Name ***Date***

28. 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?

Materials

- ☐ Data collection system
- ☐ Light sensor
- ☐ Reflector lamp or desk lamp with 60-watt
- ☐ incandescent light bulb
- ☐ Shoebox or cardboard box of comparable size
- ☐ White legal size typing paper, white butcher
- ☐ paper or white bulletin board paper
- ☐ Clear or transparent plastic wrap
- ☐ Wax paper
- ☐ Glad Press 'N Seal® Wrap
- ☐ Any other translucent materials
- ☐ Scissors
- ☐ Protractor
- ☐ Pencil
- ☐ Transparent adhesive tape
- ☐ Metric ruler and a meter stick

Safety

Always follow your teacher's directions when doing any activity.

Investigation

After you complete a step or answer a question, place a check mark in the box (☐) next to that step.

When you see the symbol "[2]" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step.

Get Started

1. ☐ What materials will you use to build your greenhouse?

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2. ☐ Do these materials allow you to create a complete greenhouse? Explain.

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3. ☐ How do you think the conditions inside your greenhouse will differ from the conditions outside? Think about different times of day and different seasons.

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4. ☐ Obtain a data collection system from your teacher and start a new experiment. ◆(1.2)

5. ☐ Connect a light sensor to the data collection system and set it to the light bulb setting. ◆(2.1) If your sensor has different settings, select the light bulb setting.

6. ☐ Display light intensity in lux in a digits display. ◆(7.3.1) Lux is the unit of measure for light intensity. We use this term to compare one light measurement to another.

Let's Explore

7. ☐ Point the light sensor at the overhead lights in your classroom and begin collecting data. ◆(6.2) When the values stop changing, stop recording data and record the intensity value of the overhead lights.

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8. ☐ Obtain a shoebox to use as your greenhouse model.

   a. Lay the shoebox on a piece of white paper and carefully trace the shoebox on the paper.

   b. Cut the white paper along the lines you just traced.

   c. Place the sheet of paper in the bottom of the box. Tape it down so it lies flat.

9. ☐ What is the purpose of the white paper, inside and on the bottom of the box?

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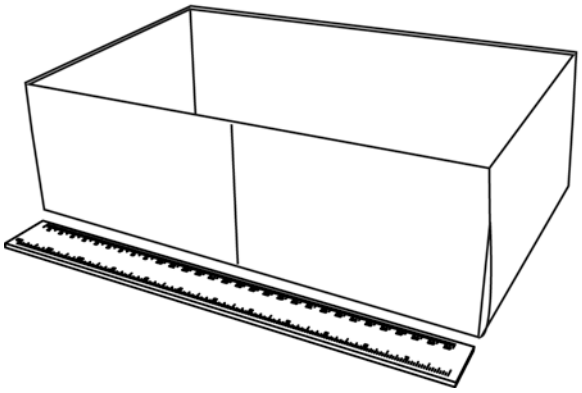
10. ☐ Measure the length of one of the longer sides of the shoebox with the metric ruler. Find the midpoint and draw a line from the top of the box to the bottom dividing it into two equal halves.

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



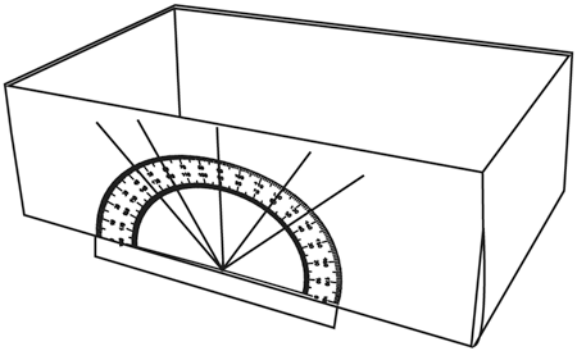
11. ☐ Align the protractor with the bottom edge of the shoebox and the line you just drew.

   a. Mark dots at 45°, 60°, 120° and 135°.

   b. Draw a line connecting each dot to the bottom of the line at the midpoint and label each new line as in Diagram 3.

   c. 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.

