chapter 11

Force and Newton's Laws

section 3 Newton's Third Law

What You'll Learn

- about forces that objects exert on each other

Before You Read

Imagine stepping out of a canoe onto the shore of a lake. What happens to the canoe when you step out?

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Read to Learn

Action and Reaction

Newton's first two laws of motion explain how the motion of one object changes. You have learned that if balanced forces act on an object, the object will remain at rest or stay in motion with constant velocity. If the forces are unbalanced, the object will accelerate in the direction of the net force.

Another of Newton's laws describes something else that happens when one object exerts a force on another object. When you push on a wall, did you know that the wall also pushes on you? **Newton's third law of motion** states that forces always act in equal but opposite pairs. When you push on a wall, you apply a force to the wall. But, the wall also applies a force equal in strength to you. When one object applies a force on another object, the second object exerts the same size force on the first object.

Why don't action and reaction forces cancel?

The forces that two objects put on each other are called an action-reaction force pair. The forces in a force pair are equal in strength, but opposite in direction. The forces in a force pair don't cancel each other out because they act on different objects. Forces can cancel each other only if they act on the same object.

Study Coach

Outline As you read the section, create an outline using each heading from the text. Under each heading, write the main points or ideas that you read.

FOLDABLES™

B Classify As you read this section, use your table Foldable to write about Newton's third law.

Force	Example in Your Life
First Law	
Second Law	
Third Law	

Action and Reaction Forces Imagine a bowling ball hitting a bowling pin. The action force from the bowling ball acts on the pin. The pin flies in the direction of the force. The reaction force from the pin acts on the ball. It causes the ball to slow down.

How do action-reaction force pairs work on large and small objects?

When you walk forward, your shoe pushes Earth backward. Earth pushes your shoe forward. So why do you move when Earth does not? Earth has so much mass compared to you that it does not appear to move when you push on it. If you step on a skateboard, the force from your shoe makes the skateboard roll backward. This is because you have more mass than the skateboard. ☑

Reading Check

1. **Describe** Why doesn't Earth appear to move when you push down on it with your foot?

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How do rockets take off?

The launching of a space shuttle is a good example of Newton's third law. When the fuel in the shuttle's engines is ignited, a hot gas is produced. The gas molecules collide with the inside walls of the engines. The walls exert an action force that pushes the gas out of the bottom of the engine. The gas molecules put reaction forces on the walls of the engine. These reaction forces are what push the engine and the rocket forward. The force of the rocket engines is called thrust.

Weightlessness

You may have seen pictures of astronauts floating inside a space shuttle. The astronauts are said to be weightless—as if Earth's gravity were not pulling on them. But, Earth's gravity is what keeps a shuttle in orbit. Newton's laws of motion can explain why the astronauts float as if there weren't any forces acting on them.

Reading Check

2. **Explain** When you stand on a scale, which force balances the downward pull of gravity on you?

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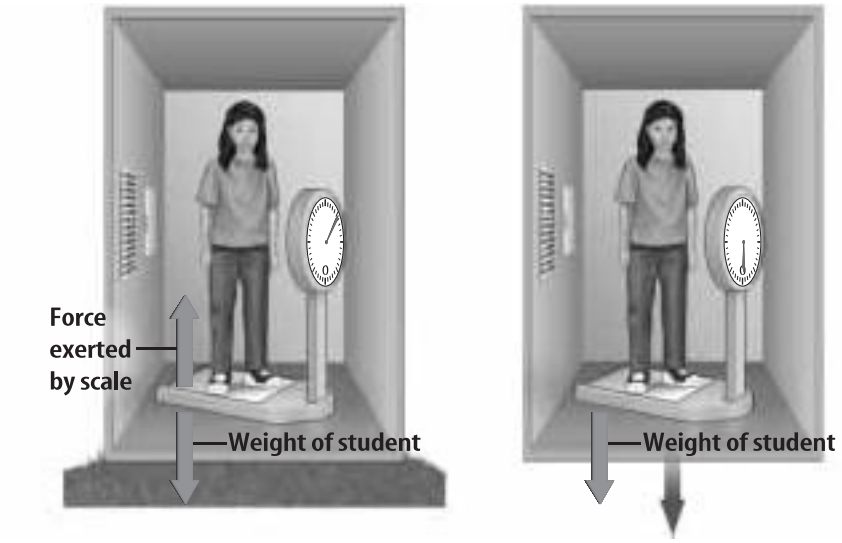
How is weight measured?

Think about how you measure your weight. When you stand on a bathroom scale, your weight pushes down on the scale. This causes the scale pointer to show your weight. Newton's third law tells you that the scale pushes back up on you with a force equal to your weight. This force balances the downward pull of gravity on you, as shown in the figure on the left on the next page. ☑

How does free fall cause weightlessness?

Imagine standing on a scale in an elevator that is falling, as shown in the figure on the right below. An object is in free fall when the only force acting on it is gravity. The elevator, you, and the scale are all in free fall. In free fall, the scale doesn't push back up on you. That's because the only force acting on you is gravity. According to Newton's third law, you are also not pushing down on the scale. So, the scale pointer stays at zero. You seem to be weightless. However, you are not really weightless. Earth's gravity is still pulling down on you. But, because nothing is pushing up on you, you have no sensation of weight.



Why are spacecraft in orbit weightless?

Remember that an object will orbit Earth when its path follows the curve of Earth's surface. Gravity keeps pulling the object down. But, the forward motion keeps it from falling straight downward. Objects that orbit the Earth, like satellites and the space shuttle, are in free fall.

Objects inside the shuttle are also in free fall. This makes the shuttle and everything inside it seem weightless, even though gravity is acting on them.

Suppose an astronaut in the shuttle is holding a ball. When she lets go of the ball, it will not move unless she pushes it. The ball does not move because the ball, the astronaut, and the shuttle are all falling at the same speed. If the astronaut pushes the ball forward, it accelerates to a speed that is faster than the shuttle and astronaut. The ball moves forward inside the shuttle.

Think it Over

3. **Explain** Why isn't an object in free fall really weightless?

Picture This

4. **Describe** Look at the figure. What is the only force acting on the girl in the elevator on the right?

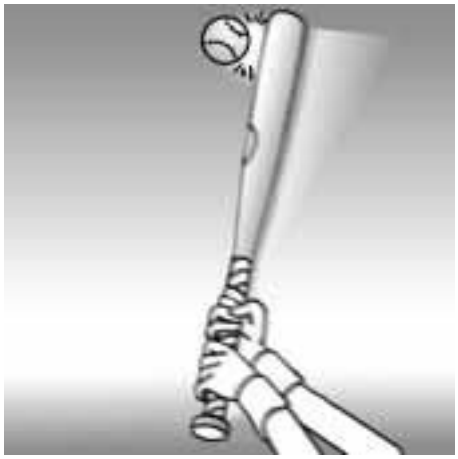
After You Read

Mini Glossary

Newton's third law of motion: forces always act in equal but opposite pairs

1. Review the term and its definition in the Mini Glossary. What are the action and reaction forces that make a rocket move forward? Answer in complete sentences.

2. On the figure below, draw arrows and label the action and reaction forces that are on the objects as the bat hits the baseball.



3. How could you use a skateboard to show Newton's third law of motion to a group of elementary school students?

End of Section

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