Case File 2

Bouncing Back: Using ground-penetrating radar to locate buried objects

Locate Mrs. Holloway's car and help solve this cold case.

To: Detective Sergeant Ashanti
Re: Possible new evidence in Holloway case

We have just received new information on this unsolved, high-profile case from several years ago. On May 6, 2000, the wife of billionaire oil tycoon Donald Holloway drove away in her car and never returned. As we never found any evidence of foul play, we believed that Mrs. Holloway left her husband and changed her identity. Recently, Mrs. Holloway's California vanity license plate, OIL GIRL, was found outside a remote gas station along the Desert Highway. This particular gas station happens to be quite close to lands owned by the Holloway oil empire. Also uncovered in recent weeks have been several documents detailing the purchase of some large properties along the road. It now looks like Holloway may have killed his wife and buried her and her car at one of the properties. Sample email is attached.

From: jwinchester@ ZongoReelEstayt.com
Date: May 8, 2000
To: dholloway@hollowayoil.com
Subject: RE: your needs

Mr. Holloway –

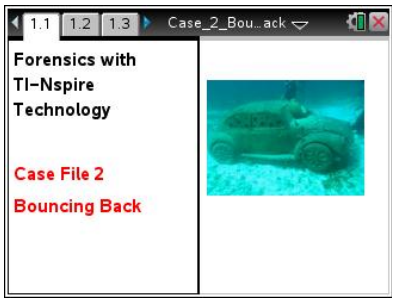
Per your request, I have identified four abandoned sites along Desert Highway that would suit your needs. The following locations are very remote and have been untouched for years:

» the old Two Tree golf course
» the 1960s government rocket-testing site (now deserted)
» the construction site on 31st and Desert
» the abandoned Bright Days housing development

Good luck with your latest endeavor.

About the Lesson

- This lab uses a TI-Nspire™ Technology with a motion detector to determine the presence and height of an unseen object.
- Teaching time: one 45 minute class period



Science Objectives

- Explore the use of ground-penetrating radar (GPR) to find buried materials.
- Detect the presence of an object using a motion detector.
- Distinguish between different-shaped objects using a motion detector.

Activity Materials

- TI-Nspire™ Technology
- *Case_2_Bouncing_Back.tns* file
- CBR 2™ or Motion Detector with Lab Cradle
- meter stick
- several large boxes (each containing an unknown object)
- small box or block of wood

TI-Nspire™ Navigator™

- Send out *Case_2_Bouncing_Back.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Teacher Notes and Teaching Tips

- The student activity sheet and .tns file contain the complete instructions for data collection. All assessment questions are also included in both places giving you the flexibility to either collect the .tns files with student data/answers using TI-Nspire Navigator or to collect the handwritten version of the answers.
- Obtain at least four large boxes (24 × 12 × 14 in or higher than 14 in). Office supply stores sell large boxes. Grocery stores may also have some large boxes available.
- If you have access to a very large box, you can have the students make several passes over the box with the CBR 2, placing the sensor farther 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.
- If students are unable to resist the temptation to look inside the boxes, divide the students into groups. Have each group image the object in one of the boxes, and then have the groups switch stations so that they each have to interpret the display for an object that they did not see.

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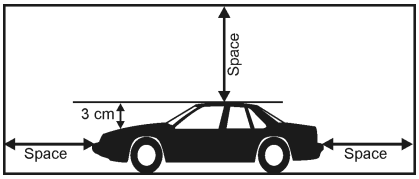
- If students are having a hard time interpreting the shapes of the various objects, they can repeat data collection with several different-shaped objects to become more familiar with data collected from a Motion Detector.
- If the motion detector or CBR 2 is not recognized, check the batteries in the detector.
- This web site provides an in-depth look at how GPR can be used in archaeology. It also contains some basic theory and methodology for GPR. http://www.du.edu/~lconyers/SERDP/GPR2.htm

Background

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 rock and water, 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.

Although GPR is a powerful tool, it does have some limitations. The waves tend to attenuate rapidly in water, making it difficult to accurately image saturated soils. The detectors also pick up reflections from surface and near-surface materials, such as trees.

Good filtering can remove these “ghost” images, but in general, GPR is best at imaging objects that are 50 cm to 1.5 m in depth. As with all types of radar and sonar, there is a trade-off between resolution and penetration: One can detect deep large objects or shallow small objects but not small objects that are very deep.



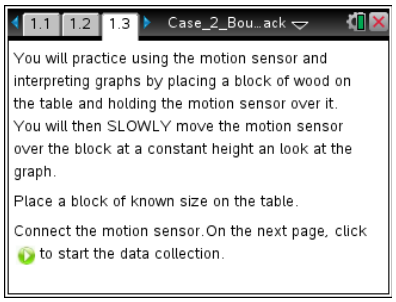
Allow students to read the forensics scenario on the first page of their student activity sheet.

Procedure

Part 1 – Preparing for Data Collection

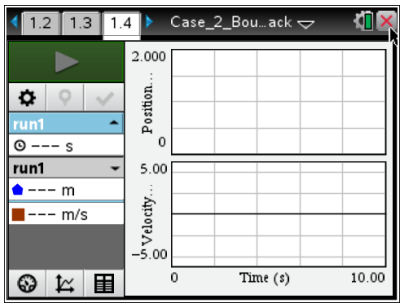
Move to pages 1.2–1.3.

