

# The Nature of Force

## Reading Preview

### Key Concepts

- How is a force described?
- How are unbalanced and balanced forces related to an object's motion?

### Key Terms

- force
- newton
- net force
- unbalanced forces
- balanced forces

## Target Reading Skill

**Asking Questions** Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write the answers to your questions.


The Nature of Force

Question	Answer
What is a force?	A force is . . .

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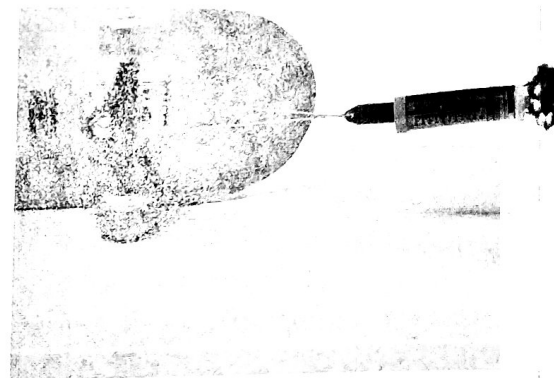
## Discover Activity

### Is the Force With You?

1. Attach a spring scale to each end of a skateboard.
2.  Gently pull on one spring scale with a force of 4 N, while your partner pulls on the other with the same force. Observe the motion of the skateboard.
3. Now try to keep your partner's spring scale reading at 2 N while you pull with a force of 4 N. Observe the motion of the skateboard.

### Think It Over

**Observing** Describe the motion of the skateboard when you and your partner pulled with the same force. How was the motion of the skateboard affected when you pulled with more force than your partner?



A hard kick sends a soccer ball shooting down the field toward the goal. Just in time, the goalie leaps forward, stops the ball, and quickly kicks it in the opposite direction. In a soccer game, the ball is rarely still. Its motion is constantly changing. Why? What causes an object to start moving, stop moving, or change direction? The answer is force.

## What Is a Force?

In science, the word *force* has a simple and specific meaning. A **force** is a push or a pull. When one object pushes or pulls another object, you say that the first object exerts a force on the second object. You exert a force on a computer key when you push it and on a chair when you pull it away from a table.

**Like velocity and acceleration, a force is described by its strength and by the direction in which it acts.** If you push on a door, you exert a force in a different direction than if you pull on the door.



FIGURE 1

### Force and Motion

The force of the kick changes the direction of the soccer ball.

The strength of a force is measured in the SI unit called the **newton (N)**. This unit is named after the English scientist and mathematician Isaac Newton. You exert about one newton of force when you lift a small lemon.

The direction and strength of a force can be represented by an arrow. The arrow points in the direction of a force. The length of the arrow tells you the strength of a force—the longer the arrow, the greater the force.



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What SI unit is used to measure the strength of a force?

## Combining Forces

Often, more than a single force acts on an object at one time. The combination of all forces acting on an object is called the **net force**. The net force determines whether an object moves and also in which direction it moves.

When forces act in the same direction, the net force can be found by adding the strengths of the individual forces. In Figure 2, the lengths of the two arrows, which represent two forces, are added together to find the net force.

When forces act in opposite directions, they also combine to produce a net force. However, you must pay attention to the direction of each force. Adding a force acting in one direction to a force acting in the opposite direction is the same as adding a positive number to a negative number. So when two forces act in opposite directions, they combine by subtraction. The net force always acts in the direction of the greater force. If the opposing forces are of equal strength, there is no net force. There is no change in the object's motion.

