Section 3: Newton's Third Law

Preview

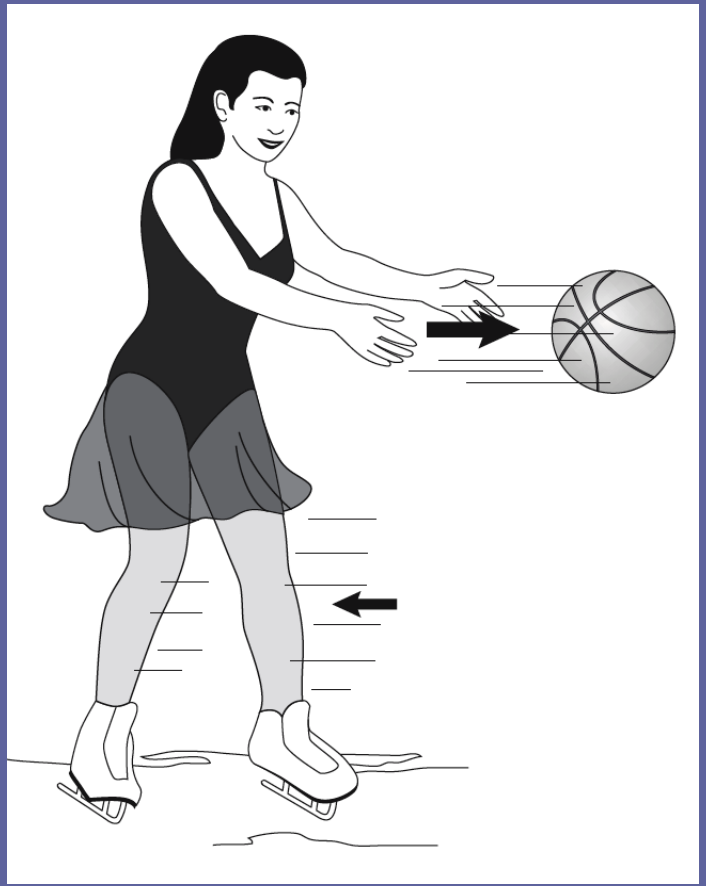
Key Ideas

- What happens when an object exerts a force on another object?
- How do you calculate the momentum of an object?
- What is the total momentum after objects collide?

Bellringer

You have learned that forces account for changes in the motion of objects. Using what you have learned, explain what happens in the following situation.

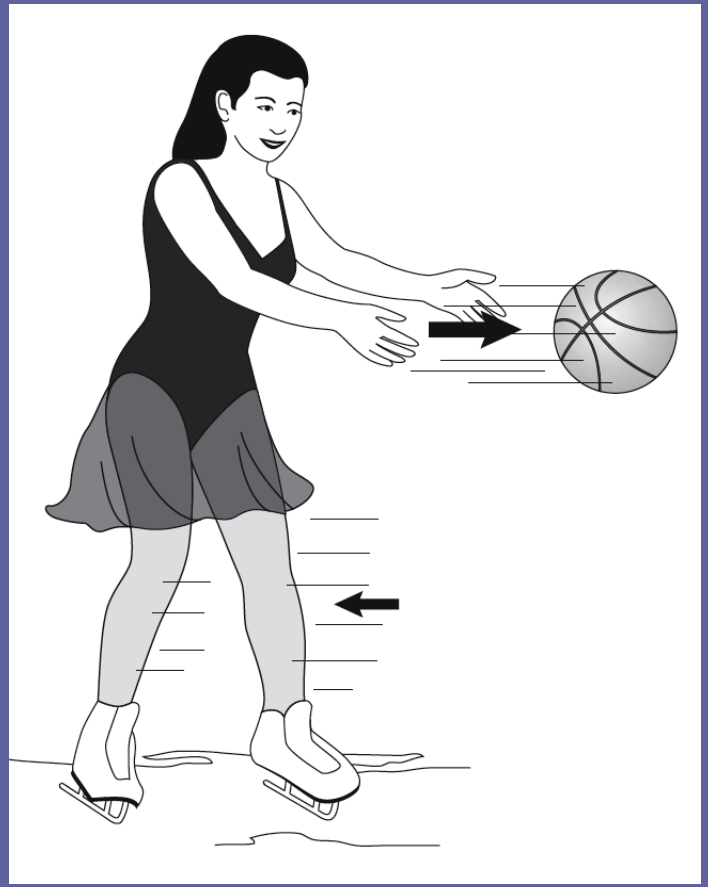
An ice skater holding a basketball is standing on the surface of a frozen pond. The skater throws the ball forward. At the same time, the skater slides on the ice in the opposite direction.



Bellringer, *continued*

1. Is the force on the ball greater than, less than, or equal to the opposite force on the skater? Explain your answer.

2. Is the acceleration of the ball greater than, less than, or equal to the acceleration of the skater? (Hint: Remember Newton's Second Law.) Explain your answer.



Action and Reaction Forces

〉 What happens when an object exerts a force on another object?

