

# Soda Sabotage

A group of high school students decides to go to the home of the Barker twins for lunch. The Barker twins offer to drive. Each twin has a Dodge Durango—Peter has a white one and Adam a black one. Their friends pile in the cars and head to the Barkers' house. They only have 50 minutes for lunch so they try to eat quickly, but some of the kids have to bring their remaining lunch food and sodas in the car so they aren't late returning to school. They get back to school just before the bell rings.

At the end of the school day, Billy asks Adam for his car keys, explaining that he may have left his can of soda in Adam's Durango. A short while later, Peter and Adam head together for the parking lot to go home. As Adam gets in his car, he sees stains on the front seats. Those weren't there after lunch! Adam thinks his car must have been vandalized during class because soda has stained the seats. He looks in Peter's car and sees that nothing has happened to that car, so he is even more convinced that his car was tampered with.

Peter suggests perhaps the soda can exploded and the soda stains are accidental. But he looks in his car and wonders why that didn't happen in his car. He had a soda can in his car too and they have the same type of car, only different colors.

You have been asked to investigate the situation. Was it a case of vandalism or did a soda can explode? If it did explode, why did it only happen in Adam's car?

## Investigation

In this experiment, you will investigate the effect of car color on heat. By measuring the temperature inside and outside a car over a period of time, you will determine if the interior and exterior color of a car affects its interior temperature.

You will use the ProScope Digital Microscope to examine the paint and seat fabric from each vehicle and take digital samples. You will use iPhoto software to prepare a report to present your findings.

## Objectives

In this experiment, you will:

- Use a Vernier Temperature Probe and Logger Lite software to record the temperature inside a car
- Use a ProScope Digital USB Microscope to examine the interior fabrics and the exterior paint of a car

- Calculate the rate of heating of the interior of a car
- Compare the rate of heating for several cars of different colors
- Use iPhoto software to document and report the results of your testing

## Materials

- iBook or PowerBook computer with Mac OS X
- iPhoto software
- Vernier Go! Link interface
- Vernier Stainless Steel Temperature Probe
- Logger Lite Software
- ProScope Digital USB Microscope
- Bodelin 50X lens
- Parked cars of different colors in a parking lot on a sunny, warm day

## Pre-lab activity

In your science journal, explain why cars get hot sitting in the sun. Predict how the interior and exterior color of a car will affect the rate at which its interior warms. Use the actual vehicles that you will be testing as examples in your hypothesis.

## Procedure

**Note:** Your team will be paired with another team, so that one team tests a light-colored car and the other team tests a dark-colored car.

- 1 Connect the Go! Link interface to the computer and connect the Temperature Probe to the Go! Link interface.
- 2 Start the Logger Lite software by double-clicking the Logger Lite icon on the desktop of your computer.
- 3 Choose Data Collection from the Experiment menu and set the experiment length to 60 minutes. In the box labeled "min/sample," type 10. Examine the information to make sure that data will be collected every 10 minutes for 60 minutes. Click Done.
- 4 Your teacher will assign a car for your group to test. As directed, proceed to the parking lot. Bring a ProScope with the 50X lens and the computer with the Temperature Probe connected.
- 5 Assign one member of your team to operate the ProScope (Steps 6 and 7). Another team member will conduct the temperature testing.
- 6 Use the ProScope to examine the seat fabric and the floor carpeting inside the car.
  - a Connect the ProScope to a USB port on the computer.
  - b Open the USB Shot application.

You should now see an image on your computer screen.
  - c Touch the tip of the ProScope to each fabric to create the images.

- d The images can be found in the SNAP folder, which is located in your Applications folder. Rename the image with the name of the material and drag it into a new folder you have created for this experiment.
  - e In your science journal, describe the fabrics.
- 7 Use the ProScope to examine the exterior paint of the car. Touch the tip of the ProScope to a flat surface on the car to create the image. In your science journal, describe the appearance of the paint. Save the images on the computer.
  - 8 Hold the Temperature Probe near the car that you are testing and check the temperature display on your computer screen. (Note: Do not click Collect!) Take a reading of the temperature outside and record it in your data table. Use the first column (Car 1) for your data.
  - 9 Record the interior and exterior color of your car in your data table.
  - 10 Open the window of the front passenger door of the car a little bit. Place the Temperature Probe inside the car through the open window. Open the car door and position the Temperature Probe so that it is dangling over the passenger seat and the tip is not touching anything. Carefully close the car door. Place the computer near the car (as the Probe cable allows) and shade the computer from the sun.
  - 11 Click the Collect button on your computer to begin collecting temperature data. The Logger Lite application will collect data for one hour.
  - 12 When the data collection ends, click the Stats button. Record the minimum and maximum temperature readings in your data table.
  - 13 Remove the Temperature Probe from the car.
  - 14 Return to your classroom and share your information with the team with which you've been paired.

### Processing the data

- 1 Record the temperature change for each car in your data table. Calculate the temperature change by subtracting the minimum temperature from the maximum temperature.
- 2 Calculate the rate of temperature change by dividing the temperature change by the elapsed time (60 minutes). Record the rate of temperature change for each car in your data table.

