LESSON **13**

# The Lever

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*U.S. gymnast Dominique Dawes performed on the balance beam at the 1996 Summer Olympic Games in Atlanta, Georgia. Her team won a gold medal.*

## INTRODUCTION

Have you ever played on a seesaw, or used a bottle opener or a fishing pole? If so, you have used a lever. In Lessons 11 and 12, you learned how inclined planes and pulleys work. In this lesson, you will investigate how levers work to balance and lift loads.

### OBJECTIVES FOR THIS LESSON

**Learn how levers work.**

**Balance loads on a lever.**

**Determine the relationship between effort force and effort distance for levers.**

**Communicate what you learn about levers to others.**

## Getting Started

1. Discuss the following question with your class: What does it mean to balance something?

2. Draw a picture of something that is balanced and share your drawing with the class.

3. Describe how you could use a lever to lift a rock out of the ground. Draw a diagram showing how to do this. What are the important parts of the lever in your diagram?

### MATERIALS FOR LESSON 13

**For your group**

- 1 pegboard assembly
- 1 pegboard lever
- 1 pegboard bracket
- 1 K'NEX® sled (from Lesson 12)
- 8 large paper clips
- 8 large washers
- 1 piece of masking tape
- 1 0- to 10-N spring scale
- 1 meterstick
- 1 piece of string

# Inquiry 13.1
# Balancing a Lever

### PROCEDURE

1. Have your science notebook ready so you can record your data and answers in it.

2. Set up the pegboard and lever as shown in Figure 13.1.

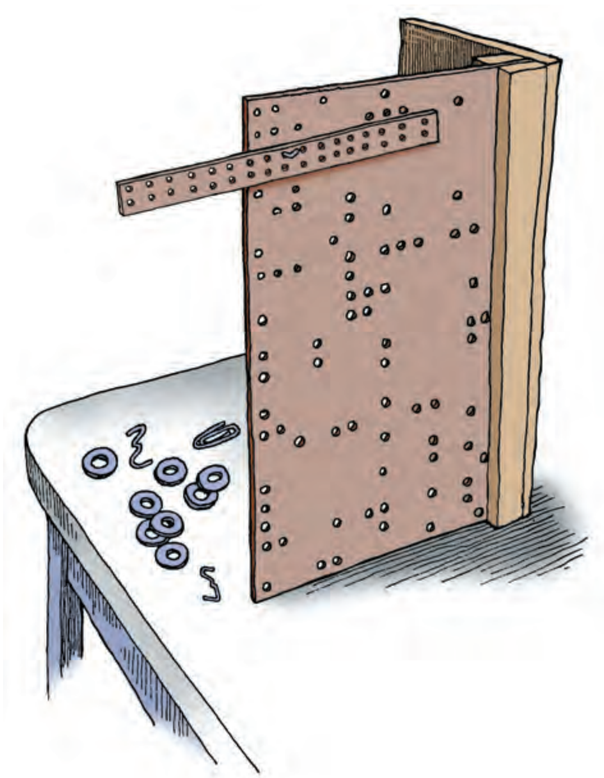

**Figure 13.1** *Pegboard and lever setup*

3. In this inquiry, you will hang washers on the arms of a lever and balance the lever. Figure 13.2 shows how to connect washers with paper clips when hanging them on the lever arm. Use a paper clip on each washer.

