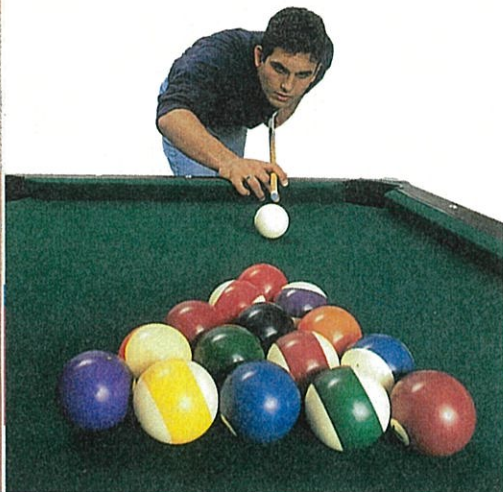


Figure 4-22

The pool player is ready to start a game. What is the total momentum of all the balls on the table?

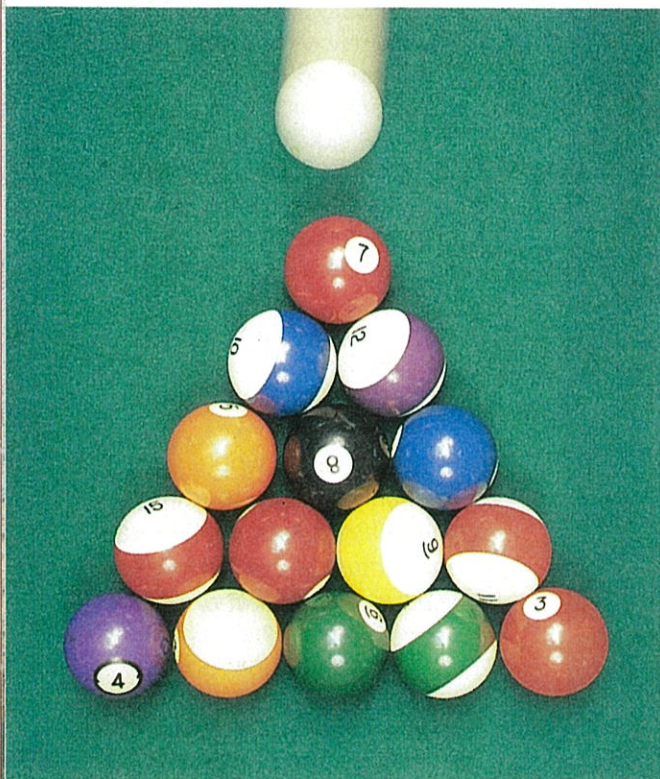


Conserving Total Momentum

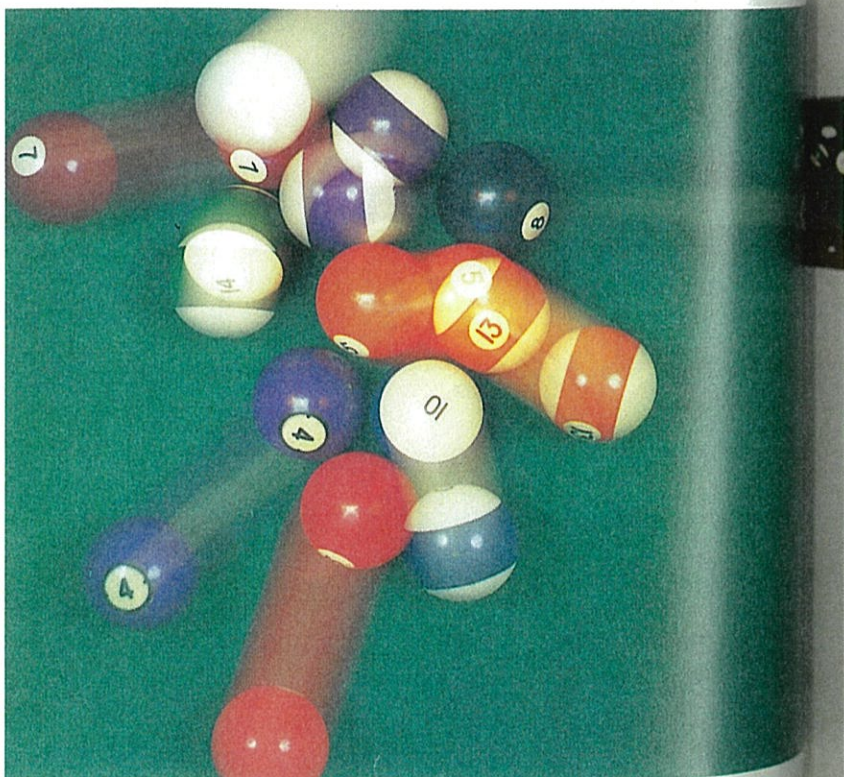
The momentum of an object doesn't change unless its mass, or velocity, or both, change. But momentum can be transferred from one object to another. Consider the game of pool shown in **Figure 4-22**. Before the game starts, all the balls are motionless. Therefore, the total momentum of the balls is zero. There can be no momentum because none of the balls has a velocity.

