Conservation II. Science Activities in Energy.

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ABSTRACT: Designed for science students in fourth, fifth, and sixth grades, the activities in this unit illustrate principles and problems related to the conservation of energy. Eleven student activities using art, economics, arithmetic, and other skills and disciplines help teachers directly involve students in exploring scientific questions and making discoveries of their own. Most activities in the unit can be conducted in the classroom, using materials readily available in any home or school. Experiments answer questions about the relationship between force and speed, heat resistance, home heat loss, lightbulb efficiency, recycling, and battery power. Each activity is outlined on an illustrated single sheet which can be photocopied for distribution. The accompanying teacher's guide provides time guidelines, learner objectives, main concepts, process skills, materials and procedure clues, background information, precautions, strategies, and results for each activity. (LH)
CONSERVATION II.

SCIENCE ACTIVITIES IN ENERGY and TEACHER'S GUIDE

Oak Ridge Associated Universities
Tennessee
1981
Science Activities in Energy

Science Activities in Energy, a series of simple, concrete, revealing experiments, was developed by Oak Ridge Associated Universities for students in the fourth through tenth grades. Conservation 11, designed for students in high schools. However, the activities can be just as useful for younger students or in community programs.

The purpose of the series is to illustrate principles and problems related to various forms of energy and their development, use, and conservation.

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How much farther will a car that's twice as heavy go when the same force is applied?

20 km
40 km

Materials

- Plywood board (30 cm x 60 cm x 1/2-inch thick)
- Masking tape
- Metric ruler
- 2 Small nails
- Popsicle sticks
- White glue
- Hobby knife
- Rubber bands
- Small toy car
- Metric scale
- Assortment of metal washers
- Textbooks
- Hammer

Set Up and Conduct Your Experiment

Construct a device to measure the distance a toy car travels:

Build a popsicle stick-launcher.

Glue stick pieces

Make a hook here.

Popsicle stick glued in place at a 20° angle from 0 cm line

Slip the hole over the nail on the left side of the board.

Hook the launcher tightly to the other nail with a strong rubber band.

Launch the toy car. Measure and record how far it travels.

Try this several times and figure the average distance.
Record Your Results

<table>
<thead>
<tr>
<th>Distance traveled</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Car without weights</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level board</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Trial</td>
<td></td>
</tr>
<tr>
<td>2nd Trial</td>
<td></td>
</tr>
<tr>
<td>3rd Trial</td>
<td></td>
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<tr>
<td>Average</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Inclined board</th>
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<tr>
<td>1st Trial</td>
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<tr>
<td>2nd Trial</td>
<td></td>
</tr>
<tr>
<td>3rd Trial</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
</tr>
</tbody>
</table>

Add enough washers to double the weight of the car.

Try the experiment again.

Then, launch the car downhill. (Add one or more textbooks at the end opposite the launcher.) Record the distance the car travels with and without weights.

Summary Question

Does the lighter car go twice as far as the heavier one?

Other Ideas to Explore

How much weight do you have to add to reduce the distance the car travels by one fourth?

How does this relate to gasoline consumption?

Would the same relationships hold if more force were used?

How does the weight of a car carrying several passengers compare to the weight of an empty car? How does weight affect the distance it travels? the gasoline consumption?
How much horsepower can you produce?

Materials
- String and weight
- Staircase
- Stopwatch
- Yardstick
- Scale

Calculate Horsepower

\[
HP = \frac{\text{weight of volunteer (lbs)}}{550} \times \text{height of stairs (ft)} \times \text{time (seconds)}
\]

Set Up
And Conduct
Your Experiment

Measure the height of the stairs by dropping a weight tied to a string from the top. Record the height in feet.

Then, weigh your volunteer runners. Be sure to vary the size of the volunteers.

Have each volunteer run up the stairs as rapidly as possible while you record each one's time in seconds.

Calculate the horsepower each volunteer produced.

Summary Question

Could you produce twice as much horsepower by running up stairs that are twice as high?

Other Ideas to Explore

Try calculating the amount of energy produced by using the metric system.

Try the same experiment with a ramp. Would the length of the ramp make any difference in the amount of horsepower that is produced?

Can girls produce as much horsepower as boys?

