Chapter 10 Problem 62 †

Given

$v = 3.7\ m/s$

Solution

Find the maximum height a hollow ball will reach going up an inclined plane.

The rolling hollow ball has both rotational and translational kinetic energy. The moment of inertia for a hollow ball is

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

The total kinetic energy is

$$K_{tot} = K_{rot} + K_{tran} = \tfrac{1}{2}I\omega^2 + \tfrac{1}{2}mv^2$$

$$K_{tot} = \tfrac{1}{2}(\tfrac{2}{3}mr^2)\omega^2 + \tfrac{1}{2}mv^2 = \tfrac{1}{3}m(r\omega)^2 + \tfrac{1}{2}mv^2$$

$$K_{tot} = \tfrac{1}{3}m(v)^2 + \tfrac{1}{2}mv^2 = \tfrac{5}{6}mv^2$$

This kinetic energy is converted to gravitational potential energy.

$$U = mgh$$

Setting the potential and kinetic energies equal and solving for height gives

$$mgh = \tfrac{5}{6}mv^2$$

$$h = \frac{5mv^2}{6mg} = \frac{5v^2}{6g} = \frac{5(3.7\ m/s)^2}{6(9.80\ m/s^2)}$$

$$h = 1.16\ m$$

† Problem from Essential University Physics, Wolfson