What happens when a cue ball rolling across a pool table hits the group of balls that is standing still? At first, the rolling ball has momentum and the motionless balls do not. When the cue ball collides with the balls that were at rest, all the balls start moving. They gain momentum. The cue ball slows down and loses momentum. If you were to measure the total momentum of all the balls before and after the collision, it would be the same. The momentum the group of balls gains is equal to the momentum that the cue ball loses. Total momentum is conserved—it doesn't change.

A The player strikes the cue ball and sends it hurtling toward the group of balls at the other end of the table. The cue ball is the only ball moving; thus, it is the only ball with momentum. It carries the total momentum of all the balls.

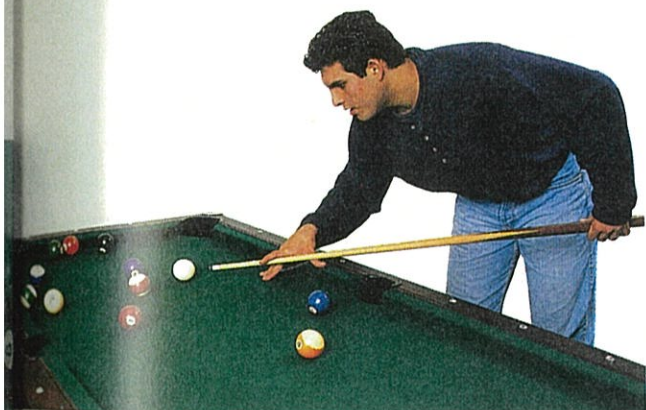


B After being struck by the cue ball, the other balls scatter around the table; some hit other balls, some hit the edge of the table, and others may hit nothing before stopping. At any instant, the total momentum of all the balls is equal to the momentum the cue ball had before it struck the rest of the balls.

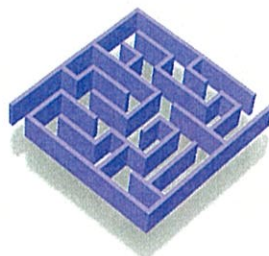


The law of conservation of momentum states that the total amount of momentum of a group of objects does not change unless outside forces act on the objects. After the collision, the balls on the pool table eventually slow down and stop rolling. What outside force makes that happen?

With Newton's third law and conservation of momentum, you can explain many types of motion that may seem complicated at first. Bouncing on a trampoline, knocking down bowling pins with a ball, and tackling a football player are a few examples. Think about how you would explain these and other examples of motion.



C All the balls have come to a stop and the player is ready to take the next shot. The total momentum of all the balls is zero again.



Problem Solving

An Icy Challenge

Suppose you are playing hockey on a frozen pond with some friends when one of them presents a challenge. From the middle of the frozen pond, you are challenged to find a way to get to the ground at the edge of the pond without pushing or walking with your legs or arms. Assume the pond is nearly frictionless. What do you have with you that will help you get off of the pond?

