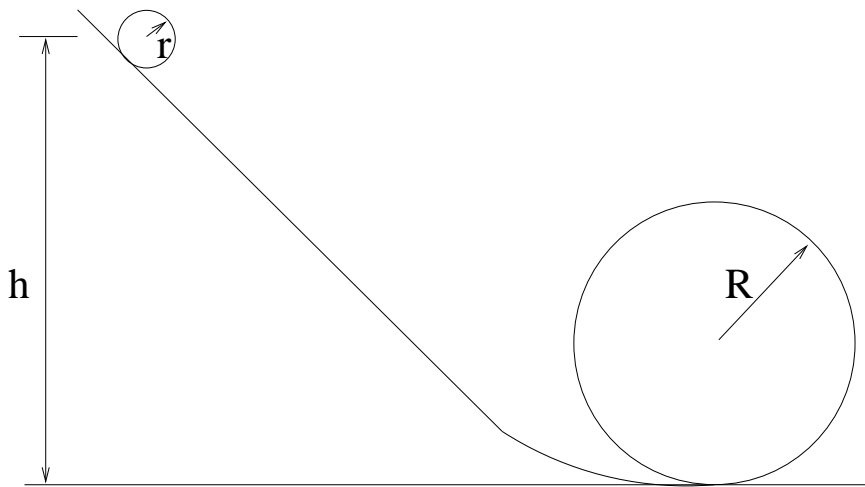


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1. A uniform bowling ball with mass M and radius R is hit by a stick and acquires an initial speed v_0 but no angular velocity ($\omega_0 = 0$) at $t = 0$. The coefficient of the kinetic friction between the ball and the horizontal surface on which it is moving is μ , and the acceleration due to gravity is g . *Hint:* $\int \sin^3 \theta d\theta = -\frac{1}{3} \cos \theta (\sin^2 \theta + 2)$.

- Calculate the moment of inertia of the ball about an axis that passes through the center of the ball.
- Calculate the time t_1 after which the ball rolls without slipping on the surface.
- Calculate the work done by friction between $t = 0$ and $t = t_1$.

2. A small uniform sphere with radius r rolls without slipping along a track as shown in the diagram. The radius of the loop is R .



- Calculate the moment of inertia of the sphere about an axis through its center.
 - What is the minimum height at which the ball must be released so that it will not fall off the track in the loop?
 - Should this height be increased or decreased if the solid sphere is replaced by a hollow one with the same mass and radius?
3. Consider the off-center elastic collision of two objects of equal mass when one is initially at rest.
- Show that the final velocity vectors of the two objects are perpendicular to each other.
 - Show that the incoming object cannot have a backward scattering component.