

# Seasons and Angle of Insolation

Have you ever wondered why temperatures are cooler in the winter and warmer in the summer? This happens because the Earth's axis is tilted. The Earth remains tilted as it revolves around the sun. Because of this tilt, different locations on the Earth receive 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 *angle of insolation* is the angle at which the sun's rays strike a particular location on Earth. When the north end of the Earth's axis points toward the sun, the Northern Hemisphere experiences summer. At the same time, the south end of the axis points away from the sun and the Southern Hemisphere experiences winter.

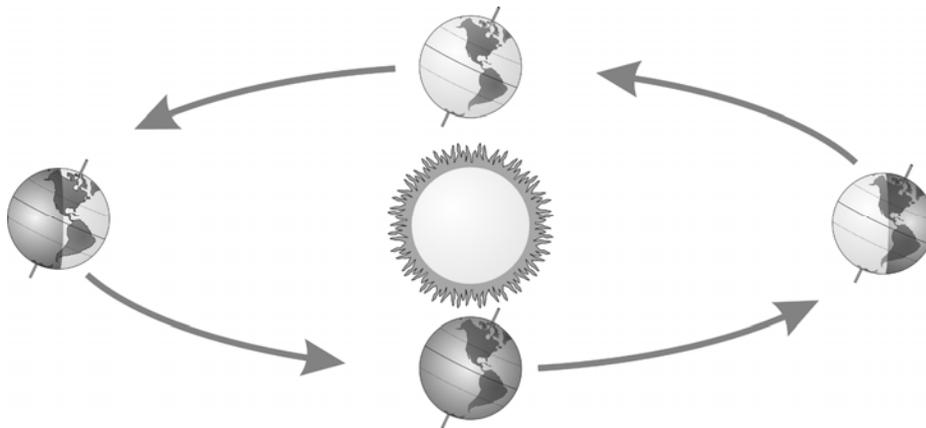


Figure 1

In this experiment you will investigate the relationship between angle of insolation and temperature change due to energy absorption from a simulated sun—a light bulb.

## OBJECTIVES

In this experiment, you will

- Use a Temperature Probe to monitor simulated warming of your city by the sun in the winter.
- Use a Temperature Probe monitor simulated warming of your city by the sun in the summer.
- Measure the angle of insolation.
- Determine the relationship between temperature change and angle of insolation.

## MATERIALS

TI-Nspire handheld **or**  
 computer and TI-Nspire software  
 EasyTemp **or** Go!Temp **or**  
 Temperature Probe and data-collection interface  
 ring stand  
 globe of the Earth

lamp with clear 150 watt bulb  
 tape  
 ruler  
 two 20 cm lengths of string  
 protractor  
 utility clamp

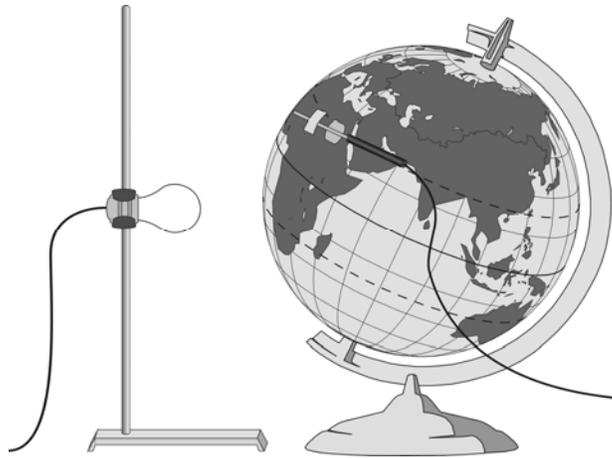
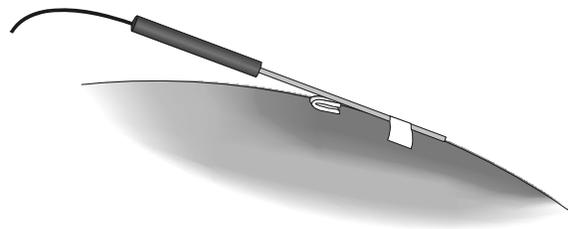


