5. HOW A GREENHOUSE WORKS: LIGHT

How does the angle of the Sun's light affect the level of light intensity that can be absorbed by plants in a greenhouse?

Background

Greenhouses have always been used to provide a warm, well-lit habitat for seedlings to start growing in the late winter and early spring. Commercial growers use elaborate large greenhouses to start seeds, while backyard gardeners erect small, closet-sized greenhouses. The one thing any greenhouse must have is a covering of translucent material and a means of controlling the temperature and humidity.

Objectives

- Investigate how light intensity or brightness depends on the angle at which the Sun's light strikes the surface of the ground and how this changes throughout the day.
- Measure, record, and interpret data.

Materials and Equipment

- Data Collection System
- Light sensor
- Reflector lamp or desk lamp
- Incandescent light bulb, 60-watt
- Shoebox or cardboard box of similar size
- White legal-size copy paper
- Clear or transparent plastic wrap
- Protractor
- Transparent adhesive tape
- Metric ruler
- Scissors
- Pencil

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Do not touch the incandescent light bulb as it will get very hot when in use.

Procedure

Part 1 - Greenhouse Construction

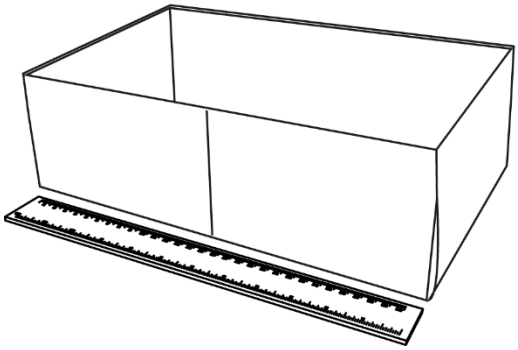
1. Use a shoebox to create your model of a greenhouse.

2. Lay the shoebox on a piece of white paper and carefully trace the shoebox on the paper and cut the white paper along the lines you just traced.

3. Place the sheet of paper in the bottom of the box and tape it so it lies flat.

4. Measure the length of one of the longer sides of the shoebox with the metric ruler. Find the midpoint and draw a line from the top of the box to the bottom dividing it into two equal halves.

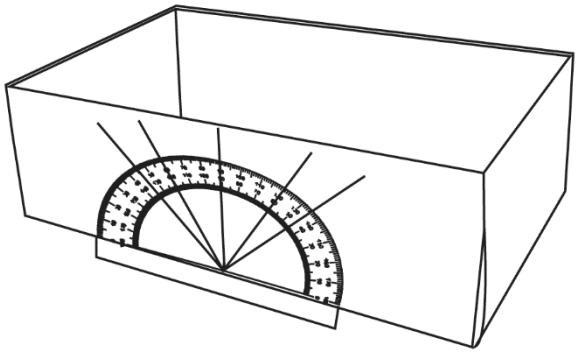
Figure 1: Shoebox with a line drawn at midpoint from top to bottom



5. Align the protractor with the bottom edge of the shoebox and the line you just drew and mark dots at 45˚, 60˚, 120˚, and 135˚.

6. Draw a line connecting each dot to the bottom of the line at the midpoint and label each new line as in Figure 2.

Figure 2: Shoebox with lines drawn and labeled at 45°, 60°, 90°, 120° and 135°

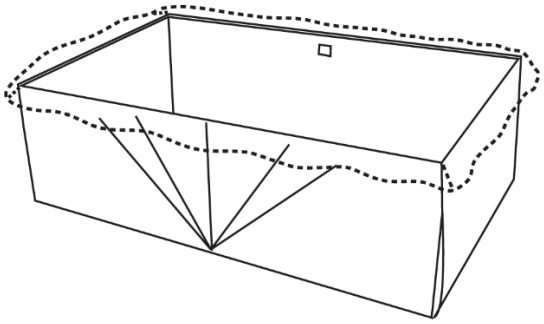


7. Label the line down the middle of the box 90˚. These lines represent the angle of the Sun's light as it enters the greenhouse and changes position throughout the day as the Earth rotates.

