Buried Objects
ID: 6748

<div align="right">

Time required: 1 class period
Suggested Grade Levels: 6-7

</div>

Activity Overview

In the hiking and camping world, a cache (pronounced cash) is a hiding place for food or other supplies. GeoCaching is an adventure game that uses that same idea. Someone hides an item and enters the latitude and longitude of the hiding place on the Internet. Then, others use that information to find the hiding place. When they find the cache, they take the item, and leave another for the next person. GeoCaching is a popular weekend activity for families who love the outdoors.

One family discovered the locations of four buried caches. They know one of the locations contains a model car, but they don't know which one it is. In this adventure, students will use the CBR 2 to identify "buried" objects. The CBR 2 will simulate a GPR (Ground Penetrating Radar) device.

Math Objectives:

- *Interpret and analyze graphs of height as a function of time*

- *Use the change in the y-coordinates of an ordered pair to determine the height of an object*

Science Objectives:

- *Collect, record, and analyze information using tools such as temperature probes, calculators, and computers*
- *Recognize that waves are generated and can travel through different media*

Associated Materials

- *TI-73 Explorer™*
- *TI-Navigator™ (for extension)*
- *Calculator-Based Ranger™ (CBR 2™)*
- *CBL/CBR™ Application*
- *small box or block of wood*
- *several large boxes, each containing an unknown object*
- *SciAct01_BuriedObjects_worksheet_TI-73.doc*
- *SciAct01_BuriedObjects_TI-73.73script*
- *SciAct01_BuriedObjects_CreateGraphs_TI-73.act*
- *SciAct01_BuriedObjects_OrderGraphs_TI-73.act*

Teacher Notes and Setup

Students may be confused as to why the objects appear to be upside-down on their displays. Stress that the distance shown is the distance between the CBR 2 and the surface it is facing, so a taller portion will be closer to the CBR 2. Sketch the graph of the practice object on the board and write some of the coordinates on the graph. Use the sketch and the y-values to show where the distances were greater and lesser. Where the distance was lesser, the surface was closer to the CBR 2. On a flat desk, that must mean an object of some height was there.

If students have a hard time interpreting the shapes of various objects, have them practice with other objects of their choice. They can predict what they think it would look like on the display, and then see the actual display. Ground-penetrating radar (GPR) is a technique that is used frequently by geologists and archaeologists to locate objects and features below the ground. It has also become common to use GPR in forensic investigations. GPR utilizes the same principles as other kinds of radar. Pulses of electromagnetic radiation (often in the frequency range of radio waves) are sent into the ground. These pulses tend to reflect off interfaces in the subsurface—places where two distinctive materials (such as dirt and oil, or water and rock, or soil and metal) meet. The reflected rays travel back to the GPR device, which records the time it takes for the waves to reflect back and the intensity with which they are reflected. With some computer processing, it is possible to create an approximate image of subsurface structures.
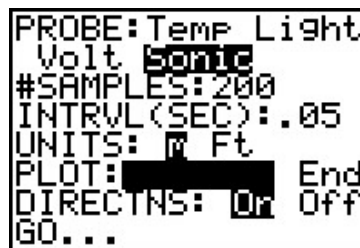
1. Obtain four large boxes (24 in. × 12 in. × 14 in. or larger). For each box, tape the top flaps up so that they make the box taller. Students should not be able to see what is inside the box when it is place on a table. Office supply stores sell large boxes. Grocery stores may have some large boxes available for customers.

2. Inside one box, place a model car. In each of the other boxes, place an object with a distinctive shape (such as a roll of tape, roller skate, or a mug).If you do not have a model car, you can 'make' a rough car shape from blocks of wood. Make sure that the hood and trunk are at least 5 cm shorter than the top of the car.

3. When choosing objects, make sure the object is small enough to fit inside the box so that the object is at least two-three inches from all the sides of the box. Students will have to be able to detect the bottom of the box on each side of the object.

4. Label the boxes with "Location 1," "Location 2," "Location 3," and "Location 4." You may wish to place each box in a different corner of the room to minimize crowding.

5. Place a box of wood or a small box on a desk. Make sure that there is nothing else on the surface of the desk. This will be used for student practice.

