

Motion, Forces, and Newton's Laws

Forces

..... 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. Objects must be in contact with one another to exert a force.	
	4. Gravity is a force that depends on the masses of two objects and the distance between them.	

..... Read to Learn

What are forces?

What do typing on a computer, lifting a bike, and putting on a sweater have in common? They involve an interaction between you and another object. You push on the keys. You push or pull on the bike. You pull on the sweater. *A push or pull on an object is a **force**.*

A force has a size and a direction. An arrow can represent force in a diagram. The length of the arrow represents the size of the force. A longer arrow means greater force than a shorter arrow. The arrow points in the direction of the force. The unit of force is the newton (N). It takes about 4 N of force to lift a can of soda.

A force can affect an object in several ways. A force can change an object's speed. It also can change the direction in which the object is moving. In other words, a force might cause acceleration. Recall that acceleration is a change in an object's velocity—its speed, its direction, or both. When you apply a force to a tennis ball with a racket, the force first stops the motion of the ball. The force then causes the ball to accelerate in the opposite direction. This changes the speed and the direction of the ball. ✓

Key Concepts

- How do different types of forces affect objects?
- What factors affect the way gravity acts on objects?
- How do balanced and unbalanced forces differ?

Mark the Text

Make an Outline As you read, highlight the main idea under each heading. Then use a different color to highlight a detail or an example that might help you understand the main idea. Use your highlighted text to make an outline to organize the main ideas.

Reading Check

1. Summarize What are some ways in which forces can affect objects?

Types of Forces

Some forces are easy to recognize. You can see a hammer apply a force as it hits a nail. Other forces seem to act on objects without touching them. For example, what force causes a dropped object to fall toward the ground?

Contact Forces

Suppose you observe a baker pressing bread dough into a pan. He pushes his fingers into the dough, causing the top of the dough to accelerate downward. The baker's hand and the dough come into contact with each other. A **contact force** is a push or a pull applied by one object to another object that is touching it. Contact forces also are called mechanical forces. The table below describes other contact forces.

Interpreting Tables

2. Apply When you open a door, what type of contact force are you exerting?

Types of Contact (Mechanical) Forces		
Force	Description	Example
applied force	a force in which one object directly pushes or pulls on another object	A baker pushes down on the top of dough.
elastic force or spring force	the force exerted by a compressed or stretched object	As you stretch an elastic band, the band exerts a force on you.
normal force	the support force exerted on an object that touches another stable object	A gymnast pushes down on a pommel horse to support her body above the horse. At the same time, the horse exerts upward force on her arms.

Noncontact Forces

Does your hair ever stick out after you brush it? Electric forces can pull your hair toward the brush, even though your hair isn't touching the brush. A force that pushes or pulls an object without touching it is a **noncontact force**.

Electric forces are one type of noncontact force. Gravity and magnetism are other types. Magnetic forces hold the like ends of two magnets apart. Gravity pulls a dropped object toward the ground.

Friction

Why does a baseball player slow down as he slides into a base? **Friction** is a contact force that resists the sliding motion between two objects that are touching. The force of friction acts in the opposite direction of the motion. As he slides to the base, the player must overcome friction from the ground, which is exerting a force away from the base.

Rougher surfaces produce greater friction than smooth surfaces. Other factors, such as the surface area and the weight of an object, also affect the force of friction.

Key Concept Check

3. Contrast What is the difference between the way contact and noncontact forces affect objects?

Gravity

If you drop a pencil anywhere on Earth, it will fall.

Gravity is a noncontact attractive force that exists between all objects that have mass.

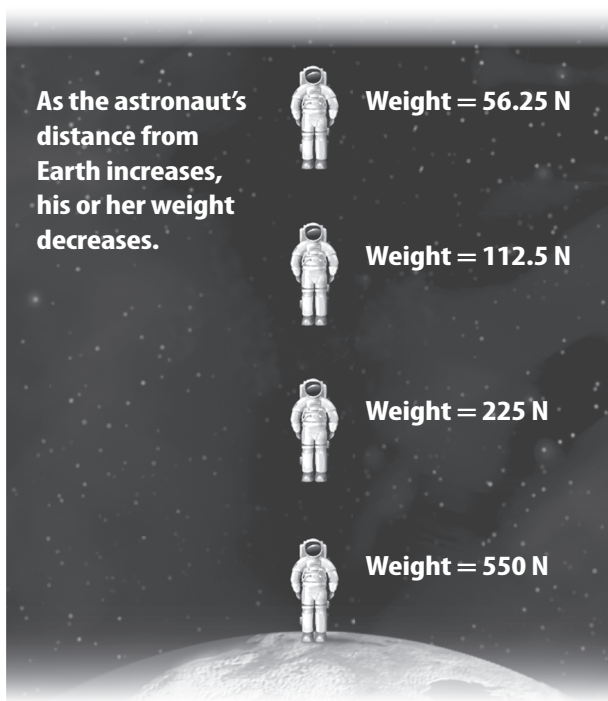
Mass is the amount of matter in an object. Your pencil and Earth have mass. They exert the same gravitational force on each other. Your pencil actually pulls Earth toward it. The pencil has very little mass, so the force of gravity causes it to rapidly accelerate downward toward Earth's surface. Earth "falls" upward toward the pencil at the same time. But because of its mass, Earth's motion is too small to see. ✓

