Reflect

A mother hears a loud crash in the living room. She walks into the room to see her seven-year-old son looking at a broken vase on the floor.

“How did that happen?” she asks.

“I don’t know. The vase just fell, all by itself,” the boy says.

The mother says, “It couldn’t have moved by itself! Didn’t you learn in school that nothing moves without a push or a pull?”

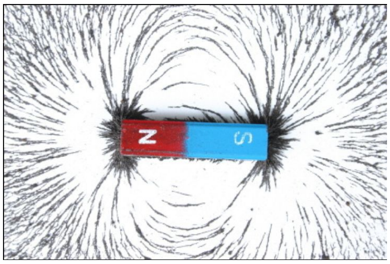
Is what the boy says possible? Or is his mother correct? In the following lesson, you will answer these and other questions about how pushes and pulls change motion.

What are some forces that can affect objects?

A *force* is a push or a pull. There are several kinds of force. Some forces are hard to notice. Other forces put on quite a show and are easy to notice! Some forces need to touch the thing they act on. Other forces can change a thing without touching it.

When someone pushes or pulls on something, it is easy to see the effect. You push on a bicycle pedal, and the bicycle moves forward. A dentist pulls on a tooth, and the tooth comes out of the patient’s mouth. Other forces may seem more mysterious.

For example, a magnet can both push and pull on another magnet. A magnet can also pull on something made of iron. This happens because of invisible lines of force surrounding the magnet. Sound impossible? Remember that, even if we cannot see the force, like in a magnet, it is still there! *Gravity* is another force that may seem difficult to figure out. Gravity is a force that pulls all things with **mass** toward all other things with mass. However, gravity is a very weak force unless one of the objects is very big, like the planet Earth. Things fall to Earth because the force of gravity pulls on them. Gravity also holds things on Earth’s surface. If it were not for gravity, things would just float away into space. Gravity is always a pull, never a push.



You can use bits of iron to see the field lines that surround a magnet.

mass – the amount of matter, or “stuff,” in something

Friction is a force that slows moving things down. Friction acts in the direction opposite to motion. Friction can also keep things from sliding around. The materials involved help make this happen. The force of friction is greater when a surface is rougher. You can walk up a steep sidewalk because friction keeps your shoes from slipping. You might not be able to walk up the same sidewalk if it were covered with ice. That is because the force of friction is much less between your shoes and the smooth ice.

What Do You Think?

A car is parked on a steep street. The car is not moving. When something is not moving, we know the forces are *balanced*. This means they cancel each other out. Which force is pulling the car down the hill? Which force is balancing this force and keeping the car from sliding? (Hint: we talked about both of these forces above.)

What are some ways that forces affect objects?
Even pushes and pulls are not totally simple. For example, forces always come in pairs. If you push on a large tree, nothing happens. If you try to pull the tree out of the ground, nothing happens. When you push the tree, another force is balancing your push. When you pull the tree, another force is balancing your pull. But where are these other forces coming from?

When you push on a tree, the tree pushes back with an equal force. The result is that the forces are balanced and nothing moves. Similarly, when you pull on that big tree, the tree pulls back. This happens for all forces. When the force of Earth's gravity pulls you to the ground, the ground pushes up with a force equal to your weight.

Forces are not always balanced, however. When forces are *unbalanced*, something must change. These are the changes that can result from unbalanced forces:

- Something speeds up.
- Something slows down.
- Something changes the direction of its motion.
- Something changes shape.

These changes happen only while the force is acting. Also, while the force is acting, the change keeps increasing. For example, something will keep going faster if the force keeps acting on it. When a rock is falling, the force of gravity is acting on it. Because this force is always acting on the rock, the rock goes faster and faster, until it hits the ground.

This car is broken down and cannot move. The car pushes back on the man with the same force he pushes on the car, therefore, the forces are balanced.

Look at this waterfall. Because of the force of gravity, the water speeds up as it falls.

When you throw a ball, it speeds up until it leaves your hand. At that point, the force of your hand has no more effect on the ball, and the ball slows down. It slows down because the force of friction between the air and the ball acts in the opposite direction of its motion.

Now, you try!
You may not have realized that force is necessary to make something change direction. To see an example, first, take the front wheel off a small bicycle. If you do not already know how to do this, ask an adult for help.

In the center of the wheel is a short axle. Hold the two ends of the axle tightly in each hand, so the wheel is straight up and down. Ask someone to give the wheel a fast spin. Now, try to tilt the axle so the whole wheel tilts. You are in for a surprise. It will be very difficult to tilt the wheel, because you are changing the direction of motion of something that is quite heavy. This takes more force than you may have expected.

How can we test the effects of forces on an object?
Here is a simple way to study the forces of gravity, friction, and magnetism and to observe balanced and unbalanced forces. This is what you will need:

- A smooth board, about 1 meter long
- A large washer made of iron
- A meterstick
- A magnet
- A sheet of sandpaper

For the activity below, you will need a large, iron washer.