Solve the Problem:

1. How does the statement that the pond is nearly frictionless affect your approach to solving this problem?
2. What is your momentum as you are standing in the middle of the frozen pond?

Think Critically:

1. Describe your plan for getting to the edge of the pond. Be sure to describe any forces involved in your plan.
2. What motions would take place and why would they occur?
3. How would you change your plan if you almost made it to the edge?

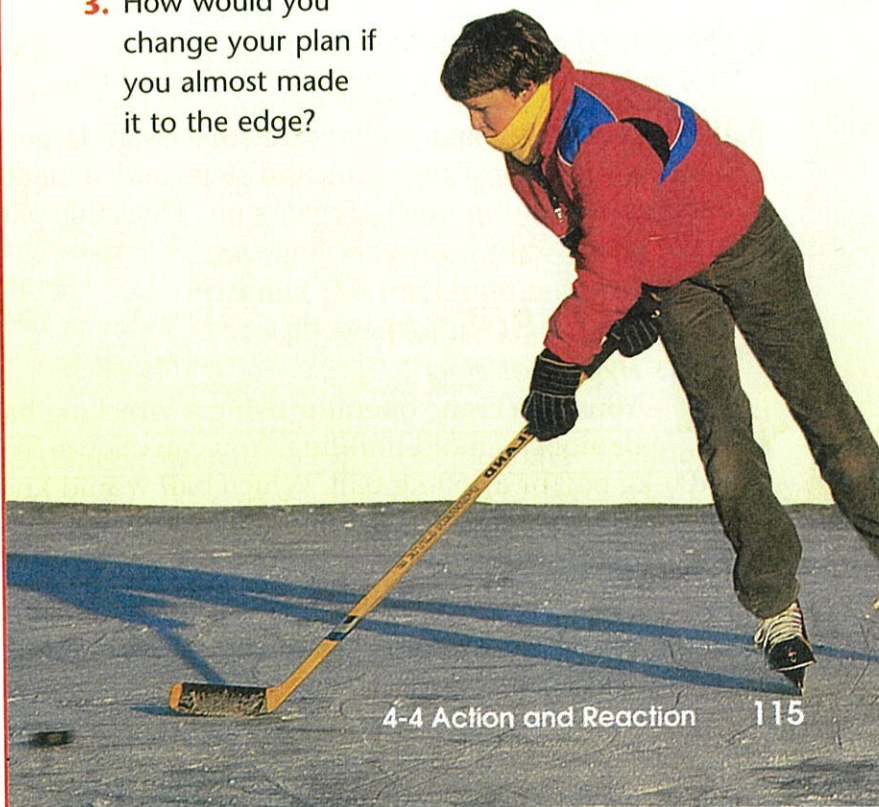


Figure 4-23

A tackle being made in football is a good example of momentum being transferred and conserved. If a football player wanted to increase his momentum, how could he do it?



Most sports involve many rapid changes in momentum. The momentums of the ball carrier and the tacklers in **Figure 4-23** change when the tackle is made. Players who are moving have momentum, and the equipment they use—bats, balls, rackets, and pucks—also have their own momentum when they are put into play. In every case, the law of conservation of momentum is in effect.

Section Wrap-up

Review

1. A boater tries to jump a few feet from a boat to land. Instead, he lands in the water. Explain why.
2. Compare the momentums of a 50-kg dolphin swimming 16.4 m/s and a 6300-kg elephant walking 0.11 m/s.
3. **Think Critically:** Some ballet directors assign larger dancers to perform slow, graceful steps and smaller dancers to perform quick movements. Does this plan make sense? Why?



Skill Builder

Hypothesizing

You are a crane operator using a wrecking ball to demolish an old building. You can choose to use a 100-kg ball or a 150-kg ball. Which ball would knock the walls down faster? Which ball would be easier for you to control? Explain. If you need help, refer to Hypothesizing in the **Skill Handbook**.

Science Journal

In your Science Journal, use the law of conservation of momentum to explain the results of a particular collision you have witnessed. For example, think of games, sports, or amusement park rides or contests.