momentum is conserved. However, because Earth has an enormous mass (6×10^{24} kg), its momentum corresponds to a tiny velocity (1×10^{-23} m/s).

Imagine two skaters pushing away from each other, as shown in **Figure 7.** The skaters are both initially at rest with a momentum of $\mathbf{p_{1,i}} = \mathbf{p_{2,i}} = 0$. When they push away from each other, they move in opposite directions with equal but opposite momentum so that the total final momentum is also zero ($\mathbf{p_{1,f}} + \mathbf{p_{2,f}} = 0$).

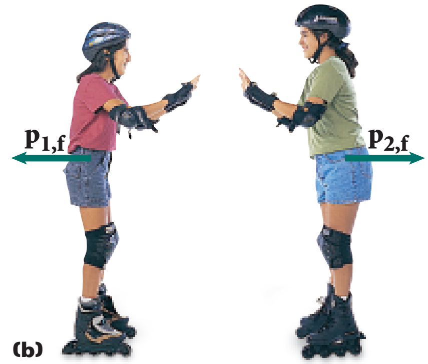


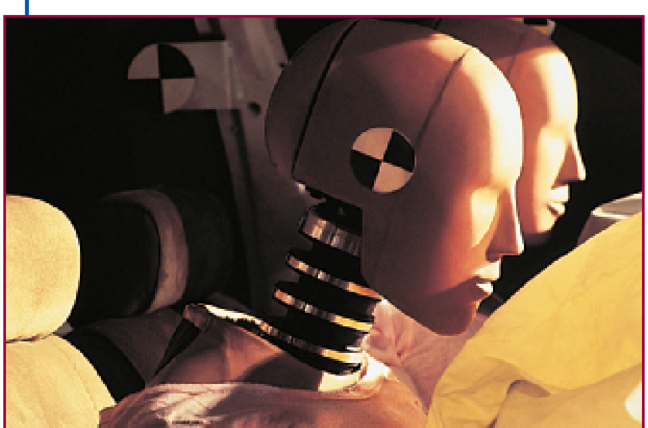
Figure 7
(a) When the skaters stand facing each other, both skaters have zero momentum, so the total momentum of both skaters is zero.
(b) When the skaters push away from each other, their momentum is equal but opposite, so the total momentum is still zero.

Why it Matters

Surviving a Collision

Pucks and carts collide in physics labs all the time with little damage. But when cars collide on a freeway, the resulting rapid change in speed can cause injury or death to the drivers and any passengers.

Many types of collisions are dangerous, but head-on collisions involve the greatest accelerations and thus the greatest forces. When two cars going 100 km/h (62 mi/h) collide head-on, each car dissipates the same amount of kinetic energy that it would dissipate if it hit the ground after being dropped from the roof of a 12-story building.



The key to many automobile-safety features is the concept of impulse. One way today's cars make use of the concept of impulse is by crumpling during impact. Pliable sheet metal and frame structures absorb energy until the force reaches the passenger compartment, which is built of rigid metal for protection. Because the crumpling slows the car gradually, it is an important factor in keeping the driver alive.

Even taking into account this built-in safety feature, the National Safety Council estimates that high-speed collisions involve accelerations of 20 times the free-fall acceleration. In other words, an 89 N (20 lb) infant could experience a force of 1780 N (400 lb) in a high-speed collision.

Seat belts are necessary to protect a body from forces of such large magnitudes. They stretch and extend the time it takes a passenger's body to stop, thereby reducing the force on the person. Air bags further extend the time over which the momentum of a passenger changes, decreasing the force even more. As of 1998, all new cars have air bags on both the driver and passenger sides. Seat belts also prevent passengers from hitting the inside frame of the car. During a collision, a person not wearing a seat belt is likely to hit the windshield, the steering wheel, or the dashboard—often with traumatic results.