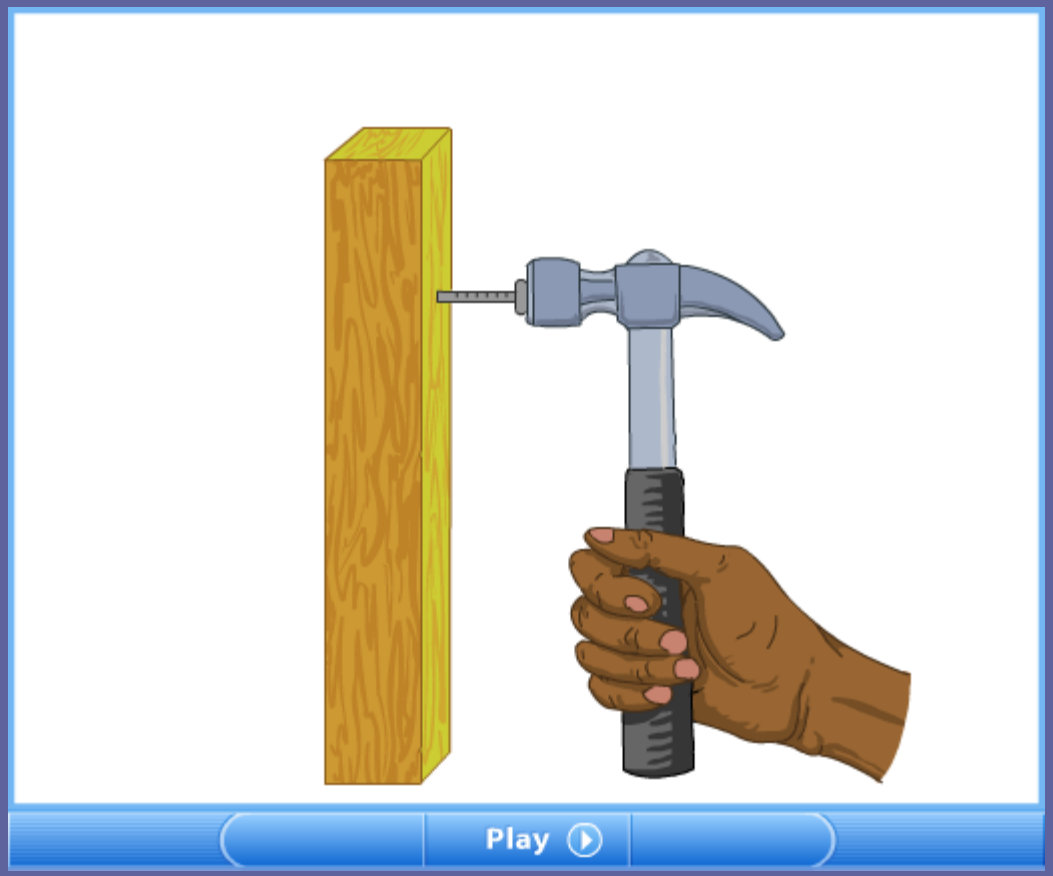
〉 When one object exerts a force on a second object, the second object exerts a force equal in size and opposite in direction on the first object.

- This is *Newton's third law.*

Action and Reaction Forces, *continued*

- Forces always occur in pairs.
  - For every *action* force, there is an equal and opposite *reaction* force.
- Forces in a force pair do not act on the same object.
- Equal forces don't always have equal effects.
  - Example: The action force of Earth pulling on an object and causing it to fall is much more obvious than the equal and opposite reaction force of the falling object pulling on Earth.

Visual Concept: Action and Reaction Forces



Momentum

〉 How do you calculate the momentum of an object?

〉 For movement along a straight line, momentum is calculated by multiplying an object's mass and velocity.

- *momentum = mass x velocity,* or *p = mv*

Momentum, *continued*

- **momentum:** quantity defined as the product of the mass and velocity of an object
  - SI units of momentum = kilograms times meters per second (kg•m/s).
  - Momentum and velocity are in the same direction.
- Momentum increases as mass and velocity increase.
- Force is related to change in momentum.
  - As the period of time of the momentum's change becomes longer, the force needed to cause this change in momentum becomes smaller.

Math Skills

Momentum

Calculate the momentum of a 6.00 kg bowling ball moving at 10.0 m/s down the alley toward the pins.

1. List the given and unknown values.

Given: *mass*, m = 6.00 kg

velocity, v = 10.0 m/s *(toward the pins)*

Unknown: *momentum*, p = ? kg • m/s (and direction)

Math Skills, continued

2. Write the equation for momentum.

momentum = mass x velocity

$p = mv$

3. Insert the known values into the equation, and solve.

$p = mv = 6.00 \text{ kg} \times 10.0 \text{ m/s}$

$p = 60.0 \text{ kg} \cdot \text{m/s}$ *(toward the pins)*

Conservation of Momentum

〉 What is the total momentum after objects collide?

〉 The total momentum of two or more objects after a collision is the same as it was before the collision. In other words, the total amount of momentum in an isolated system is conserved.

- This principle is the *law of conservation of momentum.*

Visual Concept: Momentum and Collisions