8. On the side of the shoebox, opposite the angle measurements, cut a 1-cm square hole for the light sensor, approximately 1 cm from the top edge of the box, centered on that side. See Figure 3.

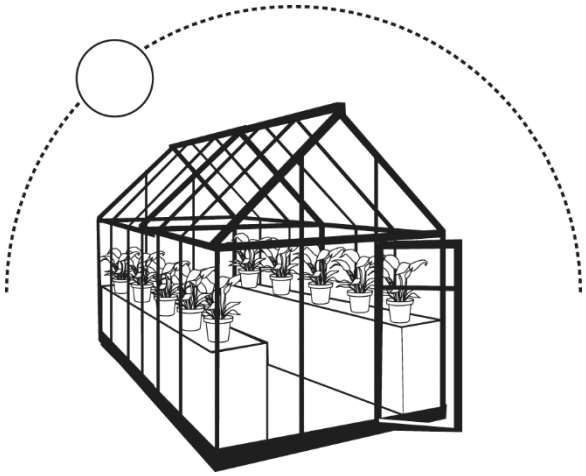
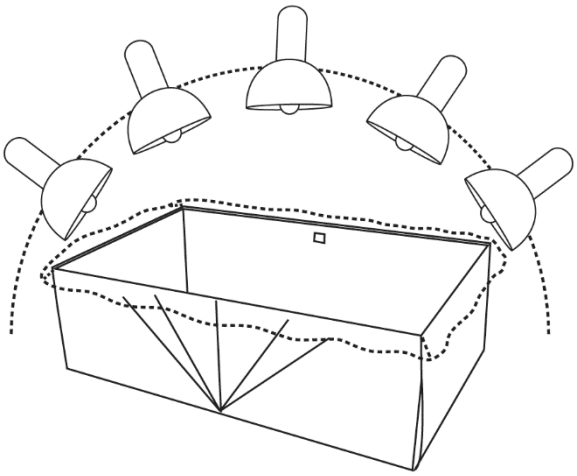
9. Cover the top of the shoebox with transparent plastic wrap and tape it in place. Be sure you do not cover the hole for the light sensor. Figure 3: Model greenhouse with 1 cm square light sensor hole, covered with transparent plastic wrap

Figure 3: Model greenhouse with plastic wrap



Part 2 - Investigating Light

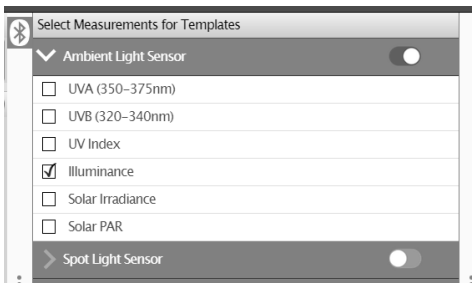
You will investigate light levels in your model greenhouse, using the lamp to model the Sun at five different positions during the day, represented by five different angles. Shown in Figure 4 is a drawing of a real greenhouse and the Sun. In Figure 5 is a drawing of your model greenhouse and a lamp modeling five different position of the Sun during the day.

Figure 4: Greenhouse and Sun at different positions during the day	Figure 5: Greenhouse model and lamp used to model the Sun in five different positions during the day
	

