

The Laws of Motion

Gravity and Friction

Key Concepts

- What are some contact forces and some noncontact forces?
- What is the law of universal gravitation?
- How does friction affect the motion of two objects sliding past each other?

Mark the Text

Building Vocabulary As you read this lesson, underline each key term about the laws of motion. Then highlight information about each term to help you review the lesson later.

Think it Over

1. Describe Give an example of a force.

..... 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
	1. You pull on objects around you with the force of gravity.	
	2. Friction can act between two unmoving, touching surfaces.	

..... Read to Learn

Types of Forces


Think about all the things you pushed or pulled today. You might have pushed toothpaste out of a tube. Maybe you pulled out a chair to sit down. *A push or a pull on an object is called a **force**.* An object or a person can apply a force to another object or person. Some forces are applied only when objects touch. Other forces are applied even when objects do not touch.

Contact Forces

You have probably seen a musician strike the keys of a piano or an athlete hit a ball with a bat. In these cases, the person or object applies a force to an object that it touches. *A **contact force** is a push or a pull on one object by another that is touching it.*

Contact forces can be weak. When you press the keys on a computer keyboard, the contact force is weak. Contact forces can also be strong. The plates, or rock slabs, that make up Earth's crust can apply strong contact forces against each other. Over long periods of time, these forces can be strong enough to form mountain ranges if one plate pushes another plate upward.

Noncontact Forces

When you drop an object, it falls toward the floor. This downward force occurs even though nothing is touching the object. *A force that one object can apply to another object without touching it is a **noncontact force**.* Gravity, which pulls on objects, is a noncontact force. The magnetic force, which attracts certain metals to magnets, is also a noncontact force. The electric force is another noncontact force. 

Strength and Direction of Forces

Forces have both strength and direction. If you push your textbook away from you, it probably slides across the desk. What happens if you push down on your book? It probably does not move. You can use the same strength of force in both cases. Different things happen each time because the direction of the force is different.


Arrows can be used to show forces. The length of an arrow shows the strength of the force. A longer arrow indicates a stronger force than a shorter arrow. The direction that an arrow points shows the direction in which the force was applied.

Force is measured in newtons (N). When you lift a stick of butter, you apply about 1 N of force. When you lift a 2-L bottle of water, you apply about 20 N of force. If you use arrows to show these forces, the water's arrow would be 20 times longer than the butter's arrow.

What is gravity?

Objects fall to the ground because Earth exerts an attractive force on them. You also exert an attractive force on objects. **Gravity** *is an attractive force that exists between all objects that have mass.* **Mass** *is the amount of matter in an object.* Mass is often measured in kilograms (kg).

The Law of Universal Gravitation

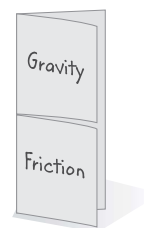
In the late 1600s, an English scientist and mathematician, Sir Isaac Newton, developed the law of universal gravitation. The law of universal gravitation states that all objects are attracted to each other by a gravitational force. The strength of the force depends on the mass of each object and the distance between them. 

