

Doing Work

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 3

Activity 21

SC.C.2.2.3

The student knows that the more massive an object is, the less effect a given force has.

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. Have students list the tools used in this activity, their units, and the properties they measure. (Metric rulers measure distance in units of meters or fractions of meters. Spring scales measure force in units of newtons.) Ask them, *What additional new unit did you use to measure the amount of work done to move an object?* (We used joule, which is the same as one newton-meter.) Ask, *How do the amount of force and the distance affect the work that is done?* (The more force or the farther the distance, the more work that is done.)

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.

Doing Work

OBJECTIVES

Students begin their investigation of simple machines by studying the relationship between force and work.

The students

- ▶ measure the force required to move an object
- ▶ measure the distance the object was moved
- ▶ calculate how much work was done when the object was moved a measured distance

SCHEDULE

About 40 minutes

VOCABULARY

force
joule
newton
work

MATERIALS



For each student

- 1 Activity Sheet 21
- 1 pr safety goggles*

For each team of four

- 1 meterstick*
- objects to test (see Preparation)*
- 1 pair scissors*
- 1 spring scale

For the class

- 1 roll string

*provided by the teacher

PREPARATION

- 1 Make a copy of Activity Sheet 21 for each student.
- 2 Cut a piece of string 2 m (about 6.6 ft) long for each team.
- 3 Have each student choose two or more objects to test during this activity. (Students will tie string around these objects and suspend them from a spring scale.) Appropriate objects include books, shoes, and so on.
- 4 Each team of four will need a spring scale, a piece of string, a meterstick, a pair of scissors, and a variety of objects to be tested.

BACKGROUND INFORMATION

Before an examination of simple machines can be conducted, students must understand the relationship between force and work.

A **force** is a push or pull on an object. The international unit of force is the **newton**, named after English scientist Sir Isaac Newton.

Work is accomplished when an object moves as a result of a force acting upon it. The **joule** is the unit of work. It is named for another English scientist, James Joule.

One joule of work is performed when a force of 1 newton moves an object a distance of 1 meter (about 3.3 ft). This relationship is expressed in the following equation:

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

In this activity, students measure the force required to lift various objects a premeasured distance, and then calculate the amount of work that was done.

▼ Activity Sheet 21

Doing Work

$Work = Force \times distance$

Object tested	Force (newtons)	distance (meters)	Work (joules)
Answers will vary. Sample answers:			
small book	4	.7	2.8
roll of tape	1	.7	.7
scissors	1	.7	.7
big book	16	.7	11.2

Answers will vary. Sample answers from above example:

- Which object required the most force to lift?
big book
- Which object required the least force to lift?
roll of tape, scissors
- Which object required the most work to lift?
big book
- Which object required the least work to lift?
roll of tape, scissors

Guiding the Activity

1 Begin a discussion by asking, **What is force?**

Have a student volunteer stand facing a wall and tell him or her to push against it. Explain that the student is exerting a force on the wall.

2 Have another student volunteer stand behind his or her desk with the chair pulled out. Direct the student to slide the chair under the desk. Ask, **What force was used to move the chair?**

Ask, **What force would be used on the chair if you wanted to move it out from under the desk again?**

Write the terms *force* and *newton* on the board. Explain that **force** is a push or pull on an object measured in units called newtons. A **newton** is the international unit of force.

Additional Information

A force is a push or pull on an object.

a push

a pull

Guiding the Activity

- 3 Ask, **What was the difference between pushing against the wall and pushing against the chair?**

Write the word *work* on the board. Point out that **work** was accomplished when the student pushed the chair because the force that was applied to the chair caused it to move over a distance. Work was not accomplished when the student pushed against the wall because the wall did not move.

Explain that work is only accomplished when an object moves as a result of a force acting upon it. If an object does not move, no matter how great the force applied to it, no work is done.

- 4 Write the term *joule* on the board. Explain that a **joule** is the unit of measurement for work. One joule of work equals 1 newton of force acting to move an object a distance of 1 m.

- 5 Distribute a spring scale, a piece of string, a pair of scissors, and a meterstick to each team of four.

Demonstrate how to use and read the spring scale and how to “zero” the scale if it fails to point to zero newtons with no load attached.

Tell the students to gather together the objects they have chosen to test.

Additional Information

The wall did not move; the chair did.

Remind students that 1 m equals approximately 3.3 ft.

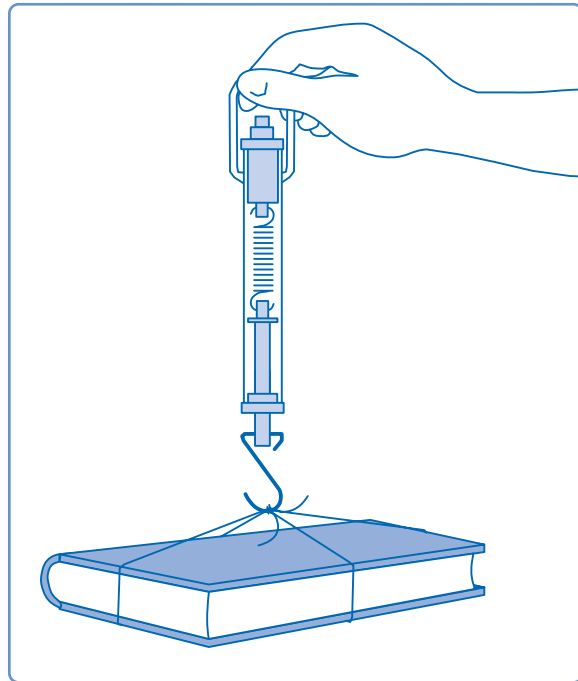
The spring scale should be held vertically by the metallic loop, with the hook hanging down. Turn the nut on the spring scale so that the zero of the scale is next to the indicator.

