

Pulleys

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 3

Activity 23

SC.C.2.2.2

The student knows that an object may move in a straight line at a constant speed, speed up, slow down, or change direction dependent on net force acting on the object.

SC.H.1.2.1

The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.

SC.H.1.2.2

The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

SC.H.1.2.3

The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

SC.H.1.2.4

The student knows that to compare and contrast observations and results is an essential skill in science.

SC.H.3.2.2

The student knows that data are collected and interpreted in order to explain an event or concept.

ACTIVITY ASSESSMENT OPPORTUNITIES

The following suggestions are intended to help identify major concepts covered in the activity that may need extra reinforcement. The goal is to provide opportunities to assess student progress without creating the need for a separate, formal assessment session (or activity) for each of the 39 hands-on activities at your grade.

1. The owner of a local hardware store bought a large flag to hang from a tall flag pole in front of his store. A single fixed pulley at the top of his flag pole will help him with the lifting. The flag weighs 100 lbs (about 45 kg). Ask, *How will the pulley help him? How will the pulley not be helpful?* (Fixed pulleys only change the direction of motion. It will help by allowing him to pull down on the cord to get the flag up the pole. However, unless he is strong, he may need help from others to lift such a heavy flag.)

2. Use the Activity Sheet(s) to assess student understanding of the major concepts in the activity.

In addition to the above assessment suggestions, the questions in bold and tasks that students perform throughout the activity provide opportunities to identify areas that may require additional review before proceeding further with the activity.

Pulleys

OBJECTIVES

The students examine a type of simple machine—the pulley. They observe how a pulley redirects force in order to lift an object.

The students

- ▶ construct a simple pulley
- ▶ measure the force required to lift an object, with and without the use of a pulley
- ▶ observe that a pulley reverses the direction of applied force

SCHEDULE

About 40 minutes

VOCABULARY

pulley

MATERIALS

For each student

- 1 Activity Sheet 23

For each team of four

- 1 book*
- 1 meterstick*
- 1 pulley
- 1 spring scale

For the class

- 1 roll fishing line
- 1 pair scissors*
- 1 roll string

*provided by the teacher

PREPARATION

- 1 Make a copy of Activity Sheet 23 for each student.
- 2 For each team of four, cut one 30-cm (1-ft) length of string, one 60-cm (2-ft) length of string, and one 1.5-m (5-ft) length of fishing line.
- 3 Each team will need two lengths of string, one length of fishing line, a pulley, a spring scale, a meterstick, and a book.

BACKGROUND INFORMATION

The **pulley** is a type of simple machine. The pulley consists of a wheel that rotates freely around a stationary axle (as opposed to being attached to it like the wheel and axle unit in a tractor). The outer rim of the pulley is grooved to accommodate a rope or chain.

Although single, stationary pulleys do not magnify force, they are useful for lifting objects high overhead. By using a pulley, the direction of applied force can be reversed so that pulling down on the rope around a pulley raises an object attached to the other end of the rope.

Theoretically, the force required to lift an object using a single pulley should be identical to the force required to lift the same object without the use of a pulley. In this activity, however, students may record slightly higher force readings when they use the pulley to lift the book. This increase in force is due to the friction of the fishing line against the pulley. If students notice this difference in their data, point out the role of friction in their system.

▼ Activity Sheet 23

Pulleys

$$\text{Work} = \text{Force} \times \text{distance}$$

1. The distance between the floor and the desktop is Varies meters.
2. The force required to lift the book to the desktop was Varies newtons.
3. The distance the book moved was Varies meters.
4. The amount of work done was Varies joules.

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5. The force required to lift the book using the pulley was approximately the same as above newtons.
 6. The distance the book moved was _____ meters. same as above
 7. The amount of work done was _____ joules. approximately the same as above

8. How does a pulley help you do work?

The pulley reverses the direction of force so that I can raise an object by pulling down on a rope or chain. It also allows me to lift objects well above my head.

Guiding the Activity

1

Write the word *pulley* on the board. Tell students that a **pulley** is a simple machine consisting of a wheel that rotates around a stationary axle.