**Data table**

|                                     | Car 1 | Car 2 |
|-------------------------------------|-------|-------|
| Exterior color                      |       |       |
| Interior color                      |       |       |
| Model                               |       |       |
| Make                                |       |       |
| Outside temperature (°C)            |       |       |
| Maximum interior temperature (°C)   |       |       |
| Minimum interior temperature (°C)   |       |       |
| Interior temperature change (°C)    |       |       |
| Rate of temperature change (°C/min) |       |       |

**Analyzing your data**

- 1 Use your data to describe the type of car that warmed to the higher temperature and had the greater rate of temperature change. Does this answer support your hypothesis?
- 2 How does the exterior color of a car affect its interior temperature?
- 3 According to one report, a can of carbonated beverage may “explode” when it reaches a temperature of 60°C. Use the rate of temperature change to determine how long it would take the cars that you studied to reach 60°C, if the initial internal temperature was 25°C.
- 4 In the scenario, if the students return to their cars three hours after returning from lunch, would it be possible for either car’s interior to heat up enough to cause a can of soda pop to burst? Explain.
- 5 Examine the ProScope images of the fabric of the car seat and of the floor carpeting. Suggest differences in how beverage stains might affect each type of fabric.
- 6 Prepare a report of your results, using iPhoto software to incorporate your data tables and ProScope images into your report.

# Teacher Information

Students will discover that dark colored surfaces absorb and radiate heat better than light colored surfaces. Students will discover that a car's interior warms at a significant rate in a relatively short period of time when it is sitting out in the sun.

In this experiment, your students will be going out to your school parking lot, presumably to test cars. For best results, select cars that are the same size so that the interior air volume is as similar as possible. Ideally, find two colors of the same model car to test. For best results, make sure all vehicles are in direct sun.

Be careful to protect the computers from becoming overheated. Place the computers in shade as much as possible during the one-hour data collection.

Students can use their data table file in their iPhoto presentation. You may want to explain the steps involved in exporting their files to iPhoto. To export a data table from a word-processing document or spreadsheet into iPhoto, follow these steps:

- 1 Take a screen shot of the information you want to include. Hold down the Command-Shift-4 keys and drag to highlight the area you want to select.  
A numbered file named Picture is created, such as "Picture 1."
- 2 Open the Preview application from the Dock or in the Applications folder. (Preview is included on every new Macintosh computer.)
- 3 Choose Open from the File menu, then locate and open your Picture screen shot file.
- 4 Choose Export from the File menu, name the file, and save it as a JPG file.
- 5 Open iPhoto and drag the JPG file into your Photo Library.

## Data table

|                                     | Car 1        | Car 2        |
|-------------------------------------|--------------|--------------|
| Exterior color                      | White        | Navy         |
| Interior color                      | Tan          | Black        |
| Make                                | Honda Civic  | Honda Civic  |
| Model                               | 4-door sedan | 4-door sedan |
| Outside temperature (°C)            | 21.1         | 21.1         |
| Maximum interior temperature (°C)   | 31.7         | 36.7         |
| Minimum interior temperature (°C)   | 23.9         | 23.9         |
| Interior temperature change (°C)    | 7.8          | 12.8         |
| Rate of temperature change (°C/min) | 0.13         | 0.21         |

## Answers to the analyzing your data questions

- 1 The car with a dark colored exterior (and dark interior, perhaps) will have the higher interior temperature and the greater rate of temperature change. In most cases, this will compare favorably with the hypothesis.
- 2 The darker a car's exterior color, the warmer the car will be when it is parked in the sun.
- 3 Using the sample data, the time it will take for each car to reach the unsafe temperature of 60°C is: Car 1—269 minutes; Car 2—167 minutes. The answers were calculated by determining the temperature change (60°C - 25°C), and then dividing the temperature change by the rate of change for each car.
- 4 Answers will vary. Using the sample data, only Car 2 would heat up fast enough for a can of soda to burst.
- 5 Answers will vary. Students may note the thickness, nap, weave, and porosity of the fabrics and relate these factors to how a beverage stain might spread, adhere to the fibers, or affect the ease of cleaning.
- 6 Reports will vary. A good report will use the iPhoto software to present a convincing case regarding the effect of car color on the interior temperature of the car. The report should also present a solid photo description of the testing process.

## Extensions

- 1 Conduct this experiment with a car parked in the sun and the same car parked in the shade.
- 2 Conduct this experiment to measure the exterior temperature of a car that is parked in the sun. Compare dark and light colored cars.

## National Science Standards

This experiment provides direct alignment to national standards by allowing students to observe and measure how heat is transferred. The design of the experiment also emphasizes alignment with measurement, inquiry, and investigative standards by having students use technology to practice and gain insight into these skills.

### Content Standard A

Science as Inquiry: B. 5-8

As a result of their activities in grades 5-8, all students should develop an understanding of

- 1 Abilities necessary to do scientific inquiry.
- 2 Understandings about scientific inquiry.

### **Content Standard B**

Physical Science: B. 5-8

As a result of their activities in grades 5-8, all students should develop an understanding of

- 2 Properties and changes of properties in matter.
- 3 Transfer of energy

### **Special thanks**

This lesson was written by Linda Eller, Instructional Technology Coordinator of Teaching and Learning Academy, Memphis, TN, and edited by Vernier Software & Technology.

