Activity B18: Insulating Properties of Water and Soil (Temperature Sensor)

Concept	*DataStudio*	*ScienceWorkshop* (Mac)	*ScienceWorkshop* (Win)
Environment	B18 Insulation	B11 Insulation Properties	B11_SOIL.SWS

Equipment Needed	Qty	Insulation material	------
Temperature Sensor (CI-6505A)	2	Protective gear	PS
Base and Support Rod (ME-9355)	1	**Chemicals and Consumables**	**Qty**
Clamp, Buret (SE-9446)	2	Ice, crushed	500 mL
Beaker, 1 L	2	Soil	1 L
Freezer	1	Tape	1 roll
Heat Lamp	1	Water	1 L

What Do You Think?

Which substance is a better "insulator", water or soil? In other words, which substance would let thermal energy move through it the quickest?

Take time to write answers to these questions in the Lab Report section.

Background

Have you ever been to the beach on a hot day? Did the sand burn your bare feet? Did the water seem much cooler than the sand?

One way that temperature changes is by a process called *convection*. Convection is defined as the transfer of heat by movement of a gas or liquid. For example, cold water is denser (maximum density at 4 ˚C) and sinks while warm water is less dense and rises. So water forms a circular convection current with the cool water sinking and warm water rising.
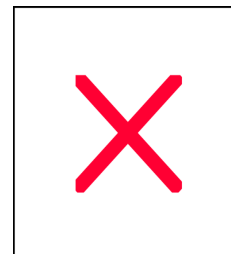
Another way that temperature changes is by a process called *conduction*. Conduction is defined as the transfer of heat through *direct* contact of one molecule with the next.

Heat transfer occurs when thermal energy moves through a substance. A good insulator has a slow heat transfer rate. A poor insulator has a fast heat transfer rate. The rate of heat transfer for a substance depends on many factors such as what it is made of or whether it is densely packed or loosely packed.

SAFETY REMINDER	
• Follow all safety instructions.	

For You To Do

Use Temperature Sensors to measure the temperature at two different depths in water and in soil. Use *DataStudio* or *ScienceWorkshop* to record and display the data.

Start with both the water and the soil at a cold temperature, and then expose the samples to a heat source (the lamp) for equal amounts of time. Compare the change in temperature in the water to the change in temperature in the soil.

Will the lamp need to be the same height above the water sample as it is above the soil sample? Why or why not?

Pre-Lab

Prepare the soil sample.

1.   Put some soil in a beaker. (Hint: Fill the beaker about half full.)

**Do you need to record the amount of soil you put into the beaker?**

2.   Set up the Channel A Temperature Sensor so the tip of the sensor is 2 cm below the surface of the soil.

3.   Set up the Channel B Sensor in the same manner, but position it so the tip is 5 cm below the surface of the soil. Make sure the tip does not touch the bottom.

   Hint: Place tape on the sensors at 2 cm and 5 cm from the tip. The marks will tell you when the sensors are at the correct depth.

4.   Put the beaker in a freezer overnight.

PART I: Computer Setup

1.   Connect the interface to the computer, turn on the interface, and turn on the computer.

2.   Connect one Temperature Sensor to Analog Channel A and the other to Analog Channel B on the interface.
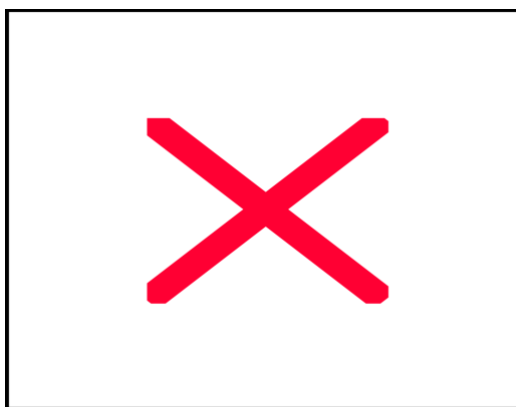
3.   Open the file titled as shown:

DataStudio	*ScienceWorkshop* (Mac)	*ScienceWorkshop* (Win)
B18 Insulation.DS	B11 Insulation Properties	B11_SOIL.SWS

•   The *DataStudio* file has a Workbook display. Read the instructions in the Workbook.

•   The *ScienceWorkshop* file has Digits displays and a Graph display.

•   Data recording is set at one measurement per 60 seconds and a 'Stop Condition' at 30,000 seconds (8.3 hours).

PART II: Sensor Calibration and Equipment Setup

> **You do not need to calibrate the Temperature Sensors.**

Equipment Setup A: Insulating Properties of Soil

1. Retrieve the beaker of soil from the freezer. Put insulating material around the beaker.

2. Use clamps and a support rod to hold the two Temperature Sensors in place.

3. Place a heat lamp above the soil so the lamp is 10 cm above the soil.

> **Should you measure the exact distance between the soil and the lamp?**

**PART IIIA. Data Recording: Insulating Properties of Soil**

1. Start recording data.

2. Leave overnight. Data recording will automatically stop after 30,000 seconds (8.3) hours.

Equipment Setup B: Insulation Properties of Water

1. Fill a beaker half full with water. Put insulating material around the beaker.

> **Should you use the same size of beaker as you used for the soil? Should you fill this beaker to the same level as the level of the soil in the first part?**

2. Use a clamp and support rod to set up the Channel A Temperature Sensor so the tip of the sensor is 2 cm below the surface of the water. Make sure the tip does not touch the beaker.

