



Case File 12

Hit and Run:

Using information from an event data recorder to reconstruct an accident

Replicate data from an event data recorder to identify the culprit in a hit and run.

Police Report

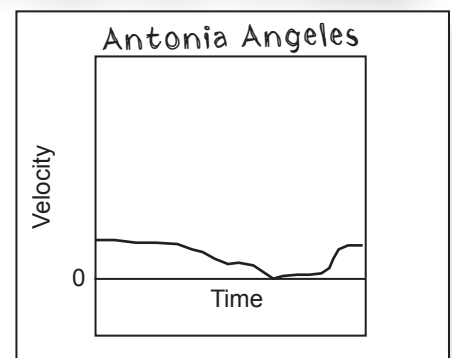
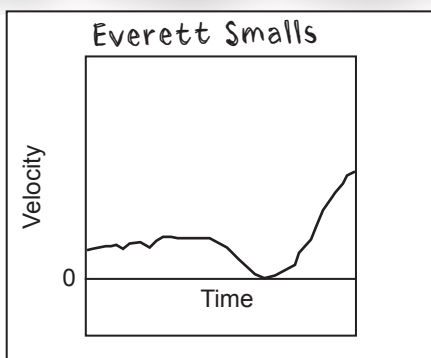
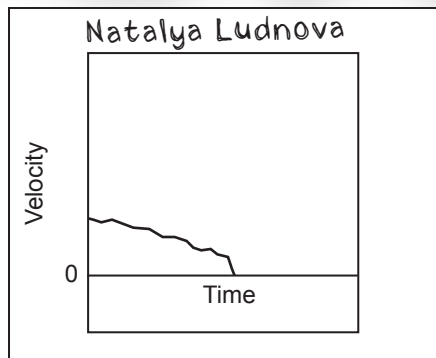
Rania Sallum, 58, was struck by a large, dark-colored SUV Wednesday around 7:20 a.m. Sallum could not see the driver or read the license plate, but she knows that she was struck by the front right bumper of the vehicle, which then slowed almost to a stop before speeding off. She estimates that the incident occurred between 7:15 and 7:25 a.m. A hit-and-run bulletin and vehicle description went out to all officers. Three police teams spotted vehicles with front right bumper damage and recorded the following information from their drivers:

Natalya Ludnova, 25--pulled over for speeding when the officer noticed bumper damage--claimed that damage was due to hitting the curb while parking.

Everett Smalls, 38--brought in for blocking a fire lane--claimed that bumper was damaged in a stop-and-go rush hour fender bender.

Antonia Angeles, 53--pulled over for speeding when the officer noticed bumper damage--claimed a neighbor backed into her car as she drove past his driveway.

EDR data downloaded from each car for the 10 seconds before and after the bumper collision show that each occurred between 7 and 8 a.m. Wednesday. See below.





Forensics Objectives

- simulate the use of an event data recorder (EDR) in order to show how the evidence gathered by this device can be used for legal purposes
- show how accident scenes can be recreated through an analysis of the data that are gathered by an EDR



Science and Mathematics Objectives

- learn how distance traveled, velocity, and acceleration are related to one another
- learn how the appearance of an acceleration, velocity, or distance vs. time graph can be used to predict the appearance of the other graphs



Materials

- TI-83/TI-84 Plus™ Family
- Vernier EasyData™ application
- Calculator-Based Ranger™ 2 (CBR™ 2)
- toy car, at least 5 cm tall



Procedure

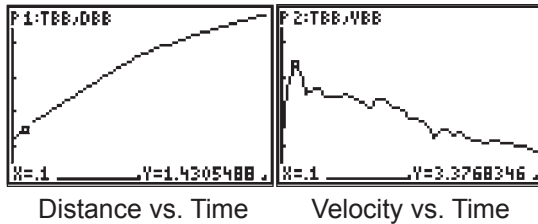
1. Connect the CBR 2 to the calculator with the USB cable. EasyData will open immediately, and the CBR 2 will begin collecting distance data. You will know when the CBR 2 is collecting data because it will be clicking.
2. Place the CBR 2 and car on a lab table or the floor. The CBR 2 should be facing the car, and they should be about 30 cm apart. Remove any surrounding objects so that the data you acquire will be relatively “noise” free.
3. Observe the calculator display to make sure that the CBR 2 is picking up the position of the car. It should show a distance of about 0.3 m.