Do athletes generate more horsepower than non-athletes?

How long can your volunteers continue to produce horsepower? What happens?
Will an R - 1 material let heat through twice as fast as an R - 2 material?

Materials
6-Pieces gypsum board (20-cm square × 1.25-cm thick)
Thermometer
White glue
Masking tape
100-Watt bulb
Ceramic socket with a plug
Stopwatch

Set Up And Conduct Your Experiment

Glue four pieces of gypsum board together to make an R-2 insulator.

Glue two pieces of gypsum board together to make an R-1 insulator.

Tape the thermometer here
Tape the thermometer to one side of the R - 1 insulator. Rest the other side of the insulator on the bulb.

Measure the time it takes for the temperature to rise 5°C.

Try the experiment using the R - 2 insulator.

Summary Question
What are some factors, in addition to R-value, that people use in deciding the type of insulation they will buy?

Other Ideas to Explore
Try the experiment using different insulation materials. Experiment with one thickness. Then, experiment with two.

Would three thicknesses in insulation be three times better than one thickness?
What is the approximate R-value of 3/4" wood?

Materials

4 30.5-cm Square pieces of plywood (one each of the following thicknesses: 1/4", 3/8", 1/2", and 5/8")

1 30.5-cm Square wood sample (1/4-inch thick)*

Thermometer

Masking tape

Ceramic socket with a plug

100-Watt bulb

Watch with a second hand

*available at hardware or building supply stores

Set Up And Conduct Your Experiment

Tape the thermometer to one side of the wood sample. Rest the other side of the sample on the bulb.

Measure the time it takes for the temperature to rise 5°C.

Try the experiment using the various thicknesses of plywood.

Graph the results of your experiment.

Using the graph and your data, what is the approximate R-value of the wood sample?

Summary Question

Did you find the R-value of the wood sample to be a good, poor, or average insulator compared to plywood?

Other Ideas to Explore

Test other woods for their insulation value.

Make your own insulator from waste materials you find at home and test its R-value.
How much longer will it take the temperature to rise 5\(^\circ\)C through one piece of glass compared to three pieces of glass?

**Materials**

- 3 Pieces of glass (25-cm square)
- 2 Pieces of corrugated cardboard (25-cm\(^2\) square x 1-cm thick)
- Masking tape
- Ceramic socket with a plug
- 100-Watt bulb
- Thermometer
- Watch with a second hand
- Hobby knife
- Metal straightedge

<table>
<thead>
<tr>
<th></th>
<th>1 glass piece</th>
<th>3 glass pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Starting temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Time to raise temperature 5(^\circ)C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Set Up And Conduct Your Experiment**

- Tape the thermometer to one side of a glass piece. Rest the other side of the glass piece against the bulb.
- Record the starting temperature.
- Measure the time it takes for the temperature to rise 5\(^\circ\)C.
- Try the experiment using a three-paned window.

**Make A Three-paned Window**

- Cut the middle out of the cardboard pieces and discard. You will have two picture frames with 1-cm borders on all sides.
- Place the cardboard between the three pieces of glass and tape them together.

**Summary Question**

Does one piece of glass allow a 5\(^\circ\)C temperature rise three times faster than three pieces of glass?

**Warning**

Tape the edges of the glass to avoid cut fingers. Also, the glass gets hot! Watch your fingers.
Other Ideas to Explore

Change the spacing between the pieces of glass. Is a cardboard picture frame with a 2-cm border a better insulator than one with a 1-cm border?

How does the heat from the bulb get to the thermometer in this experiment?

Try substituting plastic wrap for two of the pieces of glass.

Try covering the outside of the three-paneled window with drapery fabric before taping on the thermometer.

How much longer does it take to reach a 5°C rise in temperature?

How can you use windows in a house to help keep it warmer?

Call your local power company to find where energy-efficient homes are located in your community. Visit and analyze them. How many energy-saving ideas were used in the construction?
How much light does a bulb give off from a distance of 1 foot compared to a distance of 3 feet?