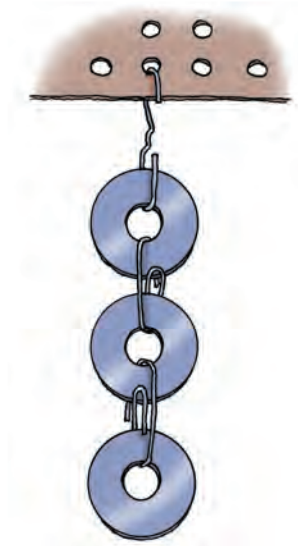

**Figure 13.2** *Washers connected with paper clips*

4. Hang four washers and paper clips three holes from the left of the pivot point, as shown in Figure 13.3.

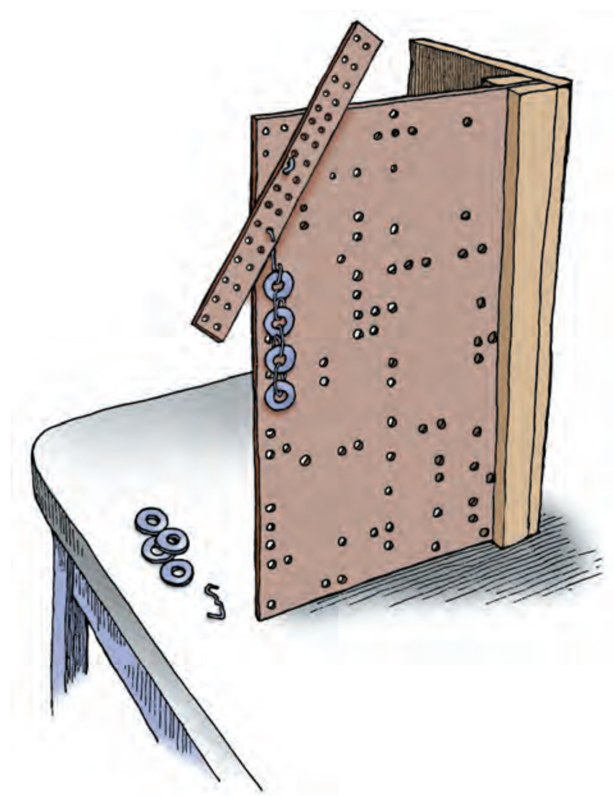

**Figure 13.3** *Four washers suspended three holes away from the pivot point*

5. When the four washers and paper clips are on the left as shown in Figure 13.3, why doesn't the lever balance? Put four washers on the right side so that they balance the lever. Where are the washers on the right located?

6. Remove the four washers on the right. Leave the four washers on the left. Put three washers somewhere on the right to balance the four washers on the left. Where did you put them?

7. Try balancing other combinations of washers. In your science notebook, make a table to record your results.

8. What factors determine whether two sets of washers will balance a lever? Support your answer with evidence from your data.

9. What general rule can you think up to describe how to balance washers on a lever? Write your rule in your science notebook.

## Inquiry 13.2
## Lifting a Sled With a Lever

### PROCEDURE

1. In this inquiry, you will use a lever to raise your sled. Set up the pegboard assembly with lever, sled, spring scale, and meterstick, as shown in Figure 13.4. The sled should be attached at the end of the lever. (Be sure to zero the spring scale when holding it upside-down since that is how it is used in this inquiry. If the scale has been calibrated right-side up and is then used upside-down, the results will be in error.) As you perform this inquiry, record your measurements on a student sheet or in your science notebook as directed by your teacher.

2. Measure a distance from the tabletop to 0.10 m above the table on the edge of the pegboard where the sled is attached and place a piece of masking tape there (see Figure 13.4). This marks the *load distance*—the distance the sled will be lifted each time.

