Figure 6.20 shows a falling firecracker exploding into two pieces. The momenta of the fragments combine by vector addition to equal the original momentum of the falling firecracker. Figure 6.19b extends this idea to the microscopic realm, where the tracks of subatomic particles are revealed in a liquid hydrogen bubble chamber.

Whatever the nature of a collision or however complicated it is, the total momentum before, during, and after remains unchanged. This extremely useful law enables us to learn much from collisions without any knowledge of the forces that act in the collisions. We will see, in the next chapter, that energy, perhaps in multiple forms, is also conserved. By applying momentum and energy conservation to the collisions of subatomic particles as observed in various detection chambers, we can compute the masses of these tiny particles. We obtain this information by determining momenta and energy before and after collisions.

Conservation of momentum and conservation of energy (which we will cover in the next chapter) are the two most powerful tools of mechanics. Applying them yields detailed information that ranges from facts about the interactions of subatomic particles to the structure and motion of entire galaxies.

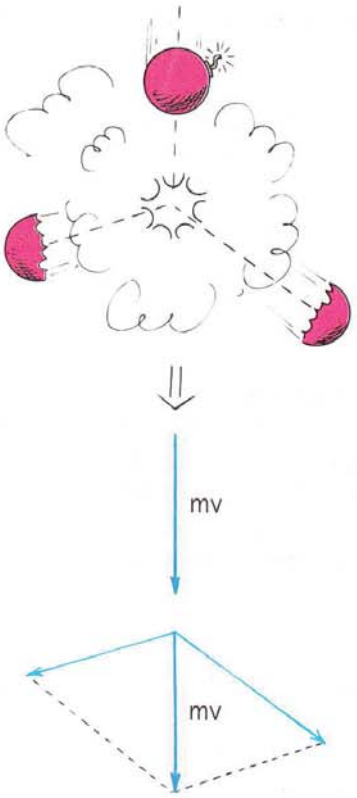

FIGURE 6.20
After the firecracker bursts, the momenta of its fragments add up (by vector addition) to the original momentum.

For instructor-assigned homework, go to www.masteringphysics.com MP

SUMMARY OF TERMS (KNOWLEDGE)

Momentum The product of the mass of an object and its velocity.

Impulse The product of the force acting on an object and the time during which it acts.

Impulse-momentum relationship Impulse is equal to the change in the momentum of the object that the impulse acts upon. In symbolic notation,

$$Ft = \Delta mv$$

Law of conservation of momentum In the absence of an external force, the momentum of a system remains unchanged. Hence, the momentum before an event involving only internal forces is equal to the momentum after the event:

$$mv_{(\text{before event})} = mv_{(\text{after event})}$$

Elastic collision A collision in which objects rebound without lasting deformation or the generation of heat.

Inelastic collision A collision in which objects become distorted, generate heat, and possibly stick together.

READING CHECK QUESTIONS (COMPREHENSION)

6.1 Momentum

1. Which has a greater momentum: a heavy truck at rest or a moving skateboard?

6.2 Impulse

2. Distinguish between force and impulse.
3. What are the two ways to increase impulse?
4. For the same force, why does a long cannon impart more speed to a cannonball than a short cannon?

6.3 Impulse Changes Momentum

5. How is the impulse–momentum relationship related to Newton's second law?