Materials
Ceramic socket with a plug
100-Watt bulb
60-Watt bulb
Yardstick
Photo light meter*
*available at camera stores, borrow one from a photographer, or make your own

Make A Light Meter
Solar cell
500-Ohm potentiometer
0.50 Microammeter
#22 Stranded, insulated hookup wire
Solder
Soldering iron

Set Up Your Experiment
Follow this pictorial diagram to make a light meter. (The schematic diagram is on the other side.)

Conduct Your Experiment
Calibrate your light meter by placing the solar cell one foot from a 100-watt bulb. This is approximately 100 foot-candles.

Note
The room must be almost dark!
Adjust the potentiometer to read full scale on the microammeter (50 amps). The scale will be linear, so a reading of 50 is 100 foot-candles, 25 is 50 foot-candles, etc.

Now, take readings at three and six feet and record your results.

**Summary Question**

Does the illumination fall off uniformly as the distance increases?

**Other Ideas to Explore**

Experiment with bulbs of different wattages. How do the results compare? What results would you expect from fluorescent bulbs?

To test the accuracy of your measurements, place a candle one foot from the solar cell and check the results.

**Light Meter Schematic Diagram**
How many 25-watt bulbs equal the light output of one 100-watt bulb?

Materials

Ceramic sockets
Lamp cord with attached plug
2 Meters of #18 hookup wire (stranded and insulated)
Photo light meter
Electrical tape
Metric ruler
25-Watt bulbs
100-Watt bulb

*ask your school custodian for some spare ones

**available at camera stores, borrow one from a photographer or make your own (see Conservation II, Activity 6)

Set Up And Conduct Your Experiment

Wire the ceramic sockets like this.

Tape all exposed wires very carefully with electrical tape. This is a parallel circuit.

Read your light meter 60 cm away from the 100-watt bulb. How many foot-candles of light do your meter measure?

Replace the 100-watt bulb with a 25-watt bulb and read the light meter from 60 cm. Keep adding 25-watt bulbs to the parallel circuit so their light outputs read together on the meter.

Summary Question

How many ceramic sockets did you have to wire to get enough light from 25-watt bulbs to equal the light from a single 100-watt bulb?

Note

The room must be almost dark!
Other Ideas to Explore

Which type of 100-watt bulb gives the most light: a long-life, unfrosted, or soft-light bulb?

Add a reflector of some kind and measure the amount of light you get from a 100-watt and a 25-watt bulb. Measure the difference in light output with and without the reflector.

Visit a hardware store and ask for a device designed to increase the life of a light bulb by five or more years. The device (a diode) is sold under many names. Measure the amount of light produced when using a diode.

Warning

Watch your fingers around ceramic sockets. Electricity is dangerous!
How much energy is saved when a dimmer switch is used with a 100-watt bulb?

Materials

- Ceramic socket
- Lamp cord with attached plug
- 100-, 60-, and 25-Watt bulbs
- 2 Meters of #18 hookup wire (stranded and insulated)
- Electrical tape
- Photo light meter
- Metric ruler
- Dimmer switch
- 0-1 A.C. Ammeter

*available at camera stores, borrow one from a photographer, or make your own (see Conservation II, Activity 6)

Note

The room must be almost dark!

Set Up And Conduct Your Experiment

Using the different bulbs, measure and record the light output in foot-candles at 30 cm and the current in amps at each dimmer setting.

Summary Question

Which method saves more energy for the same amount of light output: using lower wattage bulbs or dimming higher wattage bulbs?
Other Ideas to Explore

What results could you expect from fluorescent bulbs? How does your guess compare to your results?

Compare the light output of 5-year bulbs with a standard bulb of the same wattage. Measure the current each one uses and compare the amount of light produced. Which one produces more light per unit of electricity?
Who can make the strongest recycled paper?

Materials
Wire screen pieces
(about 25 cm x 32.5 cm each)
Blender
Old newspapers
Rolling pin
Starch suspension
Felt pieces
(about 25 cm x 32.5 cm each)

Set Up Your Experiment
Cut or tear a newspaper page into small pieces and soak them in water.

Pour off the excess water and place the pieces in a blender. Add three tablespoons of starch suspension and blend at high speed until it looks like thick soup.

Quickly pour the mixture onto a piece of wire screen, spreading it evenly.

To remove excess liquid, roll the rolling pin over the mixture while it is on the screen. Peel off the wet paper and dry it overnight.