3. Measure the force the lever must exert to lift the load.

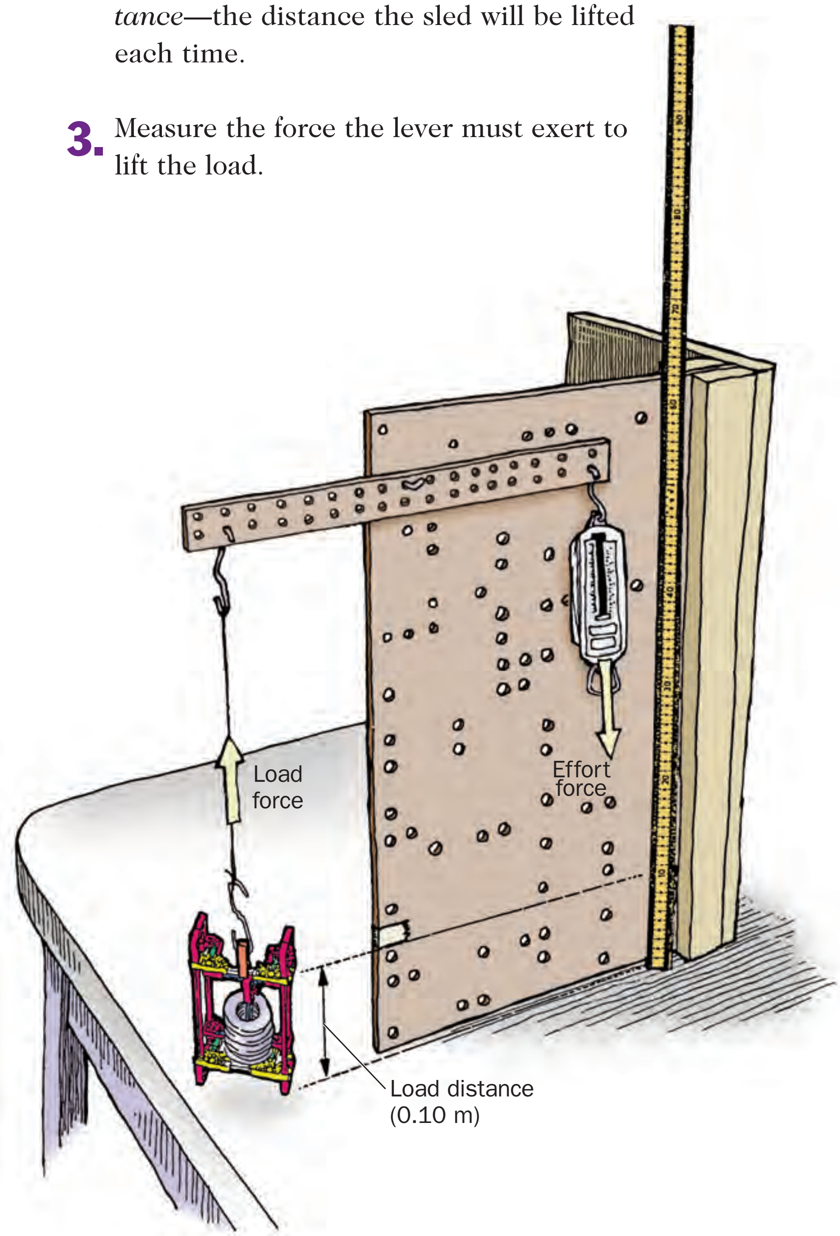


**Figure 13.4** *Setup for lifting the sled with the lever*

**4.** You will investigate the relationship between the effort force you exert to raise the sled and the effort distance—the distance you pull the spring scale. It is important to measure the effort distance and effort force accurately (see Figure 13.5).