1. Students read the directions on these pages to become familiar with how to use the CBR 2™ to collect the data.
2. Then students prepare the Motion Detector for data collection by connecting it to the handheld.



Move to page 1.4.

3. Students use a block of wood to practice using the Motion Detector to display data. Once they are comfortable using it and they are pleased with the graph, they are ready to move onto a burial site.



Part 2 – Collecting Data and Analyzing the Data

Tips for setting up the burial sites:

- Obtain at least four large boxes. For each of the boxes, tape the top flaps up so the sides of the box are taller. Students should not be able to see what is inside the box when it is placed on a table. Make sure each student group uses a meter stick as a guide on which to rest the Motion Detector. This will help to keep the CBR 2 at a constant height as the detector is moved from one end of the box to the other. Placing a long strip of cellophane tape on the meter stick will help the students to move the Motion Detector smoothly.
- Place an object with a distinctive shape (such as a box, block of wood, large eraser, stapler, roll of tape, or mug) inside each of three boxes. Inside the fourth box, place a model car. A wooden car similar to the one illustrated to the right works well. Secure each of the objects in place with tape so that the objects do not move when the boxes are moved.
- You can make a car from blocks of wood. The Motion Detector works best on objects with flat surfaces. Make sure that the hood and trunk are at least 3 cm shorter than the top of the car.
- If you are using a box that is 60 cm long, the car should be no more than 20 cm in length. If the bottom of the box cannot be detected on both sides of the car, the students will not get a good image of the car.
- Label the boxes with the four suspected burial sites for the car.
- You may want to leave one of the boxes empty.

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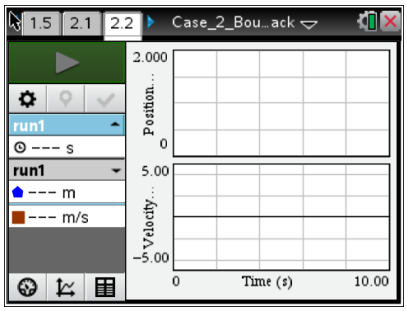
Move to pages 2.1–2.2.

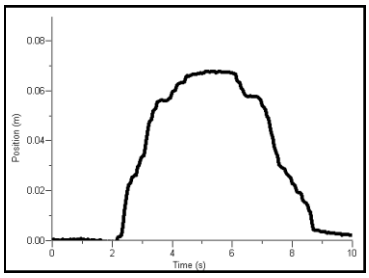


4. Without looking inside the box, students will explore each of the suspected burial sites by following the directions given on the student activity sheet.

   They should sketch their graphs in the Evidence Record.

Evidence Record

The shapes the students obtain depend on the objects they are investigating. Below is an example of what a car may look like based on data collected with a Motion Detector.

Site Probed by Detector	Sketch of Shape Found by Detector
(Burial site containing a car)	

Case Analysis

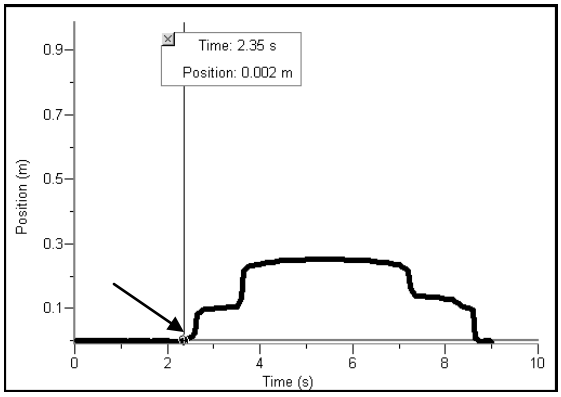
Move to pages 3.1 – 3.8.

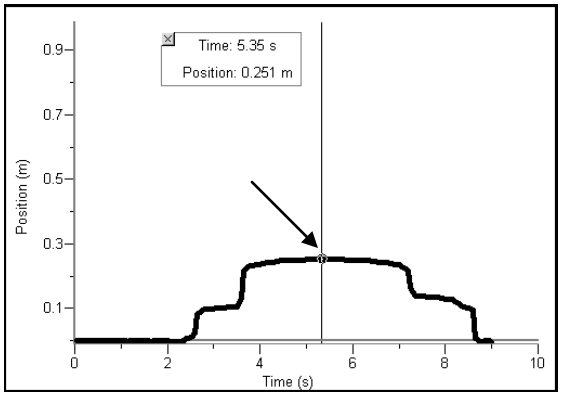
Have students answer the following questions in the .tns file, on their activity sheet, or both.

1. Analyze your sketches. Which site contains the buried car? Explain your reasoning.

   Answer: Student 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. Using the figures shown below, determine the height of the object. The cursor location is indicated by an arrow. The time and position values are shown for each cursor location.





Answer: The height of the object is 0.061 m, or 6.1 cm.

3. Why is it important to move the Motion Detector slowly but at a constant speed? What would happen if you did not move the Motion Detector at a constant speed?

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

4. What can make the Motion Detector image (or a real GPR image) of an object look different from the actual profile of the object?

Answer: The collected data won't match the profile of the object if the Motion Detector is not held at a steady height and moved at a steady speed. Also, the Motion Detector can detect only the top surface of the object. If an object is complex, many parts of its profile will not be detected. In addition, other objects between the intended object and the sensor will interfere with the profile of the intended object.

5. How could someone get a more complete image of the object if he or she used real GPR?

Answer: Making many different transects and then piecing those transects together makes a three-dimensional image.