If the distance is not being measured in meters, select **Setup** and select option **1: Distance**. Under **Units**, choose option **1: (m)**. Exit to the Main screen by selecting **OK**.

4. Perform a test run with your car. Have one team member push the car and release it. Have another team member check the readings on the calculator screen. You do not need to record the motion at this point. Just be sure that the CBR 2 is measuring the increasing distance to the car as it moves away. Also be sure that the car is pushed gently enough that it stops before the end of the table.
5. Now you are set to begin the experiment. Change the experiment parameters to have the calculator record one sample every 0.05 seconds for 3 seconds.
 - a) From the Main screen, select **Setup** and choose option **2: Time Graph**.
 - b) Select **Edit**. To change the time between samples to 0.05 seconds, press **CLEAR** and then enter **0.05**.
 - c) Select **Next** to change the number of samples that the calculator will record. Press **CLEAR** and then enter **60** for the number of samples.
 - d) Select **Next** to confirm that your settings are correct. The sample interval should be 0.05 seconds; the number of samples should be 60; and the experiment length should be 3 seconds.
 - e) When you have confirmed that the experiment setup is correct, select **OK** to return to the Main screen.

6. Position the team members so that one can start the EasyData App and the other can push the car away from the CBR 2.
7. Select (Start) to begin collecting data. (You may also have to select (OK) to overwrite the last run.) As soon as data collection begins, push the car away from the CBR 2 the same way that you did in your test run. Data collection will continue for 3 seconds, and then the screen will read **Transferring Data**.
8. After the data are transferred to the calculator, a distance vs. time graph will automatically plot on the screen. Select (Plots) to examine the velocity vs. time graph as well. These graphs should be relatively smooth, indicating that you picked up the motion of the vehicle and not a lot of extraneous noise. See the sample graphs below.



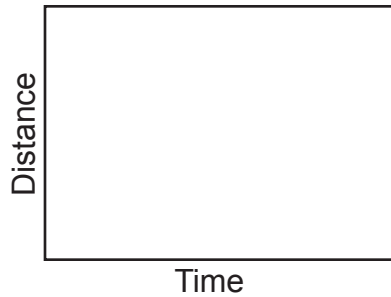
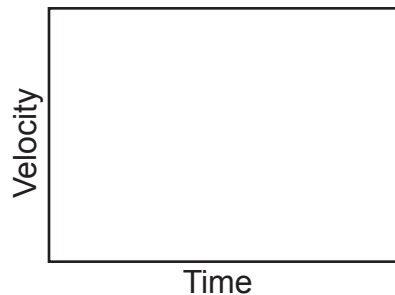
If the graphs of the distance and velocity are not relatively smooth (an absolutely smooth graph is rarely observed), repeat steps 7 and 8.

9. Sketch these plots in the Evidence Record. Then complete the Case Analysis.



NAME: _____

DATE: _____

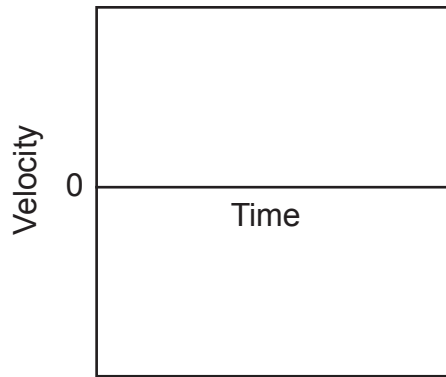
Evidence Record**Distance vs. Time****Velocity vs. Time****Case Analysis**

1. Look at the velocity vs. time graph plotted by your calculator. At what time did the car begin to move?
2. What was the maximum velocity of the car?
3. At what time did the car reach its maximum velocity?
4. Look at the distance vs. time graph plotted by your calculator. Does the time at which the car's distance from the CBR 2 increased match the time in question 1?
5. How far did the car move before it reached its maximum velocity?