Distance and Gravity

Are astronauts truly "weightless" in space? No, but they do weigh less in space than on Earth. Weight is a measure of the force of gravity acting on an object. As two objects get farther apart, the gravitational force between the objects decreases. The figure below shows how the weight of an astronaut changes as he or she moves farther from Earth.

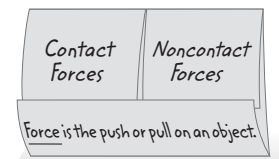
If an astronaut drops a hammer on the Moon, will it fall toward Earth? The hammer is much closer to the Moon than to Earth. The attraction between the hammer and the Moon is stronger than the attraction between the hammer and Earth. The hammer will fall toward the Moon.

Force of Gravity



FOLDABLES®

Make a two-tab book to organize your notes on forces.



✓ Reading Check


4. Explain When you drop a pencil, why does it move toward the floor?

✓ Visual Check

5. Interpret As an astronaut descends toward Earth, how does his or her weight change?

Mass and Gravity

The mass of the objects also affects the force of gravity between two objects. As the mass of one or both objects increases, the gravitational force between them increases. For example, doubling the mass of one of the objects doubles the force of attraction, as shown in the figure below. The force of attraction between the bottom two objects is twice as much as between the top two objects.

The effect of mass on gravity is easiest to see when one object is much more massive than the other. For example, Earth is massive. A person has much less mass. Even though the force of gravity acts equally on both objects, the less-massive object accelerates more quickly due to its smaller mass. Therefore, when you jump off a step, you seem to “fall” toward the object with greater mass, Earth. 

Key Concept Check

6. Name What factors affect the way gravity acts on objects?

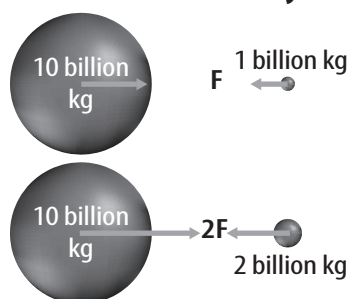
Visual Check

7. Describe the acceleration of the bottom spheres due to the gravitational force between them.

Visual Check

8. Calculate What would the total force be if the person on the right stopped pulling?

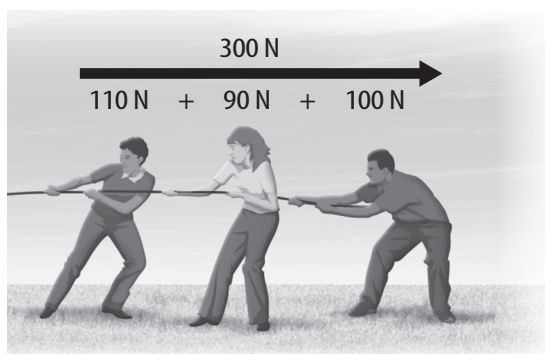
Mass and Gravity



Combining Forces

Have you ever played tug-of-war? If one person pulls against a team, the team will probably pull that person over the line. However, if you are on a team, your team might pull hard enough to cause the other team to move in your direction. When several forces act on an object, the forces combine to act as a single force, as shown below. The sum of the forces acting on an object is called the net force.

