

# 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

TI-83 Plus or TI-84 Plus graphing calculator  
EasyData application  
EasyTemp **or**  
Temperature Probe and data-collection interface  
ring stand and utility clamp

globe of the earth  
masking tape  
metric ruler  
lamp with 100 watt bulb  
20 cm length of string

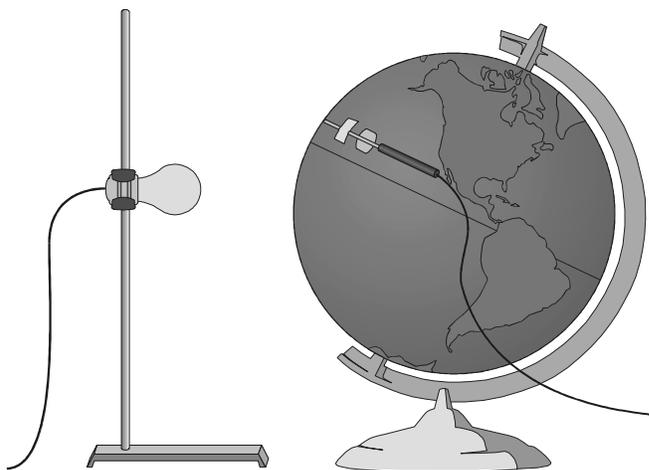


Figure 1

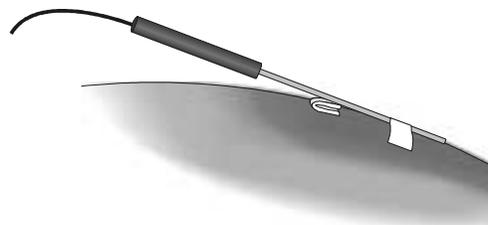


Figure 2

## 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. Turn on the calculator. Connect the Temperature Probe to the calculator. (This may require the use of a data-collection interface.)
5. Set up EasyData for data collection.
  - a. Start the EasyData application, if it is not already running.
  - b. Select **(File)** from the Main screen, and then select **New** to reset the application.
  - c. Select **(Setup)** from the Main screen, then select **Time Graph...**
  - d. Select **(Edit)** on the Time Graph Settings screen.
  - e. Enter **15** as the time between samples in seconds.
  - f. Select **(Next)**.
  - g. Enter **20** as the number of samples and select **(Next)**. Data collection will last 300 seconds.
  - h. Select **(OK)** to return to the Main screen.
6. Collect winter data.
  - a. Select **(Start)** to begin data collection and then turn on the lamp.
  - b. When data collection stops, turn the lamp off.
7. Record the beginning and final temperatures.
  - a. When data collection is complete, a graph of temperature vs. time will be displayed. Use **(D)** and **(L)** 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 above the graph.
  - b. Record the beginning and final temperatures (to the nearest 0.1°C).
  - c. Select **(Main)** to return to the Main screen.
8. 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 9.

9. Collect summer data.
  - a. Let the globe and probe cool to the beginning temperature that you recorded in Step 7.
  - b. When the globe and probe have cooled, select **(Start)**, then select **(OK)** to overwrite the latest run and start data collection.
  - c. Turn on the lamp.
  - d. When data collection stops after 300 seconds, turn the lamp off.
10. Record the beginning and final summer temperatures using the Step 7 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?

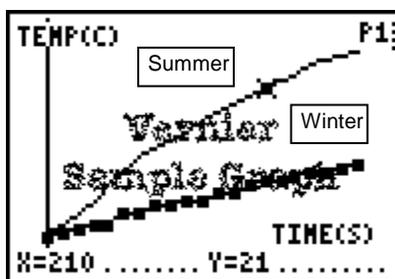
1. There are several different combinations of equipment that will work for collecting temperature data. The most common method, which uses the USB port on a TI-84 Plus calculator, is to collect data with an EasyTemp or with a Temperature Probe connected to an EasyLink. For more information on EasyTemp and EasyLink refer to Appendix A.

The other method, which works for both the TI-83 Plus and TI-84 Plus families of calculators, is to use a Temperature Probe attached to a LabPro or CBL 2.

2. If you use globes with adjustable tilt, make sure the tilt is 23.5 degrees.
3. You may wish to use a fan to cool the globe and probe between runs.
4. If you have 150 W bulbs, you may wish to use them to obtain larger temperature changes.
5. Longer data-collection periods can be used.
6. Encourage your students to collect data for other cities and locations as suggested in the extension.
7. 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  $\overline{\text{File}}$  from the Main screen, and then select **Store Run**.
  - b. Select  $\overline{\text{OK}}$  to store your latest data and overwrite the data in Lists 3 and 4 (L3 and L4).
  - c. Collect data for another run. **Note:** Do not save your last run.
  - d. From the Graph screen, select  $\overline{\text{Adv}}$  and then select **L2 and L3 vs L1** (or **L2, L3 and L4 vs L1** if you have 3 runs).

## SAMPLE RESULTS

	Winter	Summer
Final temperature	xxxx	xxxx
Beginning temperature	xxxx	xxxx
Temperature change	xxxx	xxxx



*What Causes the Seasons?*

*Experiment 10*

**ANSWERS TO QUESTIONS**

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.