The objects should be small and/or light enough to attach to the spring scale using the 2-m length of string. Tell students to make sure the objects they have selected do not exceed the weight limit of the spring scale. Some ideas include pencils, erasers, a stapler, a roll of tape, and books in a variety of sizes.

Guiding the Activity

Explain that they are going to lift a variety of objects with the spring scale, note the newtons of force required to lift each object (as indicated on the spring scale), measure the distance that each object is lifted, and then calculate the amount of work done (see Figure 21-1).

Additional Information



▲ Figure 21-1. Lifting objects with a spring scale.

6 Distribute a copy of **Activity Sheet 21** to each student.

Have each team use a meterstick to measure the distance from the floor to the desktop. Tell students to record the distance in the table on Activity Sheet 21.

Next, have each team choose an object, tie a piece of string around the object, attach the spring scale to the string, and use the scale to lift the object from the floor to the desktop. Tell students to record the spring-scale reading (using the newton side of the scale) on their activity sheets, and to repeat this procedure with the rest of their objects.

You may want to tell students that they will lift each object the same distance, and to go ahead and fill in the entire column labeled “distance (meters)” with this figure.

Remind students to raise the objects slowly and steadily so that an accurate force measurement can be read from the face of the scale.

Guiding the Activity

- 7 Write the equation $W = F \times d$ on the board. Explain that W stands for work, F for force, and d for distance.

Have students calculate the amount of work done for each object. To do this, have students multiply the force required to lift the object (newtons) by the distance the object moved (meters).

When they have finished, tell them to answer questions 1–4 on the bottom of their activity sheets.

- 8 Discuss with the students which objects required the most force and the least force to lift. Then discuss which objects required the most work and the least work to lift.

- 9 In summary, ask students to define work.

Additional Information

Note that only W and F are written in uppercase.

Remind students to record their results on their activity sheets.

You may need to remind them that force is measured in newtons and work is measured in joules.

Work is accomplished when a force that is exerted on an object causes that object to move over a distance.

REINFORCEMENT

Pose this question to students: How many joules of work will be required to move seventy-five books from the floor to a shelf 2 meters high, if each book requires a force of 2 newtons to lift? (Answer: 2 newtons \times 2 meters \times 75 books = 300 joules.)

SCIENCE JOURNALS

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

CLEANUP

Return the spring scales and pieces of string to the kit.

Connections

Science Extension

Make sure students understand that in science, work is done only when a force produces movement of an object. Ask students to suggest examples of forces operating without producing movement. They may suggest examples such as the force of Earth's gravity pulling downward on stationary objects, a person pulling or pushing against an object that is too heavy for the person to move, or balanced forces such as two people of equal weight and strength pushing against each other. Which factor in the equation $W = F \times d$ is missing for each example? (distance) Ask students to suggest how each example could be changed so that work would result.

Science and Language Arts

Ask students to write down as many specific examples as they can of the use of the word *work* in any context, scientific or otherwise. (Examples might include “going to work,” “Studying for a test is hard work,” “working on a car,” and so forth.) Give students about 10 minutes to brainstorm and complete their lists independently. Then have students share the examples they listed. As each example is offered, ask the class to determine whether it describes work in its scientific sense and to explain why or why not.

Science and Math

- ▶ Ask each student to create three math problems based on the equation $W = F \times d$. Make sure each student also calculates the answers to the problems he or she created. Then let students take turns posing their problems for the rest of the class to solve. If students' answers to a problem do not agree, work through the problem with the class. Depending on students' abilities, problems could range from fairly simple calculations in which

students solve for one unknown element—for example, 90 joules = ? newtons \times 5 meters—to more complex word problems such as the one given in the Reinforcement activity.

- ▶ Remind students that weight—the force of gravity—is measured in newtons. Have each student convert his or her weight from pounds to newtons by multiplying the weight in pounds by 4.448. Students also might enjoy using the following conversion table to calculate their weight in pounds and newtons on bodies other than Earth. (*Note:* Pluto is omitted from the table because its gravity is unknown.)

Name of Body	Gravity (Earth = 1.00)
Mercury	0.26
Venus	0.90
Mars	0.38
Jupiter	2.64
Saturn	1.13
Uranus	0.96
Neptune	1.00
Sun	28.00
Earth's moon	0.16

Science and Social Studies

Ask students to research and report on the work of Sir Isaac Newton (1642–1727) and James Joule (1818–1889). Students may already be familiar with Newton's laws of motion. Encourage students to include and explain these laws in their reports and to find out about Newton's other important achievements, including his discovery of the law of universal gravitation, his work in optics, and his design of the first practical reflecting telescope. Joule determined the relationship between heat energy and mechanical energy and discovered the first law of thermodynamics regarding conservation of energy. Ask students to explain how each man's work is related to the measurement units named in his honor.