat{k}$ acting at a point $\vec{r} = 7\hat{i} + 3\hat{j} + \hat{k}$ is

(i) $14\hat{i} - 38\hat{j} + 16\hat{k}$

(ii) $4\hat{i} + 4\hat{j} + 6\hat{k}$

(iii) $-2\hat{i} + 4\hat{j} + 4\hat{k}$

(iv) $-14\hat{i} + 38\hat{j} - 16\hat{k}$

(d) An earth satellite is moving around the earth in circular orbit. Which of the following is conserved?

(i) Velocity

(ii) Linear momentum

(iii) Angular momentum

(iv) None of the above

(e) Young's modulus of elasticity of a perfectly rigid body is

(i) unity

(ii) zero

(iii) infinity

(iv) None of the above

2. Answer any *five* of the following questions : 2×5=10

(a) Prove that div curl $\vec{A} = \vec{0}$.

(b) Show that Newton's first law of motion is simply a special case of the second law.

(c) What do you mean by homogeneous and non-homogeneous differential equations?

(d) How will the kinetic energy of a body change if its momentum is doubled?

(e) Show that the force $\vec{F} = yz\hat{i} + zx\hat{j} + xy\hat{k}$ is a conservative force.

(f) A wire of length L and cross-sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, then what is the work done?

(g) An artificial satellite moves in a circular orbit around the earth at a height $\frac{1}{2}R_e$ from the surface of the earth, where R_e is the radius of the earth. Calculate the period of revolution. Given $R_e = 6{\cdot}38 \times 10^6$ m; $g = 9{\cdot}8$ m s^{-2}.

3. Answer any *five* of the following questions : 5×5=25

(a) Find the coordinate of the centre of mass of a semi-circular disc.

(b) Prove that the velocity of a rocket at any instant when its mass is m, is given by

$$v = v_0 + u \log_e \frac{m_0}{m}$$

where v_0 and m_0 are the velocity and mass of the rocket at $t = 0$ and u is the velocity of exhaust gases relative to the rocket.

(c) State and explain the law of conservation of angular momentum. What is the difference between linear momentum and angular momentum? 3+2

(d) An astronaut inside the satellite feels weightlessness. Explain why.

(e) What is geo-synchronous orbit? Write the conditions fulfilled by a satellite to be a geo-stationary satellite. 1+4

(f) What is torsional oscillation? Derive an expression for the twisting couple per unit angular twist for a hollow cylinder. 1+4

(g) If Y, η and K represent Young's modulus, coefficient of rigidity and bulk modulus respectively, then prove that

$$\frac{9}{Y} = \frac{3}{\eta} + \frac{1}{K}$$

(h) State and explain the basic fundamental postulates of the special theory of relativity.

(Continued)

4. Answer any *one* of the following questions : 10

(a) Derive an expression for the energy of a particle executing SHM. Show that average kinetic energy of a particle executing SHM over a period of oscillation is equal to average potential energy of the particle and equal to $\frac{r^2\omega^2 m}{4}$, where symbols have their usual meanings. 5+5

(b) Write short notes on the following : 5+5

(i) Global Positioning System (GPS)

(ii) Length contraction and time dilation

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