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



12. ☐ 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 Diagram 4.

13. ☐ What is the purpose of the lines you drew on the side of the box?

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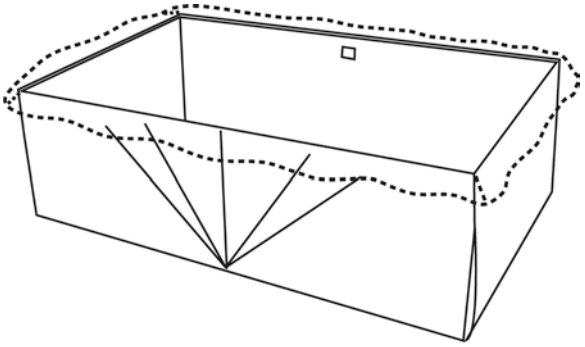
14. ☐ Cover the top of the shoebox with transparent plastic wrap and tape it in place. Be sure you do not cover the hole for the light sensor. Now it is a finished model.

➢ Diagram 3: Model greenhouse with 1 cm square light sensor hole, covered with transparent plastic wrap



15. ☐ What is the purpose of the plastic wrap?

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16. ☐ What does it mean to "transmit" light?

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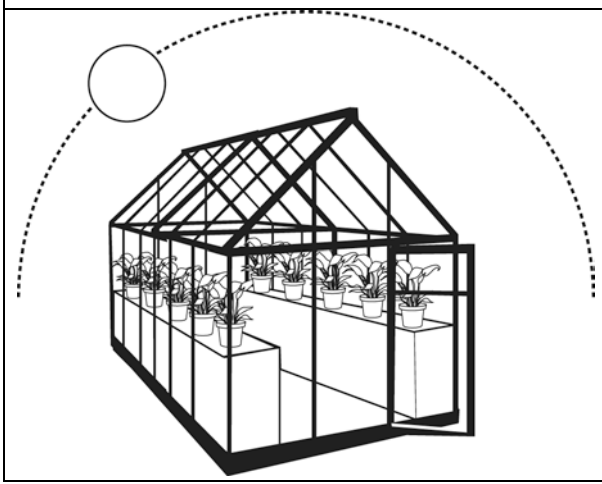
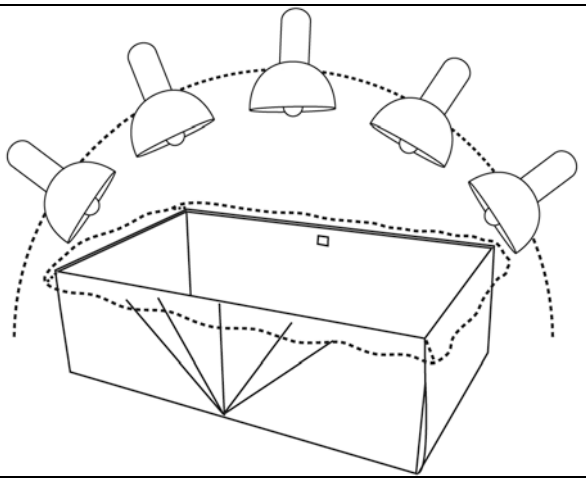
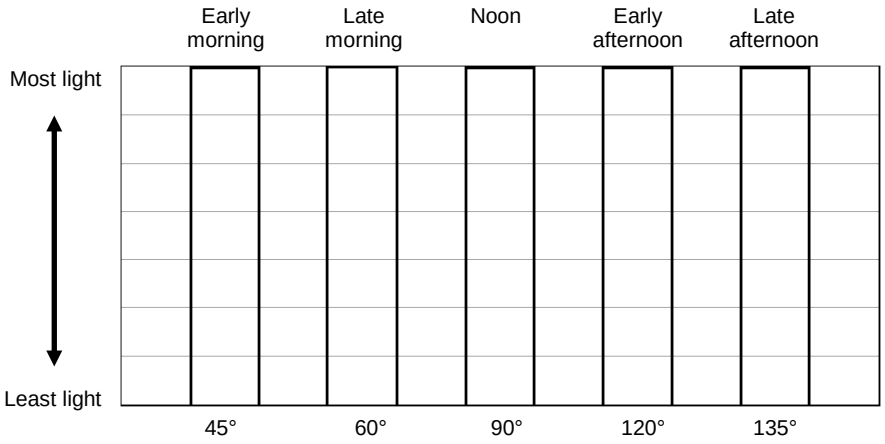
17. ☐ You will investigate light levels in your model greenhouse, using the lamp to model the sun at five different positions during the day, represented by different angles. Shown below, in Diagram 5, is a drawing of a real greenhouse and the sun. In Diagram 6 is a drawing of your model greenhouse and a lamp modeling five different positions of the sun during the day.

