ACTIVITY 1

Measuring Force

OBJECTIVES

Students make a device for measuring the strength of a push or pull.

The students

- observe the effect of pushing and pulling on objects
- make a "push-pull meter," a device used to measure force
- use the push-pull meter to measure the amount of force it takes to move various objects

SCHEDULE

About 45 minutes

All materials will be ready and waiting in the lab.

VOCABULARY

force

MATERIALS

For each student

1	Activity Sheet 1, Parts A and B

For each team of two

1	book, paperback, medium-size*
2	brass fasteners
1	plastic ring
1	push-pull meter frame
1	rubber band, small
1	ruler, dual-scale*
1 pair	scissors (blunt-tip)*

For the class

1	book, paperback, medium-size*
4	cans, soda, empty*
4	cans, soda, full (unopened)*
1	ruler, dual-scale*
1 pair	scissors*
1	spring scale
1 roll	string
1 bag	toys (paddle ball, plastic frog, walking spring toy, superball, hand-copter, spinning top, suction-cup ball, toy car)

*provided by the teacher

PREPARATION

1. Make a copy of Activity Sheet 1, Parts A and B, for each student. Preview Step 3 and determine whether you or your students will assemble the push-pull meters.

2. Cut one length of string about 60 cm (2 ft) long for yourself. Tie the string around a medium-size paperback book as you would tie a package. Knot the additional string at the top so you can slip the spring scale hook through it (see Figure 1-1). You will use this for a classroom demonstration of the spring scale. If necessary, adjust the zero setting on the spring scale so that it reads zero when no force is being applied.

3. Cut one length of string about 60 cm (2 ft) long for each team of two. Students will tie the string around a book in order to lift and drag the book. If you prefer, you can tie the books ahead of time.

4. Collect four empty soda cans. Rinse them and let them dry before class time. You

will also need to provide four full (unopened) cans of soda.

5 If students assemble the push-pull meters, each team of two will need a push-pull meter frame, two brass fasteners, a rubber band, a plastic ring, a length of string, a pair of blunt-tip scissors, a ruler, and a medium-size paperback book. Teams will need to share the soda cans. You will need the bag of toys for a classroom demonstration of how force produces motion.

BACKGROUND INFORMATION

Whether playing with friends or doing chores at home, most of the activities we engage in each day involve moving things. To move an object, a ***force***—a push or a pull—must be applied to it. The stronger the force, the farther and faster an object will move. Likewise, the more massive the object, the more force it takes to move it.

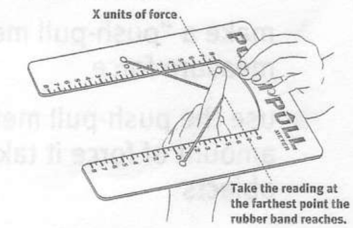
It is possible to measure the amount of force we apply to objects. This is typically done using a spring scale. In this activity, students assemble their own spring scales—called push-pull meters—using brass fasteners and rubber bands. Later, students will use their push-pull meters to measure the amount of force it takes to move a variety of objects.

All materials will be ready and waiting in the lab.

▼ Activity Sheet 1, Part A

Measuring Force

1. Describe how to make each toy move. Possible answers:
   - paddle ball: tap the ball with the paddle
   - plastic frog: press down on the frog
   - walking spring toy: pull one end down a step
   - superball: bounce the ball on the ground
   - hand-copter: twirl the hand-copter
   - spinning top: twist the top
   - suction-cup ball: toss the ball against a wall
   - toy car: push the car with a finger
2. What is another word for a push or a pull? force
3. Practice using your push-pull meter. Apply the following amounts of force to your partner's finger:
   - 2 units of force
   - 4 units of force
   - 8 units of force



This push measures 7 units of force.

▼ Activity Sheet 1, Part B

Measuring Force

4. How much force did it take to move the following objects? Write your answers in the table.

Object Moved	Amount of Force Used
push empty soda can	Answers will vary.
push full soda can	
pick up scissors	
push book	
pull book	
pick up book	

5. How much force did it take to lift the book 1 inch? 6 inches? 12 inches? Write your answers in the table.

Object	Distance Moved	Amount of Force Used
book	lift 1 inch	Answers will vary but should
book	lift 6 inches	be about the same for all
book	lift 12 inches	three distances.