1. Select Sensor Data in SPARKvue.

2. Connect your light sensor to your device.

3. Select Ambient Light Sensor and only check Illuminance. Turn off the Spot Light Sensor.

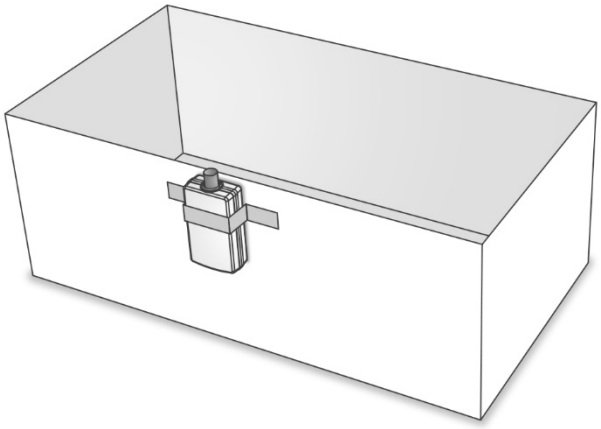


4. Choose the Digits display. Lux is the unit of measure for light intensity. We use this term to compare one light measurement from another.

5. Point the ambient part of the light sensor at the overhead lights in your classroom and begin collecting data. When the values stop changing, or stabilize, stop recording data. The light intensity value is _____.

6. Take the light sensor and tape it onto the box. Make sure the ambient portion of the sensor is facing inside the box at the hole that you cut earlier. See Figure 6.

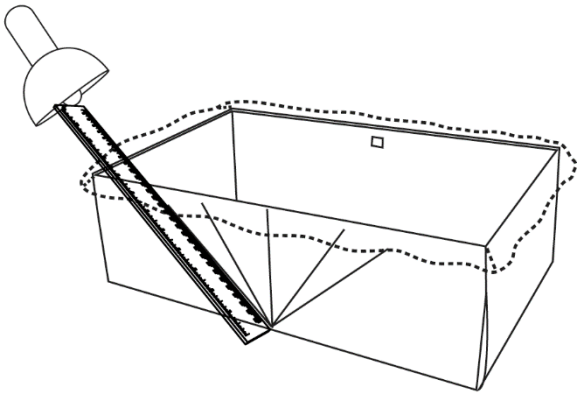
Figure 6: Ambient portion of light sensor taped over hole in greenhouse model



7. Have a partner turn on the lamp and hold it 40 cm from the bottom of the model.

8. Use a metric ruler and the lines you made outside of the model to help angle the lamp so it is shining on the inside of the model at 45˚. The bulb should line up with the ruler. See Figure 7.

Figure 7: Use a metric ruler to help angle the lamp and measure the distance from the lamp to the top of the box



9. Start recording and move the lamp to each of the five modeled positions of the Sun. Record your data in Table 1.

10. Transfer your results from Table 1 to Graph 1.

Part 3 - Modeling Data Another Way

1. Close your previous experiment without saving and start a new experiment. Again, make sure to only use the ambient part of the light sensor and Illuminance.

2. Choose the Graph template.

3. Start recording. Your partner should start with the lamp at about the 45˚ point and move the lamp slowly and smoothly across the "sky", keeping it a constant distance from the box as much as possible. Stop recording data when you reach the other side.

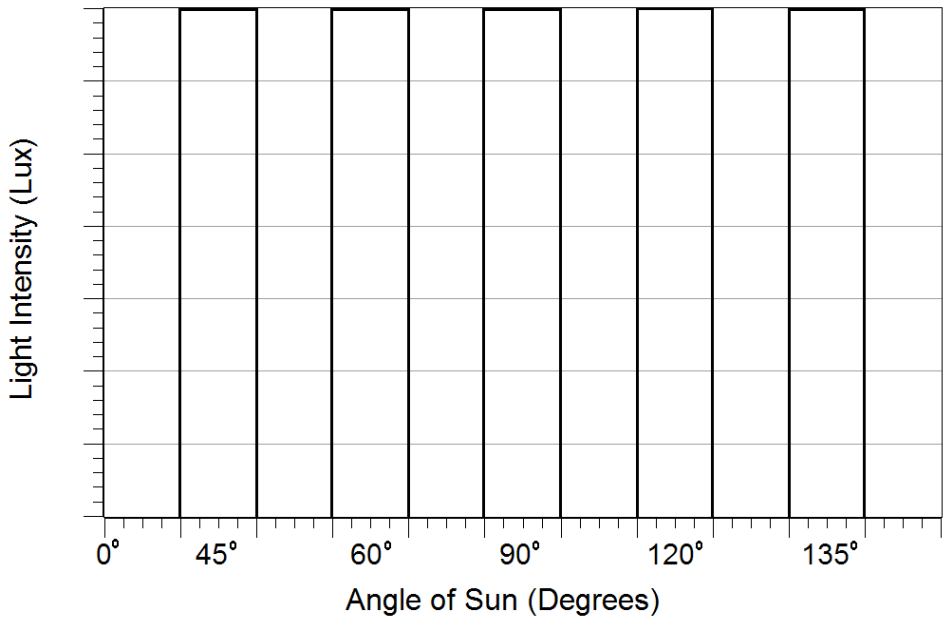
4. Sketch your data on Graph 2.