3. Set up the Channel B Sensor in the same manner, but position its tip 5 cm below the surface of the water. Make sure the tip does not touch the bottom.

**PART IIIB: Data Recording - Insulation Properties of Water**

1. *Gently* place crushed ice on the surface of the water. DO NOT drop the ice in the beaker. The ice should remain on the surface, not travel to the bottom and then float back up. Note the time when you placed the ice on the surface.

2. Start recording data.

•   Note: Data recording is preset to last for 30,000 seconds.

3. Place a heat lamp above the water so the lamp is 10 cm above the surface.

4. Leave overnight. Data recording will automatically stop after 30,000 seconds (8.3 hours).
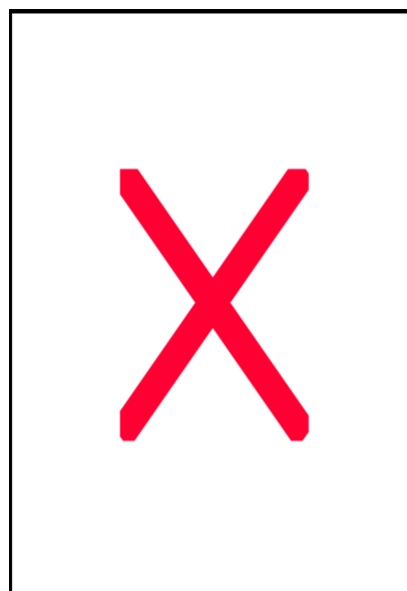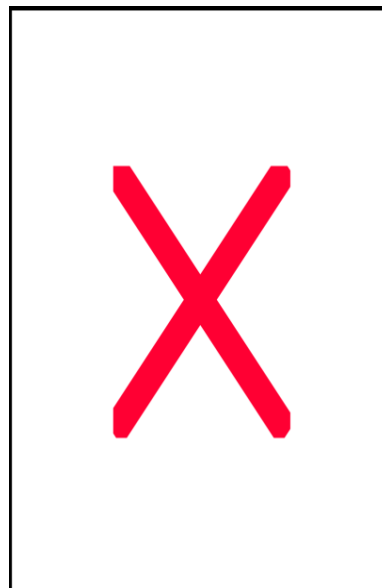
Analyzing the Data

1. Set up your Graph display so it shows your temperature data for the temperature change in the water.

2. Use the displays to find the maximum temperature of the water for the sensor near the surface and for the sensor near the bottom of the beaker. Record the time that matches the maximum temperature for each sensor.

    Hint: In the Graph display, use the Smart Tool in *DataStudio* or the Smart Cursor in *ScienceWorkshop*.
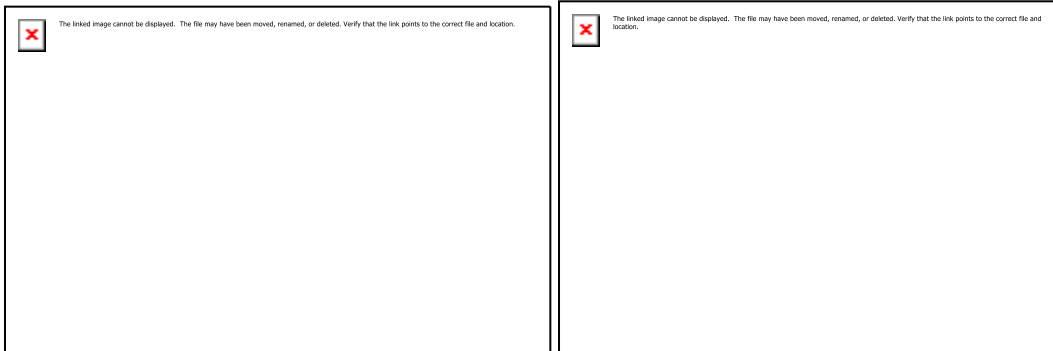
3. Next, set up your display so it shows the temperature data for the temperature change in the soil.

4. Use the displays to find the maximum temperature of the soil for the two sensors. Record the time that matches the maximum temperature for each sensor.

    Record your results in the Lab Report Section

Lab Report - Activity B18: Insulating Properties of Water and Soil

What Do You Think?

Which substance is a better "insulator", water or soil? In other words, which substance would let thermal energy move through it the quickest?

Data Table

Item	Water Channel A	Water Channel B	Soil Channel A	Soil Channel B
Minimum temperature	˚C	˚C	˚C	˚C
Maximum temperature	˚C	˚C	˚C	˚C
Time to maximum temperature	hr	hr	hr	hr

Questions

1. Using the graphs, describe the temperature changes for both beakers? Were the changes gradual or quick? How long did it take for significant temperature changes to take place?

Insulation Properties of Water

2. Was there a temperature difference between the two sensors? Why? Use the concept of convection to explain.

3. Ice is less dense than water. How does this fact benefit the aquatic life that lives in lakes and ponds?

Insulating Properties of Soil

4.   Were there temperature differences between the two sensors?

5.   Which took longer to warm up when placed under a lamp: the ice water or the frozen soil? Why?

6.   Does the density of soil affect the rate of temperature change? Form a hypothesis? How would you test it?

7.   Why do you burn your hand if pick a hot pot, but do not if you use a pot holder? Explain in terms of conduction.