SET-1

Instructions for Students

Write your Roll Number on the top immediately on the receipt of this question paper.

All questions carry equal marks. Attempt any **four** questions in all.

Q.1 (a) What are physical and non-physical quantities? How physical quantities are classified?
(***03 Marks***)

(b) Find out a unit vector lying in XY-plane and perpendicular to the vector $\vec{A} = 3\hat{\imath} + 4\hat{\jmath} + \hat{k}$.
(***03 Marks***)

(c) Show that the gradient of a scalar function $\phi(x, y, z)$ is normal to the surface $\phi(x, y, z) = c$, where 'c' is a constant. Also, find a unit vector normal to the surface $x^2 + y^2 + z^2 = 3$ at the point (1, 1, 1). (***05 Marks***)

(d) Determine the constant a, b and c so that the following vector is irrotational:
$$\vec{V} = (x + 2y + cz)\hat{\imath} + (ax - 3y - z)\hat{\jmath} + (4x + by + 2z)\hat{k}$$
(***03 Marks***)

(e) Solve the following differential Equation: $\frac{d^2y}{dx^2} + 5\frac{dy}{dx} + 4y = 3 - 2x$ (***4.75 marks***)

Q.2 (a) Define centre of mass of a system of particle. The centre of mass of a system consisting of four particles of masses 2, 3, 4 and 5 kg is at (1, 1, 1). The centre of mass shifts to (2, 2, 2) on removing the particle of mass 5 kg. Find the position of the particle of mass 5kg. (***2+4 = 06 Marks***)

(b) What are conservative and non-conservative forces? Give the examples of each forces. Write down the properties of conservative forces? Show that the work done by a conservative force around a closed path is always zero. (***2+2+2+3 = 09 Marks***)

(c) Differentiate between elastic and inelastic collisions? Prove that in elastic head-on collision, the relative velocity with which two particles approach each other before collision is equal to the relative velocity with which they recede from each other after collision.
(***1+ 2.75 = 3.75 Marks***)

Q. 3 (a) Define angular momentum. Prove that the relation between angular momentum ($\vec{J}$) about a reference point and angular momentum ($\vec{J}_{cm}$) about center of mass of a system of particles

is given by $\vec{J} = \vec{J}_{cm} + \vec{R} \times \vec{P}$ in which $\vec{R}$ and $\vec{P}$ are respectively the position vector and linear momentum of the center of mass of the system about the reference point.

(**0.75+ 8 = 8.75 Marks**)

(b) Define moment of inertia. Write down the statement of the theorems of parallel and perpendicular axes. Find out the moment of inertia of a rod having length L and mass M about an axis perpendicular to its length and passing through (i) its center of mass and (ii) its one end. (**2+4+4=10 Marks**)

Q.4 (a) Write down the most general form of central force. Prove that when a particle moves under the action of a central force, its angular momentum remains conserved and motion takes place in a fixed plane. (**0.75+3.5+3.5 = 7.75 Marks**)

(b) What are geostationary orbit and geostationary satellite? Find out the radius of the geostationary orbit and velocity of the geostationary satellite. (**3+4+4 = 11 Marks**)

Q.5 (a) Define damping. Is damping force conservative or non-conservative in nature? (**03 Marks**)

(b) Derive the differential equation of damped harmonic oscillator and find out its solution. Consider the underdamped case and show that the effect of damping is to increase the periodic time. Define logarithmic decrement. (**5+5+5+0.75= 15.75 marks**)

Q.6 (a) Differentiate between inertial and non-inertial frames of reference? Prove that the interval $S^2 = x^2 + y^2 + z^2 - c^2 t^2$ is invariant under Lorentz Transformations. (**3+5 = 08 Marks**)

(b) In Michelson-Morley experiment, the length of the arm of interferometer was 11.5 meters, the wavelength of the light 5000A and earth's velocity is 30 Km/s, calculate the fringe shift.

(**04 Marks**)

(c) Find the speed of a particle at which its mass will become 8 times of its rest mass. (**04 Marks**)

(d) What do you mean by time dilation? Why do we not observe the effect of time-dilation in everyday life? (**2.75 Marks**)