Figure 2

## PROCEDURE

1. Set up the light bulb (simulated sun).
  - a. Fasten the lamp to a ring stand as shown in Figure 2.
  - b. Stand the ring stand and lamp to the left side of your work area.
  - c. Position the globe with the North Pole tilted away from the lamp as shown in Figure 2. Position the bulb at approximately 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. Tape the probe parallel to the equator. 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 it in contact with the surface of the globe as shown in Figure 3.
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. Tape the globe in this position so that it does not rotate.
  - b. Measure the vertical distance from the Tropic of Capricorn to the table. Position the bulb so that its center is the same height from the table.
  - c. Obtain a piece of string 20 cm long.
  - d. Use the string to position your location on the globe 20 cm from the center of the end of the bulb.
  - e. Do not turn on the lamp until directed in Step 7.



Figure

4. Measure the angle of insolation.
  - a. Tape the 20 cm string from your location on the globe to the center of the end of the bulb.
  - b. Tape another piece of string from the Tropic of Capricorn to the center of the end of the bulb. This string should be taut and parallel to the table. Use only as much of the string as needed.
  - c. Use a protractor to measure the angle between the strings. Record the angle in the data table.
  - d. Remove the tape and string from the bulb and globe.
5. Connect the Temperature Probe to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer. (If you are using an EasyTemp or Go!Temp, you do not need a data-collection interface.)
6. Choose New Experiment from the  Experiment menu. Choose Collection Setup from the  Experiment menu. Enter **0.1** as rate (samples/second) and **300** as the experiment duration in seconds. The number of points collected should be 31. Select OK.
7. Collect winter data.
  - a. Record the temperature displayed on the screen, then start data collection ().
  - b. After the first temperature reading has been taken, turn on the lamp.
  - c. When data collection stops after 5 minutes, turn the lamp off.  
**Caution:** Do not touch the bulb. It will be very hot.
8. Determine and record the minimum and maximum temperatures.
  - a. Choose Statistics from the  Analyze menu.
  - b. Record the minimum and maximum temperature readings (round to the nearest 0.1°C).
9. Click the Store Latest Data Set button () to store the data.
10. Position the globe for summer data collection.
  - a. Rotate the entire globe setup so that North Pole is tilted toward the lamp. **Note:** This represents the position of the Northern Hemisphere on June 21, the first day of summer.
  - b. Turn the globe to position the North Pole, your location, and the bulb in a straight line.
  - 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 12.
11. Measure the angle of insolation.
  - a. Tape the 20 cm string from your location on the globe to the center of the end of the bulb.  
**Caution:** The bulb can be very hot. Allow the bulb to cool before touching it.
  - b. Tape another piece of string from the Tropic of Cancer to the center of the end of the bulb. This string should be taut and parallel to the table.
  - c. Use a protractor to measure the angle between the strings. Record the angle.
  - d. Remove the tape and string from the bulb and globe.
12. Collect summer data.
  - a. Click the Meter View tab () and let the globe and probe cool to the temperature that you recorded in Step 7. Then start data collection ().
  - b. After the first temperature reading has been taken, turn on the lamp.

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- c. When data collection stops after 5 minutes, turn the lamp off.
13. Determine and record the minimum and maximum temperatures.
  - a. Choose Statistics from the **AN** Analyze menu.
  - b. Record the minimum and maximum temperature readings (round to the nearest 0.1°C).
14. To display a graph of both runs, click **run2** and select All.
15. Sketch or print copies of the graph as directed by your instructor.

### DATA

Beginning temperature (°C)		
	Winter	Summer
Maximum temperature (°C)		
Minimum temperature (°C)		
Temperature change (°C)		
Angle of Insolation (°)		

### PROCESSING THE DATA

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

### QUESTIONS

1. How does the temperature change for summer compare to the temperature change for winter?
2. During which season is the sunlight more direct? Explain.
3. What would happen to the temperature changes if the Earth were tilted more than 23.5 degrees?
4. What relationship is there between angle of insolation and temperature change?
5. Draw a picture showing the setup you would use to measure the change in temperature in the Southern Hemisphere during their winter.
6. What other factors affect the weather in a region?

### EXTENSIONS

1. Repeat the experiment for other locations in the Northern and Southern Hemispheres.
2. Compare the temperature changes at various latitudes and determine the relationship between latitude and temperature change.