For a smoother-textured paper, allow the mixture to drain on the screen. Then, cover it with a piece of felt.

Turn the screen over on the felt and peel the screen off carefully. Cover the paper with another piece of felt before rolling it.

Make a Starch Suspension
Combine one cup of cornstarch with two cups of water. Mix thoroughly before using.

Optional

Official Rules
- Can you use newspaper only? Are other types of papers allowed, such as homework?
- Can you use only the standard starch suspension? Are other mixtures allowed?
- What is the minimum or maximum paper thickness?
- May colors be added?
- How many pieces of paper should be made by each student?
- Are teams allowed to participate?

Set Up Your Contest
Now that you know how to make paper, decide on the rules for the class.
Have each student or team make their secret mix.

Summary Question
How can you test the entries for wet, strength and dry strength?

My Secret Mix

Ingredients

Process

Award a badge to the winner. Be sure to make it with recycled paper!

Other Ideas to Explore
How could you make colored paper? Could you make recycled white paper?

How does recycling paper save energy?
How much energy does it take to heat the water for your shower?

Materials
- 5-Gallon bucket
- Metric measuring cup
- Clock
- Thermometer

Set Up And Conduct Your Experiment

Measure and record the temperature of the cold water out of your shower faucet.

Turn on your shower faucet, like you were going to take a shower. Adjust the water to your usual shower temperature.

Measure the temperature of your shower water.

Collect the water in a bucket for one minute and record the number of liters used.

How many liters of water do you think you normally use when taking a shower?

Take a shower as you normally do. Record the length of time your shower water is actually running.

**SHOWER DATA**

| Temperature of cold water | °C |
| Temperature of shower water | °C |
| Difference in temperature | °C |
| Liter of water in one minute |                |
| Total time in shower |                |
| Total number of liters used |                |
| Total liters per minute x total time in shower |                |

Summary Questions

Did you use more or less energy than you thought you would? How does your energy use compare to others?
Other Ideas to Explore

How much energy could you save by installing a water-saving device in your showerhead?

Does a tub use more water than a shower? How much?

How much energy could a dripping hot water faucet waste?

What other ways can you use to save hot water?

Try keeping a record of your showers and note any differences on your electric meter. (See Electrical Energy, Activity 16.)
What is the least expensive battery to use in an electronic device or toy?

Set Up And Conduct Your Experiment

Place a set of batteries in the electronic device or toy and operate it until it stops.

Record the amount of time it takes for the device to stop working.

Test the other batteries in the same way and record the results.

<table>
<thead>
<tr>
<th>Type of Battery</th>
<th>Cost of one battery</th>
<th>Number of hours it worked</th>
<th>Cost per 1000 hours of use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use this formula.

\[
\text{Cost per 1000 hours of use} = \frac{\text{Cost of battery}}{\text{Number of hours battery worked}} \times 1000
\]

Summary Question

Which battery is cheapest to use?

Other Ideas to Explore

Is the most expensive battery always the best for every use?
Science Activities in Energy

Science Activities in Energy, a series of simple, concrete, revealing experiments, was developed especially for students in the fourth through tenth grades. The purpose of the series is to illustrate principles and problems related to various forms of energy and their development: use, and conservation.

More importantly, Science Activities in Energy was designed to help you directly involve students in exploring intriguing scientific questions and in making discoveries on their own.

You don’t need to be an expert in science to use these materials. In fact, many of the activities use art, economics, arithmetic, and other skills and disciplines. Since the series stresses investigation and exploration, you are not expected to know the “right” answer to every question.


Most activities in the series can be conducted in the classroom, using materials readily available in any home or school. A few activities require materials purchased from a local or national supplier. The series’ developers have made a concerted effort to design activities which use the same materials or materials that can be saved for use in other units.

Each activity begins with a question. At the beginning of the activity, try to get your students to predict the outcomes, even if they lack experience or knowledge to justify their predictions. Urge them to guess! This helps them to become more interested and involved in the activity.

When working on answering a question, each student (or the class as a group) follows the instructions which lead him or her through the activity. This kind of direct participation leads students to other questions—some of which are suggested on the activities and others they generate themselves. The activities encourage exploration by the experimenters on their own.