Remember, the sun does not actually move across the sky. As the Earth rotates, it makes it appear to us that the sun is moving.

➢ Diagram 4: Greenhouse and sun at different positions during the day	➢ Diagram 5: Greenhouse model and lamp used to model the sun in five different positions during the day
	

18. ☐ Before using the light sensor to collect data, predict how you think the sun's light intensity will change as the sun's position and angle of its light rays change during the day. Draw and shade a bar graph showing your prediction.

➢ Graph 1: Predicted light intensity for five different positions of the sun during the day



19. ☐ Now, use the data collection system to check your predictions. Push the light sensor's tip through the hole in the side of the model and point it towards the fold on the paper in the bottom of the model. One person must hold this steady throughout the experiment.

20. ☐ Now have another partner turn on the lamp and hold it above the model about 40 cm from the bottom of the model.

21. ☐ Why is it important to keep the lamp at the same distance from the bottom of the model?

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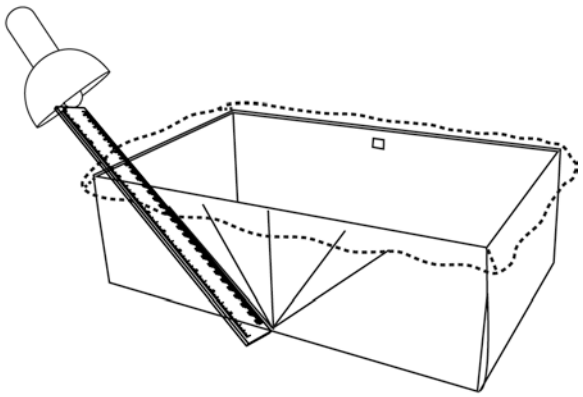
22. ☐ Use a metric ruler and the lines you made on the outside of the model to help angle the lamp so it is shining on the inside of the model at a 45° angle. The bulb should line up with the ruler.

➢ Diagram 6: Use a metric ruler to help angle the lamp and measure the distance from the lamp to the top of the box



23. ☐ Record a run of data. (6.2) Copy each light intensity measurement in the chart below.

24. ☐ Move the lamp to each of the other four modeled positions of the sun, taking care to maintain a consistent distance to the model. Record the light intensity.

