Workshop 2
Force and Work

Force and work play an important role in a scientist's definition of energy. In this session, the everyday meanings of these words are contrasted with their scientific definitions. Viewers will explore how energy is related to work, which physicists calculate as the force applied to an object multiplied by the distance the object travels under the influence of that force (work = force x distance). As an example, an archer does work when he draws back his bow-string, and that work stores potential energy in the string and bow. The potential energy is then transformed into the kinetic energy of the arrow's motion. During extended interviews with children, the program shows how young people may begin to think about these ideas while exploring the behavior of balls and waterwheels.

The second half of the program looks closely at the concept of power, defined as the rate at which energy is expended or stored (power = energy / time). The relationship between power, time, and energy is explored through everyday examples such as light bulbs and electric bills. The program documents a number of classroom activities as well as a visit by a fourth-grade class to the historic textile mills in Lowell, Massachusetts, where the students have first-hand experiences with the energy of falling water.

On-Site Activities

Getting Ready (30 minutes)

The Sun and Energy

You read the article "Our Star the Sun" and identified three facts about the Sun that relate to energy. Have each member of the group take turns offering one of the facts you identified and continue until all items are mentioned.

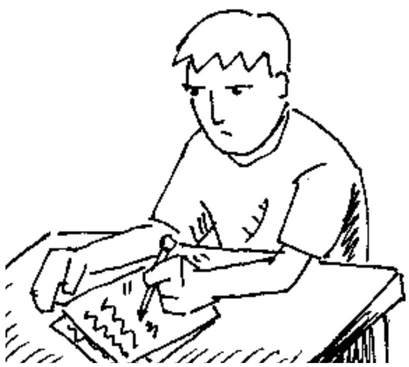
Shared Language

The terms force, work, and power are used in different contexts. Write a sentence using each of these words. Do you think you are using the word in the scientific sense, the everyday sense, or are they the same?

Physics Workout?

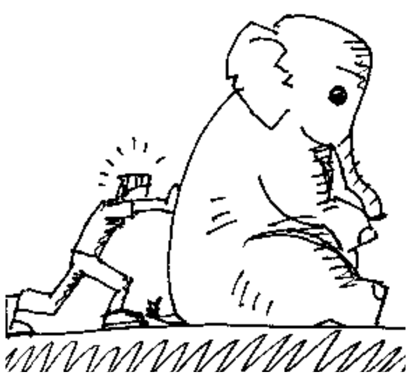
1. Rank the following pictures in order from the one showing the greatest amount of work to the one showing the least amount of work.

2. Discuss the reason for your selections with a partner and then share your ideas with the entire group.

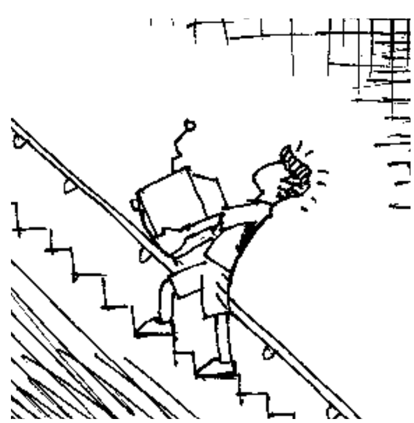


Picture 1: Student writing a paper

Picture 2: Student throwing a baseball



Picture 3: Student pushing a sitting elephant that is not moving



Picture 4: Student carrying a large TV up a flight of stairs

On-Site Activities, cont'd.

Picture 5: Student typing at a computer

Watch the Video (60 minutes)

As you watch the video, consider the following questions and answers:

1. What are forces and what do they do? ***A force is a push or a pull. Forces can transmit energy from one object to another.***
2. What is work? ***Work equals the force on an object multiplied by the distance the object moves while the force is being exerted.***
3. How are work and energy related? ***Work is a way of transferring energy from one system to another or converting energy from one form to another.***
4. What is power? ***Power is the rate at which energy is transferred from one system to another or converted from one form to another.***

Going Further (30 minutes)

How Powerful Are You?

In this activity, you will determine how much power you generate when you ascend a flight of stairs. Do you think you can put out as much power as a 100-watt light bulb? More? Less? Write down your answer and let's find out!

Materials: 1 ruler, 1 stopwatch

1. Find a staircase that is not currently in use. With a ruler, measure the height of one stair and multiply by the number of stairs to determine the height of the staircase in inches.

   Height of staircase (in inches) _______________

   Your weight (in pounds) _______________

By multiplying your weight by the height of the stairs, you can determine how much work you do in order to climb the stairs. How fast you do the work is your power output.

On-Site Activities, cont'd.

2. Have a member of your group stand at the top of the stairs and time each member as he or she runs up the stairs. (If you do not wish to run, feel free to walk—you will still be able to do the calculation, you just won't be the most powerful one in the group.)

Your time to go up the stairs (in seconds) ________________

3. To calculate how much power you generate while climbing the stairs, you will divide the work you do by the time it takes you to do it. The formula shown below includes a conversion factor of 0.113 that changes your answer into watts.

$$\text{power} = \frac{\text{weight} \times \text{distance} \times 0.113}{\text{time}} \quad \text{or} \quad \text{power} = \frac{\text{work}}{\text{time}}$$

4. How many watts of power did you generate while going up the stairs?

5. How many 100-watt light bulbs could you light with this amount of power? How does this compare with your estimate?

6. Would the number be the same if the stairs were steeper? Why or why not?

For Next Time

Homework Assignment

Predict which member of your family will be the most powerful. Do you think it will be the person who weighs the most? Weighs the least? Is the fastest? Is the slowest? Is the tallest? Is the shortest? Do the activity at home with your family members to find out.

Reading

Read Chapter 3: "Children's Ideas on Energy" from Joan Solomon's book *Getting To Know About Energy,* found in the Appendix of this guide. Be prepared to discuss some of the ideas that you have seen your students express in class. Were they confusing the everyday and scientific meanings of words or did they not understand the concepts involved?