Forces in the Same Direction

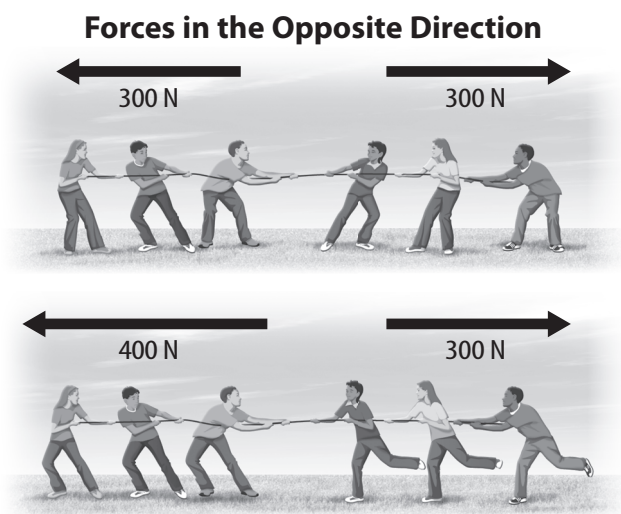


Forces in the Same Direction

When different forces act on an object in the same direction, the net force is the forces added together. In the figure at the bottom of the previous page, each team member is pulling in the same direction. The net force on the rope is $110\text{ N} + 90\text{ N} + 100\text{ N} = 300\text{ N}$.


Forces in Opposite Directions

When forces act in opposite directions, you must include the directions when you add the forces. Like numbers on a number line, forces to the right are usually considered to be positive values. Forces to the left are negative values. In the first panel below, the team on the right pulls with a force of 300 N . The team on the left pulls with a force of -300 N . The net force is $300\text{ N} + (-300\text{ N}) = 0$.



Balanced and Unbalanced Forces

The net force on the rope in the top panel of the figure above is 0 . When the net force on an object is 0 , the forces acting on it are **balanced forces**. If the forces acting on an object are balanced, they will not affect the motion of the object.

When the net force acting on an object is not 0 , the forces acting on the object are **unbalanced forces**. The forces acting on the rope in the bottom panel of the figure above are unbalanced. Unbalanced forces cause objects to change their motion. As you can see in the second panel of the figure above, unbalanced forces cause the team on the right to accelerate to the left. 



Think it Over

9. Analyze How does a net force of 0 N affect the motion of the objects?



Visual Check

10. Calculate In the second panel, suppose that "to the left" is the positive direction. What is the net force?



Key Concept Check

11. Contrast How do balanced and unbalanced forces differ?

Mini Glossary

balanced forces: forces acting on an object with the net force of 0

contact force: a push or a pull applied by one object to another object that is touching it

force: a push or a pull on an object

friction: a contact force that resists the sliding motion between two objects that are touching

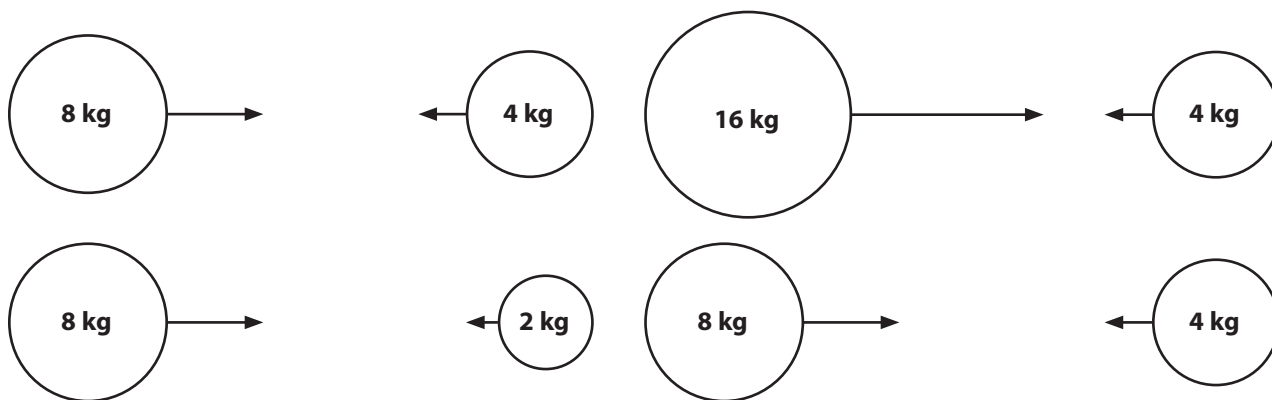
gravity: a noncontact attractive force that exists between all objects that have mass

noncontact force: a force that pushes or pulls an object without touching it

unbalanced forces: forces acting on an object with a net force that is not 0

1. Review the terms and their definitions in the Mini Glossary. Write a sentence that gives an example of friction that you have experienced.

2. Below each diagram, describe how the force of gravity changes from the top two sets of objects to the bottom two sets of objects.



3. How does an increase in distance between objects affect the gravitational force?

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?



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

END OF LESSON