FIGURE 2

### Combining Forces

The strength and direction of the individual forces determine the net force. **Calculating** How do you find the net force when two forces act in opposite directions?

$$\begin{array}{c}
 5\text{ N} \quad 5\text{ N} \quad 10\text{ N} \\
 \longrightarrow \quad \longrightarrow \quad = \quad \longrightarrow
 \end{array}$$

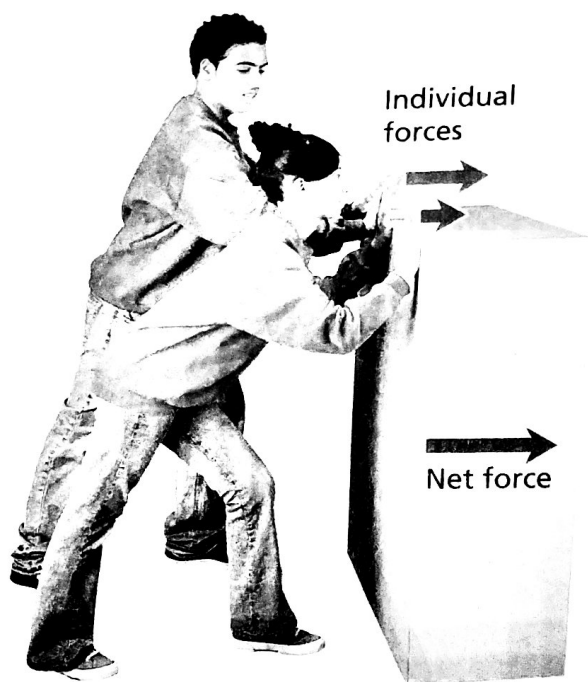
Two forces can add together to produce a larger net force than either original force.

$$\begin{array}{c}
 5\text{ N} \quad 10\text{ N} \quad 5\text{ N} \\
 \longrightarrow \quad \longleftarrow \quad = \quad \longleftarrow
 \end{array}$$

Two forces can subtract to produce a net force in the direction of the larger force.

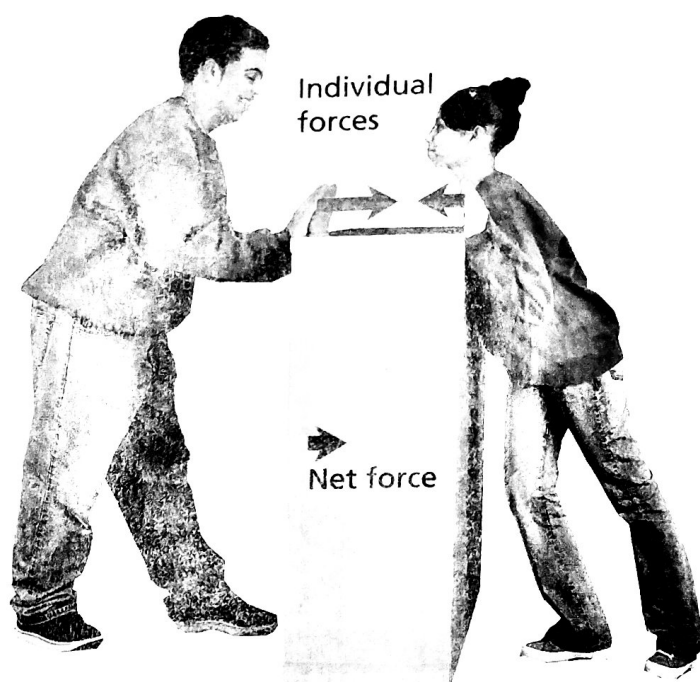
$$\begin{array}{c}
 5\text{ N} \quad 5\text{ N} \\
 \longrightarrow \quad \longleftarrow \quad = \quad 0
 \end{array}$$

Forces may cancel each other and produce no net force.



### Unbalanced Forces in the Same Direction

When two forces act in the same direction, the net force is the sum of the two individual forces. The box moves to the right.



### Unbalanced Forces in the Opposite Direction

When two forces act in opposite directions, the net force is the difference between the two individual forces. The box moves to the right.

**Unbalanced Forces** Whenever there is a net force acting on an object, the forces are unbalanced. **Unbalanced forces** can cause an object to start moving, stop moving, or change direction. **Unbalanced forces acting on an object result in a net force and cause a change in the object's motion.**

Figure 3 shows two people exerting forces on a box. When they both push a box to the right, their individual forces add together to produce a net force in that direction. Since a net, or unbalanced, force acts on the box, the box moves to the right.

