Soil Temperature

How do flowers and other plants know when to start growing in the spring? How do farmers know when it is safe to plant their crops? Soil temperature plays an important role in both of these decisions. Each spring, soil is heated from above by warmer air and by solar radiation. Once the soil reaches a certain temperature, it is time to plant and grow.

Soil temperature changes more slowly than the air temperature, so there is always a lag time between the extremes of air temperatures and soil temperatures. Because of daily temperature fluctuations, the soil could be cooler than the air in the daytime and warmer than the air in the nighttime.

Soil temperatures also change with depth. The deeper the soil, the more constant the temperature will be. Because of this, when referring to soil temperatures, the depth at which the measurements were taken is also important. Figure 1 shows the average soil temperatures across the United States at a depth of 4 inches. This is the depth used by the U.S. Department of Agriculture (USDA) and the National Oceanographic and Atmospheric Administration (NOAA) in their *Weekly Weather and Crop Bulletin*. This particular figure shows data from April 2002. If you look carefully, you can see the isotherms indicating the regions where various crops such as wheat and corn can develop.

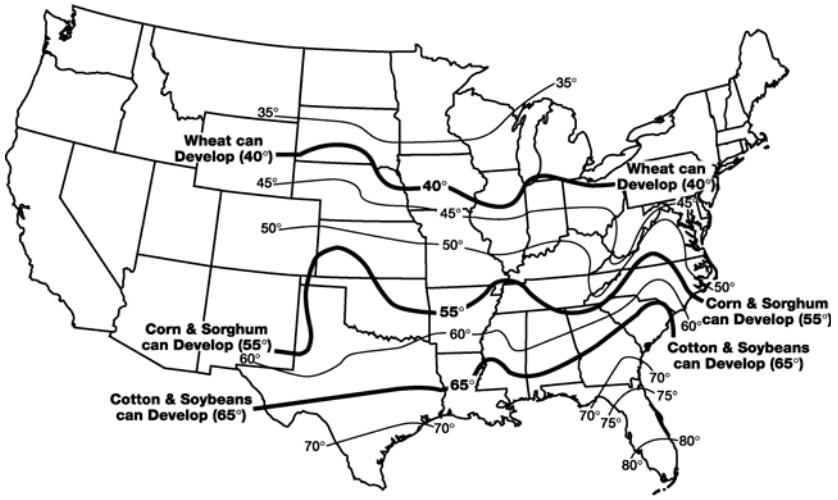

Figure 1: Soil temperatures at a depth of four inches.

In this experiment, you will use Temperature Probes to monitor the soil temperature at three different depths. A lamp and a bowl of ice will be used to simulate day and night over a two-day period. You will observe how soil temperatures vary at different depths and the timing of these variations.

OBJECTIVES

In this experiment, you will

- Simulate temperature changes over a two-day period.
- Use Temperature Probes to measure the temperature of soils at different depths.
- Explain your results.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
3 Temperature Probes
tape
plastic milk jug containing soil
bowl
lamp
ruler
ice
watch with a second hand

PROCEDURE

1. Connect the three Temperature Probes to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.

2. Choose New Experiment from the Experiment menu. Choose Collection Setup from the Experiment menu. Using the pull down menu, change the sample Rate (samples/second) to Interval (seconds/sample). Enter **30** as the time between samples in seconds and **2400** as the experiment length in seconds (40 minutes). **Note:** the number of points should be 81. Choose the Data Marker option and select OK.

3. A plastic milk jug has already been prepared with soil. On one side, you should find three small holes, at 1 cm, 3 cm, and 7 cm below the soil surface.
   a. Insert Probe 1 (the Probe in Channel 1) into the hole that is 1 cm below the soil surface. Push the probe in far enough so that the tip of the probe is in the center of the jug.
   b. Insert Probe 2 the same distance into the hole that is 3 cm below the soil surface.
   c. Insert Probe 3 the same distance into the hole that is 7 cm below the soil surface.

4. The Temperature Probes must be parallel to the tabletop during data collection. Secure them in this position by taping them to a ruler, as shown in Figure 2.