6. Connect the CBR 2 to the calculator using the I/O unit-to-unit cable.
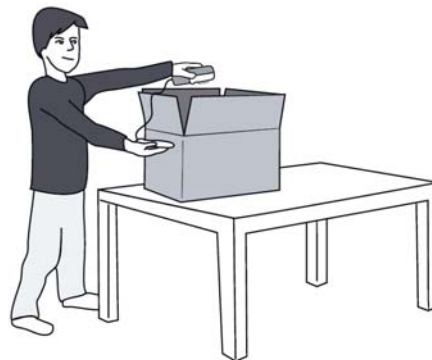
7. To launch the CBL/CBR App, press the [APPS] key, select **CBL/CBR** and then press [ENTER] to view the CBL/CBR screen.

```
APPLICATIONS
1:Link…
2:AreaForm
3:CBL/CBR
4:GEOBOARD
5:NUMLINE
```

8. Press [ENTER] to access the application, and then select **2:DATA LOGGER.** The Settings Screen launches. Use the arrow keys to highlight each choice and press [ENTER]. For **PROBE**, select **SONIC**. For **#SAMPLES**, select **200**. For **INTRVL(SEC)**, select **.05**. For **UNITS**, select **m** (meters).

```
CBL/CBR APP:
1:GAUGE
2:DATA LOGGER
3:RANGER
4:QUIT
```

```
PROBE:Temp Light
  Volt Sonic
#SAMPLES:200
INTRVL(SEC):.05
UNITS: M Ft
PLOT:         End
DIRECTNS: On Off
GO...
```

9. Highlight **GO** and press [ENTER]. The next screen asks **ARE YOU USING…**, choose **2:CBR**. Next, you are reminded **USE UNIT-TO-UNIT CORD TO LINK THE CBR AND TI-73.** Press [ENTER] for that screen and for the next one that is checking the calculator CBR link connection. The last screen before you begin data collection reads **PRESS [ENTER] TO BEGIN.**

```
ARE YOU USING ..
1:CBL
2:CBR
```

```
      CBR      TI-73
USE UNIT-TO-UNIT
CORD TO LINK THE
CBR AND TI-73.
          [ENTER]
```

```
NOW CHECKING THE
 CALCULATOR CBR
LINK CONNECTION.
PLEASE WAIT....

  STATUS: O.K.
          [ENTER]
```

```
PRESS [ENTER] TO
BEGIN.
```
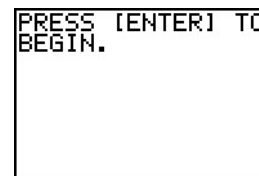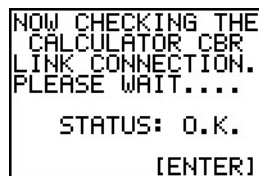
Data Collection

1. Begin by having students practice using the CBR 2 on the block of wood or box to get to know how the CBR 2 displays its data. This may require several bouts of practice.

NOTE: Unless you have a very small class, this activity works best with students divided into groups. Make sure at least one student in each group practices using the CBR 2.

2. Hold the CBR 2 about a meter above the desktop and toward one end of the desk.

3. When ready, press [ENTER]. You will hear a rapid clicking sound from the detector. Very slowly and carefully move the motion detector, at a constant height above the desktop, from one end of the desk to the other end. Make sure the round sonic-emitter is facing the desk and that it passes over the top of the block or box.

4. After 25 seconds, the clicking will stop. The screen will show a graph of the data. Your graph should look similar to the screen on the right. If you do not get a graph like the one shown, repeat the trial. Make sure that the desk is clear, that the light-gray part of the detector is facing the desk, and that you maintain a constant speed and height above the desk. Press ENTER, highlight **GO**, and press ENTER again to start over.
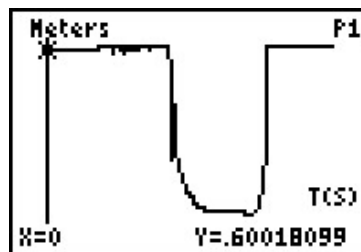
5. Using the arrow keys (◄ ►), you can see how far the desktop and the top of the box were from the CBR 2.

