Elastic and perfectly inelastic collisions are limiting cases; most collisions actually fall into a category between these two extremes. In this third category of collisions, called *inelastic collisions*, the colliding objects bounce and move separately after the collision, but the total kinetic energy decreases in the collision. *For the problems in this book, we will consider all collisions in which the objects do not stick together to be elastic collisions.* Therefore, we will assume that the total momentum and the total kinetic energy each will stay the same before and after a collision in all collisions that are not perfectly inelastic.

Kinetic energy is conserved in elastic collisions

Figure 12 shows an elastic head-on collision between two soccer balls of equal mass. Assume, as in earlier examples, that the balls are isolated on a frictionless surface and that they do not rotate. The first ball is moving to the right when it collides with the second ball, which is moving to the left. When considered as a whole, the entire system has momentum to the left.

After the elastic collision, the first ball moves to the left and the second ball moves to the right. The magnitude of the momentum of the first ball, which is now moving to the left, is greater than the magnitude of the momentum of the second ball, which is now moving to the right. The entire system still has momentum to the left, just as before the collision.

Another example of a nearly elastic collision is the collision between a golf ball and a club. After a golf club strikes a stationary golf ball, the golf ball moves at a very high speed in the same direction as the golf club. The golf club continues to move in the same direction, but its velocity decreases so that the momentum lost by the golf club is equal to and opposite the momentum gained by the golf ball. *The total momentum is always constant throughout the collision. In addition, if the collision is perfectly elastic, the value of the total kinetic energy after the collision is equal to the value before the collision.*

MOMENTUM AND KINETIC ENERGY ARE CONSERVED IN AN ELASTIC COLLISION

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

$$\tfrac{1}{2}m_1v_{1,i}^2 + \tfrac{1}{2}m_2v_{2,i}^2 = \tfrac{1}{2}m_1v_{1,f}^2 + \tfrac{1}{2}m_2v_{2,f}^2$$

Remember that v is positive if an object moves to the right and negative if it moves to the left.

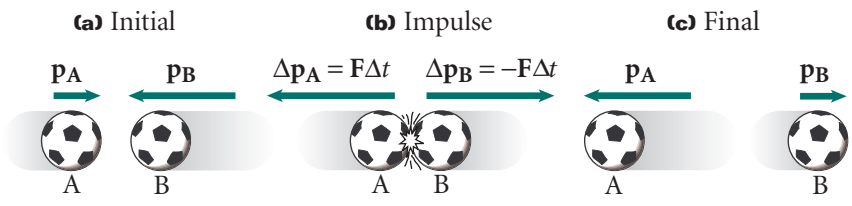

Figure 12
In an elastic collision like this one **(b),** both objects return to their original shapes and move separately after the collision **(c).**

Quick Lab

Elastic and Inelastic Collisions

MATERIALS LIST

- **2 or 3 small balls of different types**

SAFETY

Perform this lab in an open space, preferably outdoors, away from furniture and other people.

Drop one of the balls from shoulder height onto a hard-surfaced floor or sidewalk. Observe the motion of the ball before and after it collides with the ground. Next, throw the ball down from the same height. Perform several trials, giving the ball a different velocity each time. Repeat with the other balls.

During each trial, observe the height to which the ball bounces. Rate the collisions from most nearly elastic to most inelastic. Describe what evidence you have for or against conservation of kinetic energy and conservation of momentum for each collision. Based on your observations, do you think the equation for elastic collisions is useful to make predictions?