Guiding the Activity

1 Tell students that you have some toys that might be fun to play with. Place the paddle ball, plastic frog, walking spring toy, superball, hand-copter, spinning top, suction-cup ball, and toy car on a desk where all students can see the objects. Stare at the objects for a moment or two and ask, **What's wrong with these toys? Why don't they work?**

Additional Information

Safety Note: *Remind students to handle the toys carefully, especially those that require bouncing, tossing, or batting, to avoid injury.*

Students should suggest that you have to make them move in order to play with them.

Invite student volunteers to demonstrate how each toy works.

Have students bat the paddle ball with the paddle; press down on the frog to make it jump; pull one end of the walking spring toy down a step to start it "walking"; bounce the superball on the floor; twirl the hand-copter handle back and forth to spin the rotor blades; twist the top to set it spinning; toss the suction-cup ball so that it sticks to a surface and then pull it off to "unstick" it; and push the toy car with a finger to get it to roll.

Ask, **What did you have to do to get these toys to move?**

Elicit that students had to push or pull on the toys.

Explain that every time we push or pull an object, we are applying force to that object. Write the term *force* on the board. Tell students that **force** is another word for a push or a pull. In order for an object to move, force must be applied to it.

Ask, **What do you think happens to objects when you increase the amount of force that is applied to them?**

Accept all reasonable answers.

Have students apply more force to each toy and observe what happens. For example, have students push the toy car harder or twirl the hand-copter faster, and so on.

The objects should move faster and/or farther.

Explain that the more force that is applied to an object (the harder the push or pull), the faster and farther the object will move.

Hold up the toy car. Ask, **What would happen if you tried to push a real car with just your finger?**

A real car would not move.

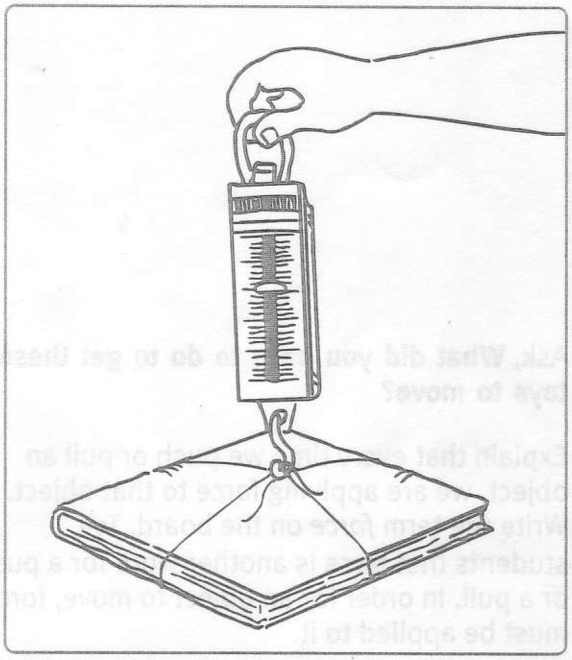
Guiding the Activity

Guide students to understand that the larger and heavier an object, the more force it takes to move the object.

Distribute a copy of **Activity Sheet 1, Part A,** to each student. Take several minutes to pass around the objects for students to examine individually. Give students time to write their answers to questions 1 and 2 on their activity sheets.

2 Point out that it is difficult to know just how hard we are pulling an object without a tool to measure the force. A spring scale is one tool that can be used to measure force. Explain that a spring scale measures force in units called newtons.

Additional Information



▲ *Figure 1-1. A spring scale.*

Demonstrate for students how to measure the force required to lift a medium-size paperback book. First, show students the book you tied in Preparation Step 2. Resting the book on a flat surface, insert the hook of the spring scale through the tied loop of the string. Without pulling the book up, ask a student volunteer to read the units of force while the book is resting on the surface.

The student should note that zero newtons are used.

Gently pull up on the spring scale until the book is completely lifted off the desk. Ask the student volunteer to read the units of force required to lift the book.

