The Laws of Motion

Newton's First Law

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	3. Forces acting on an object cannot be added.	
	4. A moving object will stop if no forces act on it.	

Read to Learn

Identifying Forces

Imagine a bird of prey that lives near a lake. It dives through the air at a high speed toward a fish swimming in the water. It moves its legs forward to grab the fish with its talons. It then uses its wings to climb high into the air. The bird then slows its speed and lands softly on the edge of the nest, near the young birds waiting for it.

Forces helped the bird change speed and direction. Recall that a force is a push or a pull. Some forces are contact forces, such as air resistance. Other forces are noncontact forces, such as gravity. When an object moves, it often has several different forces acting on it at the same time. To understand the motion of an object, you need to identify the forces acting on it. In this lesson you will read how forces change the motion of objects.

Combining Forces—The Net Force

Imagine that you are trying to move a piece of heavy furniture. If you push on it by yourself, you will have to push hard to get it to move. But if you ask a friend to push with you, you do not have to push as hard. When two or more forces act on an object, the forces combine. *The combination of all the forces acting on an object is the* **net force.** The way in which forces combine depends on the direction of the forces applied to the object.

Key Concepts

- What is Newton's first law of motion?
- How is motion related to balanced and unbalanced forces?
- What effect does inertia have on the motion of an object?

Mark the Text

Underline Main Ideas As you read, underline the main ideas under each heading. After you finish reading, review the main ideas that you have underlined.

Think it Over

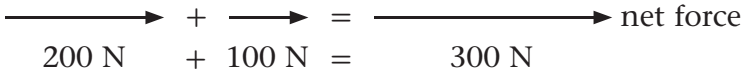
1. Analyze When a soccer ball is in flight, what forces are acting on it?

Combining Forces in the Same Direction

When the forces acting on an object are in the same direction, the net force is the sum of the individual forces. The direction of the net force is the same direction as the forces you add together.

REVIEW VOCABULARY
reference direction
a direction that you choose from a starting point to describe an object's position

Because forces have direction, you have to specify a reference direction when you combine forces. For example, if two people are pushing on a dresser from the left side, you would probably choose "to the right" as the reference direction. Both forces would then be positive. One person pushes the dresser with a force of 200 N to the right. The other person pushes with a force of 100 N to the right. To calculate the net force, add the two forces together, as shown below. The net force is 300 N to the right.



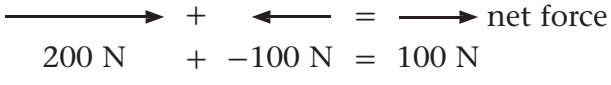
The force exerted on the dresser is the same as if one person pushed on the dresser with a force of 300 N to the right.

Reading Check

2. Describe How do you calculate the net force on an object if two forces are acting on it in the same direction?

Combining Forces in Opposite Directions

When forces act in opposite directions on an object, the net force is still the sum of the forces. Imagine that two people push on a dresser in opposite directions. One pushes with a force of 200 N to the right. The other person pushes with a force of 100 N to the left. You choose "to the right" as the reference direction. A force in that direction, then, is positive. A force in the opposite direction is negative. The net force is the sum of the positive and negative forces, as shown below. The net force is 100 N to the right.

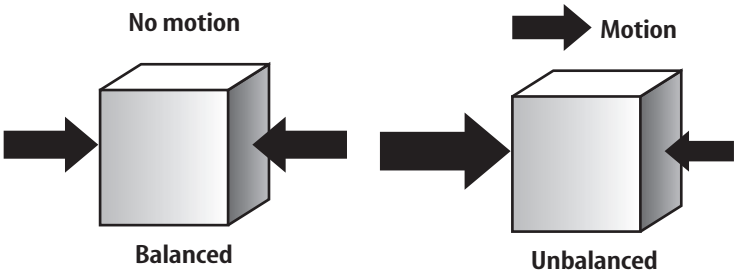


Balanced and Unbalanced Forces

If two people push in opposite directions, but with the same amount of force, the net force on the object is zero. The effect is the same as if there were no forces at all acting on the object. *Forces acting on an object that combine and form a net force of zero are* **balanced forces.** As shown in the figure on the opposite page, balanced forces do not change the motion of an object. *Forces acting on an object that combine and form a net force that is not zero are* **unbalanced forces.**

Think it Over

3. Interpret What does a negative number in the net-force equation mean?



$100\ \text{N} + -100\ \text{N} = 0\ \text{N}$ $200\ \text{N} + -100\ \text{N} = 100\ \text{N}$

Newton's First Law of Motion

Sir Isaac Newton studied how forces affect the motion of objects. He developed three rules that are known as Newton's laws of motion. *According to* **Newton's first law of motion,** *if the net force on an object is zero, the motion of the object does not change*. As a result, balanced forces and unbalanced forces have different results when they act on an object.