The series’ developers have purposely used metric measurements throughout the experiments. They believe that this will be part of the learning process for many young people and also for some adults.

Each activity is outlined on a single sheet. The sheets can be photocopied for distribution or easily projected on a screen or a wall.
Question: How much farther will a car that's twice as heavy go when the same force is applied?

Time: 30 to 50 minutes.

Objective: The student will measure the distances the toy cars travel and discover the relationship between distance and weight.

Materials & Procedure Clues:
Select matchbox cars that have the same weight. Add clay or washers to one of the cars to double its weight. The plywood board should be secured to a level table or floor. Select rubber bands carefully. Have the students measure carefully.

Concept: The same force causes cars of different weights to move different distances.

Background:
Assuming all things are equal, the relationship between the force applied to an object and the speed it attains is uniform. The more massive an object is, the less it will accelerate for a given force.

Although friction is a variable which affects the experiment, the heavier car travels a shorter distance for the same amount of force from the launcher.

Many factors influence gasoline consumption in automobiles: the way a person drives, the type of engine oil, tire pressure, type of tire, speed, etc. However, the weight of a car is one of the major factors which influence the number miles per gallon.

Precautions: None

Results: The heavier toy car will travel a shorter distance on the plywood board.

Strategies:
Before: Predict which car will go farther.

After: Discuss and compare the results of the activity with the class. Have the students do the activity several times. What variables need to be controlled closely? Which car goes farther? How does this relate to the care of automobiles and trucks?
How much horsepower can you produce?

30 minutes.

The student will identify the unit of measurement for power and measure the power the volunteers produce.

When one machine does the same amount or more work than another in a shorter amount of time, the first machine produces more power than the second.

The most horsepower a person can produce for a short time is one horsepower. A person can only produce about 1/10 horsepower for longer periods of time.

Work (W) is defined as the mathematical product of weight which is lifted (w) to a given height (h). \( W = w \times h \).

If a 110-lb student ran up stairs that are 12 feet high, he did 1320 foot-pounds of work.

\[ 1320 \text{ (foot-pounds of work)} = 110 \text{ (w)} \times 12 \text{ (h)} \]

If the student climbed the stairs in five seconds, he produced 264 foot-pounds of work in one second. (1320 foot-pounds of work)

\[ \frac{264 \text{ foot-pounds of work}}{5 \text{ seconds}} \]

A machine that does 550 foot-pounds of work in one second has produced one horsepower. Therefore, the student produced .48 horsepower. (264 foot-pounds)

\[ \frac{264 \text{ foot-pounds}}{550 \text{ foot-pounds}} \]

Students should be careful not to trip and fall while running up the stairs. Be sure others do not use the stairs during the experiment. Don't run down the stairs. It is dangerous!

The most horsepower anyone can produce for a short time is one horsepower. Students will produce about 1 3/10 to 1 2/10 horsepower. About one tenth horsepower is all that can be produced for long periods of time.
**Question**  Will an R-1 material let heat through twice as fast as an R-2 material?

**Time**  50 minutes.

**Objective**  The student will measure the R-value of gypsum and other materials used as home insulation.

**Concept**  All building materials conduct heat. The R-value of a material is a measure of its resistance to the flow of heat.

**Background**

R-value is a measure of the resistance to heat flow of materials used in building construction.

One way to understand what R-value means is to compare materials which have different R-values. The speed that heat flows through materials is one way to measure their relative R-values. In general, there is an inverse relationship between heat loss and R-value. A higher R-value means that less heat is lost from a building.

<table>
<thead>
<tr>
<th>Material</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum board or sheetrock, 1/2&quot;</td>
<td>0.45</td>
</tr>
<tr>
<td>Plywood, 1 1/2&quot;</td>
<td>0.62</td>
</tr>
<tr>
<td>Asphalt shingles</td>
<td>0.44</td>
</tr>
<tr>
<td>Wood shingles</td>
<td>0.94</td>
</tr>
<tr>
<td>Structural insulating boards</td>
<td>1.32</td>
</tr>
<tr>
<td>Expanded polystyrene, 1&quot;</td>
<td>3.57</td>
</tr>
</tbody>
</table>

**Precautions**

Be careful students do not burn themselves on the 100-watt bulb.

