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

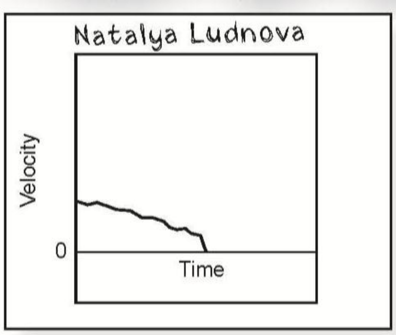
Rania Sallum, 58, was struck by a large, dark-colored SUV Wednesday around 7:20 a.m. Sallum could not see the driver or read the license plate, but she knows that she was struck by the front right bumper of the vehicle, which then slowed almost to a stop before speeding off. She estimates that the incident 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:

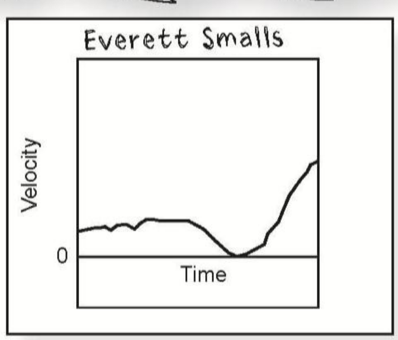
Natalya Ludnova, 25--pulled over for speeding when the officer noticed bumper damage—claimed that damage was due to hitting the curb while parking.

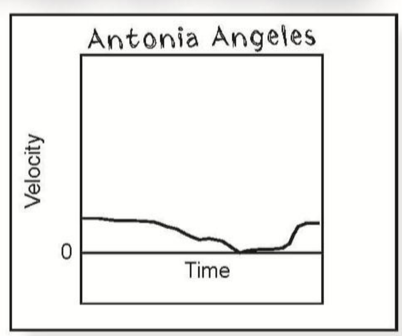
Everett Smalls, 38--brought in for blocking a fire lane—claimed that bumper was damaged in a stop-and-go rush hour fender bender.

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.

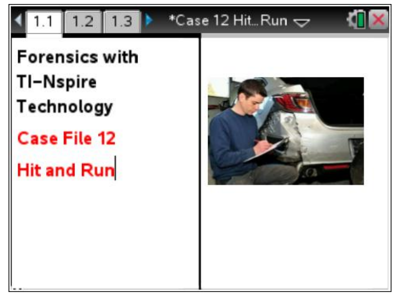






About the Lesson

- This lab introduces students to the concept that displacement, velocity, and acceleration are related quantities. Patterns in one measurement can be used to predict patterns in the others.
- Teaching time: one 45 minute class period



Science 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
- 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

Activity Materials

- TI-Nspire™ technology
- *Case 12 Hit and Run.tns* file
- *Case_12_Hit_and_Run_Student.doc* student activity sheet
- Vernier Motion Detector and TI-Nspire Lab Cradle or CBR 2™
- metric tape measure or meter stick
- toy car, at least 5 cm tall

TI-Nspire™ Navigator™

- Send out *Case 12 Hit and Run.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 the student activity sheet.
- Either a dynamics cart or a free-rolling toy car can be used in this activity.

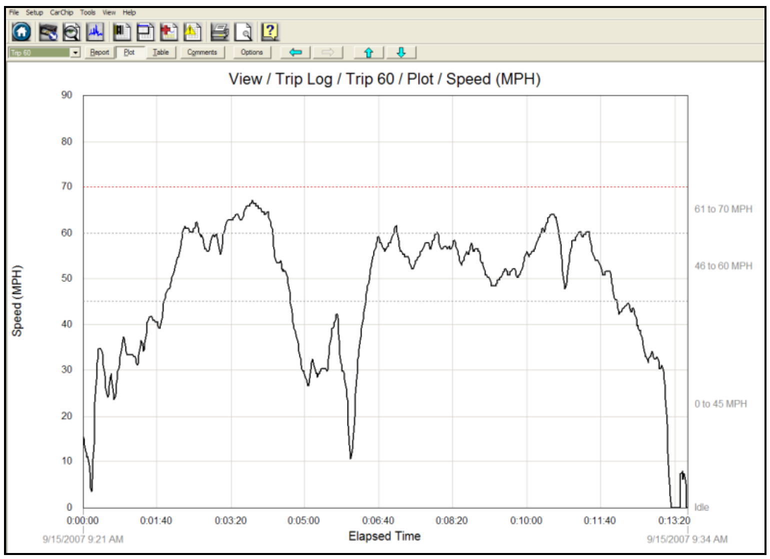
  Running this activity on a smooth surface, such as an uncarpeted floor or smooth table, will result in better data.
- Demonstrate the correct procedure for students: Position the Motion Detector behind the toy car. Start data collection, wait an instant, and then push the car. Have the students hold and push the car from the top of the car. If they push from the back of the car the motion detector will pick up the motion of their hand. Be sure that the Motion Detector records the push and release. These are important points on the velocity and acceleration graphs.