Distribute a copy of **Activity Sheet 23** to each student, and a 60-cm (about 2-ft) piece of string, a spring scale, and a meterstick to each team of four. Have each team choose a book to lift using the pulley.

Have the teams measure the distance from the floor to the top of their desks. Then tell them to tie the string around the book and use the spring scale to lift the book from the floor to the desktop.

Remind the students to record on the activity sheet the force required to lift the book and the distance the book was lifted. They should then calculate how much work was done.

Additional Information

Show students that the outer rim of the pulley is grooved to accommodate a rope or chain.

Guiding the Activity

- 2 Distribute a pulley, a 30-cm piece of string, and a 1.5-m piece of fishing line to each team. Show the students how to construct a pulley system like the one in Figure 23-1.

Have one team member insert the 30-cm piece of string through the center of the pulley and hold the pulley above the desktop by the ends of the string.

Have another team member tie the 1.5-m piece of fishing line to the string around the book, loop the fishing line over and into the groove on the pulley, and attach the spring scale to the other end of the line.

Have the students pull on the spring scale to lift the book from the floor to the desktop. Tell them to record on their activity sheets the force (in newtons) used to lift the book and the distance that the book was lifted.

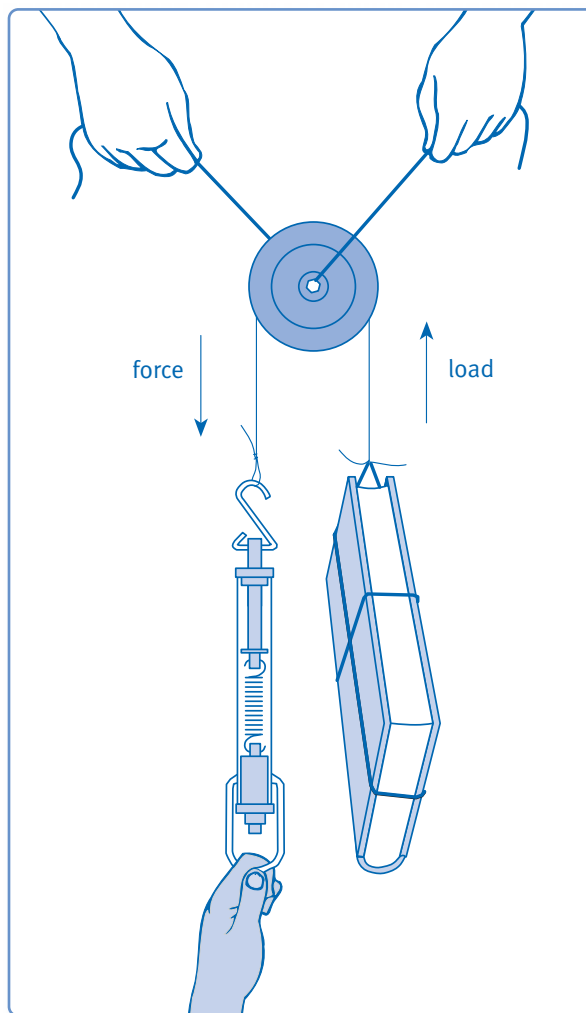
- 3 Compare lifting the book with and without the pulley. Ask, **In which direction was force applied when lifting the book without the use of a pulley?**

Ask, **In which direction was force applied when lifting the book with the help of a pulley?**

Ask, **In which direction did the book move when lifted without using the pulley?**

Ask, **In which direction did the book move when lifted with the pulley?**

Additional Information



▲ Figure 23-1. The pulley system.

upward

downward

upward

upward

Guiding the Activity

Ask, **Did you use the same amount of force when you used the pulley as when you did not use it?**

Ask, **Then how did the pulley help you do work?**

Point out that a person can often apply more force in a downward direction than in an upward direction.

Ask, **What else can a pulley help you do?**

Have students complete their activity sheets.

Additional Information

yes, approximately

The students should point out that a pulley transfers force applied in a downward direction to gain an upward lift.

A pulley enables you to raise an object high above you simply by pulling downward. For example, flags are raised up on flagpoles in this manner.

