ISI Physics I - Final test 2 Dec. 2002

Maximum marks : 50 Time : 10:00 - 13:00

1. A particle moves with a constant speed v along the cardioid $r = k(1 + cos\,\theta)$. Draw a rough sketch of the orbit. Show that the radial component of accceleration is constant. What is the force acting on the particle ?

2. A scoop of mass m_1 is attached to an arm of length L and negligible weight. The arm is pivoted so that the scoop is free to swing in a vertical arc of radius L. At a distance L directly below the pivot is a heap of sand. The scoop is lifted until the arm is at a 45° angle with the vertical, and released. The scoop picks up some sand of mass m_2 and rises on the other side to an angle θ with the vertical. By applying the appropriate conservation laws in each part of the motion find θ. Friction is to be neglected except that the sand in the scoop does not slip out and remains there.

3. Calculate the gravitational force on a particle of mass m due to a thin circular disc of radius R and having uniform density σ per unit area. Take the particle to be at a distance z on the axis passing through the centre of the disc and perpendicular to its plane. Comment on the case $R \to \infty$. What is the gravitational potential energy ?

4. Two men, each of mass 100 kg, stand at opposite ends of the diameter of a rotating turntable of mass 200 kg and radius 3 m. initially the turntable makes one revolution every 2 sec. The two men make their way to the middle of the turntable at equal rates.

   (a) Calculate the final rate of revolution and the factor by which the kinetic energy of rotation has been increased.

   (b) Analyze qualitatively the means by which the increase of rotational kinetic energy occurs.

   (c) At what radial distance from the axis of rotation do the men experience the greatest centrifugal force ?

5. A tourist on a Himalayan slope (at 30°) sees a spherical snowball rolling down (without slipping) at $25\,m/s$ speed. At that time it is $100\,m$ behind him. To escape being crushed he pushes himself instantly and starts sliding at a speed of $10\,m/s$. Assume that the snowball's mass M and radius R are not changing. Will he escape ?

Distribution of marks : Q1- 10, Q2- 12, Q3- 7, Q4a- 6, Q4b- 3, Q4c- 5, Q5- 7.