chapter 2

Forces

lesson 2 Types of Forces

Grade Eight Science Content Standard. 2.d. Students know how to identify separately the two or more forces that are acting on a single static object, including gravity, elastic forces due to tension or compression in matter, and friction. **Also covers:** 2.a, 2.c, 2.e, 2.f

Before You Read

On the lines below, write a descriptive sentence about what you know about the force of gravity, friction, or elastic force. Read the lesson to learn more about each type of force.

MAIN Idea

Different types of forces act on objects.

What You'll Learn

- the force of gravity depends on mass and distance
- to analyze static and sliding friction forces
- about elastic forces

Read to Learn

What is gravity?

Picture a basketball game. The basketball is at rest until a player picks it up. The player exerts an unbalanced force on it. After shooting the ball, the player no longer exerts a force on it. According to Newton's first law of motion, the ball should move in a straight line at a constant speed unless an unbalanced force acts on it. The basketball does not move in a straight line. It moves in a curved path toward the basket. So, there must be an unbalanced force acting on it. **Gravity**, an attractive force between all objects that have mass, is the force that causes the ball to follow the curved path.

What is the law of universal gravitation?

When Isaac Newton was thinking about gravity, he wondered if the motion of falling objects and the motion of the Moon around Earth are caused by the same type of force. Newton found that it was gravity that pulled objects downward and caused the Moon to orbit Earth.

In 1687, Newton published the law of universal gravitation (yew nuh VER sul • gra vuh TAY shun) that showed how to calculate this force. According to the **law of universal gravitation**, all objects are attracted to each other with a force that depends on the masses of the objects and the distance between them.

Mark the Text

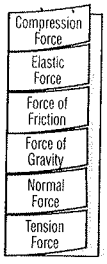
Underline Main Ideas

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

FOLDABLES™

B Define and Explain

Make a six-tab Foldable. Label the tabs as illustrated. Define each term under the tabs.



What affects the force of gravity?

The size of the force of gravity depends on the mass of objects and the distance between them. The gravitational force becomes stronger as the mass of one or both of the objects increases. The force of gravity becomes weaker as objects move away from each other.

The table below compares the force of gravity exerted on a 70-kg person by a book, the Sun, and Earth. The force exerted by the textbook is extremely small because its mass is small. The force exerted by the Sun is also small because it is so far away. Only Earth is close enough and massive enough to exert a noticeable gravitational force on the person.

Picture This

1. Identify What is being compared in the table?

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_____

_____

Gravitational Forces on 70-kg Person			
Object	**Mass of Object (kg)**	**Distance to Object (m)**	**Size of Force (N)**
Book	2.0	1.0	9.3×10^{-9}
Sun	1.99×10^{30}	1.5×10^{11}	0.41
Earth	5.98×10^{24}	6.4×10^{6}	690

How do weight and mass differ?

When you stand on a bathroom scale, you are measuring the pull of Earth's gravity—a force. The **weight** of an object is the gravitational force exerted on an object. Recall that mass is the amount of matter in an object. Mass is not a vector, and it does not change with location. In contrast, weight is a force vector. Weight has a size and a direction. Your weight is a force that always points toward the center of Earth. ☑

Reading Check

2. Explain What does it mean that mass is not a vector? (Circle your answer.)

a. Mass changes depending on location.

b. Mass does not change with location.

The size of an object's weight at the surface of Earth is proportional to the object's mass. For example, if the mass of an object doubles, the weight of the object doubles. If the mass of an object is reduced by half, the weight of the object is reduced by half.

Weight and Mass High Above Earth In addition to mass, the distance between objects also affects weight. For example, an astronaut on the surface of Earth may have a mass of 70 kg and weight of 690 N directed toward the center of Earth. While is orbit, the astronaut's mass doesn't change. However, the gravitational force on her would be smaller because she is farther from Earth. As a result, the astronaut's weight would be reduced to about 620 N.

Friction

Imagine pushing a book away from you across a table. As the book slides, it slows down and then stops. The force causing the book to slow down is a type of friction. **Friction** (FRIHK shun) is a force that opposes the movement between two surfaces in contact. The size of the friction force depends on the types of surfaces in contact. Smooth surfaces usually have less friction force than rough surfaces.

What is static friction?

What if you give a book on a table a tiny push? The book does not move. Why? The push is balanced by a force acting on the book in the opposite direction. This force is called static friction. Static friction occurs between two objects that are touching. It keeps the objects from sliding when a force is applied. The static friction force is exerted on the bottom of the book where it touches the table.

Static friction increases when force increases. However, a strong enough force can overcome static friction. A hard push on the book causes it to slide on the table.

What is sliding friction?