Key Concept Check

2. Identify What are some contact forces and some noncontact forces?

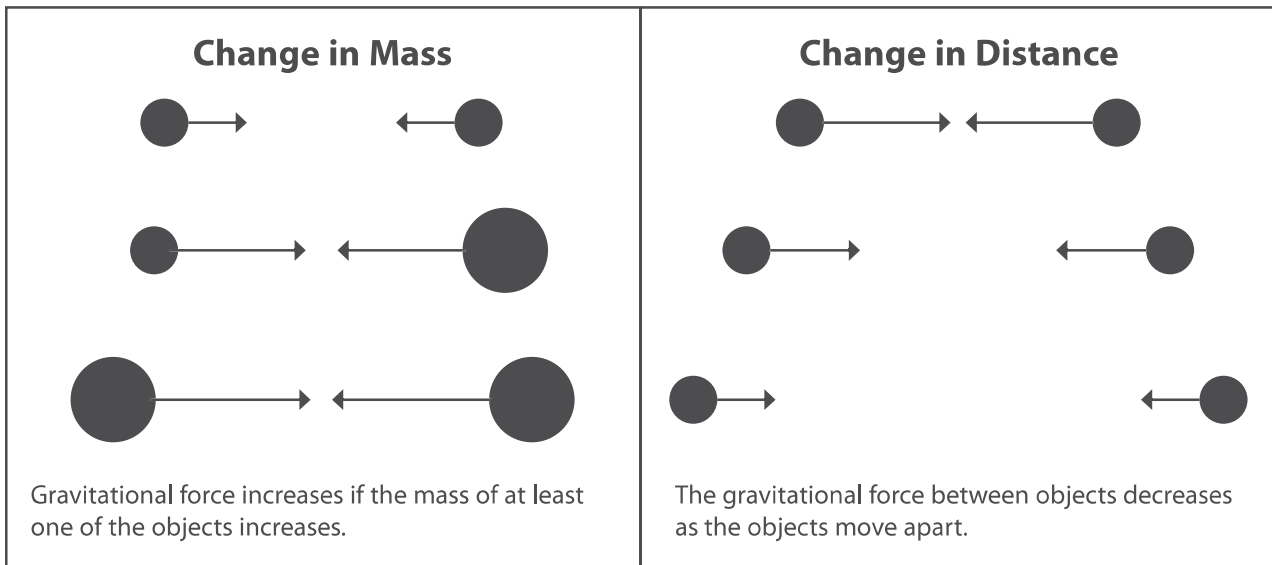


Use a two-tab book to organize your notes on gravity and friction.



Key Concept Check

3. Identify What is the law of universal gravitation?



Visual Check

4. Interpret How does the gravitational force between objects change if one object increases in mass but the other does not increase?

Reading Check

5. Explain What effect does distance have on gravity?

Reading Check

6. Describe What is the relationship between mass and weight?

Gravitational Force and Mass The way in which the mass of objects affects gravity is shown above on the left. When the mass of one or both objects increases, the gravitational force between them also increases. Look at each pair of objects in the figure on the left above. Notice that the force arrows for each pair of objects are the same length, even when one object has less mass. Each object exerts the same attraction on the other object.

Gravitational Force and Distance The effect of distance on gravity is shown above on the right. The attraction between objects decreases as the distance between the objects increases. For example, if your mass is 45 kg, the gravitational force between you and Earth is about 440 N. On the Moon, about 384,000 km away, the gravitational force between you and Earth would only be about 0.12 N. ✓

Weight—A Gravitational Force

Earth has more mass than any object near you. As a result, the gravitational force that Earth exerts on you is greater than the force exerted by any other object.

Weight is the gravitational force exerted on an object. Near Earth's surface, an object's weight is the gravitational force exerted on the object by Earth. Because weight is a force, it is measured in newtons.

The Relationship Between Weight and Mass An object's weight is proportional to its mass. For example, if one object has twice the mass of another object, it also has twice the weight. ✓

Weight and Mass High Above Earth Astronauts in orbit around Earth are not weightless. Their weight is about 90 percent of what it is on Earth. Why is there no significant change in weight when the distance increases so much? Earth is so large that an astronaut must be much farther away before the gravitational force will change much. The distance between the astronaut and Earth is small compared to the size of Earth. ✓

Friction

Friction is a force that resists the motion of two surfaces that are touching. There are several types of friction.

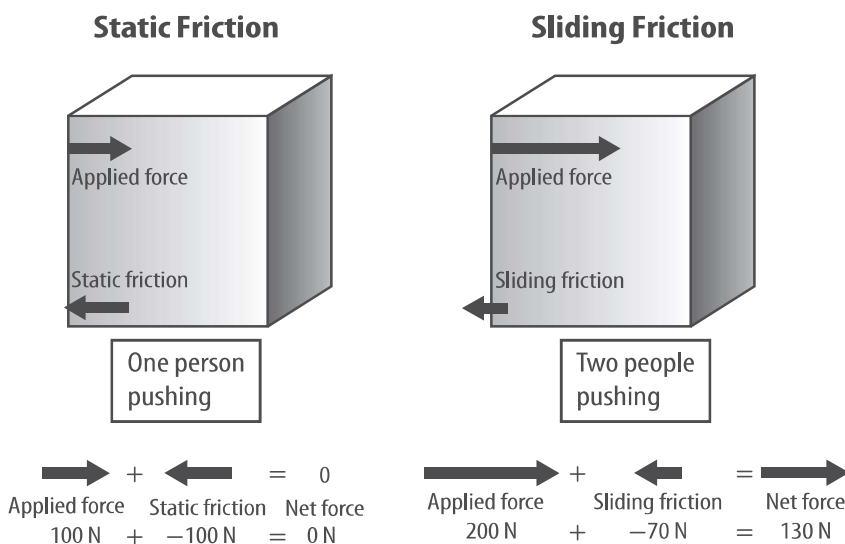
Static Friction

Static friction prevents surfaces from sliding past each other. The box on the left below does not move because the strength of the static friction is equal to the force a person is applying to the box. Up to a limit, the strength of static friction changes to match the applied force. If the person increases the applied force, the static friction will also increase. The box still will not move.

