

## Section 2

# What Is a Force?

**Key Concept** Forces acting on an object can be combined and may cause changes in motion.

### What You Will Learn

- A force is a push or a pull that acts on an object. Forces have magnitude and direction.
- Net force is the combined effect of two or more forces acting on an object.
- Balanced forces do not cause changes in motion.
- Unbalanced forces cause changes in an object's velocity.

### Why It Matters

You exert forces to move objects around you.

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You probably hear the word *force* used often. People say things such as "That storm had a lot of force" or "Our football team is a force to be reckoned with." But what exactly is a force? In science, a **force** is a push or a pull. All forces have two properties: direction and magnitude. A **newton** (N) is the unit used to describe the magnitude, or size, of a force.

**Standards Check** What two properties do all forces have?



## Forces Acting on Objects

All forces act on objects. For any push to occur, something has to receive the push. The same is true for any pull. Your fingers exert forces to pull open books or to push the keys on a computer. So, the forces act on the books and keys.

A force can change the velocity of an object. This change in velocity can be a change in speed, direction, or both. In other words, forces can cause acceleration. Anytime you see a change in an object's motion, you can be sure that the change was caused by a force. **Figure 1** shows an example of a force causing a change in motion.



**Figure 1** The soil starts to move because the bulldozer is exerting a force on the soil.

However, a force can act on an object without causing the object to move. For example, the force that you exert when you sit on a chair does not cause the chair to move. The chair does not move because the floor exerts a balancing force on the chair.



## Combined Effect of Forces

When two or more forces act on an object, the result is the combined, or cumulative, effect of the forces. So, the object's motion changes as if only one force acted on the object. That one force is the net force. The **net force** is the combination of the forces acting on an object. How do you find the net force? The answer depends on the directions of the forces.

### Forces in the Same Direction

Suppose that the music teacher asks you and a friend to move a piano. You pull on one end, and your friend pushes on the other end, as **Figure 2** shows. The forces that you and your friend exert on the piano act in the same direction. So, the two forces can be added to find the net force. In this case, the net force is 45 N. This net force is large

enough to move the piano—that is, if the piano is on wheels!



**Figure 2** When forces act in the same direction, you add the forces to determine the net force. The net force will be in the same direction as the individual forces.

Notice that the lengths of the arrows in **Figure 2** represent the magnitudes of the forces. The longer the arrow, the larger the force. Also notice that the combined length of the force arrows equals the length of the net-force arrow.

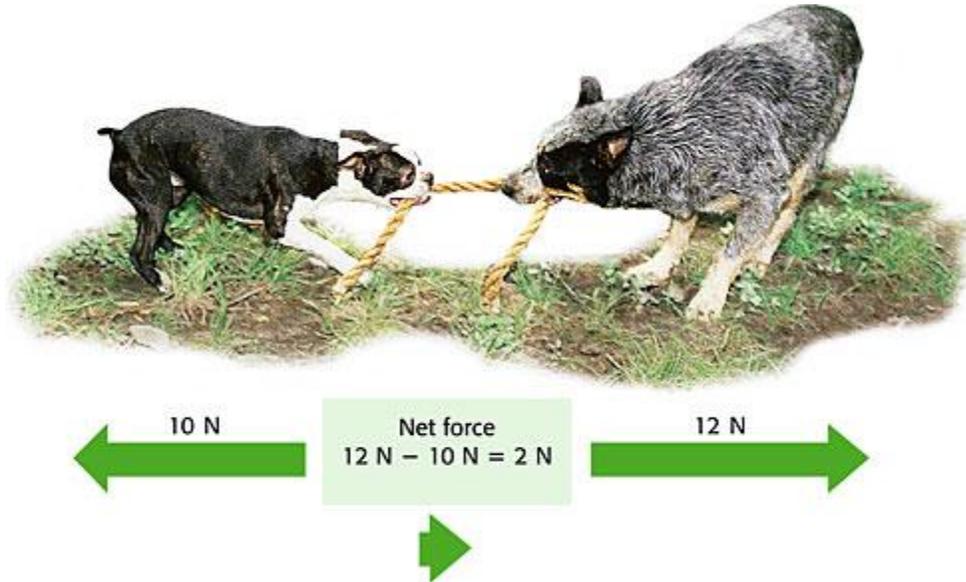
**Standards Check** How do you calculate the net force when two or more forces act in the same direction?



### **Forces in Opposite Directions**

Look at the two dogs playing tug of war in **Figure 3**. Each dog is exerting a force on the rope. But the forces are in opposite directions.

Which dog will win the tug of war?