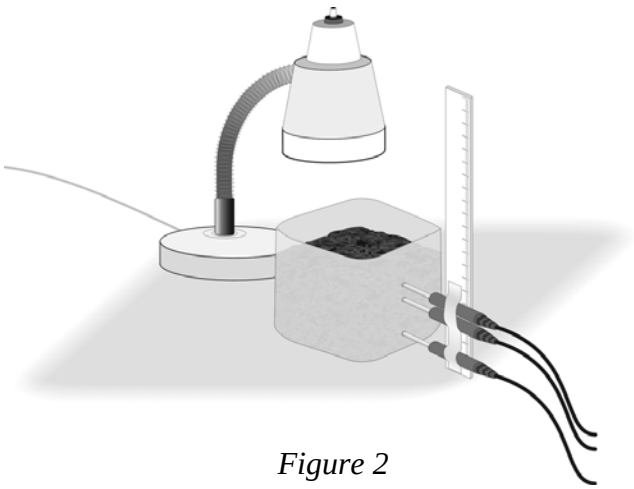

Figure 2

5. Position the lamp so that the bulb is between 5 and 10 cm from the soil surface. Do not turn it on yet. Once it is in position, move it slightly off to the side to make room for the bowl of ice to be placed on the soil. Later, when you are instructed to turn on the lamp, move it back over the soil.

6. Fill the bowl with ice.

7. When everything is ready, place the bowl of ice on the surface of the soil as shown in Figure 3, and start data collection ( ). Immediately record the time displayed on your watch.

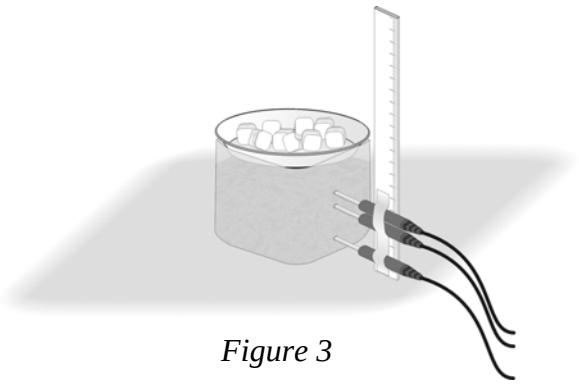

Figure 3

8. Once every five minutes, you will need to make a change to the setup. These changes will simulate the temperature changes over a two-day period. Calculate the times that will be displayed on your watch when you will be making changes. Record these times in the table below. Watch the time displayed on your watch and use the chart below to make your changes. When you make a change, click the Add Data Marker button ( ) to mark when you made the change.

Time (minutes)	Time on Watch	Change to Setup	Time of Day (simulated)
0		Place bowl of ice on soil	Nighttime
5		Remove ice and position lamp above soil (do not turn lamp on)	Morning
10		Turn on lamp	Daytime
15		Turn off lamp and move it aside	Evening
20		Place bowl of ice on soil	Nighttime
25		Remove ice and position lamp above soil (do not turn lamp on)	Morning
30		Turn on lamp	Daytime
35		Turn off lamp and move it aside	Evening
40		Data collection will stop	

9. Data collection will stop after 40 minutes.

10. Label the marked points.
    a. The Data Marked points will be highlighted in the graph with a large point icon. There will be one point on each of the temperature graphs for each time you marked. Double-click on one of the marked points at 5 minutes (300 s), and label it **Morning**, then select OK. This will label all of the points marked at 5 minutes.
    b. Repeat Step 10a for one of the marked points at 10 minutes (600 s). Label this point **Daytime**.
    c. Repeat Step 10b for the other marked points labeling them as described in the Time of Day column in the table above.
    d. The point label is displayed in the Graph View Details box to the right of the graph.

11. Analyze your data to determine the temperature changes.
    a. After data collection is complete, choose Statistics ► Run 1.Temperature from the Analyze menu. The statistics for Probe 1 will be displayed.
    b. Record the minimum and maximum temperatures.
    c. Repeat this process, choosing Run 1.Temperature2 and Run 1.Temperature3, to the get the statistics for Probes 2 and 3.
    d. Subtract to find the change in temperature for each sensor and record the results.

12. Print or sketch your graph according to your instructor's directions.

DATA

	1 cm depth	3 cm depth	7 cm depth
Maximum temperature (°C)			
Minimum temperature (°C)			
Change in temperature (°C)			

QUESTIONS

1. Study your graph. Describe the shapes of the three lines. Refer to the lines as the 1 cm line, the 3 cm line, and the 7 cm line, indicating their depth beneath the soil surface.

2. Propose an explanation for why the three lines have different shapes.

3. Study the timing of the temperature changes.
   a. Did the rising and falling temperatures reach their peaks and valleys at the same time?
   b. How long after the light was turned off did the 1 cm line reach its first temperature peak?
   c. How long after the 1 cm line reached its first peak did the 3 cm line reach its first peak?

4. Propose an explanation for your answers to Question 3.

EXTENSIONS

1. Move the experiment outside and measure temperatures over longer periods of time. Describe how the results compare to the simulated exercise in class.

2. Explain how a blanket of snow could actually protect plants in the soil from freezing.