When static friction reaches its limit between the surfaces, the box will move. The box on the right below moves because the two people are pushing with greater force than the static friction between the box and the floor.

Sliding Friction

Sliding friction opposes the motion of surfaces sliding past each other. As long as the box is sliding, the sliding friction does not change. If the pushing force increases, the box will slide faster. If the two people stop pushing, sliding friction will cause the box to slow down and stop.



ACADEMIC VOCABULARY

significant
(*adjective*) important, momentous

Reading Check

7. Explain Why is the gravitational force that a friend exerts on you less than the gravitational force exerted on you by Earth?

Visual Check

8. Visualize Do frictional forces act in the same direction or in the opposite direction to the applied force?



Think it Over

9. Specify How can fluid friction be decreased?



Key Concept Check

10. Describe How does friction affect the motion of two objects sliding past each other?



Reading Check

11. Identify What are two causes of friction?

Fluid Friction

Fluid friction is friction between a surface and a fluid. A fluid is any material that flows. For example, water and air are fluids. Fluid friction between air and a surface is air resistance.

The amount of fluid friction on an object depends on the amount of surface area that faces the oncoming fluid. The greater the facing surface area, the greater the fluid friction is on the object. Imagine that you drop a crumpled paper and a flat paper. The crumpled paper will fall faster than the flat paper because the crumpled paper has less surface area facing the oncoming air. The crumpled paper has less air resistance than the flat paper.

What causes friction?

If you rub your hands together when they are soapy, they will slide past each other easily. If you rub your hands together when they are dry, you will feel more friction. Your dry hands will not slide past each other as easily as when they are soapy.

What causes friction between surfaces? Microscopic dips and bumps cover all surfaces. The dips and bumps on one surface catch on the dips and bumps on the other surface when they slide past each other. This microscopic roughness slows sliding and is a source of friction.

In addition, small particles—atoms and molecules—make up all surfaces. These particles contain weak electrical charges. When a positive charge on one surface slides by a negative charge on the other surface, there is attraction between the particles. This attraction slows sliding and is another source of friction between the surfaces.

Reducing Friction

Soap acts as a lubricant. When you rub soapy hands together, the soapy water slightly separates the surfaces of your hands. This creates less contact between the microscopic dips and bumps and between the electrical charges of your hands. Friction decreases with less contact.

Like soap on your hands, motor oil also acts as a lubricant. It reduces friction between the moving parts of a car's engine. With less friction, surfaces can slide past each other more easily. Reducing an object's surface area also reduces the fluid friction between the object and the fluid.

..... **After You Read**

Mini Glossary

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

force: a push or a pull on an object

friction: a force that resists the motion of two surfaces that are touching

gravity: an attractive force that exists between all objects that have mass

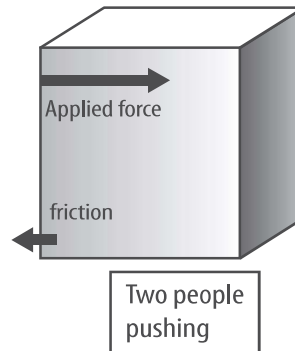
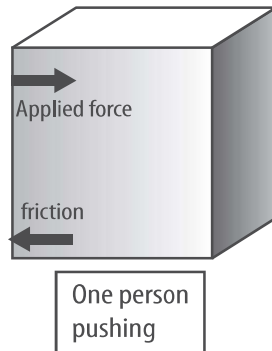
mass: the amount of matter in an object

noncontact force: a force that one object can apply to another object without touching it

weight: the gravitational force exerted on an object

1. Review the terms and their definitions in the Mini Glossary. Write a sentence comparing contact forces and noncontact forces.

2. Label each of the diagrams below with the type of friction that is represented.



3. Give an example of something you could do to reduce friction.

Copyright © McGraw-Hill Education.

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.



Lesson 1 | Gravity and Friction (continued)

Main Idea

What is gravity?

I found this on page _____.


I found this on page _____.

I found this on page _____.




Details

Distinguish mass *and* gravity.

Mass	Gravity

 **Cite** the law of universal gravitation.

Illustrate the relationship between gravitational force and mass. Draw arrows in the diagrams to indicate the size and direction of the attractive force of each object.

Description	Diagram
Objects with smaller masses	
Objects with larger masses	
Objects with different masses	

Copyright © McGraw-Hill Education.