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Harnessing Solar Energy

Background Information

The sun radiates a tremendous amount of energy. Even from a great distance away, sunlight warms Earth. As the cost of fossil fuels rises, solar energy becomes a more attractive alternative energy source. Some people install solar panels on the roofs of their houses. These devices are often used to heat water that is then used as a hot-water source or to heat the house.

In order to make the greatest use of energy from the sun, it is necessary to focus the sun's rays. This can be accomplished by using a curved, or concave, mirrored surface or a magnifying lens.

In this investigation, you will use a mirror to focus the sun's rays and measure the effect it has on the temperature of a sample of water.

Problem

What happens to the thermal energy of a substance when light rays from the sun are focused on it?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. **Applying Concepts** Suppose parallel rays of light strike a plane mirror at an angle. How will the directions of the reflected rays compare with the directions of the incident rays?

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2. **Interpreting Diagrams** Two plane mirrors are joined at an angle of 120° and oriented toward two parallel incident rays of light, as shown in Figure 1. Construct the normal lines for each plane mirror, measure the angles of incidence, and draw the reflected rays as dashed lines with arrowheads to show their directions. Are the reflected rays parallel to each other? Explain.

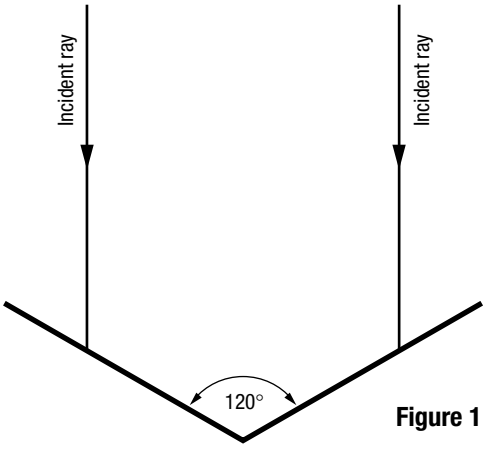

Figure 1

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3. **Interpreting Diagrams** A spherical concave mirror is shown in Figure 2. Draw dashed lines to represent the reflected rays and use arrowheads to indicate direction. Label the point at which the rays cross as the Focus. How is this concave mirror similar to the V-shaped mirror in Question 2? How does the concave mirror affect the direction of the incident rays?

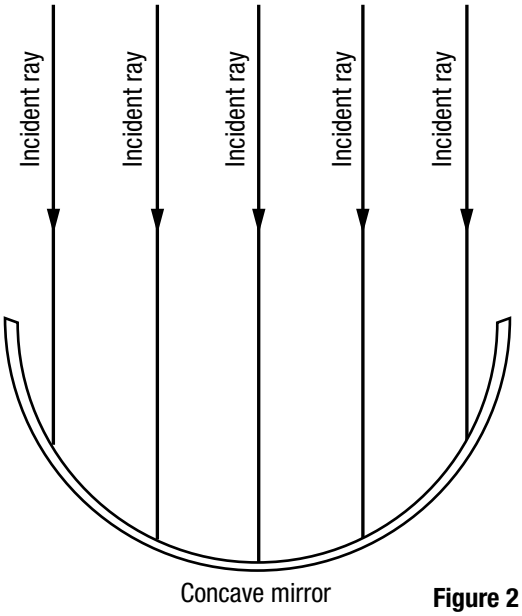

Figure 2

4. **Inferring** How does the amount of light energy at the focus compare to the amount of energy at any other location near the mirror? Explain.

5. **Predicting** Two water-filled test tubes are set up so the sun is shining on them. One of the test tubes is positioned to be at the focus of a concave mirror. How would you expect the temperature of the water in the two test tubes to compare after they have each had sun shining on them for an hour? Explain.

