SET A

Unique Paper Code : **32221102**

Name of Paper : **Mechanics**

Name of Course : **B.Sc. Hons. Physics-CBCS_NC_Core**

Semester : **I**

Duration : **3 Hours** Maximum Marks: 75

Answer any **four** of the six questions. Each question carries equal marks.

1. Two identical billiard balls are initially at rest when they are struck symmetrically by a third identical ball moving with velocity $v_o\hat{\imath}$. Find the velocities of all the three balls after they undergo an elastic collision.

   Find the centre of mass of a thin uniform wire bent in the form of a semi–circle of radius R.

   Find positions of stable equilibrium of a particle moving in a force field of potential $V = 18r^2e^{-2r}$. If the particle is released at r = ¼, find the speed when it reaches the equilibrium position. Also, find the period of small oscillations about the equilibrium position.

2. What is the difference between torque and force? Explaining whether there can be a torque on a system with a zero net force or a force with a zero net torque. Give two examples of systems in which there is a torque exerted by gravity.

   An ice skater is spinning at a speed of 4.3 rev/s with her arms extended. She has a moment of inertia of 4.14 kg m^2 with her arms extended and of 0.582 kg m^2 on pulling her arms close to her body. What is the angular velocity of the skater when her arms are pulled in? Find her initial as well as final rotational kinetic energy.

   A hollow cylinder made of a material of uniform density is closed at both ends and has mass of 10 g, length 8 cm, and radius 1.4 cm. Find the mass of the top and bottom of the cylinder and also of the cylindrical shell. What is the moment of inertia of the cylinder about its axis of cylindrical symmetry?

3. Find the position where the gravitational field due to two bodies of masses m_1 and m_2, placed a distance d apart is zero. Also find the expression for gravitational potential at that point and evaluate it for m_1 = 5 g and m_2 = 20 g. Take $G = 6.67 \times 10^{-11}$ Nm^2/kg^2.

   A particle of mass 0.5 kg moves under an attractive central force of magnitude $5r^3$ N. The angular momentum of the particle is 40 kg m^2/s. Find the effective potential energy function and plot it. Determine the energy corresponding to circular motion, and the

radius of this circle. Indicate this energy on the effective potential energy diagram. If the particle does not move in a circular orbit, but its radius varies between r_0 and $2r_0$, determine r_0 and the corresponding energy.

What is an artificial satellite? Derive an expression for the period of revolution of an artificial satellite at a height h from the surface of the earth in terms of R, the radius and g, the gravitational acceleration of the earth. What would be its altitude if the satellite is Geostationary? Take R= 6400 Km.

4. Explain the origin of Coriolis and Centrifugal forces? Give an example each of a situation where they come into play.
   A toy attached to a string of length 20 cm, is suspended for decoration on the front roof of the car that is moving with a constant acceleration a = $2ms^{-2}$. Find the mean angle that the toy makes with the horizontal and the time period of its oscillation.

   A mass of 50 g on the end of a certain spring executes simple harmonic motion according to the equation $x = 2 \times 10^{-2}\, sin(10t)$, where x is in metres and t is in seconds. Find the spring constant C and the maximum kinetic energy of the mass. What will be the maximum potential energy and the total energy of the mass? What is the initial form of mechanical energy possessed by the mass? How much time does it take for all of the initial energy to get converted into the other form?

5. What was the aim of Michelson–Morley experiment? Explain the physical significance of its negative results. Calculate the expected fringe shift if the effective length of each path in the experimental setup is 6m, velocity of the earth is 3×10^4 m/s and the wavelength of the monochromatic light used is 5000A^o.

   What are the assumptions made in deducing the Lorentz transformation equations?
   What is the proper time interval between the occurrences of two events separated in space by 10^9m, occurring at an interval of 5s in some inertial frame? What would be the relative speed of the frame w.r.t. the given frame that would measure the proper time interval?

   Calculate the percentage contraction of a rod moving with a velocity 0.8c in a direction inclined at 60^0 to its own length.

6. Two rods having the same length L_o move lengthwise towards each other parallel to a common axis with the same velocity v relative to the Laboratory frame. Determine the length of each rod in the frame fixed to the other rod.

   A train with proper length L moves at speed 3c/5 with respect to the ground. A ball is thrown from the back to the front, at speed c/2 with respect to the train. How much time does this take, and what distance does the ball cover in: the train frame, the ground frame and the ball frame?
   Find the velocity that an electron must be accelerated to so that its momentum is $10\, m_e c$, where m_e is the rest mass of electron. What is the energy of the electron at this speed?