This activity will be easier if you work with a partner. Follow these steps:

1. Put the washer at one end of the board.
2. Slowly, lift the end of the board with the washer, until the washer begins to slide. Your partner should use the meterstick to measure the height of the board at the point where the washer began to slide.
3. Lower the board. Tape the magnet to one end of the board, and let the washer stick to the magnet.
4. Repeat step two. (If the washer cannot break free from the magnet, tape a piece of cardboard to the surface of the magnet.)
5. Lower the board. Remove the magnet and tape the sandpaper to one end of the board. Place the washer on the sandpaper.
6. Repeat step 2.

Based on your observations, answer these questions:

- Which forces were acting in steps 2, 4, and 6?
- Which force was strongest: friction, magnetism, or gravity?
- Why did the washer speed up as it slid down the board?

Look Out!

You may think that, if an object is motionless, no forces are acting on it. In fact, forces act on everything on Earth. Even when you are sitting still on the ground, gravity is pulling you toward Earth. The force of Earth pushing against you balances the force of gravity. You are motionless because these forces balance each other. It is easy to ignore the force of gravity—unless we are falling! But it is always present and always the same.

Getting Technical: How Do Scales Work?

The force of your body pushing down on Earth's surface is called your weight. In America, weight is usually measured in pounds on a scale. Many scales measure weight by pushing or pulling on springs. The spring moves a pointer up or down. The number the pointer points to is the object's weight.

You may have a bathroom scale that measures weight by *compressing*—or pushing—a spring. It is easier to understand spring scales by studying a simpler scale that stretches, or pulls on, a spring. You can see these scales at most grocery stores. There is usually one hanging near the fruits and vegetables.

Try weighing different things on a spring scale. Notice that when you double the weight, the spring stretches twice as far. Two apples should weigh about twice as much as one. A quart of milk should weigh about twice as much as a pint. Which force are you noticing that causes these changes?

Here is a simple spring scale. When an object hangs from the hook, it stretches a spring that moves a pointer. The pointer shows the object's weight.

Try Now

Think back to the broken vase at the beginning of this lesson. Do you think the boy broke the vase? If he did, what forces could have been involved? If he did not, what forces could have been involved? What one force must have been involved, no matter what happened?

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Match the names of the forces with their descriptions. Draw a line from each force to the correct description.

gravity	slows down moving objects
friction force	pulls on iron objects
spring	used to measure weight on scales
magnetic force	pulls a ball to the ground

Connecting With Your Child

Studying a Pendulum

You can use a simple pendulum to study the forces of gravity and friction with your child. You can quickly make a pendulum with a weight (called a bob), a string, and a point from which to hang it, as shown in the following diagram.

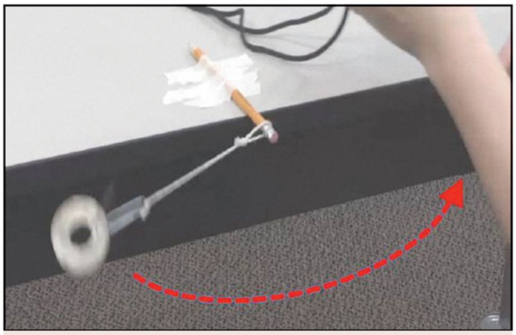
Gravity is the force that always returns the bob from the height of its swing to the bottom of the arc, and friction is the force that gradually slows the pendulum down. Sources of friction are air resistance and mechanical friction at the pivot point. (In other words, the pendulum rubs against the point around which it swings. As it rubs, some of its energy changes to heat and is lost from the system.)

You can also introduce your child to kinetic and potential energy. Explain how potential energy (PE) is at a maximum at the top of the pendulum's arc and that this energy is converted to kinetic energy (KE) as the bob falls to the bottom of the arc.

Studying how the variables of the pendulum affect the period of its motion is interesting. The *period* is the length of time it takes the bob to travel from one high point to the other high point. The variables are the mass of the bob, the length of the string, and the height from which the bob is dropped. You may not have expected this, but only the length of the string affects the period. Try changing each of the variables separately as you measure the period. Measuring the time it takes to make many swings and then dividing by the number of swings will give you the most accurate information.

Here are some questions to discuss with your child:

1. Was the force of friction acting on the pendulum very strong? How can you tell?
2. Name three places where you have seen pendulum motion.
3. Which things affect the period of a pendulum?
4. If you replaced the metal bob with a playing card, how would the motion of the pendulum change, and why?



To make a simple pendulum, tape a pencil to a desk so one end of the pencil hangs over the edge of the desk. Tie one end of a string to the pencil and the other end to an iron washer (the bob). Raise the bob so it is level with the desk; then, release the bob and watch your pendulum swing.