**Strategies**

Before: Discuss how R-values are determined. Is insulation value and R-value the same?

After: Identify what materials make the best insulators. Is gypsum board a good insulation material to use in homes? Why don’t people use stone or bricks as insulation?

**Results**

It takes about twice as long for heat to go through R-2 insulation as it does R-1 insulation.
Question: What is the approximate R-value of 3/4" wood?

Time: 50 minutes.

Objective: The student will compare how long it takes to raise the temperature 5°C through a piece of wood with how long it takes using insulators with known R-values.

Materials & Procedure Clues:
Be sure the 100-watt bulb and the thermometer are touching the wood. Place the thermometer on the wood at the same height where the bulb touches the wood. The wood should be dry.

Concept: All building materials conduct heat. The resistance to the flow of heat is measured by a unit called R-value.

Background:
The R-value of wood depends on several factors, such as its moisture content and its density. Some kinds of wood, cedar for example, have a very high R-value. A house built with five-inch thick cedar walls has R-11 walls. Since wood has a higher R-value than stone, a wooden house’s walls generally will have a higher R-value than a stone house.

Although the method used to measure R-value is complicated, interested students should research how it is done and try it outside of class.

The method used for measuring R-value in this experiment is easier. A number of materials with known R-values are tested along with one with an unknown R-value. After the data is graphed, the material with the unknown R-value is read from the chart. The accuracy of the results depends on how carefully the data is obtained and graphed.

<table>
<thead>
<tr>
<th>Material</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/8&quot; plywood</td>
<td>0.79</td>
</tr>
<tr>
<td>1/2&quot; plywood</td>
<td>0.63</td>
</tr>
<tr>
<td>3/8&quot; plywood</td>
<td>0.47</td>
</tr>
<tr>
<td>1/4&quot; plywood</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Precautions:
Be careful when using the 100-watt bulb.

Strategies:
Before: Discuss the reasons for using wood in constructing homes.

After: Is pine a better insulator than gypsum board? What are the variables in the activity? What is required to insulate a home well?

Results:
The R-value of the plywood will be between 0.75 and 1.00.
Question: How much longer will it take for the temperature to rise 5°C through one pane of glass compared to three panes of glass?

Objective: The student will compare the time required to raise the temperature 5°C through one pane of glass with three panes of glass.

Time: 50 minutes.

Concept: Glass is not a very good insulator. However, if air is sealed between glass panes its insulation ability improves.

Background: The greatest heat loss in a house occurs through the windows. In the winter, when humidity is high, the moisture in the air condenses on the inside of the windows. Although triple-pane windows have an even higher R-value, generally it is more economical to use double-pane windows. Compared to the walls in a house, triple-pane windows have a very low R-value.

In planning an energy-efficient house, most of the windows should be on the south side of the house. Very few, if any, should be on the north side. In the summer, the south-facing windows must be shaded by an overhang or trees.

The R-value of a single-pane window is approximately 1; a double-pane window is approximately 2; a triple-pane window is not quite 3.

Precautions: Students should handle the glass and bulb carefully.

Results: The results will vary greatly. The three pieces of glass will take at least three times as long to raise the temperature 5°C than one piece of glass.

Materials & Procedure Clues: Be sure the 100-watt bulb and the thermometer are touching the glass. Each pane of the three-paned window should be separated by a piece of cardboard that is 1-cm thick.

Process Skills: Observing, controlling variables, measuring, and hypothesizing.

Strategies: Before: Emphasize the need to control the variables in the activity.

After: Where should windows be located in a house? Why? Discuss the need for energy conservation practices in buildings.
Conservation II - 6

Question How much more light does a bulb give off from a distance of 1 foot compared to a distance of 3 feet?

Time 50 minutes after constructing the photo light meter.

Objective The student will compare how much light is obtained by the light meter at one-foot and three-foot distances from the bulb.

Concept The intensity of illumination from a point source of light is inversely proportional to the square of the distance to the light. For example, a distance twice as far from the light source will give one-fourth the illumination.

Background Lights used in a house are not point sources. Therefore, they do not follow the inverse square law exactly. However, the light at twice the distance is far less than one half.

