This question paper contains 7 printed pages]

Your Roll No.....

5181

B.Sc.(Prog.) PHYSICAL SCIENCES/I Sem. B

Paper PHPT–101 : MECHANICS

Time : 3 *Hours* *Maximum Marks* : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *Five* questions in all.

Question No. **1** is compulsory.

Attempt *Four* questions from the rest of the paper.

1. Attempt any *five* of the following : 5×3=15

(*a*) For a constant vector $\vec{a}$, prove that $\nabla(\vec{a} \cdot \vec{r}) = \vec{a}$, where $\vec{r}$ is the position vector.

(*b*) Prove that $\nabla \cdot \vec{r} = \frac{2}{r}$, where $\vec{r}$ is the position vector.

(*c*) Explain what do you understand by elastic and non-elastic collisions.

P.T.O.

(*d*) For a particle of mass m, position $\vec{r} = 12\vec{i} + 8\vec{j}$ and velocity $\vec{v} = 6\vec{i}$, calculate its angular momentum about the origin.

(*e*) Calculate the mass of a proton of rest mass 1.67×10^{-24} gm moving with a velocity $0.9c$.

(*f*) Find whether the force given by

$$\vec{F} = (y^2 - x^2)\vec{i} + 2xy\vec{j}$$

is conservative or non-conservative.

(*g*) What is centre of mass ? Where does the centre of mass of a triangular plate lie ?

(*h*) Calculate what quantity of mass would possess an energy of 1 eV.

2. (*a*) State and prove Stokes' theorem for vector fields. 10

(*b*) Prove the identity :

$$\nabla.(\vec{A} \times \vec{B}) = \vec{B}.(\nabla \cdot \vec{A}) - \vec{A}.(\nabla \cdot \vec{B}).$$ 5

3. (*a*) What do you understand by inertial frame and Galilean invariance ? Show that while length and acceleration are Galilean invariant, velocity is non-invariant. 9

(*b*) Two inertial frames S and S' have their axes parallel and the position of the origin O' of the frame S' relative to origin O of the frame S is given by $\vec{r}_0 = \vec{i} + 2\vec{j} + 3\vec{k}$ at time $t = 0$. If the position of a point P in the frame S be (3, 4, 5), calculate its position in the frame S'. 3

(*c*) A bomb of mass 4 M explodes in flight at a time when its velocity is $5\vec{i} + 4\vec{j}$. It splits into two fragments of masses M and 3 M and the smaller mass M is observed to fly with a velocity $10\vec{i} + 100\vec{j}$ just after the explosion. Calculate the velocity of the larger fragment of mass 3M just after the explosion. 3

4. (*a*) State Kepler's laws of planetary motion. 3

(*b*) What is a central force ? Give *two* examples of such a force. 3

(*c*) What is a conservative force ? How is it related to potential energy ? Show that in the case of a conservative force, the work done around a closed path is zero. 9

5. (*a*) Define modulus of rigidity. What are its SI units ? 3

(*b*) Derive an expression for the couple required to twist one end of a cylindrical wire when its other end is fixed. 9

(*c*) An iron wire of length 1 m and radius 0.5 mm twists through 0.5 radians when equal and opposite torques of 3×10^4 dynes cm are applied at its ends. Calculate the value of modulus of rigidity of the iron wire. 3

6. (*a*) State theorem of parallel and perpendicular axes of moment of inertia. 4

(*b*) Define the terms 'radius of gyration' and 'moment of inertia'. Determine the 'moment of inertia' of a cylinder about an axis passing through its centre and perpendicular to its length. 11

7. (*a*) What was the motivation behind Michelson–Morley experiment ? What conclusions were drawn from the experiment regarding the existence of ether ? 5

(*b*) Calculate the expected fringe shift in the Michelson-Morley experiment in which monochromatic light source of wavelength 5900 Å was used and the effective length of each path was 11 m.

(Given : velocity of the earth = 3×10^4 ms^{-1} and $c = 3 \times 10^8$ ms^{-1}). 5

(*c*) A π meson, moving with velocity $0.99c$, decays with a mean lifetime of 2.6×10^{-8} s as measured in its proper or rest frame. Calculate its lifetime as measured in the laboratory frame. 5

8. (*a*) What do you mean by the divergence of a vector field ? Obtain an expression for the divergence of a vector field in Cartesian coordinates. 10

(*b*) By applying Green's theorem in a plane, show that the area bounded by a simple closed curve C in the $x - y$ plane is given by $\frac{1}{2}\oint(x\,dy - y\,dx)$. 5