EXPLORATIONS

Activity 10

Collecting Solar Rays

Objectives

- To understand which surfaces make the best solar collectors
- To understand the difference between absorption and reflection

Materials

- TI-73
- Unit-to-unit cable
- CBL 2™
- Three temperature sensors
- Three soda cans, spray painted black, white, and silver
- Putty or clay
- Heat source (heat lamp or sun)
- Data Collection and Analysis pages (p. 88 - 91)

In this activity you will

- Make three solar collectors — black, white, and silver — and test them using either a heat lamp or the sun as an energy source.
- Use the CBL 2™ with temperature sensors to test which solar collector absorbs the most heat.

Problem

Which surface color will make the best solar collector?

Introduction

Radiation from our sun heats and lights the earth. A good absorber reflects very little radiant energy. A solar collector traps radiant energy from the sun or any other energy source. This energy can be used to power appliances or to heat a home.

Hypothesis

Before testing, complete the **Hypothesis** and **Experimental Design** sections on the **Data Collection and Analysis** page.

Procedure: Collecting the Data

1. Collect the three soda cans, painted black, white, and silver.
2. Plug the three temperature sensors into Channel 1 (**CH 1**), Channel 2 (**CH 2**), and Channel 3 (**CH 3**) on the CBL 2.

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3. Start the DATAMATE program.
4. The Main Screen is displayed. If **CH 1:TEMP(C)**, **CH 2:TEMP(C)**, and **CH 3:TEMP(C)** are displayed at the top of the screen, go to step 9. If **CH 1:TEMP(C)**, **CH 2:TEMP(C)**, and **CH 3:TEMP(C)** are not displayed, go to step 5.
5. Select **1:SETUP**.
6. Select **CH1:**, **CH2:**, or **CH3:**, as necessary. Select **1:TEMPERATURE**.
7. If you are using the TI stainless steel temperature sensor, select **4:STAINLESS TEMP(C)**. If you are using a different temperature sensor, select the appropriate item from the menu.

   Note*: The flexible TI temperature sensor is the same as the TI stainless steel temperature sensor.*
8. Repeat steps 6 and 7 until all three channels are correct. Then select **1:OK** to return to the Main Screen.
9. Select **1:SETUP**. Select **MODE**, and then select **2:TIME GRAPH**.
10. The **TIME GRAPH SETTINGS** are displayed. If the screen shows **TIME INTERVAL: 30**, **NUMBER OF SAMPLES: 20**, and **EXPERIMENT LENGTH: 600**, go to step 12. If the settings are not correct, go to step 11.
11. Select **2:CHANGE TIME SETTINGS**. For **ENTER TIME BETWEEN SAMPLES IN SECONDS**, enter **30**. For **ENTER NUMBER OF SAMPLES**, enter **20**. The **TIME GRAPH SETTINGS** screen reappears, showing the new settings.
12. Select **1:OK** twice to return to the Main Screen.
13. Place one temperature sensor into each can and seal the openings with putty.
14. Place each can the same distance from the heat source. Measure the distance if using the heat lamp and place them as close as possible to the lamp. If outside, place the cans in the sun at exactly the same time.
15. When you are ready to begin, select **2:START**. The CBL 2™ beeps twice, displays a graph, and begins collecting the data. At the end of each 30-second interval, the data point for each temperature sensor is plotted on the graph.
16. After 20 data samples from each sensor have been collected and plotted, the line graphs are displayed. Use ▶ and ◀ to move to the points along the first line. Record the values in the table on the **Data Collection and Analysis** page.
17. Use ▲ and ▼ to move to the other two lines; trace them and record their values.

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Procedure: Graphing the Data

1. Press ENTER to return to the Main Screen.
2. Select **3:Graph**.
3. On the Graph menu, select **4:More**.
4. Use ▶ and ◀ to displays times with corresponding temperatures on all three lines. Use ▲ and ▼ to move among the three plots.

Data Analysis

Answer the questions on the **Data Collection and Analysis** page to evaluate the data you collected and the three solar collectors.

Extensions

- Predict which color *emits* heat best. Design a lab to collect temperature data with the CBL 2™ for 10 minutes after turning off the heat lamp. Compare actual results to your prediction.
- Design a lab to test other materials of the same colors. Which materials would make the best solar collector? Which would reflect best?
- Design a lab to test which color and/or material used for car interiors keeps the car's interior temperature lowest.
- Design a new solar collector that you think will absorb the most heat. Explain why you choose the materials, colors, and shape. Test your design against the others in your class with the CBL 2 and temperature sensors. Discuss reasons for the performance of each solar collector.

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Data Collection and Analysis

Name _____

Date _____

Activity 10: Collecting Solar Rays

Problem

Which surface color will make the best solar collector?

Hypothesis

If the surface is painted _____, more heat will be absorbed and the temperature will increase, as compared to the colors _____ and _____.

Experimental Design

1. Independent Variable: _____
2. Dependent Variable: _____
3. Constants: _____
4. Number of Trials: _____
5. Collection Interval : _____
6. Number of Samples: _____

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Data Collection

1. Using the graph displayed after the 20 samples have been collected, record the times and temperatures in the table below.