Use the arrow keys to move the cursor along the graph. To change the type of plot that is displayed without changing the position of the cursor, select **(Plots)** and then select the graph you want to see.

6. EDRs in vehicles record information on velocity and acceleration for moving vehicles. The data recorded by EDRs help reconstruct the events of an accident. For example, data from the EDR can show when a car's brakes were applied, if at all. Suppose a vehicle were traveling at a constant speed, using cruise control, when suddenly the brakes were applied until the vehicle stopped. Sketch a velocity vs. time graph for this situation. Label the point at which the brakes were applied and the point at which the vehicle came to a complete stop.



7. Do the EDR data taken from the suspects support their stories? Do the EDR graphs suggest that any of these suspects is the culprit in the hit and run? Explain your answers.



Case File 12**Hit and Run:****Using information from an event data recorder to reconstruct an accident**

Teacher Notes

Teaching time: one class period

This lab introduces students to the concept that displacement, velocity, and acceleration are related quantities and that patterns in one can be used to predict patterns in the others.

Tips

- Position the CBR 2 behind the toy car. Select **(Start)**, wait an instant, and then push the car. Be sure that the CBR 2 records the push and release. These are important points on the velocity and acceleration graphs.
- Be sure that the students have chosen option **2: Time Graph** under the **(Setup)** menu (Procedure step 5a). Otherwise, the data for distance and velocity will not be saved.

Lab Preparation

- There are only a few things necessary for this lab: a toy car large enough to be picked up by the CBR 2, a CBR 2 attached to a calculator with the EasyData App, and a clear space on the floor or a long table to roll the car on.
- A toy car or truck at least 5 cm high works well with the CBR 2.

Background Information

Event data recorders, or automobile black boxes, can make many contributions to automobile safety; however, they also raise many important questions concerning an individual's right to privacy. The balance of these two seemingly conflicting objectives is one of the dilemmas of life in the technological age.

The relationship between the two graphs (distance vs. time and velocity vs. time) that the CBR 2 generates is important for students to understand. They should learn the fundamentals of how the behavior of one graph can predict the appearance of the other graph. For example, when the velocity is positive and increasing, the vehicle is moving away from the CBR 2.

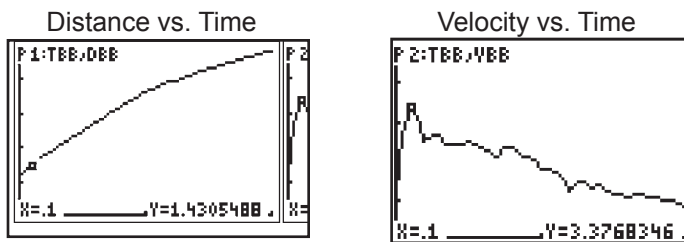
Modifications

- If your students are more advanced, you can have them examine the acceleration vs. time graphs available on the calculator at Procedure step 8. You can also have them sketch or predict the shape of an acceleration vs. time graph in Case Analysis question 7. Be aware that these graphs tend to be very noisy and can be confusing unless the student is fairly comfortable with the concept of acceleration.
- If you have access to a computer with TI Connect™, you can have students print out their graphs. TI Screen Capture will allow screen shots to be saved as .bmp, .tif, or .jpg files, which can be printed from any compatible program (e.g., Word or Paint from Microsoft®). Start Connect and attach the USB cable to the computer. Then have the students follow the directions below after they complete Procedure step 8:

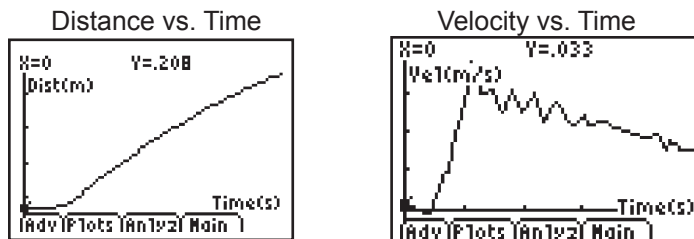
9. Select **(Plots)** and select option **1: Dist(m) vs Time** to display the distance vs. time graph.

