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Experiment 10

What Causes the Seasons?

Because the axis of the earth is tilted, the earth receives different amounts of solar radiation at different times of the year. The amount of solar radiation received by the earth or another planet is called *insolation*. The tilt of the axis produces the seasons. In this experiment, a simulated sun—a light bulb—will shine on a Temperature Probe attached to a globe. You will study how the tilt of the globe influences warming caused by the lighted bulb.

OBJECTIVES

In this experiment, you will

- monitor simulated warming of your city by the sun in the winter
- monitor simulated warming of your city by the sun in the summer
- interpret your results

MATERIALS

LabPro or CBL 2 interface
TI Graphing Calculator
DataMate program
Temperature Probe
ring stand and utility clamp
globe of the earth
masking tape
metric ruler
lamp with 100-watt bulb
20-cm length of string

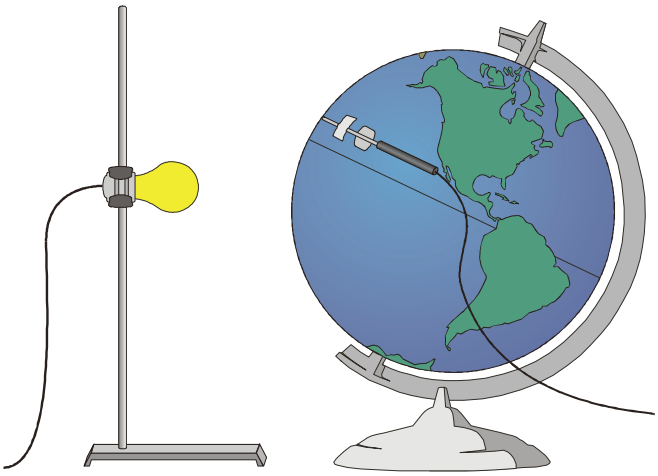

Figure 1

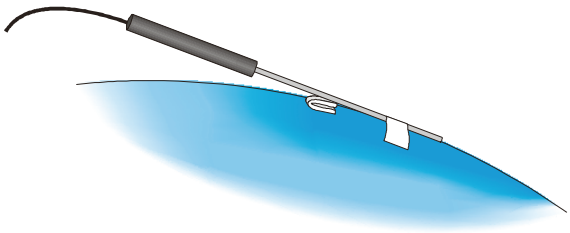

Figure 2

PROCEDURE

1. Prepare the light bulb (simulated sun).
   a. Fasten the lamp to a ring stand as shown in Figure 1.
   b. Stand the ring stand and lamp in the center of your work area.
   c. Position the globe with the North Pole tilted away from the lamp as shown in Figure 1.
   d. Position the bulb at the same height as the Tropic of Capricorn. Note: The sun is directly over the Tropic of Capricorn on December 21, the first day of winter.

2. Attach the Temperature Probe to the globe.
   a. Find your city or location on the globe.
   b. Tape the Temperature Probe to the globe with the tip of the probe at your location. Place the tape about 1 cm from the tip of the probe.
   c. Fold a piece of paper and wedge it under the Temperature Probe to keep the tip of the Temperature Probe in contact with the surface of the globe as shown in Figure 2.

3. Position the globe for winter (in the Northern Hemisphere) data collection.
   a. Turn the globe to position the North Pole (still tilting away from the lamp), your location, and the bulb in a straight line.
   b. Cut a piece of string 20-cm long.
   c. Use the string to position your location on the globe 20 cm from the bulb.
   d. Do not turn on the lamp until directed in Step 8.

4. Plug the Temperature Probe into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

5. Turn on the calculator and start the DATAMATE program. Press [CLEAR] to reset the program.

6. Set up the calculator and interface for the Temperature Probe.
   a. Select SETUP from the main screen.
   b. If the calculator displays the correct Temperature Probe in CH 1, proceed directly to Step 7. If it does not, continue with this step to set up your sensor manually.
   c. Press [ENTER] to select CH 1.
   d. Select TEMPERATURE from the SELECT SENSOR menu.
   e. Select the correct Temperature Probe (in °C) from the TEMPERATURE menu.

7. Set up the calculator and interface for data collection.
   a. Use [▲] and [▼] to select MODE and press [ENTER].
   b. Select TIME GRAPH from the SELECT MODE menu.
   c. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
   d. Enter "15" as the time between samples in seconds.
   e. Enter "20" as the number of samples. Data collection will last 300 seconds (5 minutes).
   f. Select OK to return to the setup screen.
   g. Select OK again to return to the main screen.