Answers will vary depending on the size of the book used.

Guiding the Activity

Depending on the time available, you may wish to try the demonstration with other materials you have in the classroom.

3 Next, explain to students that they will be making their own tools to measure force. With their tools, they will be able to measure both pushes and pulls.

Divide the class into teams of two. Give each team a push-pull meter frame, two brass fasteners, a ruler, and a rubber band. Tell students to follow your directions to make a push-pull meter. They will insert a brass fastener into each hole of the push-pull meter frame. Then they will stretch the rubber band between the fasteners.

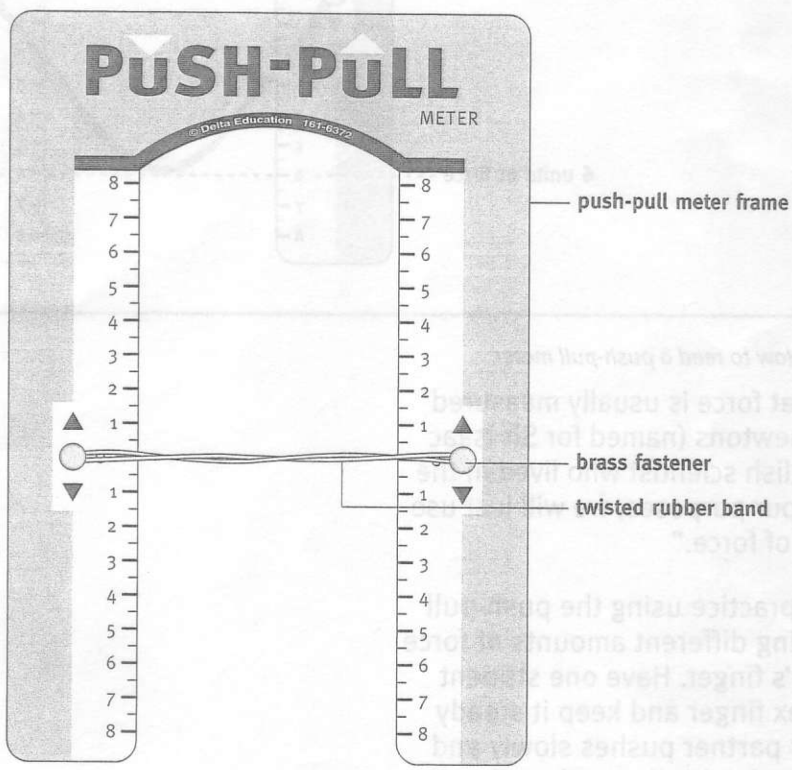
The finished push-pull meter should look like the one shown in Figure 1-2.

Additional Information

If you have already assembled the push-pull meters, distribute them (one to each team of two students) and proceed to Step 4.

Tell students to twist the rubber band a couple of times before hooking it around the fasteners.

Safety Note: *Caution students to handle the rubber bands carefully to ensure that none are "accidentally" shot across the room. They should always handle the push-pull meter as a tool, not a toy.*