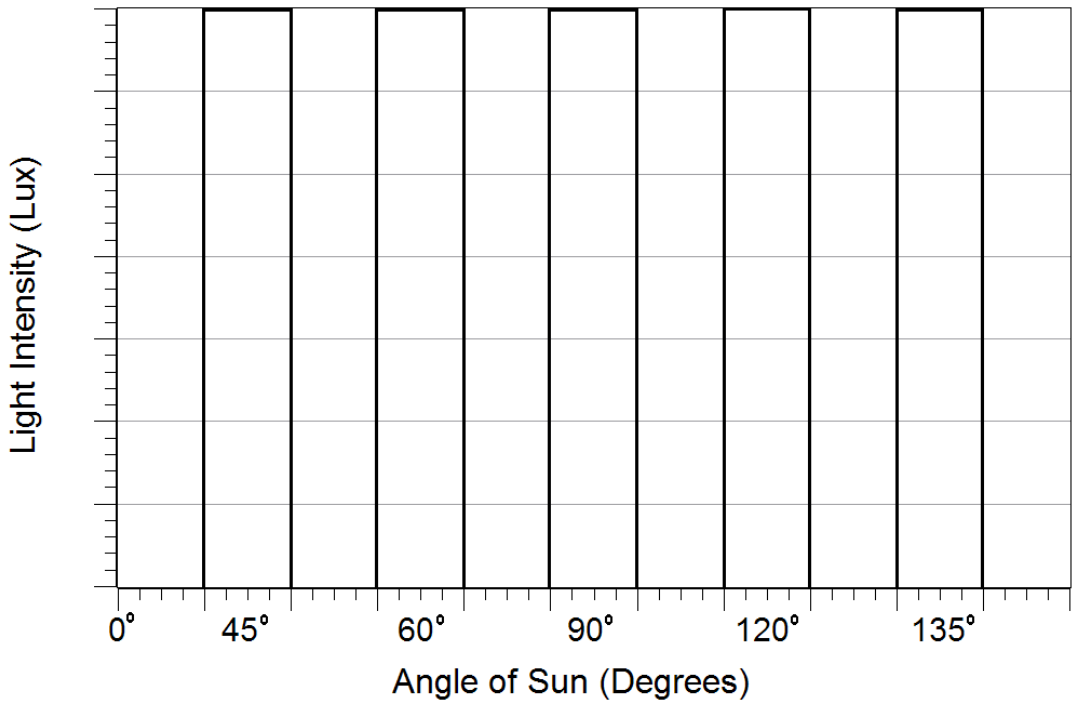
➢ Table 1: Data for modeled positions of the sun

Angle	Light Intensity in lux (lx)
45°	
60°	
90°	
120°	
135°	

25. ☐ Transfer your results from the table to the bar graph below.

➢ Graph 2: Bar graph of measured light intensities

➢ Light intensity comparison of the sun's positions during the day



26. ☐ Were your results the same as, similar to, or completely different from your predictions?

Explain It

27. ☐ Look at your bar graph and explain how the angle of the light affected the intensity of the light.

28. ☐ Compare your findings to the position of the sun during the day. When during the day could you expect sunlight to be most intense?

29. ☐ Throughout the year, the sun's path across the sky shifts in relation to the seasons. In winter, the sun's path is lower in the sky than in the summer. How would that affect the sunlight intensity?

30. ☐ You covered your box with clear plastic wrap so that light could be transmitted through the wrap and into the box. Clear plastic wrap is transparent, meaning that light can pass through the material without any change in intensity. Would the same be true of waxed paper? Explain.

31. ☐ Look up the following terms and write their definitions. Then give some examples of a material that fits each definition.

➢ Vocabulary and Definitions

Word	Definition	Examples
Transparent		
Translucent		
Opaque		

32. ☐ In your investigation of how the angle of the sun's light affects the intensity of the light as it falls on your greenhouse, you learned some new scientific ideas. These ideas have their own terms. In science it is important to be able to discuss your results using these words and terms correctly.

Write the meaning of the following terms in your own words using what you have learned from the lab.

➢ Vocabulary and Definitions

Word	Definition
Greenhouse	
Intensity	
Lux	
Diffuse	
Independent variable	
Dependent variable	
Controlled variables	