Light sources are measured in candle-power — a measure of how much light is produced compared to a standard candle. A 100-watt bulb has approximately 100 candle-power. A one-candle-power bulb produces one foot-candle of illumination, one foot away. Therefore, a 100-watt bulb produces about 100 foot-candles, one foot away.

Most light meters are made with solar cells and sensitive electric meters. See the activity sheet for light meter construction details.

Since most photo light meters are calibrated in foot-candles, the measurements in this experiment are made in feet instead of meters.

Precautions Be careful when working with electricity.

Results Students should obtain three to four times more light 1 foot away from the bulb than 3 feet away from the bulb.

Materials & Procedure Clues Have students assemble the light meter before conducting the activity. Be sure to explain how to read the light meter. Check the wiring.

Process Skills Observing, measuring, controlling variables, and hypothesizing.

Strategies Before: Explain how the light meter works.
After: How much light is needed to read comfortably? How do people use light?
Question: How many 25-watt bulbs equal the light output of one 100-watt bulb?

Time: 50 minutes after constructing the photo light meter

Objective: The student will determine how many 25-watt bulbs equal the light output of one 100-watt bulb.

Process Skills: Observing, measuring, controlling variables, and hypothesizing.

Materials & Procedure Clues: Use the photo light meter developed in Conservation II, Activity 6 to measure the light output. Be sure to hold the light meter 60 cm from the bulbs.

Concept: The efficiency of a bulb increases with its power. Low wattage bulbs give off less light per watt than higher wattage bulbs.

Background: The efficiency of small incandescent bulbs increases with the power of the bulbs. That is, you get more light output for a given unit of electricity used.

All bulbs in a house are connected in a parallel circuit so they operate independently of each other.

The 25-watt bulbs should be connected in parallel as shown on the activity sheet. Use porcelain sockets that do not have exposed terminals.

When taking the light readings, the room should be dark. Bunch the sockets as closely together as possible. Place the photo light meter the same distance from the 25-watt bulbs as you do for the 100-watt bulb.

Precautions: Be careful when working with electricity.

Be sure to use a parallel circuit as illustrated.

Results: It will take at least five 25-watt bulbs to equal one 100-watt bulb.

Strategies: Before: Introduce different size bulbs to students. Why are they different? How do they work?

After: How do we measure light? How efficient are different types of bulbs, such as long-life, unfrosted, soft-white, or square bulbs?
**Question** How much energy is saved when a dimmer switch is used with a 100-watt bulb?

**Time** Two 50-minute class periods to construct the apparatus and conduct the activity.

**Objective** The student will determine if a dimmer switch is energy efficient.

**Concept** Usually, dimmer switches only serve aesthetic purposes. Care must be taken in selecting various home apparatus and appliances that claim to be energy efficient.

**Background**
- Modern electronic dimmers are efficient devices that waste little energy compared to rheostats used in the past. However, dimmer switches should be used mainly for their aesthetic appeal, not their energy efficiency. They do not save energy compared to the amount of light that is lost.
- Light bulbs are made of tungsten, a material that has low electrical resistance when cold. The hotter tungsten becomes, the more light is produced.
- When a dimmer switch is used, it lowers the average amount of current flowing through a bulb, thus cooling it. The bulb gets dimmer and also uses less power. However, the power doesn’t decrease as much as the light output.
- A smaller bulb operating at normal high temperatures gives more light per watt than a larger bulb and a dimmer switch.

**Precautions** Be careful when working with electricity. Be sure the wires are connected securely and that all exposed wiring is covered with electrical tape. Be sure to follow diagram exactly. All parts are connected in series, one following the other.

**Materials & Procedure Clues**
Be sure to check the students’ wiring before plugging into the wall outlet. Read the AC ammeter and photo light meter carefully. Take several readings.

**Results** Lower wattage bulbs will provide more of a cost savings than a dimmer switch.

**Process Skills**
Observation, measuring, controlling variables, and hypothesizing.

**Strategies**
Before: Discuss how ammeters and photo light meters work. Discuss how a dimmer switch works.
After: Compare the results the students obtained in the activity. Why are dimmer switches so popular? Are they energy efficient?
### Process Skills
Observing, measuring, and hypothesizing.