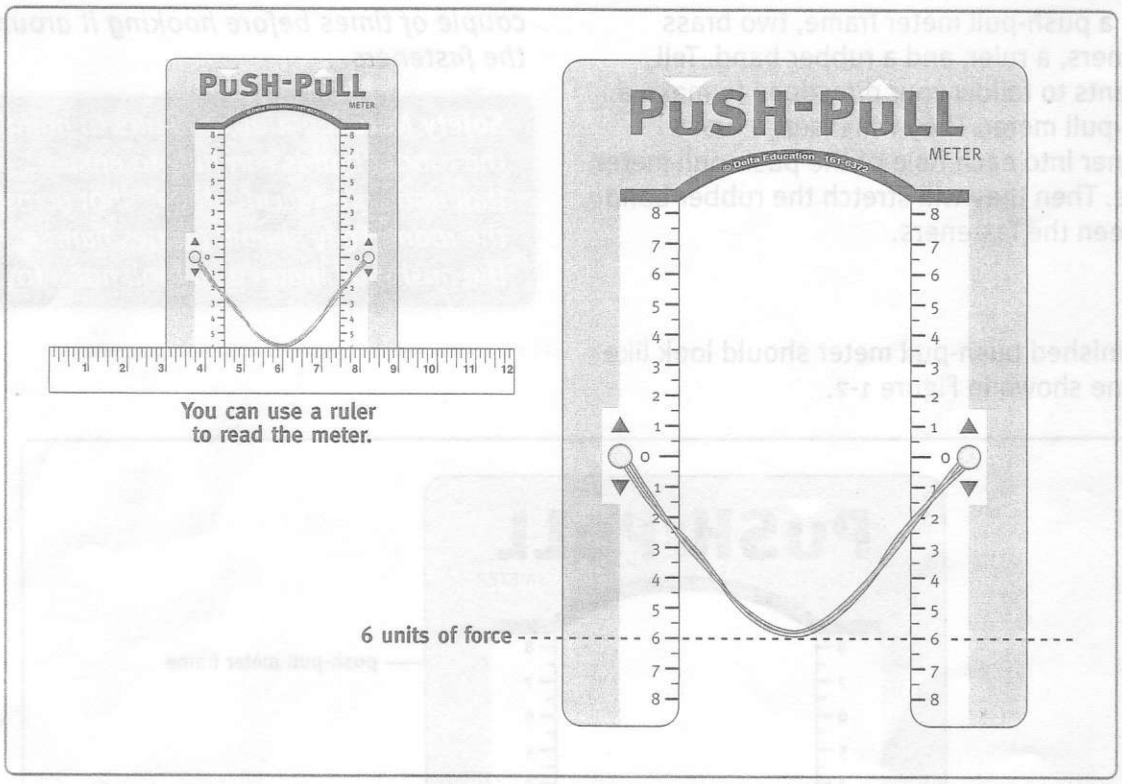


▲ *Figure 1-2. A push-pull meter.*

Guiding the Activity

Additional Information

4 Explain how the push-pull meter works: When you use the push-pull meter to push, pull, or lift an object, the rubber band stretches according to the amount of force applied to the object. The greater the force pushing or pulling on the rubber band, the farther the rubber band will stretch, and the higher the reading on the meter's scale. Figure 1-3 shows how to read a push-pull meter.



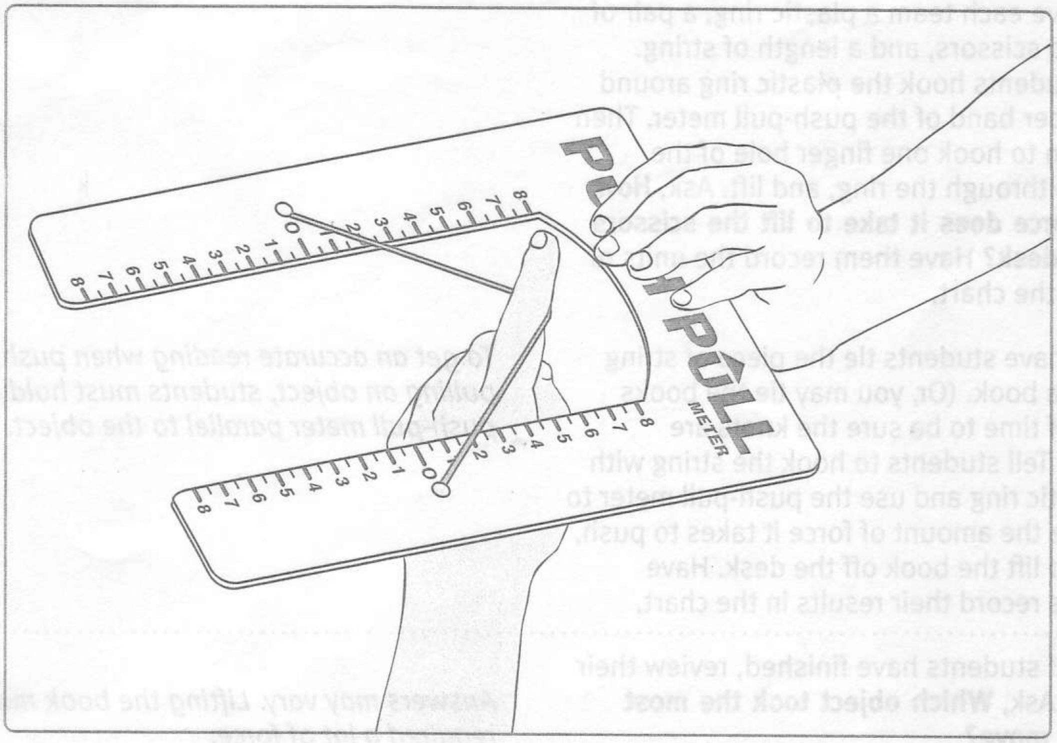
▲ *Figure 1-3. How to read a push-pull meter.*

