Physics 180A Chapter 9 Problem 64

A basketball (which can be closely modeled as a **hollow spherical shell**) rolls down a mountainside into a valley and then up the opposite side, starting from rest at a height H_o above the bottom. In the figure, the rough part of the terrain prevents slipping while the smooth part has no friction. How high **h**, in terms of H_o, will the ball go up the other side? (20 pts)

What is the Energy of the ball at the top of this hill? (2 pts)

$PE_G =$

$KE_T = \frac{1}{2}mv^2 =$

$KE_R =$

Rotational Dynamics

What is the Energy of the ball at the top of this hill? (2 pts)

What is the moment of Inertia for a **hollow sphere**?

$I =$

$a = r\alpha$

$v = r\omega$

What is the Energy of the ball at the bottom of the hill? (2 pts)

$PE_G =$

$KE_T =$

$KE_R = \frac{1}{2}I\omega^2$

On the diagram, draw the ball at the bottom of the hill and where it will stop. Indicate its velocity and height. (2 pts)

Conservation of Energy (5 pts)

Energy Before (Top of Hill) = Energy After (Bottom of Hill)

$PE_G + KE_T + KE_R =$ ______

$=$

Solve the equation above symbolically for the linear velocity at the bottom of the hill.

Conservation of Energy (5 pts)

Energy Before (Bottom of Hill) = Energy After (Top of Hill)

______ $= PE_G + KE_T + KE_R$

$=$

Using the linear velocity at the bottom of the hill, solve for the height **h** in terms of H_o.

Why didn't the ball go all the way up to H_o on the smooth hill? (2 pts)

Physics 180A Chapter 9 Problem 64 Solution

A basketball (which can be closely modeled as a hollow spherical shell) rolls down a mountainside into a valley and then up the opposite side, starting from rest at a height H_o above the bottom. In the figure, the rough part of the terrain prevents slipping while the smooth part has no friction. How high **h**, in terms of H_o, will the ball go up the other side? (20 pts)

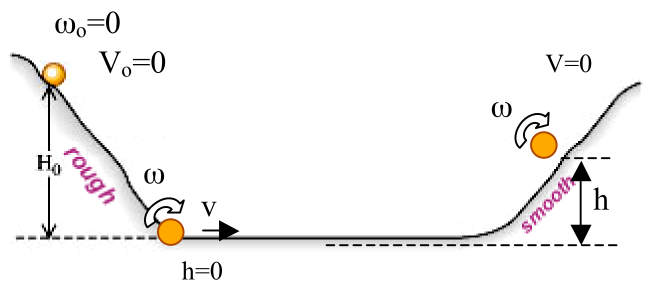
Rotational Dynamics

What is the Energy of the ball at the top of this hill?

$$PE_G = mgH_o$$

$$KE_T = \frac{1}{2}mv^2 = 0$$

$$KE_R = \frac{1}{2}I\omega^2 = 0$$



What is the Energy of the ball at the top of this hill?

$$PE_G = mgh$$

$$KE_T = \frac{1}{2}mv^2 = 0$$

$$KE_R = \frac{1}{2}I\omega^2$$

What is the moment of Inertia for a hollow sphere?

$$I = \frac{2}{3}mR^2$$

$$a = r\alpha$$

$$v = r\omega$$

What is the Energy of the ball at the bottom of the hill?

$$PE_G = mgh = 0$$

$$KE_T = \frac{1}{2}mv^2$$

$$KE_R = \frac{1}{2}I\omega^2$$

On the diagram, draw the ball at the bottom of the hill and where it will stop. Indicate its velocity and height.

Conservation of Energy

Energy Before (Top of Hill) = Energy After (Bottom of Hill)

$$PE_G + KE_T + KE_R = PE_G + KE_T + KE_R$$

$$mgH_o + 0 + 0 = 0 + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Solve the equation above symbolically for the linear velocity at the bottom of the hill.

Substitute the Moment of Inertia and the linear velocity.

$$mgH_o = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgH_o = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{3}mR^2\right)\left(\frac{v}{R}\right)^2$$

$$mgH_o = \frac{1}{2}mv^2 + \frac{1}{3}mv^2$$

$$mgH_o = \frac{5}{6}mv^2$$

$$\frac{6}{5}gH_o = v^2$$

Plug into

Conservation of Energy

Energy Before (Bottom of Hill) = Energy After (Top of Hill)

$$PE_G + KE_T + KE_R = PE_G + KE_T + KE_R$$

$$0 + \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh + 0 + \frac{1}{2}I\omega^2$$

Using the linear velocity at the bottom of the hill, solve for the height **h** in terms of H_o.

$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh + \frac{1}{2}I\omega^2$$

$$\frac{1}{2}mv^2 = mgh$$

$$\frac{1}{2g}v^2 = h$$

$$\frac{1}{2g}\left(\frac{6}{5}gH_o\right) = h$$

$$\frac{3}{5}H_o = h$$

The rot. KE is the same on both sides of the equation. We can subtract it

Why didn't the ball go all the way up to H_o on the smooth hill?

It takes energy to cause the ball to rotate. The Grav. PE provides the force and the static friction provides the torque that causes the ball to rotate. The ball is still rotating on the smooth side of the hill because there is no frictional force to stop it from doing so. This energy 'lost' to rotation is the reason the ball did not return to its original height.