Exploration Lab

CONSUMER

Relating Window Shading and Temperature

Passive solar buildings have many features that help to keep these buildings warm in the winter and cool in the summer. Heavily insulated floors, ceilings, walls, and windows trap heat inside such buildings during the winter. Vents in the roof allow hot air to escape during the summer. In summer, eaves or roof overhangs will help to shade south-facing windows that let sunlight in. In winter, heat is lost through windows when the sun is not shining. Deciduous trees planted on the south sides of passive solar buildings help to keep the structures cool in the summer months. In this laboratory activity, you will predict how a roof overhang affects temperatures inside and outside a house. You will test your predictions by constructing a model. Finally, you will use your results to determine how long an overhang needs to be in order to keep a house cool or warm during various times of the year.

OBJECTIVES

Hypothesize how an eave affects temperature both inside and outside a house.

Construct a model house to test your hypothesis.

Compute the length that an eave needs to be in order to keep a house cool or warm during certain months of the year.

MATERIALS

- cardboard box, rectangular (about 35 cm x 10 cm x 20 cm)
- Celsius thermometer (2)
- pencils, colored (12)
- construction paper, black (3 to 4 sheets)
- directional compass
- metric ruler
- overhead transparency
- poster board, white (1 sheet)
- protractor
- scissors
- scrap paper (1 small piece)
- tape

Procedure

PART I—CONSTRUCTING THE MODEL

1. Hypothesize how an eave affects the temperature of a house both indoors and outdoors (near the eave). Record your hypothesis below.

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2. Use the black construction paper to completely line the inside of your model house. Use tape to hold the paper in place.
3. Use the scissors to carefully cut a window into one of the box's smaller sides, as shown in Figure 5. Like most windows in an actual one-story house, locate your window just under the 'roof line' on your model.
4. Make a windowpane from the overhead transparency. Tape the windowpane into place. Make sure that all of the edges of the windowpane are securely taped down.
5. Use tape to completely seal any open flaps on the box. Make sure you seal off the flaps along all of their edges.
6. Use the scissors to carefully poke a small hole into the box's other small side. This hole is for the thermometer.
7. Use the poster board to make a flat roof for your model house. Note that as shown in the figure, the roof must be as wide as your house is and just long enough to extend over one edge of the house so that the window is completely shaded.

PART II—EXPERIMENTING AND COLLECTING DATA

8. With a partner, take your model house and the thermometer outdoors on a sunny day as close to noontime as possible. Use the compass to determine geographic north. Orient the house so that the window is facing south.
9. Adjust your roof so that the window is completely in the sun. After about 5 minutes, use the thermometers to measure the temperature both inside and outside the house. Your outside temperature should be measured about 5 cm from the window. Make sure to shade the thermometer with a small piece of paper so that the temperature is not affected by the direct light source. Record your measurements in Table 1 on the next page.
10. Repeat step 9 by adjusting and recording the length of the eave at the positions described in Table 1. Remember to allow at least 5 minutes between measurements so that the thermometer can reach air temperature.

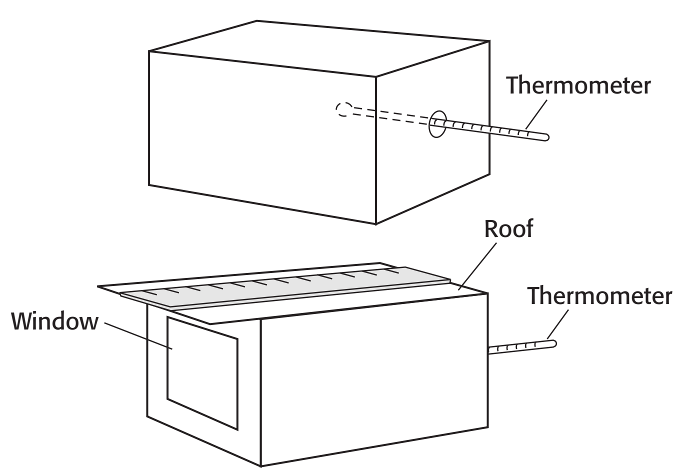

TABLE 1: TEMPERATURE DATA

Length (cm) of eave when window is:		Temperature (°C) Inside the House	Temperature (°C) Outside the House near Window
Not shaded	0 cm		
One-quarter shaded			
Half shaded			
Three-quarters shaded			
Completely shaded			

Analysis

1. **Examining Data** In which case (length of eave) was the temperature inside the house the highest?

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2. **Examining Data** In which case (length of eave) was the temperature inside the house the lowest?

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3. **Recognizing Patterns** Describe how the temperature just outside the house's window changed with a change in the length of the eave over the window.

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Conclusions

4. **Evaluating Data** How did your results compare with your predictions?

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5. **Evaluating Methods** Would you have gotten the same results if your window had faced north? Explain.

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6. **Applying Conclusions** Do you think eaves over east- and west-facing windows in the Northern Hemisphere have the same effect on temperature as south-facing eaves? Explain.

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7. **Drawing Conclusions** How do most houses—solar-heated and conventional—make use of eaves over windows?

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8. **Applying Conclusions** How would your results differ if you had conducted the activity during a different season of the year?

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9. **Applying Conclusions** What are some other things that can be done to a building so that the structure efficiently avoids energy from the sun?

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10. **Applying Conclusions** Would you have gotten the same results if you had done this experiment during the same month in Auckland, New Zealand? Explain.

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Extension

1. **Making Predictions** The data below show the elevation of the sun in degrees above the south horizon on the 21st day of the given month in various cities. Use these data, the colored pencils, the metric ruler, and your protractor to make a sketch that shows how the sun would enter a south-facing window in a house with a slanted roof in each of the cities in each set of months. Make your drawings on other sheets of paper and include labels.

TABLE 2: ELEVATION (IN DEGREES) OF SUN ABOVE SOUTH HORIZON DURING CERTAIN MONTHS

City	March and September	May and August
City A	38°	58°
City B	32°	52°
City C	27°	47°
City D	25°	45°