Ahmedabad University

School of Arts and Sciences

PHY111 - Classical Mechanics

Mid Semester Examination 2024 (Winter Semester)

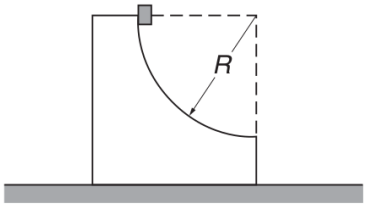
Total Marks = 50 **Time – 1.5 hours**

Date: 20-02-2024 (Exam date)
No. of printed pages: 2 (Pages of question paper)

1. Find the moment of inertia of a thin sheet of mass M in the shape of an equilateral triangle around an axis through a vertex, perpendicular to the sheet. The length of each side is L. [7]

2. A block of mass M slides down a plane of angle θ. Find the speed of the block after it has descended through height h, assuming that it starts from rest and that the coefficient of friction μ is constant. [5]

3. As shown, a small cube of mass m slides down a circular path of radius R cut into a large block of mass M. M rests on a table, and both blocks move without friction. The blocks are initially at rest, and m starts from the top of the path. Find the velocity v of the cube as it leaves the block. [5]



4. Plot and explain the energy diagram for [12]
   a. a harmonic oscillator for which the potential energy $U = kx^2/2$ is a parabola centered at the origin.
   b. a particle constrained to a radial line and acted on by a repulsive inverse-square law force $(A/r^2)\hat{\mathbf{r}}$. Here U = A/r, where A is positive.
   c. a typical two-atom.

5. Show that a simple pendulum, a point mass hanging from a massless string executes simple harmonic motion using energy methods. [5]

6. A rod of length L has a non-uniform density. The mass per unit length of the rod, λ, varies as $\lambda = \lambda_0 (x/L)$, where λ_0 is a constant and x is the distance from the end marked 0 (origin). Find the center of mass. [5]

7. An instrument-carrying rocket accidentally explodes at the top of its trajectory. The horizontal distance between the launch point and the point of explosion is L. The rocket breaks into two pieces that fly apart horizontally. The larger piece has three

times the mass of the smaller piece. To the surprise of the scientist in charge, the smaller piece returns to Earth at the launching station. How far away does the larger piece land? Neglect air resistance and effects due to the Earth's curvature. [5]

8. A wheel is attached to a fixed shaft, and the system is free to rotate without friction. To measure the moment of inertia of the wheel–shaft system, a tape of negligible mass wrapped around the shaft is pulled with a known constant force F. When a length L of tape has unwound, the system is rotating with angular speed ω_0. Find the moment of inertia I_0 of the system. [6]