When the two people push the box in opposite directions, the net force on the box is the difference between their individual forces. Because the boy pushes with a greater force than the girl, their forces are unbalanced and a net force acts on the box to the right. As a result, the box moves to the right.



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**What is the result of unbalanced forces acting on an object?**

**Balanced Forces** When forces are exerted on an object, the object's motion does not always change. In an arm wrestling contest, each person exerts a force on the other's arm, but the two forces are exerted in opposite directions. Even though both people push hard, their arm positions may not change.

Equal forces acting on one object in opposite directions are called **balanced forces**. Each force is balanced by the other.

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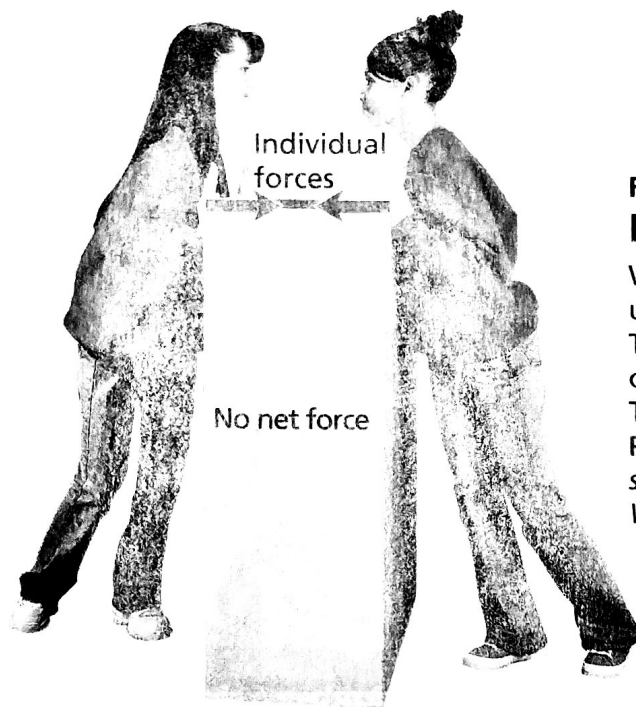


FIGURE 3

## Balanced and Unbalanced Forces

When the forces acting on an object are unbalanced, a net force acts on the object. The object will move. When balanced forces act on an object, no net force acts on the object. The object's motion remains unchanged.

**Predicting** If both girls pushed the box on the same side, would the motion of the box change? Why or why not?

### Balanced Forces in Opposite Directions

When two equal forces act in opposite directions, they cancel each other out. The box doesn't move.

**Balanced forces acting on an object do not change the object's motion.** When equal forces are exerted in opposite directions, there is no net force. In Figure 3, when two people push on the box with equal force in opposite directions, the forces balance each other. The box does not move.

## Section 1 Assessment

**Target Reading Skill Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

### Reviewing Key Concepts

1. a. **Defining** What is a force?  
 b. **Explaining** How is a force described?  
 c. **Interpreting Diagrams** In a diagram, one force arrow is longer than the other arrow. What can you tell about the forces?
2. a. **Reviewing** How can you find the net force if two forces act in opposite directions?  
 b. **Comparing and Contrasting** How do balanced forces acting on an object affect its motion? How do unbalanced forces acting on an object affect its motion?

- c. **Calculating** You exert a force of 120 N on a desk. Your friend exerts a force of 150 N in the same direction. What net force do you and your friend exert on the desk?

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### At-Home Activity

**House of Cards** Carefully set two playing cards upright on a flat surface so that their top edges lean on each other. The cards should be able to stand by themselves. In terms of balanced forces, explain to a family member why the cards don't move. Then exert a force on one of the cards. Explain to a family member the role of unbalanced forces in what happens.