Materials *(per group)*

compass
protractor
reflector from a large flashlight
ring stand
graduated cylinder
2 thermometers
2 test tubes
2 test-tube clamps
triangular file
tape

Safety

Put on safety goggles. Be careful to avoid breakage when working with glassware. Be careful when handling sharp instruments. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

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Procedure

1. Insert one of the test tubes through the hole in the center of a flashlight reflector so that it extends about 1 cm below the bottom of the reflector. The test tube should fit snugly. If the hole is too small, enlarge it with a triangular file. If the test tube is loose, secure it with some tape.
2. Set up a ring stand with two test-tube clamps. Secure the test tube in the reflector and the second test tube in the test-tube clamps, as shown in Figure 3. Place a thermometer into each test tube.
3. Using a graduated cylinder, add 5 mL of water to each test tube. Wait a few minutes. In the data table, record the initial temperature in each test tube.
4. Place the test setup in bright sunlight and position the reflector toward the sun. Tilt the reflector in such a way that a bright spot appears in the water of the test tube. Adjust the position of the other test tube so that it is tilted the same way as the test tube in the reflector.
5. Expose the test tubes to the sun for 5 minutes. Observe the temperatures of the water in each test tube and record the values in the data table.

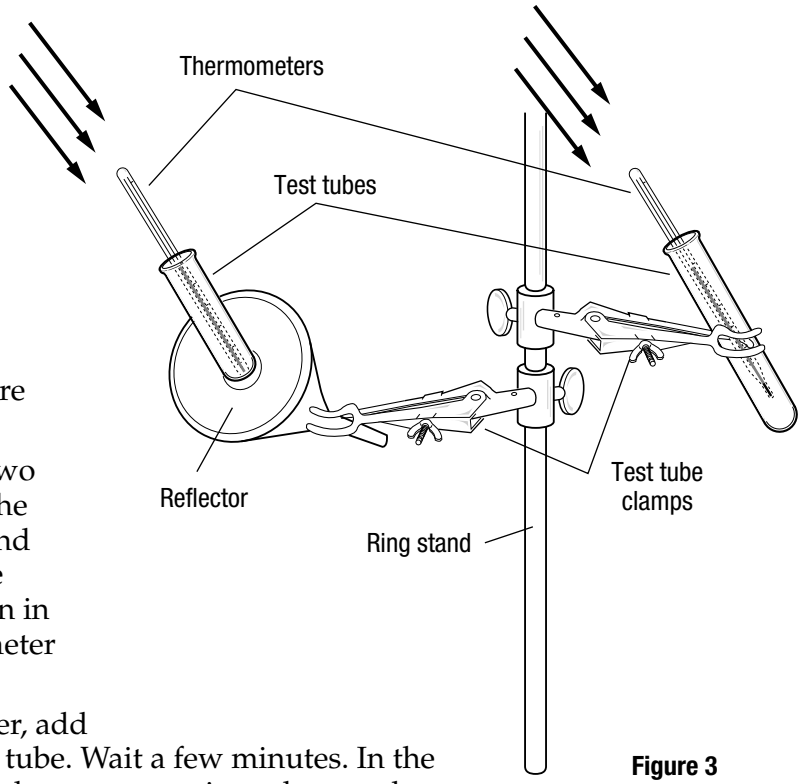

Figure 3

Observations

DATA TABLE

Test Tube	Initial Temperature (°C)	Final Temperature (°C)
With Reflector		
Without Reflector		

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Analysis and Conclusions

1. **Comparing and Contrasting** How did the temperature in the two test tubes compare? What caused the difference in temperature? How did this result compare to your earlier prediction?

2. **Controlling Variables** Why did you need to set up two test tubes with the same amount of water in each?

3. **Relating Cause and Effect** How did the concave mirror heat the water? What observations support your explanation?

4. **Applying Concepts** Explain how an apparatus similar to the one you constructed could be used to change the sun's radiant energy into mechanical energy.

Go Further

With adult supervision, construct a device to heat water by using a magnifying lens. Use a similar apparatus to the one you used in the investigation. Use two test tubes so that you can evaluate the effect of the lens. Attempt to position the lens in such a way that a large amount of sunlight is focused in a small volume of water. Compare the results of your experiment with the results from this investigation. **CAUTION:** *Focused light from the lens can produce very high temperatures.*