SAMPLE PROBLEM G

Elastic Collisions

PROBLEM

A 0.015 kg marble moving to the right at 0.225 m/s makes an elastic head-on collision with a 0.030 kg shooter marble moving to the left at 0.180 m/s. After the collision, the smaller marble moves to the left at 0.315 m/s. Assume that neither marble rotates before or after the collision and that both marbles are moving on a frictionless surface. What is the velocity of the 0.030 kg marble after the collision?

SOLUTION

1. DEFINE

Given: $m_1 = 0.015$ kg $\quad m_2 = 0.030$ kg

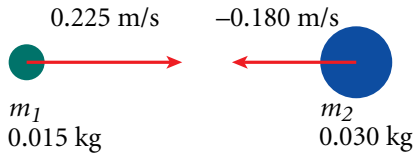
$\mathbf{v_{1,i}} = 0.225$ m/s to the right, $v_{1,i} = +0.225$ m/s

$\mathbf{v_{2,i}} = 0.180$ m/s to the left, $v_{2,i} = -0.180$ m/s

$\mathbf{v_{1,f}} = 0.315$ m/s to the left, $v_{1,f} = -0.315$ m/s

Unknown: $\mathbf{v_{2,f}} = ?$

Diagram:



2. PLAN

Choose an equation or situation: Use the equation for the conservation of momentum to find the final velocity of m_2, the 0.030 kg marble.

$$m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} = m_1\mathbf{v_{1,f}} + m_2\mathbf{v_{2,f}}$$

Rearrange the equation to isolate the final velocity of m_2.

$$m_2\mathbf{v_{2,f}} = m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}$$

$$\mathbf{v_{2,f}} = \frac{m_1\mathbf{v_{1,i}} + m_2\mathbf{v_{2,i}} - m_1\mathbf{v_{1,f}}}{m_2}$$

3. CALCULATE

Substitute the values into the equation and solve: The rearranged conservation-of-momentum equation will allow you to isolate and solve for the final velocity.

$$v_{2,f} = \frac{(0.015\text{ kg})(0.225\text{ m/s}) + (0.030\text{ kg})(-0.180\text{ m/s}) - (0.015\text{ kg})(-0.315\text{ m/s})}{0.030\text{ kg}}$$

$$v_{2,f} = \frac{(3.4 \times 10^{-3}\text{ kg•m/s}) + (-5.4 \times 10^{-3}\text{ kg•m/s}) - (-4.7 \times 10^{-3}\text{ kg•m/s})}{0.030\text{ kg}}$$

$$v_{2,f} = \frac{2.7 \times 10^{-3}\text{ kg•m/s}}{3.0 \times 10^{-2}\text{ kg}}$$

$$\boxed{\mathbf{v_{2,f}} = 9.0 \times 10^{-2}\text{ m/s to the right}}$$