REINFORCEMENT

If the students are having trouble visualizing how pulleys work on a flagpole, take them outside and show them. Try to arrange a time when the flag is being raised or lowered.

SCIENCE JOURNALS

Have students place their completed activity sheets in their science journals.

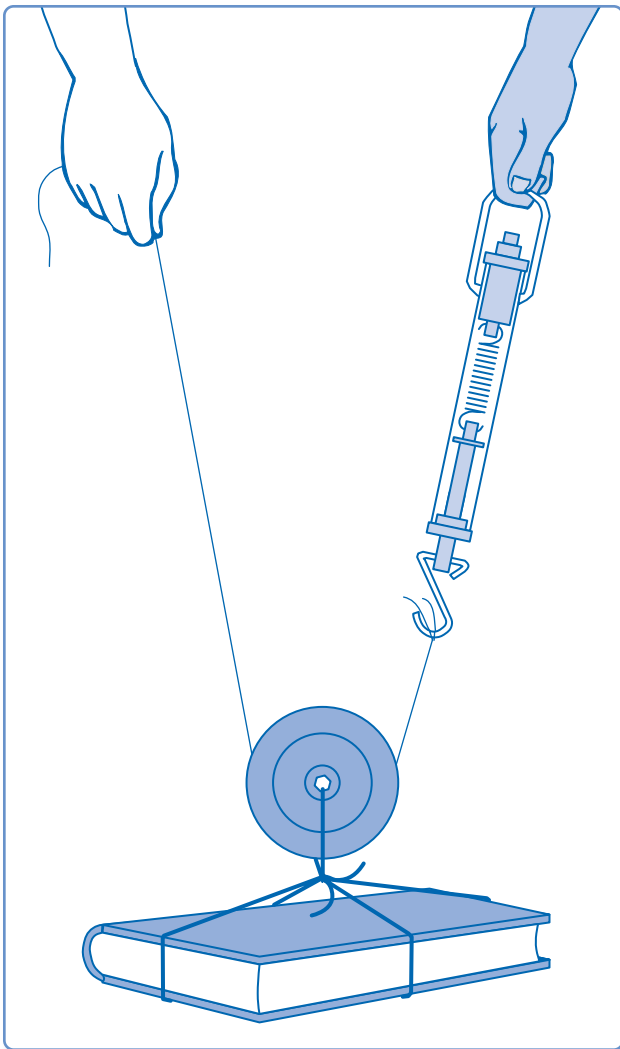
CLEANUP

Discard the strings and fishing line. Return the pulleys and spring scales to the kit.

Connections

Science Extension

Have students investigate the second use of pulleys: reducing the amount of effort required to lift an object. In this arrangement, the book should be fastened to the pulley using a small piece of string threaded through the center of the pulley and tied to the string-bound book. One student should hold one end of the long length of fishing line. The line should then be brought down and around the bottom of the pulley, and back up. A second student should attach the spring scale to the free end of the line and pull upward on it to lift the book.



Students will discover that the effort required to lift the book with this arrangement is about half the effort required with the activity sheet arrangement. However, they also will find that the fishing line must be pulled a greater distance to lift the book to the same height. Ask students to explain why this is so. If necessary, remind them of the formula used to calculate work: $W = F \times d$. (Ignoring the additional weight of the pulley, the same amount of work is done with both pulley arrangements, but the values of F and d change. In this arrangement, d is doubled so that only half the force, F , must be supplied to do the same amount of work.) Tell students that in the type of arrangement used in the activity sheet investigation, the pulley is called a *fixed pulley*. In this Extension arrangement, the pulley is called a *movable pulley*. Fixed pulleys change the direction of force; movable pulleys reduce the amount of effort required.

Science Challenge

This Science Challenge is best done as a follow-up to the Science Extension connection. Let each team experiment with different arrangements of two, three, or more pulleys to lift one or more books. What effect does increasing the number of pulleys have on the amount of effort required?

Science, Technology, and Society

Encourage students to research and report on the practical applications of pulleys, including systems that use combinations of pulleys, such as the block and tackle. Students may be interested in how pulleys are used in combination with a motor and a counterweight to operate an elevator.