Tell students that force is usually measured in units called newtons (named for Sir Isaac Newton, an English scientist who lived in the 1600s), but for our purposes, we will just use the term "units of force."

Have students practice using the push-pull meter by applying different amounts of force to their partner's finger. Have one student hold up an index finger and keep it steady while his or her partner pushes slowly and smoothly against it with the push-pull meter. See Figure 1-4 and question 3 on the activity sheet.

Guiding the Activity

Additional Information



▲ *Figure 1-4. Using the push-pull meter to measure the amount of force applied to a partner's finger.*

Have students apply 2 units of force, then 4 units of force, then 8 units of force to his or her partner's finger. Then have students pull on their partner's finger with the push-pull meter. Finally, have students switch places and repeat the exercise.

When students have finished, ask, **Which felt stronger: 2 units of force or 4 units of force? 4 units of force or 8 units of force?**

Students should have been able to feel the difference in applied force.

Tell students that they are now going to use their push-pull meters to measure the amount of force it takes to move a variety of objects. Distribute **Activity Sheet 1, Part B.**

5 Distribute the empty and full soda cans. Have students use their push-pull meters to measure the amount of force it takes to push the empty can, then the full can, across their desks. Tell them to record their results in the chart on Activity Sheet 1, Part B, question 4.

Tell students to push with a slow, steady motion. Pushing with an uneven, jerky motion will give an inaccurate reading on the push-pull meter. Teams will need to share the cans.

Guiding the Activity

Additional Information

Next, give each team a plastic ring, a pair of blunt-tip scissors, and a length of string. Have students hook the plastic ring around the rubber band of the push-pull meter. Then tell them to hook one finger hole of the scissors through the ring, and lift. Ask, **How much force does it take to lift the scissors off the desk?** Have them record the units of force in the chart.

Finally, have students tie the piece of string around a book. (Or, you may tie the books ahead of time to be sure the knots are secure.) Tell students to hook the string with the plastic ring and use the push-pull meter to measure the amount of force it takes to push, pull, and lift the book off the desk. Have students record their results in the chart.

To get an accurate reading when pushing or pulling an object, students must hold the push-pull meter parallel to the object.

6 When all students have finished, review their results. Ask, **Which object took the most force to move?**

Answers may vary. Lifting the book may have required a lot of force.

Ask, **Does it take more force to push an object or to pull it?**

Students should have discovered that it takes the same amount of force to push an object as it does to pull it.

Ask, **Does it take more force to pick up an object or slide it across the desk or floor?**

In general, it takes more force to pick up an object than it does to slide it across a desk or floor.

7 Finally, ask students, **Do you think it takes more force to lift a book 1 inch off the desk or 12 inches off the desk?**

Accept all reasonable answers.

Have students use the push-pull meter and a ruler to measure the amount of force it takes to lift their books 1 inch off the desk, 6 inches off the desk, then 12 inches off the desk. Tell them to record their results in the chart on Activity Sheet 1, Part B, question 5.

Ask, **How much force did it take to lift the book 1 inch? 6 inches? 12 inches?**

It should have taken the same amount of force.

Ask, **What can you conclude from this experiment?**

Students should conclude that the same amount of force is used to lift an object, regardless of the distance the object is moved.

Tell students that in the next activity, you are going to put them to work!