This question paper contains 8 printed pages]

Your Roll No.....

5702

B.Sc. (Hons.) Physics/I Sem. B

Paper—PHHT-102

MECHANICS

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

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

Attempt *four* questions in all including

Q. No. 1 which is compulsory.

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

(*a*) What do you understand by inertial mass and gravitational mass ?

(*b*) Explain what is meant by recessional red shift.

(*c*) Define radius of gyration and centre of mass of a rigid body.

(*d*) A particle of mass 1 kg starts from rest under the action of force varying with time as shown in Fig. 1. What is the speed of particle at the end of 6 sec ?

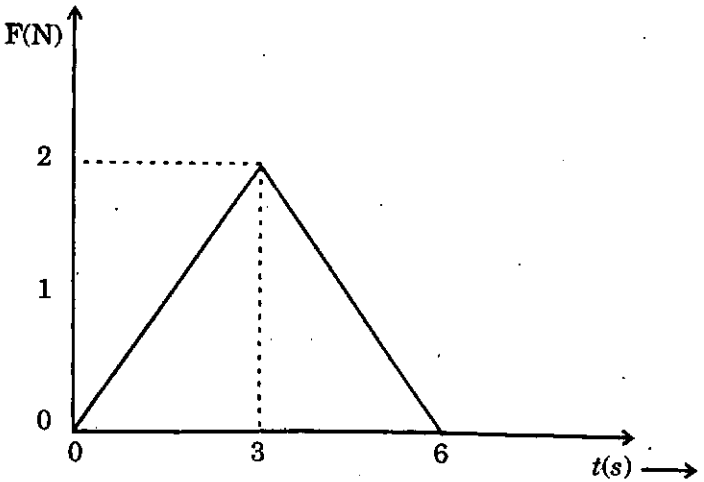

Fig. 1

(*e*) A hollow cylinder and a solid sphere of the same mass and radius are allowed to roll down without slipping along an inclined plane. Determine the ratio of their accelerations.

(*f*) An α-particle moving east with a speed of $0.6c$ is passed by an electron moving west with a speed of $0.9c$. Find the speed of electron with respect to the α-particle.

(*g*) Find the centre of mass of a thin uniform wire bent in the form of a semi-circle of radius R.

(*h*) In how much time will the plane of oscillation of Foucault's pendulum will turn through 90° at 30° latitude ?

2. (*a*) Find the centre of mass of solid hemisphere of radius R. 6

(*b*) If the force is given by $\vec{F} = -\vec{\nabla} V$, where V is single-valued, then prove that work done in moving a particle from point $P(x_1, y_1, z_1)$ to the point $Q(x_2, y_2, z_2)$ is independent of path joining these two points. 6

(*c*) A force is given by :

$$\vec{F} = (y^2z^3 - 6xz^2)\hat{i} + 2xyz^3\hat{j} + (3xy^2z^2 - 6x^2z)\hat{k}.$$

Check whether this force is conservative or not. 3

P.T.O.

3. (*a*) A particle of mass m_1 moving with velocity u_1 undergoes an elastic collision with another particle of mass m_2 at rest. After the collision, m_2 is deflected through an angle θ_2 with the incident direction with speed v_2 and m_1 is deflected through an angle 90° with the incident direction with speed $u_1/\sqrt{3}$ (θ_1 and θ_2 are in the laboratory frame). Determine :

(*i*) the angle θ_2

(*ii*) the ratio m_1/m_2

(*iii*) the angle θ_{1C}, scattering angle of m_1 after collision in C-frame

(*iv*) the angle θ_{2C}, scattering angle of m_2 after collision in C-frame. 2,2,2,1

(*b*) A 2.8×10^6 kg rocket is fired vertically upward near the surface of the Earth. If 2.1×10^6 kg of its initial mass is fuel and the rocket experiens a thrust of

39×10^6 N, with a constant gas exhaust speed of 1300 m/s, then find :

(*i*) the rate of burning of fuel

(*ii*) the time in which fuel will burn out completely

(*iii*) the speed of rocket after the fuel burn out.

[Take $g = 10$ m/s^2 and ln 4 = 1.386] 1,1,3

(*c*) Find the impulse developed by a force $\vec{F} = 4t\hat{i} + (6t^2 - 2)\hat{j} + 12\hat{k}$ from time $t = 0$ to $t = 2$ sec. 3

4. (*a*) Find the moment of inertia of uniform solid cylinder (radius R, height H, mass M) about an axis passing through its centre of mass and perpendicular to its axis of symmetry. 6

(*b*) A rigid massless rod of length l joins two particles each of mass m. The rod lies on a frictionless table, and is struck by a particle of mass m and velocity v_0, moving as shown in Fig (2). After collision, the projectile moves straight back. Prove that the angular speed of the rod about its centre of mass after the collision is given by $w = \frac{u\sqrt{2}}{7}\frac{v_0}{l}$. 6

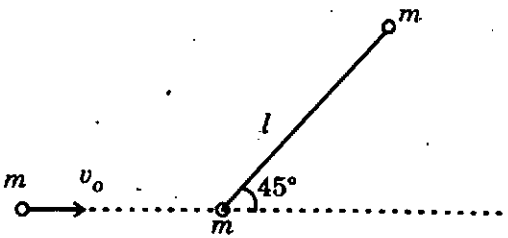

Fig. 2

(*c*) A particle of mass 2 kg moves along a straight line given by the equation $y = \frac{x}{\sqrt{3}} + 3$, with a constant speed of 4 m/s. Find the angular momentum of the particle about the origin. 3

5. (*a*) Define gravitational potential and Intensity of Gravitational Field. Establish the relation between these two. 6

(*b*) Prove that Central Force is conservative. 5

(*c*) When a particle moves under a central force, prove that :

(*i*) the angular momentum is conserved

(*ii*) the particle moves in a fixed plane. 4

6. (*a*) How can a system of two bodies interacting through a gravitational force be reduced to a one-body problem ? What would be the corresponding expressions for angular momentum and kinetic energy ? 8

(*b*) A satellite of mass m is revolving around the earth (mass M, radius R) in a circular orbit at height h above the earth's surface. Derive the expressions for the orbital *velocity* and time period of the satellite. Also prove that the total energy of the satellite is given by $E = -\frac{GMm}{2r}$, where $r = R + h$. 7

7. (*a*) What are centrifugal and Coriolis forces ? Under what conditions do they come into picture ? Why are these forces called fictitious forces ? 5

(*b*) Consider the earth to be a sphere of radius R having angular speed ω. Prove that :

(*i*) effective value of '*g*' at latitude λ is given by

$$g_{eff} = g_0\left[1 - (2x - x^2)\cos^2\lambda\right]^{1/2},$$

where g_0 is the true acceleration due to gravity and $x = \omega^2 R/g_0$.

(*ii*) If $x << 1$; then $g_{eff} = g_0 - \omega^2 R\cos^2\lambda$. 7,3

8. (*a*) Why is classical expression for the kinetic energy not applicable in relativistic region ? Prove that relativistic kinetic energy is given by $k = (m - m_0)\,c^2$. Also, show that if $v << c$, it leads to classical expression. 2,6,2

(*b*) A particle at rest decays into two particles of rest mass m_0 and $2m_0$. If the lighter particle moves with a speed of 0.8*c*, then find the speed of the other particle in lab frame and hence find the rest mass of the original body. 5