[This question paper contains 5 printed pages.]

1212 *Your Roll No. .....*

B.Sc. (Hons.)/I **A**

PHYSICS – Paper II

(Mechanics)

Time : 3 Hours *Maximum Marks : 38*

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

Attempt **Five** *questions in all.*
Q. No. **1** *is compulsory.*
Attempt **one** *question from each Section.*

1. Answer any **five** :

(a) Show that a particle of zero rest mass must always move with the velocity of light.

(b) Two satellites of mass 100 kg each are revolving round the earth at distances 'r' and '2r' from the centre of the earth. Calculate the ratio of their K.E. and P.E.

(c) A rod of length 'l_0' placed along x'-axis in S'-frame appears to be contracted by 25% to an observer in S-frame. What is the velocity of the rod.

P.T.O.

(d) A simple pendulum of length 100 cm has an energy equal to 2 Joules when its amplitude is 4 cm. Calculate its energy when its length is doubled.

(e) An electron has an initial velocity $\vec{v} = 10^4 \hat{i}$ m/s and its position is $\vec{r} = j$ m. Find its position and velocity after 10^8S in an electric field of $300\hat{i}$ v/m.

(f) The P.E. between an proton and a neutron inside a nucleus is given by

$$u(r) = -\frac{r_0}{r} u_0 e^{-r/r_0}$$

where r_0 and u_0 are constants. Compute the ratio of the force at $r = 2r_0$ and $r = 4r_0$. (5×2)

SECTION A

2. (a) A particle of mass m_1 moving with a velocity v_1 collides elastically with a particle of mass m_2 at rest in laboratory frame. Obtain the relation between scattering angle θ_1 of m_1 measured in laboratory frame with scattering angle θ measured in c.m. frame. Discuss the relation when, (i) $m_1 = m_2$, (ii) $m_1 >> m_2$, (iii) $m_1 << m_2$.

(b) A particle of mass 'm' move along a path given by,

$$\vec{r} = a\cos wt\,\hat{i} + b\sin wt\,\hat{j}.$$

Calculate the angular momentum about the origin. (5,2)

3. (a) State and prove work-energy theorem.

(b) A system consists of two masses 2 kg and 5 kg. The positions of the particles at t = 0s are $\left(4\hat{i} + 3\hat{j}\right)$m and $\left(6\hat{i} - 7\hat{j} + 7\hat{k}\right)$m respectively, their velocities being $\left(10\hat{i} - 6\hat{k}\right)$m/s and $\left(3\hat{i} + 6\hat{j}\right)$m/s respectively. Find the position and velocity of centre of mass at t = 0s and t = 4s.

(c) Check if the force $\vec{F} = 3xy\,\hat{i} - y\,\hat{j}$ a conservative or not. (2,3,2)

SECTION B

4. (a) State and prove parallel axis theorem at moment of inertia for a 3-dimensional body.

(b) A musician's tuning fork rings of 440 Hz. A sound level meter indicates that the sound intensity decreases by a factor of 5 in 4 seconds. What is the quality factor of the tuning fork ? (4,3)

P.T.O.

5. (a) What is a compound pendulum ? Derive an expression for the time period of its oscillation. Under what conditions does the time period become maximum and minimum ?

(b) A solid cylinder of mass M and radius R starts from rest and rolls without slipping down an inclined plane. Find the speed of its centre of mass after it has descended a height h. (5,2)

SECTION C

6. (a) Define gravitational potential and intensity at a distance r from a point mass M.

(b) Find expressions for gravitational potential and intensity inside and outside a spherical shell of mass M and radius R. Plot the results. (2,5)

7. (a) Define gravitational self energy. Calculate the self energy of a solid sphere of mass M and radius R.

(b) Prove that the least velocity with which a particle must be projected from the surface of a planet of radius R and density ρ in order that it escapes completely is $R\sqrt{\frac{8\pi g\rho}{3}}$, where G is the gravitational constant.

Calculate the escape velocity for the planet with given data :

$\rho = 6 \text{ gm/cm}^3$

$R = 6000 \text{ km}$

$G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ (4,3)

SECTION D

8. (a) State basic postulates of special theory of relativity. Derive an expression for Lorentz transformation for space-time coordinates.

(b) A spaceship travelling in space detects an alien space probe. As the probe approaches it, the frequency received by the ship is 130 MHz and is 60 MHz when it recedes. What is the proper frequency of the transmitter ? (5,2)

9. (a) Derive an expression for the mass of an object moving with a velocity u.

(b) What is fractional increase in mass of a particle moving with a speed of 0.8 C ? (5,2)