Static friction keeps an object at rest. Sliding friction slows down an object that slides. It acts on an object in the opposite direction of its motion. Unlike static friction, sliding friction does not change when forces change. Sliding friction stays the same whether the forces are small or large. If friction did not exist, the sliding baseball player pictured below would continue moving at a constant speed.

Academic Vocabulary
occur (oh KUR) (verb)
to happen

Picture This

3. Predict What would happen to the sliding baseball player if the force of friction did not exist?

What causes motion?

People once thought that forces caused motion. In other words, an object would move only if unbalanced forces were acting on that object. Suppose you stop pushing a skateboard. The skateboard slows down and stops. You might think that the skateboard stops because there are no forces acting on it. However, the skateboard stops because friction acts on it. On Earth, friction is present whenever something moves. Without friction, the skateboard would continue to move in a straight line with constant speed. Instead of causing motion, unbalanced forces cause changes in motion. When friction is greatly reduced, objects move with a nearly constant velocity. ☑

Reading Check

4. Identify According to the first law of motion, what do unbalanced forces cause? (Circle your answer.)
a. motion
b. changes in motion

Elastic Forces

Imagine a diver standing on the end of a diving board. She is not accelerating. So, the forces acting on her are balanced. The downward pull of Earth's gravity is one of the forces acting on her. An upward force must be acting on her to balance the downward force of gravity. This force is exerted on the diver by the diving board and is called an elastic (ih LAS tik) force. An **elastic force** is the force exerted by a material when the material is stretched or compressed. When the diving board is bent downward, it exerts an elastic force upward on the diver.

What is tension?

When you stretch a rubber band, you can feel the rubber band pulling back as it is stretched. The force the rubber band exerts is an elastic force. The force you exert on the rubber band is a tension (TEN shun) force. A **tension force** is a pulling force exerted on an object that can make it stretch. The elastic force exerted by the object when it is stretched is the same size as the tension force that is stretching the object.

Think it Over

5. Explain Which force is acting on a sweater when you pull it over your head? Explain.

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What is compression?

When you squeeze a rubber ball, the ball changes shape. You can feel the ball push back on your hand as you squeeze. The force the ball exerts on your hand is an elastic force. The force you exert on the ball is a compression force. A **compression force** is a pushing or squeezing force applied to an object that can make the object shrink. The elastic force exerted by an object when it is compressed is the same size as the compression force that is squeezing the object.

What are normal forces?

An elastic force balances the downward force of gravity. The force pushes upward on a diver, perpendicular to the surface of a diving platform. This force is a **normal force**, which is a force exerted by an object that is perpendicular to the surface of the object. The table below summarizes the forces discussed in this lesson.

Types of Forces

Force	Properties	Direction
Gravity	• noncontact force • strength increases as masses get closer together • strength increases if one or both masses increase	force on one mass is toward the other mass
Static friction	• contact force • force prevents the surfaces from sliding past each other	opposite to motion of object
Sliding friction	• contact force • force exists when surfaces are sliding past each other	opposite to motion of object
Tension force	• contact force that causes an object to be stretched	direction of stretching
Compression force	• contact force that causes an object to be squeezed	direction of squeezing

Identifying Forces on an Object

More than one force can act on an object at the same time. The forces can act in the same direction or in different directions. The forces acting in the vertical direction can cause an object's vertical motion. Horizontal forces can change an object's horizontal motion.

How do forces balance horizontally?

Suppose you push a book at a constant speed across a flat table. The book is moving in a horizontal direction with a constant velocity as you push it. According to the first law of motion, the forces acting on the book are balanced. For the forces to be balanced horizontally, an equal force must be acting on the object in the opposite direction. That force is sliding friction. ☑

Picture This

6. Determine Highlight the force that is a noncontact force. Circle the force related to stretching.

Reading Check

7. Identify What is the force that works against a horizontal push?

_____

_____

How do forces balance vertically?

A book does not move up or down as you push it across the table. But gravity is always pulling down on the book. So, some other force is balancing the force of gravity. The force balancing gravity is the normal force of the table pushing upward on the book. The normal, upward force exerted by the table balances the downward pull of gravity.

What have you learned?

There are different types of forces. Gravity is an attractive force between two objects. The size of the gravitational force depends on the masses of the objects and the distance between them. Friction is a force that always opposes the sliding motion of two surfaces in contact. An elastic force results when an object is stretched or compressed.

Gravity, friction, and elastic forces can act on an object at the same time. Forces can also be grouped into horizontal and vertical forces. By combining the horizontal forces, you can predict how the motion of the object will change in the horizontal direction. Similarly, the vertical motion of an object can be explained by combining the vertical forces acting on the object.

Think it Over

8. Evaluate You are standing on a sidewalk. What two forces are acting on you vertically?