Balanced Forces and Motion

According to Newton's first law of motion, balanced forces cause no change in the motion of an object. This is true when an object is at rest or in motion. A dresser is at rest before anyone pushes on it. It remains at rest when balanced forces are applied.

Both gravity and air resistance act on the motion of a parachutist. Gravity pulls the parachutist toward the ground. Air resistance against the parachute slows the fall. When the air resistance and gravity on the parachutist are balanced, the parachutist moves downward with a constant velocity known as terminal velocity. Recall that velocity is the speed and the direction of motion. Terminal velocity is the constant velocity reached when air resistance equals the force of gravity on a falling object.

Unbalanced Forces and Motion

Newton's first law of motion applies only to balanced forces acting on an object. When unbalanced forces act on an object, the object's velocity changes. If an object is at rest, unbalanced forces cause it to start moving. If an object is already moving, unbalanced forces cause its velocity to change.

Visual Check

4. Evaluate Why doesn't the box on the left move?

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Key Concept Check

5. Define What is Newton's first law of motion?

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Key Concept Check

6. Explain How is motion related to balanced and unbalanced forces?

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Inertia

According to Newton's first law, the motion of an object will not change if balanced forces act on it. *The tendency of an object to resist a change in its motion is called* **inertia** (ihn UR shuh). Inertia explains the motion of a crash-test dummy. Before a crash, the car and the dummy move with constant velocity. If no other force acts on them, the car and the dummy continue to move with constant velocity because of inertia. The car crashing into a wall results in an unbalanced force on the car, and the car stops. The dummy continues moving forward because of its inertia.

Key Concept Check

7. Summarize What effect does inertia have on the motion of an object?

Why do objects stop moving?

Think about how friction and inertia together affect an object's movement. A book sitting on a table, for example, stays in place because of inertia. When you push the book, the force you apply to the book is greater than static friction between the book and the table. The book moves in the direction of the greater force. If you stop pushing, friction stops the book.

If there were no friction between the book and the table, inertia would keep the book moving. According to Newton's first law, the book would continue to move at the same speed in the same direction as your push.

On Earth, friction can be reduced but not totally removed. For an object to start moving, a force greater than static friction must be applied to it. To keep the object in motion, a force at least as strong as friction must be continuously applied. Objects stop moving because friction or another force acts on them.

Think it Over

8. Apply Why does a rolling ball eventually stop rolling?

FOLDABLES

Make a chart with six columns and six rows to define and show how this lesson's vocabulary words are related.

	Net Force	Balanced Forces	Unbalanced Forces	Newton's First Law	Inertia
Net Force					
Balanced Forces					
Unbalanced Forces					
Newton's First Law					
Inertia					

Mini Glossary

balanced forces: forces acting on an object that combine and form a net force of zero

inertia (ihn UR shuh): the tendency of an object to resist a change in its motion

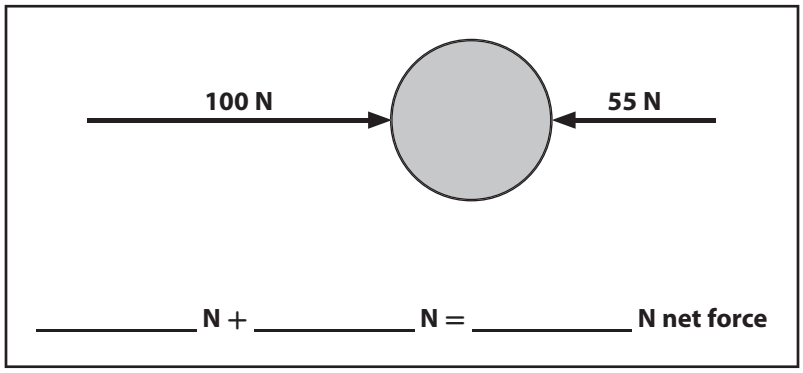
net force: the combination of all the forces acting on an object

Newton's first law of motion: the law that states that if the net force on an object is zero, the motion of the object does not change

unbalanced forces: forces acting on an object that combine and form a net force that is not zero

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that explains how balanced forces affect an object at rest.

2. Use the information in the diagram to complete the equation and determine the net force on the object. The reference direction is "to the right."



3. How did underlining the main ideas help you review Newton's first law of motion?

What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

ConnectED

Log on to ConnectED.mcgraw-hill.com and access your textbook to find this lesson's resources.

END OF LESSON