Tell Me More

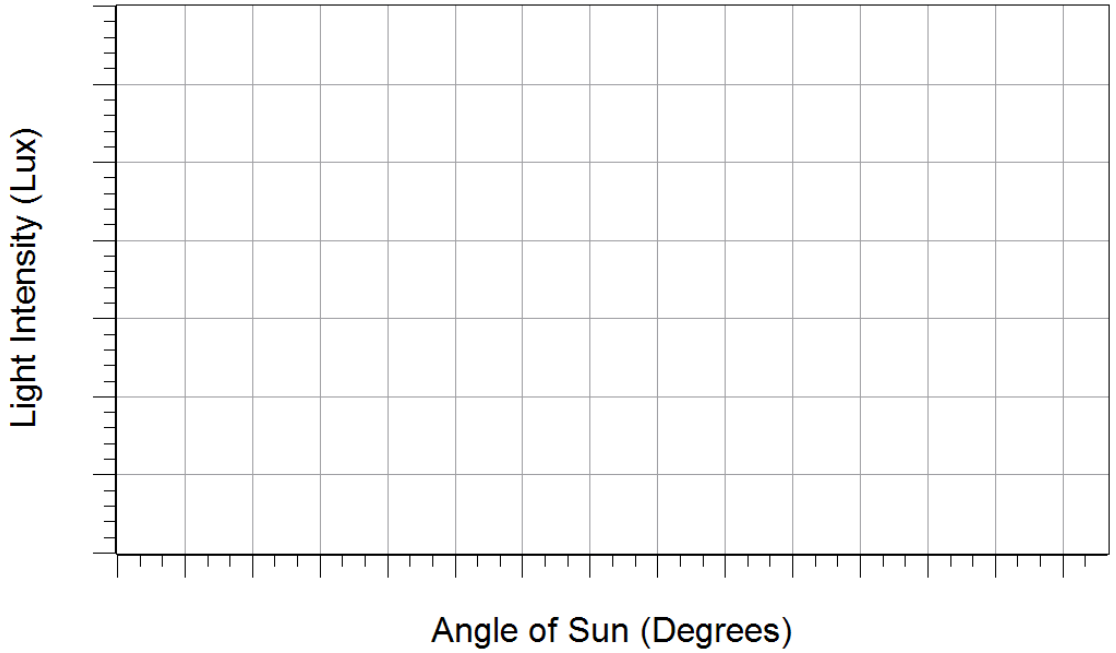
33. ☐ Let's model this data in another way. Close your previous experiment on your data collection system without saving and start a new experiment with the light sensor plugged in. (2.1)

34. ☐ Display your data in a graph. (7.1.1)

35. ☐ Turn on the lamp and place your light sensor in the hole on the side of the box.

36. ☐ Begin recording data. Starting with the lamp at about the 45° point, move the lamp slowly and smoothly across the "sky", keeping a constant distance from the box as much as possible. Stop recording data when you reach the other side. (6.2)

37. ☐ On the blank graph below, sketch the shape of your curve. This will serve as your control for the next part of this activity.



38. ☐ Plants in greenhouses grow best when the light is scattered, or diffused, throughout the greenhouse. Materials used to cover the greenhouse have different properties. Glass is transparent and allows most of the sunlight to pass through. However, this can cause plants to burn. Translucent materials work better because they scatter the light.

39. ☐ Select three translucent but not transparent materials from those supplied by your teacher. Predict the ability of these materials to transmit light. Word it in such a way that you say how each material will affect the light intensity.

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40. ☐ Test the three different materials to determine which material is best to use as a covering for your greenhouse.

    a. Cover your greenhouse with a sheet of one of the materials and tape it down.

    b. Insert the light sensor into the hole and point it towards the crease in the middle of the shoebox.