Data Collection

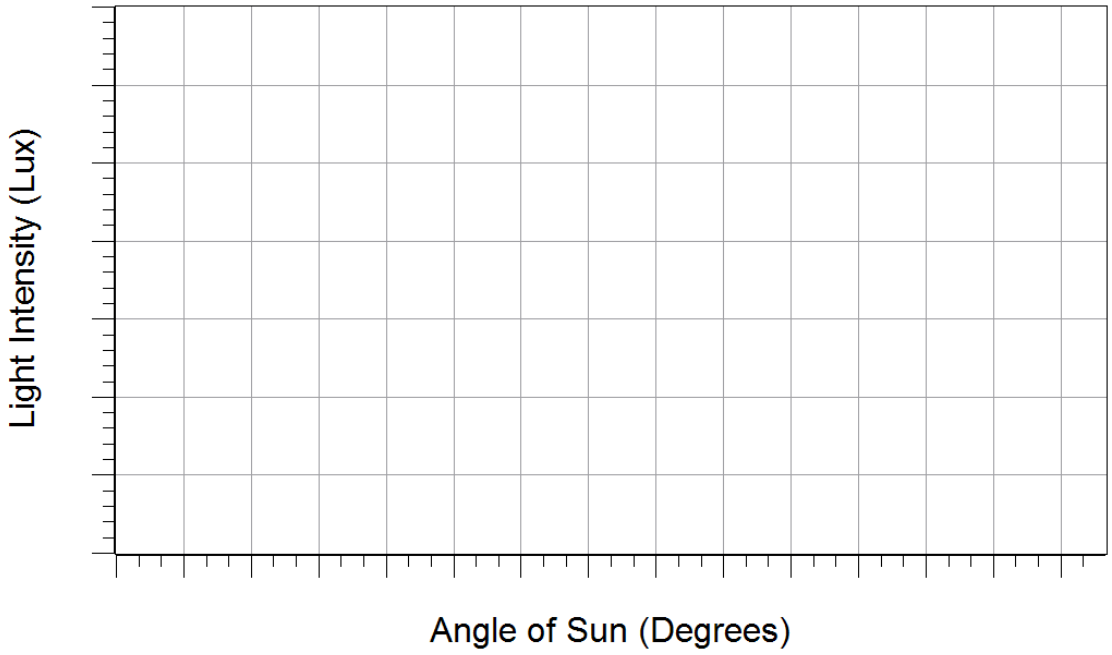
Table 1: Data for modeled positions of the Sun

Angle	Light Intensity (lux)
45˚	
60˚	
90˚	
120˚	
135˚	

Graph 1: Bar graph of measured light intensities



Graph 2: Light intensity for sunrise to sunset model



Questions and Analysis

1. Using the data from Table 1, which angle had the highest intensity of light? Which angle had the lowest level of intensity?

2. Using your data from Table 1 what was the difference in light intensity from 90˚ to 135˚? Show your work below.

3. Using data from Graph 2, did you see a pattern? What real-world pattern is being modeled in this graph?

4. Do you think there is a connection between light intensity, or brightness, and temperature change throughout day? How could you test this?