10. Disconnect the CBR 2 from the calculator. Use the USB cable that is connected to the computer to connect the calculator to the computer.
11. From the Connect main screen, select Screen Capture. Wait a few seconds for the computer to detect the calculator and load the image on the screen.
12. When an image of the graph on your calculator shows up on the Screen Capture screen, select File > Save As... to save the image to the computer's hard drive.
13. On the calculator screen, select (Plots) and then select option **2: Vel(m/s) vs Time** to display the velocity vs. time graph.
14. Repeat step 12 for the velocity vs. time graph. Both graphs can now be printed from any program that allows you to print image files.
15. When both graphs have been saved, disconnect the calculator from the computer's USB cable. Use the distance vs. time and velocity vs. time graphs to answer the Case Analysis questions.

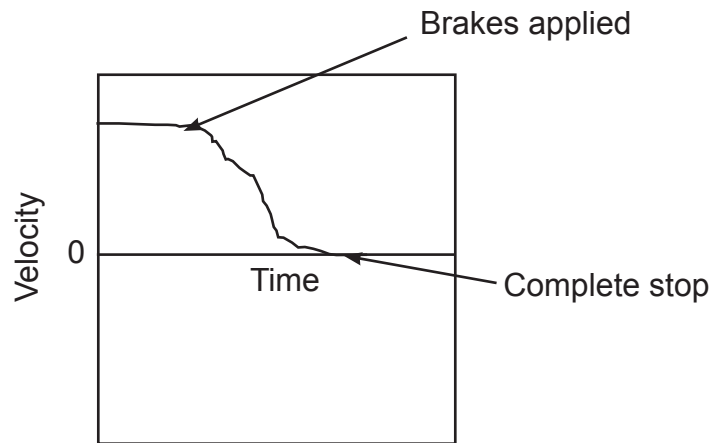
Sample Data (using a high plastic truck with extra weight in the truck bed)



Case Analysis Answers (using results from pushing a Hall's carriage)



1. Look at the velocity vs. time graph plotted by your calculator. At what time did the car begin to move?
0.3 seconds
2. What was the maximum velocity of the car?
0.714 m/s
3. At what time did the car reach its maximum velocity?
0.7 seconds
4. Look at the distance vs. time graph plotted by your calculator. Does the time at which the car's distance from the CBR 2 increased match the time in question 1?
Yes
5. How far did the car move before it reached its maximum velocity?
0.127 m
6. Suppose a vehicle were traveling at a constant speed, using cruise control, when suddenly the brakes were applied until the vehicle stopped. Sketch a velocity vs. time graph for this situation. Label the point at which the brakes were applied and the point at which the vehicle came to a complete stop.
(Note: The details of the graph are not extremely important. The important point that the students should demonstrate is that velocity is constant (non-0) until the brakes are applied, at which time it decreases sharply before ending at constant 0.)



7. Do the EDR data taken from the suspects support their stories? Do the EDR graphs suggest that any of these suspects is the culprit in the hit and run? Explain your answers.

Natalya Ludnova's graph supports her story. The graph shows a sudden stop followed by no movement, which is consistent with a sudden stop while parking. The graph for Antonia Angeles supports her story; it shows a slowing and then an increase to the previous speed, which can happen with a small jolt from the side. The graphs suggest that Everett Smalls was involved in the hit and run. His EDR data show a rapid deceleration followed by a rapid acceleration. If he had been involved in a fender bender in rush hour traffic as he claimed, the EDR probably would have shown no deceleration or acceleration, or a very small amount. He almost certainly would not have been able to accelerate rapidly in rush hour traffic. Instead, it seems likely that he sped away from the hit-and-run scene.

