Workshop 7
Heat, Work, and Efficiency

During any process that uses energy—and that means just about any physical process at all—some of the energy is converted to heat. Conversely, sometimes we start with heat and need to convert some of it to mechanical work. Why can't we harness all of the energy we put into a system to do useful work? It turns out that it's not just friction or waste: there is a fundamental physical limit to how efficient any engine can be. This program examines the central relationship between heat, work, and efficiency.

In addition, the program looks at what heat actually is and why warm objects cool down and cold objects heat up. The program then explores how the energy involved in orderly motion—such as the motion of a pendulum—tends to be converted into the disorderly motion of atoms and molecules—in other words, into heat.

On-Site Activities

Getting Ready (30 minutes)

Is Your Car a Gas-Guzzler?

1. Using the automobile mileage data you started collecting as homework for Workshop 1, record on a blackboard or an overhead transparency the total miles per gallon for each vehicle in the group.

2. Compare the mileage for different cars. Which car was the most fuel-efficient? Which was the least fuel-efficient?

3. What do the fuel-efficient cars have in common?

4. What do the less fuel-efficient cars have in common?

What Are Your Options?

1. In an earlier program we saw a hybrid (gas- and electric-powered) car. There are several models now available and they are about twice as efficient as conventional vehicles but they cost considerably more to purchase and maintain. Think a minute about the following question and then take a vote.

   If you were ready to purchase a new car, would you purchase one of these more efficient vehicles? What factors would influence your decision?

2. High-efficiency fluorescent light bulbs have been available for many years. They give the same amount of light as conventional bulbs, but last eight times longer and use one quarter the electricity. Think a minute about the following question and then take a vote.

   If you needed some new light bulbs, would you purchase these more efficient ones? What factors would influence your decision?

3. "Energy Star" home appliances use 20% to 40% less electricity than older or less-efficient models, but cost more. Think a minute about the following question and then take a vote.

   If you had to replace a home appliance, would you purchase one of the more efficient ones? What factors would influence your decision?

Watch the Video (60 minutes)

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

1. How can we get work from heat?

   We get work from heat by using a temperature difference between two parts of a system, usually by expanding and contracting a gas.

2. Why do hot things cool down and cold things warm up?

   Molecules in hot places transfer their kinetic energy by randomly bumping and jostling slower-moving molecules.

3. What factor limits a system's efficiency in getting work from heat?

   The key factor is the temperature difference between the system's heat source and the heat sink. The greater the temperature difference, the higher the possible efficiency.

4. How are heat, work, and friction related?

   Friction converts the ordered energy of mechanical motion into the disordered—and less useful—energy of heat.

On-Site Activities, cont'd.

Going Further (30 minutes)

Where Do You Get All That Energy?

We have already discussed the seven different kinds of energy. Now we will take a critical look at where we get that energy.

1. Make a list of all the different sources of energy you know. Share your list with the group, recording all of the suggestions on the blackboard or an overhead transparency.
2. Label each item in your group list:
    a. **C** for a *convenient* energy source or **D** for those that are more *difficult* to use
    b. **E** for an *expensive* source or **I** for *inexpensive* source
    c. **F** for sources *friendly* to the environment or **P** for those that *pollute* the environment
    d. **R** for sources that will eventually *run out* and **L** for those that will *last* indefinitely
3. Are any of the energy sources inexpensive, convenient, non-polluting, and long-lasting?

For Next Time

Homework Assignment

Reading

Read the articles "Classroom Catapults" by Diane D. Villano and "Learning From Your Mistakes" by Pamela J. Galus, found in the Appendix of this guide, and be prepared to discuss the following:

1. Describe something that you have your students build and then use to collect data. If you have a picture of the device, bring it to the next workshop session to share with your colleagues.
2. Describe a situation where a mistake in your classroom lead to greater student learning.

Notes