8. Collect winter data.
   a. Select START to begin data collection.
   b. After the interface has been beeped and the first temperature reading has been taken, turn on the lamp.
   c. When data collection stops after 300 seconds, turn the lamp off.

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9. Record the beginning and final temperatures.
   a. When data collection is complete after 300 seconds, a graph of temperature *vs*. time will be displayed. Use ▶ to examine data points along the curve. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed below the graph.
   b. Record the beginning and final temperatures (to the nearest 0.1°C).
   c. Press ENTER to return to the main screen.

10. Position the globe for summer data collection.
   a. Move the globe to the opposite side of the lamp.
   b. Position the globe with the North Pole tilted toward the lamp. Note: This represents the position of the Northern Hemisphere on June 21, the first day of summer.
   c. Turn the globe to position the North Pole, your location, and the bulb in a straight line.
   d. Use the string to position your location on the globe 20 cm from the bulb.
   e. Do not turn on the lamp until directed in Step 11.

11. Collect summer data.
   a. Let the globe and probe cool to the beginning temperature that you recorded in Step 9.
   b. When the globe and probe have cooled, select START to begin data collection.
   c. After the interface has beeped and the first temperature reading has been taken, turn on the lamp.
   d. When data collection stops after 300 seconds, turn the lamp off.

12. Record the beginning and final summer temperatures using the Step 9 procedure.

DATA

	Winter	Summer
Final temperature	°C	°C
Beginning temperature	°C	°C
Temperature change	°C	°C

PROCESSING THE DATA

1. In the space provided in the Data table, subtract to find the temperature change for each season.

2. How does the temperature change for summer compare to the temperature change for winter?

3. During which season is the sunlight more direct? Explain.

4. What would happen to the temperature changes if the earth were more tilted than 23.5 degrees?

5. As you move the globe from its winter position to its summer position, the part of the globe closest to the bulb changes. Describe how it changes.

6. What other factors affect the weather in a region?

EXTENSION

1. Repeat the experiment for other locations in the Northern and Southern Hemispheres.

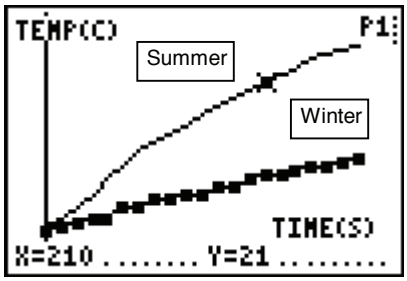
TEACHER INFORMATION

What Causes the Seasons?

1. If you use globes with adjustable tilt, make sure the tilt is 23.5 degrees.
2. You may wish to use a fan to cool the globe and probe between runs.
3. If you have 150-watt bulbs available, you may wish to use them to obtain larger temperature changes.
4. Longer data-collection periods can be used.
5. Encourage your students to collect data for other cities and locations as suggested in the extension.
6. The following procedure can be used to display graphs of 2 (or 3) successive runs, like the graph shown in the Sample Results below:
   a. After the first run, select TOOLS on the main screen.
   b. Select STORE LATEST RUN. This stores the latest run in L3 (and moves the old L3 to L4).
   c. Collect data for another run, then return to the main screen.
   d. Select GRAPH to display the graph again, then press ENTER.
   e. Select MORE on the graph screen.
   f. Select L2 AND L3 VS L1 (L2, L3 AND L4 VS L1) on the more graphs screen.

SAMPLE RESULTS

	Winter	Summer
Final temperature	19.4°C	21.8°C
Beginning temperature	17.8°C	17.9°C
Temperature change	1.6°C	3.9°C



What Causes the Seasons?

ANSWERS TO QUESTIONS

1. See the Sample Results above.

2. Answers will vary. In the Sample Results above, the summer temperature change is 2.3°C greater than the winter temperature change.

3. In the Northern Hemisphere, the sunlight is more direct in the summer because the earth is tipped toward the sun. A greater amount of solar radiation is directed at a smaller area.

4. If the earth were tilted at a greater angle, summers would be warmer and winters would be colder.

5. When the globe is rotated from its winter position to its summer position, the lamp goes from a position directly above the Tropic of Capricorn in the Southern Hemisphere to a position directly above the Tropic of Cancer in the Northern Hemisphere.

6. Other factors that affect weather in an area include proximity to water, movement of air masses, and geographic features.