STICKY BOOKS

Concept

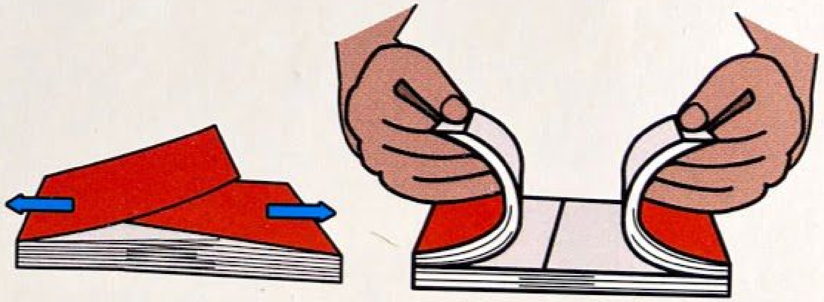
- Friction

Materials

- 2 paperback books (e.g., novels)

When is friction stranger than fiction?

1. Place two paperback books on a table or other flat surface. The bindings of the books should be to the outside.
2. Spread the books open and interlace the pages, like shuffling a deck of cards. It is not necessary to alternate every page but interlace as many of the pages as you can within a minute or two.
3. Call on a student volunteer to come up and grasp the books by their bindings. Challenge the student to pull the books straight apart. (He or she won't be able to do it!)
4. Call up another student to grasp one of the books and have a tug-of-war with the first student. What happens?



TIP

For the best effect, use two paperback books that have slightly rough pages. High-quality books with smooth pages won't work as well.

STICKY BOOKS

DISCUSSION QUESTIONS

- **Can you and your partner pull the books apart?** *No.*
- **Why can't you pull the books apart?** *Friction.*
- **Is friction harmful?** *Friction can be useful or harmful, depending upon how it is used (see below).*

FYI

This is a very simple demonstration of an important concept. **Friction** holds the books together. Friction is an interesting **force** that can be useful or harmful, depending upon what you are trying to do. Friction is essential when we drive our cars. The friction of the tires as they turn exert a force on the road surface. This moves the car forward. At the same time, friction inside the car's engine is harmful. Metal parts rubbing against each other quickly wear out. That is why we add oil (a lubricant) to the engine to help the parts slide smoothly.

Different surfaces have different amounts of friction. Two pieces of smooth wood will easily slide across each other, while two pieces of rough-cut wood resist sliding. Sandpaper has more friction than notebook paper. The pages in the books produce little friction when only a couple of pages are interlaced. However, when the whole book is interlaced, the surface area of the paper in contact is greatly increased, which magnifies the friction force and prevents the books from being pulled apart.

EXTRA

Have students experiment with friction by rolling a marble over different surfaces, such as sandpaper, cardboard, carpet, and tile. Use a slightly tilted inclined plane to produce the same amount of rolling force on the marble each time. Challenge students to predict which surfaces will cause the most friction before they test it. (The marble won't roll as far over rough surfaces as it will over smooth surfaces.)

PING-PONG FLYERS

Concepts

- Bernoulli's principle
- Air pressure
- Lift

Materials

- 2 or 3 Ping-Pong balls
- Hand-held hair dryer

Find out how lift helps make a Ping-Pong ball fly.

1. Show students two or three Ping-Pong balls and bounce them off a tabletop. Ask students: *How can we make a Ping-Pong ball fly?* (Some may suggest hitting or throwing it, while others may propose adding wings or a helium balloon.)
2. Tell your class that you can make a ball fly indefinitely without hitting or throwing it or adding wings.

3. Pick a student volunteer to assist you. Give the student a hair dryer and have him or her point the nozzle straight upward.
4. Turn on the hair dryer on low without heat. Place one ball in the upward-moving airflow. The ball will hover in the air!
5. Carefully place a second ball in the airflow above the first. With practice, you should be able to have two balls flying at the same time.

PING-PONG FLYERS

DISCUSSION QUESTIONS

- **Why doesn't the ball just fly away?** *The air stream not only provides a force that lifts the ball, it also produces a small suction force that pulls the ball back into the center of the airflow every time the ball drifts to the edge.*
- **What happens when the hair dryer is set to high?** *(Demonstrate this for the class.) The ball flies higher but pops out of the airflow more easily when it is higher above the hair dryer.*

FYI

The floating Ping-Pong ball is a demonstration of **Bernoulli's principle.** Daniel Bernoulli (1700–1782) discovered that as the speed of a moving fluid (air, in this case) increases, the **pressure** within the fluid decreases. You can see this principle in action by blowing air across the surface of a strip of paper. The paper lifts into the airflow instead of being pushed away. The moving air has a lower pressure than the air beneath the paper strip and, consequently, the higher pressure below lifts the paper up.

With the hair dryer and ball, a somewhat cylindrical flow of air is directed upward. The flow provides **lift** to the ball. According to Bernoulli's principle, the pressure inside the air stream is lower than the surrounding static air. If the ball tries to leave the stream sideways, outside air pushes it back into the stream.

Bernoulli's principle has many applications, including how liquids flow through pipes and how air flows around airplane wings.

EXTRA

Cut off the top spout of a plastic beverage bottle. Place the opening over the hair dryer's nozzle to focus and increase the speed of the air flow. Not only will you be able to support the ball, you can tilt the hair dryer to the side and still keep the ball floating.