### Materials & Procedure Clues
Follow the recipe carefully. Let the paper dry on the screen for one or two days, depending on the thickness of the pulp on the screen and the humidity level. Peel the recycled paper off the screen carefully. Students should be encouraged to experiment in making recycled paper. Allow them to use other methods.

### Background
Recycling materials to make paper dates from when paper was made from old linen clothes. When this supply became inadequate to meet the demand for paper, the paper makers turned to trees. It takes a great deal of energy to harvest the trees, shred them, and separate the fibers from the lignin which holds the fibers together. Waste chemicals are also produced. Getting rid of these chemicals could mean heavy pollution of streams and rivers. Water purification associated with paper making is an expensive, energy-consuming process.

### Precautions
Do not overfill the blender.

### Results
Surprisingly good paper can be made, but it will be off-white to gray in color.

### Strategies
**Before:** What are some uses for recycled paper? Why isn't it used more often?

**After:** You may want to develop an apparatus to test the strength of the paper. How much energy would be saved by recycling paper? What else could be recycled to save energy? What cannot be recycled?
**Question**
How much energy does it take to heat the water for your shower?

**Time**
30 to 50 minutes.

**Objective**
The student will determine how many kilocalories are used to heat the water for a shower.

**Materials & Procedure Clues**
Be sure to collect the water with the pail for one minute. Measure it carefully. Students can use their showers at home or those in the athletic locker room at school.

**Concept**
Heating and storing hot water takes a great deal of energy. Conserving hot water is useful in saving large amounts of energy and money.

**Background**
Some methods of heating and storing hot water are expensive and wasteful. Since fuel has to be burned to generate electricity, electric water heating is not as efficient as gas water heating. In fact, only about one-fourth of the energy from the fuel used to make electricity is available to heat water.

There are several ways to conserve hot water. One quick way is to reduce the amount of time spent in the shower. Another easy way to cut down on hot water usage is to use cold water when possible, for example when washing clothes. Energy-saving shower heads also reduce hot water usage.

Heat can be saved by wrapping additional insulation around a water heater. Instant-demand water heaters, which eliminate the need for storage water holding tanks, are also available.

Solar water heaters are an effective way to conserve energy and still supply adequate amounts of hot water.

**Precautions**
None.

**Results**
A nine-minute shower at 7.71 liters per minute with the shower water at 53°C and the cold water at 15°C will use approximately 293 kc per minute or 2737 kc total.

**Strategies**
Before: How do water heaters work?
After: Discuss the need to control the variables in the activity. What costs more, a bath or a shower? How much would a daily shower cost for a month? A year?
**Question**
What is the least expensive battery to use in an electronic device or toy?

**Time**
One hour or more depending upon the toy and battery used.

**Objective**
The student will identify the most economical battery (dry cell) to use in electrical devices or toys.

**Materials & Procedure Clues**
Obtain an assortment of batteries: carbon-zinc, alkaline, etc. Keep records of the battery costs. Use each battery until the device or toy stops operating. If a battery lasts longer than one class period, turn it off and restart it the next time the class meets.

**Concept**
The least expensive battery may be the most expensive to operate. The use of limited-life, lower-priced carbon-zinc batteries may be far more expensive than purchasing alkaline or other types of batteries.

**Background**
The dry battery is not really dry, but has its moisture sealed in the cell. All cells contain a metal and a chemical solution which tends to dissolve the metal as the battery is used. The metal is the source of the electrons which flow through the device back to the positive pole of the battery. The internal structure and the nature and purity of the chemicals determine the cost of a battery and how long it will last.

Battery power is relatively expensive. It can only be justified where portable power is required and the amounts needed are small. For example, to find out battery cost for 1000 hours of use, determine how long a battery might last. For our example we assumed each battery would last ten hours. Therefore, it would take 100 batteries to last 1000 hours. If a battery costs 25c, total cost would be $25.00 for 100 batteries lasting a total of 1000 hours.

\[
\frac{1000}{10} = 100 \times .25 = \$25.00
\]

**Precautions**
Do not short circuit a battery since that will shorten its life drastically.

**Strategies**
Before: Discuss the use of batteries in the home.
After: Discuss the results of the experiment.

**Results**
Generally, alkaline and higher quality batteries cost less to operate.
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