Time (seconds)	Temperature (°C) Silver	Temperature (°C) Black	Temperature (°C) White

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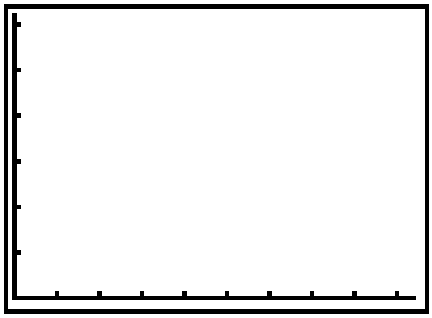
2. Sketch the plot showing the three xyLine graphs displayed on your TI-73, or print it on the computer and attach it to this page. The graph shows a general trend of the temperature inside each can over time. Plot time on the *x*-axis and temperature on the *y*-axis.



Data Analysis

1. Subtract the initial temperature from the final temperature to find the change in temperature for each color.

   ΔT Silver = _____

   ΔT White = _____

   ΔT Black = _____

2. Which can color made the best solar collector? _____

   Which color reflected the best? _____

3. Rank the solar collectors from the greatest temperature increase to the least. Give reasons why these results seem reasonable/unreasonable.

   _____

   _____

   _____

4. Did the length of your experiment allow enough time for the temperature to level off at a maximum value? If not, how could you adjust your interval and the number of samples to find out the maximum temperature for each color of can?

   _____

   _____

   _____

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5. Why do you think people tend to wear light-colored clothing in the summer?

_____

_____

_____

6. Astronauts are often exposed to the sun's radiation. Explain how you could use these results to design the color and material for space suits.

_____

_____

_____

Conclusions

1. If the can's or solar collector's surface is painted _____, more heat will be absorbed and the interior temperature will increase more than if the color were _____ or _____.
2. _____ made the best solar collector, while

   _____ made the best reflector.

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Teacher Notes

Activity 10

Collecting Solar Rays

Objectives

- To understand which surfaces make the best solar collectors
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NSES Standards

- Physical Science: Transfer of energy
- Earth and Space Science: Earth in the solar system

Preparation

- To teach students experimental design vocabulary and to practice data collection with equipment before they begin this lab, have them test the effect of a foil surface on the heat absorption of a can. Use an uncovered can as a control.
- Spray paint three soda cans for each lab station. Use black, glossy white, and metallic silver.
- Heat lamps with clamps designed for labs are optimal; however, student desk lamps with flexible necks and 60- to 100-watt bulbs work fine. Keep the distance from the heat source constant for all trials.
- If students only have one temperature sensor, the trials can each be run separately. Data should be saved in a program after each trial so that the results can be recalled later. Graph all three xyLine graphs together on the calculator.

Management

- Assign these student jobs for this lab:
  - Materials/setup person (sets up cans/lamp)
  - Tech person (operates CBL 2™ and TI-73)
  - Data recorder (reads temperatures from the emerging graph on the TI-73 at each collection interval)
  - Runner (brings CBL 2 and TI-73 to the computer to print graphs with TI-GRAPH LINK™ or TI™ Connect and brings **Data Collection and Analysis** pages to the teacher)
- Sticky tack used to hang posters works well to seal the cans. Students like to walk off with this so manage accordingly.
- Clear covered plastic shoeboxes will hold the CBL 2, temperature sensors, putty, and other equipment neatly at each station.

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- Students can record data points in their lab journals as they are displayed on the TI-73. This keeps them engaged throughout the data collection period and if they lose the data/graph later, they can still write up their lab reports. Students can also access the data in the TI-73 lists after data collection. You can send lists to all students' calculators using APPS **1:Link**.

  a. Press APPS.

  b. Press ENTER to select **1:Link.**

  c. Select **4:List** and press ENTER.

  d. Press ▼ to move the ▶ beside the list you wish to send. Press ENTER.

  e. Repeat step **d** for each list you wish to send.

  f. Set the receiving unit by pressing APPS ENTER ▶ to select **RECEIVE**. Press ENTER. **Waiting…** displays on the TI-73 screen.

  g. On the sending unit, press ▶ to select **TRANSMIT** and press ENTER.

  For more permanent storage of data, use TI-GRAPH LINK™ or TI™ Connect to save the lists in a computer folder. However, students may inadvertently lose their data or overwrite it in the next trial, so recording data in journals is a good option.

- Students can assess each other using a teamwork rubric after the lab. Provide a check list of positive and negative behaviors. Copy these on quarter sheets of paper.

Data Analysis

- Students can print their graphs on the computer using TI-GRAPH LINK or TI Connect software and cable. They can also paste the graph into a word processing program. Students can then write their lab report/conclusion with the graph.
- In a one-computer classroom, a student from each lab station can use TI-GRAPH LINK or TI Connect to print copies of the graphs for each team member. Students then can incorporate these graphs into their lab reports.
- Middle school students are often learning initial graphing skills. Determining the scale for the axes is difficult for many. Therefore, the **Data Collection and Analysis** page provides space for those students to hand plot the data points for each graph and write their conclusions.

Selected Answers

Experimental Design

1. Independent Variable: *color*
2. Dependent Variable: *temperature*
3. Constants: *composition of the cans, time under the heat lamp, distance from the heat lamp, CBL 2 and sensors*.

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4. Number of Trials: *1 to 2 depending on available time*.
5. Collection Interval: *30 seconds (suggested)*.
6. Number of Samples: *20 samples (suggested)*.

Conclusions

1. If the can's or solar collector's surface is painted *black*, more heat will be absorbed and the interior temperature will increase more than if the color were *silver* or *white*.
2. *Black* made the best solar collector, while *silver* made the best reflector.

Extension

- *Black* is the best emitter of heat. Good absorbers are also good emitters.

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