FALLING WATER

Concepts

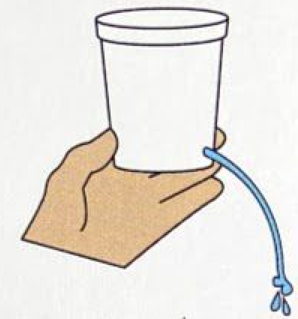
- Gravity
- Forces and motion
- Microgravity

Materials (for each group of students)

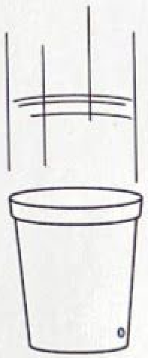
- 2 paper coffee cups
- Sharp pencil
- Water
- Wastebasket or sink
- Paper towels

Simulate microgravity on Earth with a cup of water.

1. Using a sharp pencil, punch a hole in the side of a paper coffee cup near the bottom. Push the pencil tip through to make a small round hole about 3 to 5 mm in diameter.
2. Hold the cup with a finger over the hole. Fill the cup three-quarters full of water. Position the cup over a wastebasket or sink. Remove your finger. Have students observe the streaming water.
3. Ask students: *What will happen if you drop the cup as the water is streaming out?*
4. Divide the class into small groups. Distribute the materials and have students try it out themselves. First, have them observe the water stream from the held cup. Then have them refill the cup and drop it.



5. Give groups a second cup so that members can switch roles and observe the falling cup from different positions.



TIP

If you do this outside, you won't need catch basins or towels for cleanup.

FALLING WATER

DISCUSSION QUESTIONS

- **What does the water stream pouring out of the cup look like?** *The water stream arcs away from the cup. As the cup empties, the stream slows and falls closer to the cup.*
- **What happens to the stream when you drop the cup?** *The stream stops.*

FYI

Astronauts inside the International Space Station (ISS) appear to float. Many students think **gravity** goes away in space. That's not true. Gravity keeps the station in orbit. The reason astronauts appear to float is that the station is falling, like the cup in the activity.

When you hold the cup stationary, the water's weight forces the water to stream out the hole. The stream stops when falling because the cup and its water fall at the same rate. It's as though the water becomes weightless when it falls.

The ISS is falling too. The reason it doesn't hit the ground is because it is moving very fast over Earth's surface. Its curving path matches Earth's curve, causing it to fall around Earth. Like the falling water cup, the ISS and the astronauts and other things inside the station fall together. This makes everything appear to be weightless. Scientists call this condition **microgravity**.

EXTRA

Go to the NASA website to learn about how NASA uses microgravity for scientific research on the International Space Station. The site features short videos that show astronauts floating on the station: *www.nasa.gov/mission_pages/station/main/index.html.*

GHOST ARMS

Concepts

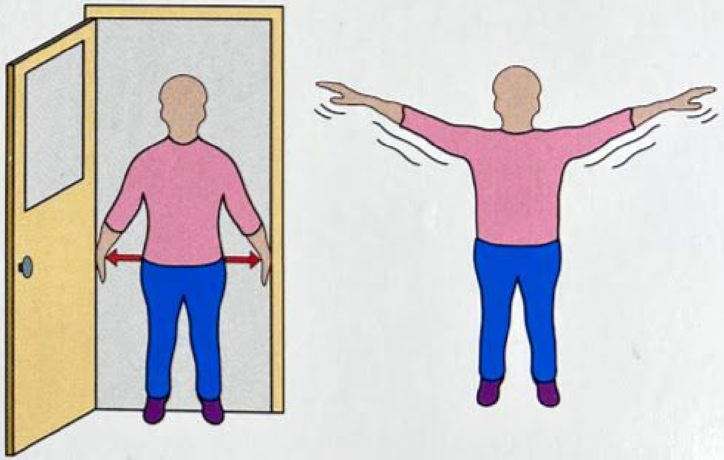
- Forces and motion
- Voluntary and involuntary muscle motion

Material

- Door frame
- Timer or clock

Try this activity that tricks the brain, nervous system, and muscles.

1. Select a student volunteer for this demonstration.
2. Have the student stand in the doorway and push his or her hands against the door frame as if in an attempt to raise them up. It is important that the student push hard for a count of 30 seconds to 1 minute. Longer is better.
3. At the end of the count, have the student step out of the door frame. His or her arms will magically move upward as though a ghost were raising them.



TIP

This effect can also be accomplished by having a second student hold the first student's arms as he or she tries to raise them. Again, the first student must push hard for the time count until the second student releases the other's arms.

GHOST ARMS

DISCUSSION QUESTIONS

- **What causes the student's arms to move upward?** *Involuntary muscle commands from the nervous system.*
- **Is there really a ghost making the arms move upward?** *No. This is a trick with the brain, nervous system, and muscles.*

FYI

This little bit of body magic is also called "the floating arms experiment." Calling it "ghost arms" is much more fun. It is actually a brain/nervous system/muscle effect, first described by scientist Oskar Kohnstamm (1871–1917) in 1915. The Kohnstamm phenomenon occurs when voluntary **muscle contractions** (lifting the arms) are blocked (in this example, by a door frame) for an extended time. When the arms are released by stepping out of the door frame, the arms rise upward.

The mechanism of the Kohnstamm phenomenon is poorly understood. Essentially, it is an involuntary muscle contraction that follows a sustained voluntary muscle contraction. It is as though the arm muscles temporarily fail to receive the command that it is okay to quit trying to raise the arms. In research studies, subjects were told to not let their arms rise up after the sustained muscle contraction. They reported a sensation of an upward force trying to raise their arms. While this research may seem silly, it may actually help scientists better understand Parkinson's disease and Tourette syndrome.

EXTRA

Although tiring, extending the sustained muscle contraction to 1 minute will increase the "ghost arms" effect. As an alternate version to this activity, have a student hold a hand weight with an outstretched arm at about a 45-degree angle from the floor for about a minute. Take away the weight and have students observe what happens.