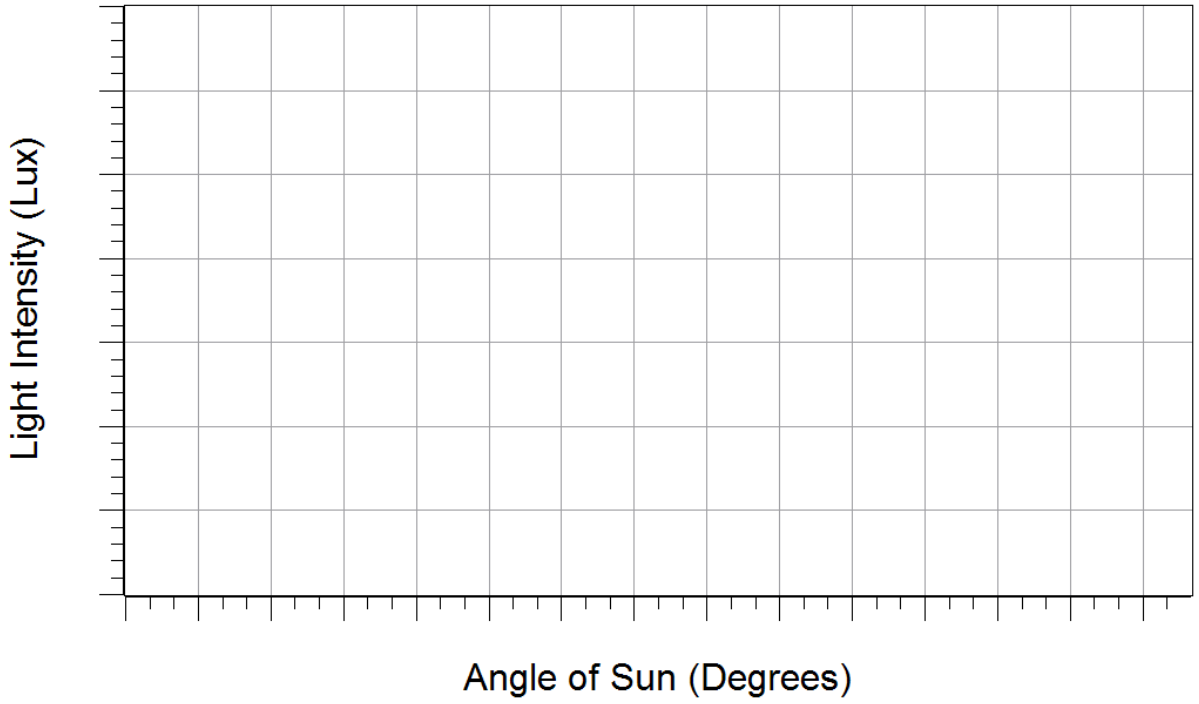
    c. Turn on the lamp.

    d. Start recording data (6.2) and move the lamp across the "sky" in the same way you did for the clear wrap covering.

    e. Stop recording data (6.2) and replace the covering material with the next choice.

    f. Repeat the test for both of the remaining coverings, making a new run of data for each covering.

41. ☐ Copy each line, including the one for the control, onto the graph below and label each line. Alternatively, print out a copy of your graph from your data collection system. (11.2)



Sum It Up

42. ☐ If a material diffuses light very well, will the light intensity be higher or lower? Would this be good for plants?

43. ☐ Looking at the graphs of these materials, compared to the graph of the effect of clear plastic wrap, how did the shapes of the lines change?

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44. ☐ Recall the driving question for the first part of this activity.

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

Rewrite the driving question to match the second part of the activity that you just completed.

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45. ☐ What is the independent variable in this second part of the activity?

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46. ☐ Write a paragraph that summarizes what you have learned from this activity that answers the driving question and includes what you learned about materials that also scatter light.

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Assessment

Multiple Choice

Darken the circle of the best answer to each of the questions below. Be prepared to give the reasons for your choices.

1. Which material below will allow almost all of the sun's light to pass through?

   Ⓐ translucent plastic

   Ⓑ transparent glass

   Ⓒ opaque white plastic

   Ⓓ translucent white paper

2. To convey across or through a barrier is to

   Ⓐ transmit

   Ⓑ transport

   Ⓒ transduct

   Ⓓ transpire

3. Another word for scattered light or light that is spread out is

   Ⓐ transmitted

   Ⓑ intensity

   Ⓒ diffused

   Ⓓ translucent

4. The intensity of light is also the _____ of the light.

   Ⓐ Amount of energy

   Ⓑ Strength

   Ⓒ Both A and B are correct

   Ⓓ None of the above

5. Light is most intense at what time of day?

   Ⓐ Early morning

   Ⓑ Late afternoon

   Ⓒ Midday

   Ⓓ Late morning