6. Try the CBR 2 with the box in a different orientation, such as on one of its ends. Explore the graphs until you are comfortable with how the graph shows the location and shape of the object.

7. When ready to begin the investigation, move to one of the "cache locations."

8. Without being able to see the object, practice slowly moving the CBR 2 at a constant height above it. You need to move the CBR 2 at a speed that will let you move from one end of the box to the other in about 25 seconds. Practice this until you can move the detector at the correct speed and at a constant height. Use the top edge of the flap as a guide.

   NOTE: It may be easier for students to move the CBR 2 smoothly if it is attached to a meterstick.

9. When you are ready, press ENTER. Begin moving the detector just after you begin to hear the rapid clicking noise.

10. Examine the graph when the data collection is complete. Repeat the trial to see if you get a similar shape on your second try. If not, continue to repeat the trial until you get a consistent shape.

11. When you are satisfied with your graph, sketch it on your worksheet and move on to the next location. Sketch the graph of each location on your worksheet.

12. When finished with all trials, press ENTER. Then, press 2nd [QUIT]. Choose **4:QUIT**.

   NOTE: If students are unable to resist the temptation to look inside the boxes, have groups interpret displays for objects they did not image.

Extension Activity

Obtain a very large box, and have students make several passes over the box with the CBR 2, placing the sensor at different distances from the edge of the box for each pass. In this way, students can produce a slightly more detailed picture of the bottom of the box. They will also simulate the use of GPR more accurately. However, the CBR 2 transmits and receives signals in a cone of about 8°, so only a *very* large box will work.

For TI-Navigator™

1. Load the *SciAct01_BuriedObjects_OrderGraphs_TI-73.act* activity settings file.

2. Use Quick Poll (with Open Responses) to have students list the graphs of the blocks in the following order:

    Tall and wide

    Tall and narrow

    Short and wide

    Short and narrow

    To aggregate data, have all students list the four letters without spaces or commas between them. Minimize the Quick Poll window so students can see the graphs while answering.

3. Load the *SciAct01_BuriedObjects_CreateGraphs_TI-73.act* activity settings file.

4. Split students into groups of 4-6 per group. Challenge groups to create a graph of what it would look like if a different object was in the box. Each student can submit 10 points; together they can submit enough points to simulate a CBR 2 display. Some objects students can use include a ball, a construction cone, a cowboy hat, a bowl upside down, a bowl right side up, and a boot.

5. If the objects are kept secret among the groups, an option is to have each group guess each other's object.

Worksheet Answers

The shapes the students obtain depend on the objects that they are investigating. Here is an example of what a car may look like on the CBR 2 screen.
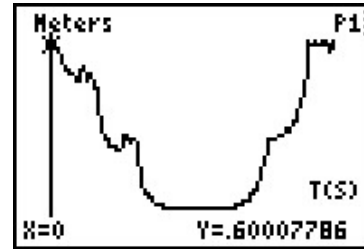
1. Students should explain that the shape of the car is different from the other shapes observed; it has contours similar to those of a car.

2. Subtract the lowest *y*-value from the highest *y*-value on the display.

3. It is important to move the CBR 2 at a constant speed so that time can be used as an estimate of distance or location. If you change the speed of the CBR 2, the horizontal profile will be out of proportion.

4. The CBR 2 image won't match the profile of the object if the CBR 2 isn't held at a steady height and moved at a steady speed. Also, the CBR 2 can pick up only the top surface of the object. If the object is complex, many parts of its profile will not be picked up. In addition, other objects between the intended object and the sensor will interfere with the profile of the intended object.

Buried Objects

Name _____

Class _____

In this adventure, you will use the CBR 2 to identify "buried" objects. The CBR 2 will simulate a GPR (Ground Penetrating Radar) device.

Problem 1

Analyze the sketches that you have made. Which location contains the model car? Explain your answer.

Problem 2

Explain how you would be able to determine the height of the model car.

Problem 3

Why is it important to move the CBR 2 slowly but at a constant speed? What would happen if you didn't move it at a constant speed?

Problem 4

What can make the CBR 2 image (or a real GPR image) of an object look different from the actual profile of the object?

	Sketch of Shape	Guess of Object
Location 1		
Location 2		
Location 3		
Location 4		