**Figure 3** When two forces act in opposite directions, you subtract the smaller force from the larger force to determine the net force.

Because the forces are in opposite directions, the net force on the rope is found by subtracting the smaller force from the larger one. The net force is in the same direction as the larger force. In this case, the net force is 2 N in the direction of the dog on the right.

What will happen if each dog pulls with a force of 10 N? The effect of the two forces will be canceled, and the net force on the rope will be 0 N.

**Standards Check** What is the net force on an object if a force of 7 N north and a force of 5 N south act on the object?



## Balanced Forces: No Change in Motion

When the forces on an object produce a net force of 0 N, the forces are *balanced*. Balanced forces will not cause a change in the motion of an object.

Many objects that have balanced forces acting on them are not moving, or are *static*. Often, tension or compression is acting on these static objects. *Tension* is a force that is exerted when matter is pulled or stretched. *Compression* is a force that is exerted when matter is pushed or squeezed. Static objects will not start moving when balanced forces are acting on them. So, a light hanging from the ceiling does not move because the force of gravity pulling down on the light is balanced by the force of tension in the cord pulling upward. **Figure 4** shows other examples of balanced forces.

**Figure 4** Examples of Balanced Forces



◀ The kittens rest comfortably without moving. The downward force of their weight is balanced by the force of compression in the cushion pushing upward.



▶ The bird feeder does not fall down because the weight of the bird and the bird feeder is balanced by the force of tension in the wire.

◀ The dog cannot walk into the surf because the force that the dog is exerting is balanced by the tension in the leash held by the dog's owner.



An object may also be moving when balanced forces are acting on it. Neither the speed nor the direction of the object will change. A car driven in a straight line at a constant speed is an example of balanced forces acting on a moving object.

**Standards Check** How do you know that the forces on a hanging light are balanced? What forces act on the light?





## Unbalanced Forces: Velocity Changes

When the net force on an object is not 0 N, the forces on the object are *unbalanced*. When unbalanced forces are acting on an object, they cause a change in the velocity of the object. The change in velocity may be a change in speed, a change in direction, or both. Unbalanced forces will also cause a static object to start moving or cause a moving object to slow down and stop moving.

### Unbalanced Forces and Moving Objects

Unbalanced forces are needed to change the velocity of moving objects. For example, think about a soccer game, such as the one shown in **Figure 5**. The soccer ball is already moving when one player passes it to a second player. When the ball reaches the second player, that player exerts an unbalanced force—a kick—on the ball. After the kick, the ball moves in a new direction and at a new speed.



**Figure 5** The soccer ball moves because the players exert an

unbalanced force on the ball each time they kick it.

### Unbalanced Forces and Static Objects

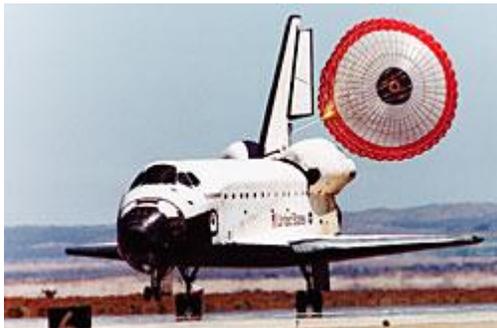
Unbalanced forces are needed to cause static objects to start moving. Every moving object started moving because an unbalanced force acted on it. But a moving object can keep moving without an unbalanced force acting on it. For example, when it is kicked, a soccer ball receives an unbalanced force. The ball keeps rolling after the force of the kick has ended.

**Standards Check** What can happen to the velocity of an object when unbalanced forces act on it?



### Unbalanced Forces and Direction of Motion

You have learned that forces have direction. You have also learned that unbalanced forces can cause a change in the direction of motion. So, you may think that objects always move in the direction of the unbalanced force. But objects do not always move in this direction. Imagine twirling a ball on a string. The string exerts an unbalanced force on the ball. The direction of that force is toward your hand. Yet the ball travels in a circle and does not move toward your hand. **Figure 6** shows another object moving in a direction that differs from the direction of the unbalanced force acting on the object.



**Figure 6** The shuttle is moving forward even though an unbalanced force is acting on it in the opposite direction.

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## Section Summary

- A force is a push or a pull. Forces have magnitude and direction and are expressed in newtons.
- Forces always act on objects.
- The combined effect of the forces acting on an object is the net force.
- Forces acting in the same direction are added. Forces acting in opposite directions are subtracted.
- Balanced forces cause no change in motion. The forces on a static object are balanced and can be identified.
- Unbalanced forces cause a change in velocity.