Background

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 Motion Detector 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 Motion Detector.

The following graph shows data collected with a Davis Instruments CarChip, which records data using the On-board Data Port of a car, similar to an event data recorder.



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

Procedure

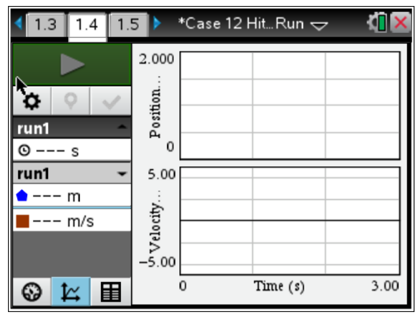
Part 1 – Collecting Data

Move to page 1.2–1.4.

Students will follow the directions on how to prepare the Motion Detector for data collection. They will connect the Motion Detector on page 1.4. Remind students to remove any surrounding objects so that the data they acquire will be relatively "noise" free.

Part 2 – Analyzing the Data

Move to pages 1.4–1.5.



Students should examine the distance and velocity graphs on the "graph view". These graphs should be relatively smooth, indicating that they picked up the motion of the car and not other objects. If the graphs of the distance and velocity are not relatively smooth (an absolutely smooth graph is rarely observed), have them repeat data collection. Students should sketch their graphs in the Evidence Record below and then complete the Case Analysis.

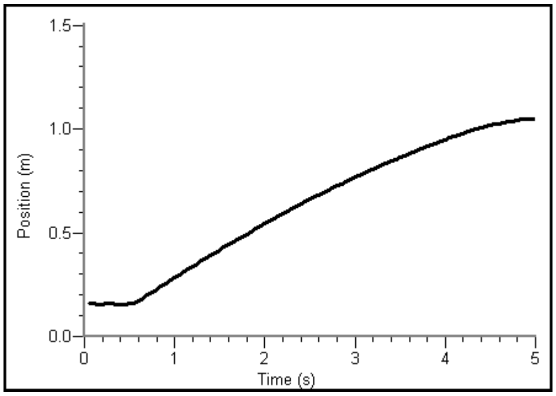
Modifications

If your students are more advanced, you can have them plot and examine the acceleration data collected during the procedure. 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.

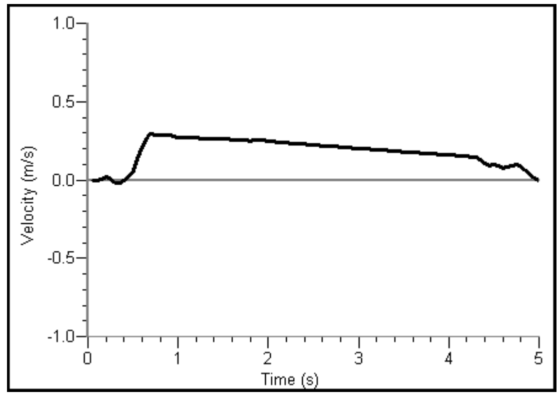
Evidence Record

SAMPLE DATA

Pushing a Dynamics Cart



Distance vs. Time



Velocity vs. Time

Case Analysis

Move to pages 2.1–2.9.

Have students answer the following questions on the handheld, on their activity sheet, or both.

Q1. Look at the velocity vs. time graph. At what time did the car begin to move?

Answer: 0.6 seconds

Q2. What was the maximum velocity of the car?

Answer: 0.3 m/s

Q3. At what time did the car reach its maximum velocity?

Answer: 0.75 seconds

Q4. Look at the distance *vs*. time graph. Does the time at which the car's distance from the Motion Detector increased match the time in Question 1?

Answer: Yes

Q5. How far did the car move before it reached its maximum velocity?

Answer: 0.75 m

Q6. 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 was 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.

Answer: 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.

Q7. 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.

Answer: 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.