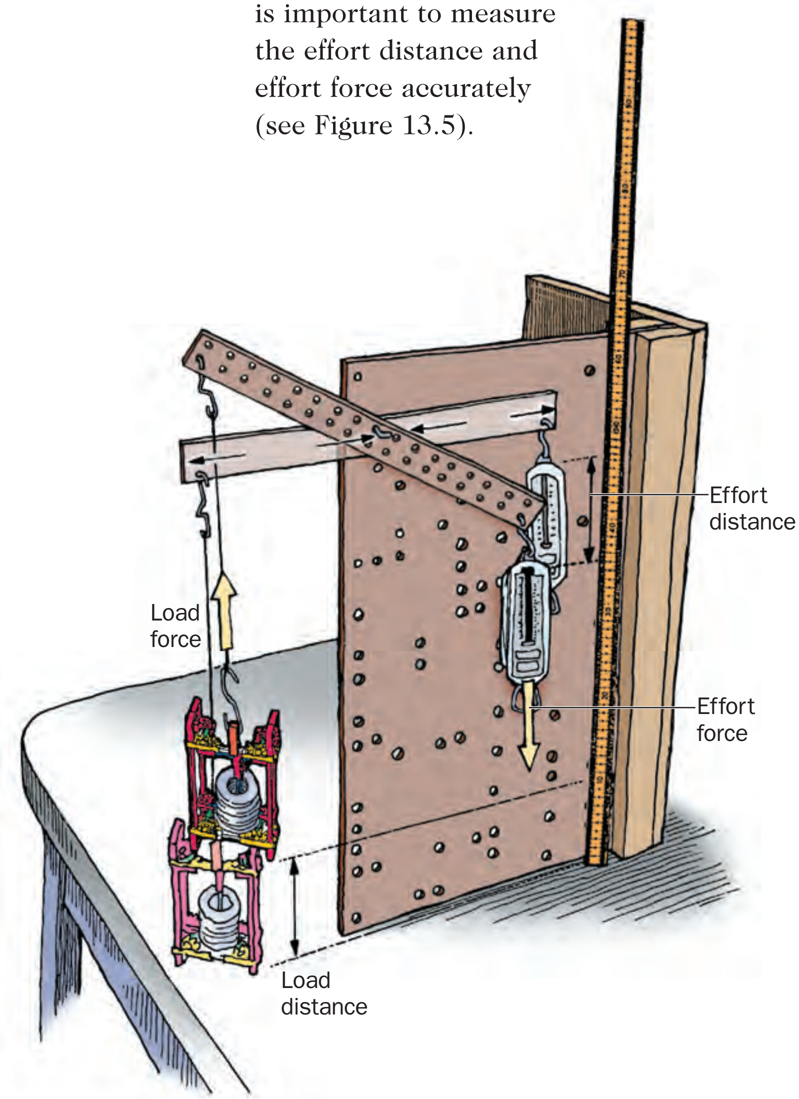


**Figure 13.5** *Effort distance and effort force when using the lever*

**5.** Attach the spring scale at the end of the lever on the opposite side from the sled.

**6.** Pull on the spring scale and raise the sled 0.10 m. Observe the force reading on the spring scale as you use the lever to lift the sled. Record the effort force and the effort distance in Table 1 on your student sheet.

**7.** Attach the spring scale at different positions from the pivot point. Measure and record the effort distance and the effort force to raise the sled 0.10 m each time.

**8.** What happens to the effort force as the distance of the spring scale from the pivot point changes? Answer this question in your science notebook. Then discuss it with your classmates.

## REFLECTING ON WHAT YOU'VE DONE

**1.** Answer the following questions in your science notebook:

*A. On the basis of the results of this lesson, describe how you would balance two sets of washers on a pegboard lever.*

*B. Was the amount of work done by the lever when it lifted the sled the same each time or different? Explain your reasoning.*

*C. How did the work you did each time compare with the work done on the sled by the lever?*

*D. Do you agree or disagree with the following statement: The lever is another example of a simple machine. Cite evidence to support your answer. Discuss your answer to this question with the class.*

**2.** With the class, discuss the advantages and disadvantages of using levers.

# UNDERSTANDING LEVERS AS EASY AS 1•2•3

A lever is one of the handiest tools you will ever find. With a lever, a child weighing 200 newtons can do as much work as a weight lifter who weighs 1000 newtons.

People have used levers for thousands of years. They have always been amazed by their power. In fact, the Greek inventor Archimedes once said, “Give me a lever long enough, and I could move the world.”

Of course, he was joking. No one could manufacture a lever big enough to lift the planet. Nevertheless, levers are used every day for hundreds of purposes.

A lever is a simple machine. There are three kinds of levers—first-class, second-class, and third-class. Learning about them, you could say, is as easy as 1, 2, 3.

### First-Class Levers: Go Ahead, Pry!

If you’ve ever ridden a seesaw, you’ve experienced the power of a first-class lever. A seesaw is a simple lever. The board pivots on a center stand, or

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*A seesaw is one example of a first-class lever. Where is the pivot point (fulcrum) for this lever?*

fulcrum. The board goes up or down, depending on how much weight is on each end and on the position of these weights.

Suppose your 18-year-old brother is on one end of the board. He weighs about 900 newtons. You're on the other end. You weigh about 500 newtons. Even if your brother weighs 400 newtons more than you, you can lift him on the seesaw just by sitting on the far end of your side of the board. This is because the seesaw acts as a lever. It multiplies the effort that you supply to lift the load (your brother).

Levers such as the seesaw, in which the fulcrum lies between the load and the effort, are called "first-class" levers. With these levers, you exert a force in the opposite direction from where you want the load to move: In other words, to make your brother move up, you must push down.

### Second-Class Levers: Hoisting a Heavy Load

A wheelbarrow is a good example of a second-class lever. In this case, the load is between the effort and the fulcrum, which is the wheel. With a second-class lever such as a wheelbarrow, you exert a force in the same direction as the force that does the work (a big difference from the seesaw).

Suppose that your next-door neighbor is doing some landscaping. He's already put three 25-kilogram bags of gravel in his wheelbarrow. The bags weigh a lot—740 newtons! Now he asks you to give him a hand and bring the bags to him. No problem! You walk over to the wheelbarrow and lift the handles, and the load moves up, too. You give a push and you're rolling. The wheelbarrow, which acts like a second-class lever, enables you to lift the 740-newton load by exerting an upward force much smaller than 740 newtons.

### Third-Class Levers: Goin' Fishing

When you use a third-class lever, you can move a load a large distance by exerting a big force over a small distance. That's because these levers amplify distance.

