# Summary

**THE BIG IDEA** **Momentum is conserved for all collisions as long as external forces don't interfere.**

## 8.1 Momentum

**A moving object can have a large momentum if it has a large mass, a high speed, or both.**

- **Momentum** is the mass of the object multiplied by its velocity.
- A moving truck has more momentum than a car moving at the same speed because the truck has more mass.
- A fast car can have more momentum than a slow truck.
- A truck at rest has no momentum at all.

## 8.2 Impulse Changes Momentum

**The change in momentum depends on the force that acts and the length of time it acts.**

- The quantity *force* × *time interval* is called **impulse.** In short-hand notation, impulse = $F\Delta t$.
- The greater the impulse exerted on something, the greater will be the change in momentum. The exact relationship is impulse = change in momentum or $Ft = \Delta(mv)$.
- To increase the momentum of an object, apply the greatest force possible for as long as possible. A golfer teeing off and a baseball player trying for a home run do both of these things when they swing as hard as possible and follow through with their swings.
- In the case of decreasing momentum, a longer contact time reduces the force and decreases the resulting deceleration. A padded dashboard in a car is safer than a rigid, metal one because the padded dashboard increases the time of contact.

## 8.3 Bouncing

**The impulse required to bring an object to a stop and then to "throw it back again" is greater than the impulse required merely to bring the object to a stop.**

- It takes a greater impulse to catch a flower pot and throw it back up than merely to catch it.
- A karate expert strikes the bricks in such a way that her hand is made to bounce back, yielding as much as twice the impulse to the bricks.

## 8.4 Conservation of Momentum

**The law of conservation of momentum states that, in the absence of an external force, the momentum of a system remains unchanged.**

- The **law of conservation of momentum** describes the momentum of a system.
- If a system undergoes changes wherein all forces are internal—for example, in atomic nuclei undergoing radioactive decay, cars colliding, or stars exploding—the net momentum of the system before and after the event is the same.
- The momentum before firing a cannon is zero. After firing, the momentum is still zero because the momentum of the cannon is equal and opposite to the momentum of the cannonball.

## 8.5 Collisions

**Whenever objects collide in the absence of external forces, the net momentum of both objects before the collision equals the net momentum of both objects after the collision.**

- When objects collide without being permanently deformed and without generating heat, the collision is said to be an **elastic collision.**
- Colliding *objects* bounce perfectly in perfect elastic collisions.
- A collision in which the colliding objects become distorted and generate heat during the collision is an **inelastic collision.**
- Whenever colliding objects become tangled or couple together, a totally inelastic collision occurs.
- Perfectly elastic collisions are not common in the everyday world. At the microscopic level, however, perfectly elastic collisions are commonplace. For example, electrically charged particles bounce off one another without generating heat.

## 8.6 Momentum Vectors

**The vector sum of momenta is the same before and after a collision.**

- Momentum is conserved even when the interacting objects don't move along the same straight line.
- The momentum of a car wreck is equal to the vector sum of the momenta of each of the cars before the collision.
- When a firecracker bursts, the vector sum of the momenta of its fragments adds up to the firecracker's momentum just before bursting.