

## Problem 1.30

Conservation laws, such as conservation of momentum, often give a surprising amount of information about the possible outcome of an experiment. Here is perhaps the simplest example: Two objects of masses  $m_1$  and  $m_2$  are subject to no external forces. Object 1 is traveling with velocity  $\mathbf{v}$  when it collides with the stationary object 2. The two objects stick together and move off with common velocity  $\mathbf{v}'$ . Use conservation of momentum to find  $\mathbf{v}'$  in terms of  $\mathbf{v}$ ,  $m_1$ , and  $m_2$ .

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### Solution

Since the two objects are subject to no external forces, conservation of momentum applies.

$$\sum \mathbf{p}_{\text{initial}} = \sum \mathbf{p}_{\text{final}}$$

This type of collision in which the masses stick together is called an inelastic collision—mechanical energy (kinetic plus potential energy) is not conserved, but that's not important here. Object 1's initial momentum is  $m_1\mathbf{v}$ , and object 2's initial momentum is  $\mathbf{0}$  because object 2 is stationary before the collision. The final momentum is  $(m_1 + m_2)\mathbf{v}'$ , as the two objects are stuck together after the collision and moving with velocity  $\mathbf{v}'$ . By conservation of momentum, then,

$$m_1\mathbf{v} + \mathbf{0} = (m_1 + m_2)\mathbf{v}'.$$

Therefore, dividing both sides by  $m_1 + m_2$ ,

$$\mathbf{v}' = \frac{m_1}{m_1 + m_2}\mathbf{v}.$$