SET A

Unique Paper Code : **32221102**

Name of Paper : **Mechanics**

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

Semester : **I**

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

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

1. A projectile launched at an angle θ to the horizontal reaches a maximum height h. Show that its horizontal range is $\frac{4h}{tan\theta}$.

   A motorcyclist driving in a 60Km/h zone hits a stopped car on a level road. The cyclist is thrown from his bike and lands 39m down the road. Was he speeding and what was his speed?

   A particle of mass m and velocity v_o collides elastically with a particle of mass M initially at rest and is scattered through an angle θ in the center of mass frame. Find an expression for the velocity of m in the laboratory frame.

   A body at rest explodes and breaks up into three pieces. Two pieces of equal mass fly off perpendicular to each other with the same speed of 30 m/s. The third piece has three times the mass of each of the other pieces. Find the magnitude and direction of the velocity immediately after explosion.

2. On what factors does radius of gyration depend? Find the ratio of the radii of gyration of a solid disk of mass M and radius R spinning about an axis through its center and perpendicular to its plane and a solid sphere of the same mass and radius spinning about its diameter.

   Explain any two daily life examples of conservation of angular momentum. The maximum and minimum distances of a comet from the sun are $2x10^{12}$ m and $8x10^{10}$ m respectively. If the speed of the comet at the nearest point is 60 km/sec, calculate its speed at the farthest point.

   A narrow uniform metal bar, 1 m long weighing 3 kg rotates once per second. What is its kinetic energy if its axis of rotation is perpendicular to the bar and passes through its (i) Centre of gravity (ii) one extreme end?

3. Define gravitational potential. Derive the expression for the gravitational potential due to a spherical shell of radius R and mass M at a point outside the shell and also at a point inside the shell.

   Discuss general features of central force motion giving at least two examples. Also show that in case of central forces, the orbit of the particle is restricted to a plane.

   Calculate the maximum velocity with which a body may be projected so that it may become a satellite of the earth. Show that it is $\sqrt{2}$ times the minimum velocity with which it may be projected to move in a circular orbit close to the earth.

Show that a satellite increases its speed as it approaches its parent planet and decreases its speed as it moves away from it. Earth's orbit is slightly elliptical, with a semi-major axis of 152 million km and a semi-minor axis of 147 million km. If Earth's period is 365.26 days, what area does an Earth-to-sun line sweep past in one day?

4. Establish the equation of motion of a damped harmonic oscillator subjected to a resistive force that is proportional to the first power of its velocity. If the damping is less than critical, show that the motion of the system is oscillatory with its amplitude decaying exponentially with time.
A person normally weighing 60Kg stands on a platform which is oscillating up and down harmonically with a time period of 1.0s and amplitude of 10cm. If a weighing machine on the platform gives the person's weight against time, what will be the maximum and minimum readings shown by it?

   How does the rotation of Earth about its axis affect the acceleration due to gravity experienced by a body at rest at a point on the surface of earth? Support your answer with a suitable derivation and diagram.
Calculate the values of the centrifugal and the Coriolis forces on a mass of 20g placed at a distance of 10cm from the axis of rotating frame of reference, if the angular speed of rotation of the frame be 10 $rads^{-1}$.

5. What is proper time? Deduce an expression for time dilation effect on the basis of Lorentz transformation equations. With what velocity should a rocket move so that every year spent on it corresponds to 4 years on earth?

   Highlight the difference between the transformation of velocity under Classical and the Special theory of Relativity. Support your answer with a suitable derivation.
A spaceship moving away from the earth with velocity 0.6c fires a rocket (whose velocity relative to the spaceship is 0.7c): (i) away from the earth (ii) towards the earth. What will be the velocity of the rocket, as observed from the earth in the two cases?

6. What are conservative and non- conservative forces? Give an example of each. Show that the force field $\boldsymbol{F} = (y^2z^3 - 6xz^2)\boldsymbol{i} + 2xyz^3\boldsymbol{j} + (3xy^2z^2 - 6x^2z)\boldsymbol{k}$ is a conservative force field. Hence, find the work done in moving a particle from the point A (-2, 1, 3) to point B (1, -2, -1) in the given force field.

   An empty freight car of mass 500Kg starts from rest under an applied force of 100N. At the same time, sand begins to run into the car at steady rate of 20Kg/s from a hopper at rest on the track. Find the speed of the car when 100Kg of sand has been transferred.
Two bodies of different masses $m_1$and m_2 $(m_1 > m_2)$ are moving with the same kinetic energy of translation. Which one has greater momentum?

   A particle of mass m_0 moves with speed $\frac{c}{\sqrt{2}}$. Calculate the mass, momentum, total energy and kinetic energy of the particle.