A fishing pole is an example of a third-class lever. The fulcrum is close to the handle—near you. The effort exerted by your hand is used to pull the fish from the water. You can lift the load several meters without moving your hand more than a few centimeters or so. Good news for you, not-so-good news for the fish. ☐

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### QUESTIONS

1. Think about the following list of everyday devices. Be prepared to discuss what type of lever each one is and to identify the fulcrum, the load, and the effort.

   crowbar
   claw hammer
   pliers
   bottle opener
   nail clippers
   pull-open cap
     (on aluminum soda can)
   tweezers

2. How do first-class, second-class, and third-class levers differ?
3. Give an example of each class of lever.

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Opposite: *A wheelbarrow uses the principles of second-class levers to make moving a load easier. Where is the pivot point (fulcrum) for this lever?*
Top: *Fishers take advantage of the principles of a third-class lever to pull fish out of the water. Where is the fulcrum for this lever?*
Left: *Arms are third-class levers. Where are fulcrums for these levers?*

# ALEXANDER CALDER:
## Making Art Move



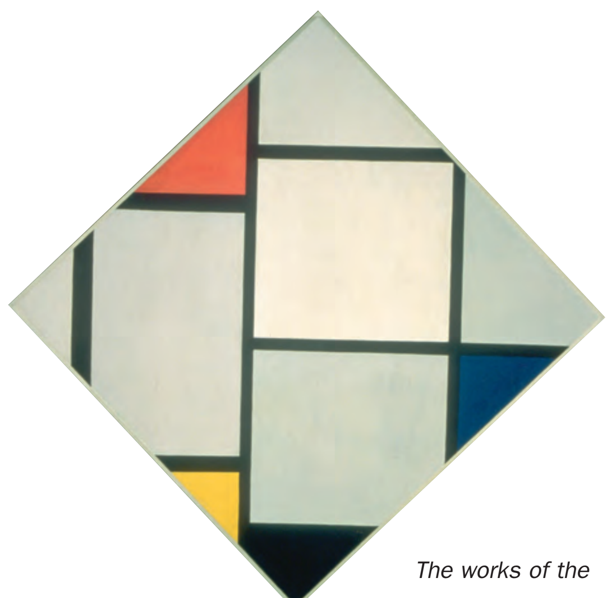
*This mobile, moving in the breeze, captures even a baby's attention.*

If you believe that artists and scientists are two totally different kinds of people, you need to know about one of the most famous American sculptors of the 20th century. His name was Alexander Calder. Among his best-known creations are mobiles—moving sculptures made of wood, metal, or other materials, connected by wire, and suspended in the air.

Mobiles are common today—you might see one suspended above your baby sister's crib. But Calder was the genius who first created them.

A good mobile must be beautiful, but it must also balance. This requires engineering skills as well as artistic ability.

First, the beauty. Calder's inspiration was the work of another artist, Piet Mondrian, whose paintings often featured brightly colored squares and black lines. When Calder saw Mondrian's canvases, he said he wanted to make them move.





*The works of the Dutch painter Piet Mondrian inspired Calder to create his mobiles.*



*Alexander Calder at work on a sculpture. In all, Calder created 16,000 works of art.*

*Calder created many kinds of mobiles. Not all of them were suspended from ceilings.*

Calder's first mobiles were made of wood, clay, and other objects. Many of his early mobiles needed some help to keep them moving; as a result, they were built with cranks or motors.

But motors were unpredictable—and noisy! Calder decided to construct mobiles that moved naturally—with air currents. He began to use metal and other lighter materials to build his beautiful, airy creations. Some of these beautiful structures are enormous—the one in the atrium of the National Gallery of Art in Washington, D.C., for example, is more than 9 meters high and 23 meters wide.

Calder built his mobiles in different ways. Sometimes he started by attaching two objects to a rod and finding the balance point. Once he found the first balance point, he attached a wire at that spot. He then attached more rods with objects and again found the balance point. Sometimes the mobile got quite complicated!

Other times, Calder started with the pieces. He arranged them in an order that he thought was beautiful. Then he cut and trimmed the pieces until they balanced.

Calder was an artist throughout his life. He began as a child by designing jewelry. Later, he created a mechanical circus made of wire and cork. He continued to make pieces for his circus throughout his life. ☐

## QUESTIONS

1. How do you make a mobile?
2. Describe a mobile you have seen. How many pieces did it have? Did it have a theme or main idea?