Activity 7

How Fast Was That Truck Going, Anyway?

Objectives

- ♦ To understand speed, velocity, and acceleration and know how to calculate them
- ♦ To use a motion sensor to measure the distance an object travels and calculate its speed

Materials

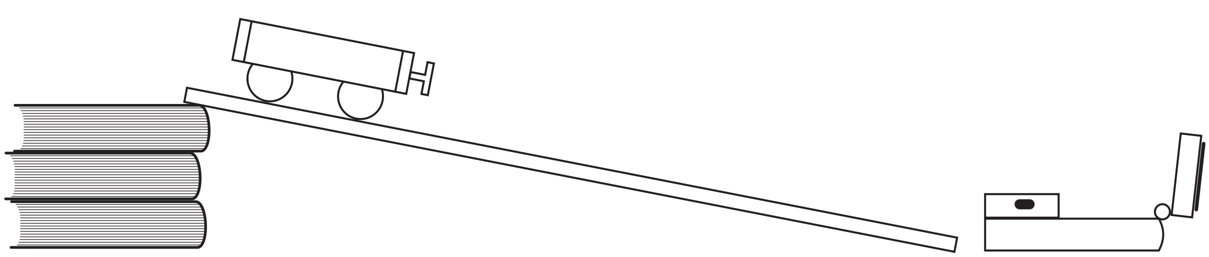
- ♦ TI-73
- ♦ Unit-to-unit cable
- ♦ CBL 2™
- ♦ Motion detector or CBR™ with CBR to CBL 2™ cable
- ♦ Vehicle (toy car or truck)
- ♦ Ramp (optional)
- ♦ Data Collection and Analysis pages (p. 60 – 62)

In this activity you will

- ♦ Roll a vehicle down a ramp and use the CBL 2™ with a motion detector to find how far the vehicle travels in a given amount of time.
- ♦ Use mathematical formulas and the TI-73 to calculate the vehicle's speed, velocity, and acceleration.
- ♦ Graph the data collected by the CBL 2.

Problem

Does the speed of a vehicle that is rolled down a ramp increase or decrease over time?



Introduction

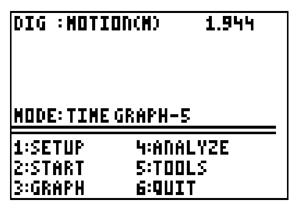
Motion is the movement from one place to another. The rate at which motion occurs (or its change in distance) over time is measured as *speed*. The formula for speed is distance divided by time or $s = \frac{d}{t}$. In this activity, a vehicle's change in distance over time will be measured using the CBL 2 and a motion detector. The movement will be measured as the vehicle's distance from the detector increases with time. It is important to notice the shape and slope of the line that results when the data is graphed on the TI-73. Once the data has been collected, the vehicle's velocity will be determined. *Velocity* is speed in a given direction.

Hypothesis

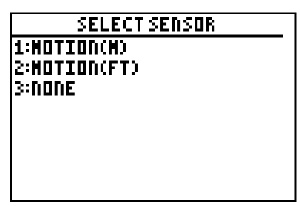
Before testing, complete the **Hypothesis** section on the **Data Collection and Analysis** page.

Procedure: Collecting the Data

1. Assemble the ramp as shown in the illustration.
2. Collect your vehicle and assign duties to the members of the lab group. One person needs to start the data collection and another person needs to release or push the vehicle.
3. Plug the motion detector or CBR™ into the DIG/SONIC channel on the CBL 2™.
4. Start the DATAMATE program.
5. The Main Screen is displayed. If **DIG :MOTION(M)** is displayed at the top of the screen, go to step 8. If **DIG :MOTION(M)** is not displayed, go to step 6.

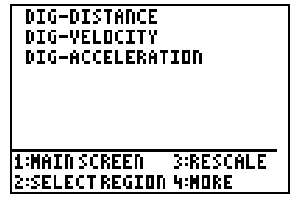


6. Select **1:SETUP**.



7. Select **DIG**. Select **1:MOTION(M)**. Select **1:OK** to return to the Main Screen.
8. Make sure that the testing area is clear so that the vehicle will not run into any obstacles.
9. When you are ready to begin, select **2:START**. The CBL 2 beeps twice and the motion detector starts clicking.
10. Either let the vehicle roll down the ramp or push it so that it travels in a straight line. The CBL 2 beeps again when it has finished collecting data.

11. The program displays three choices for graphing the data. Select **DIG-DISTANCE**.



12. The graph is displayed showing the data that was collected. Use [▸] and [◂] to move to each data point and record the distance for each one-second interval in the table on the **Data Collection and Analysis** page.

13. Repeat steps 9 through 12 two more times for a total of three trials.

14. To exit from the DATAMATE program, press [ENTER] **6:QUIT** [ENTER].

Data Analysis

Using the data you collected, answer the questions on the **Data Collection and Analysis** page to analyze your results.

Data Collection and Analysis

Name ______________________________

Date ______________________________

Activity 7: How Fast Was That Truck Going, Anyway?

Problem

Does the speed of a vehicle that is rolled down a ramp increase or decrease over time?

Hypothesis

The speed of a vehicle that is rolled down a ramp will (increase / decrease) over time. (Circle the correct response.)

Briefly explain your answer. You may want to draw a diagram to help explain your prediction.

____

____

____

Data Collection

1. After each trial, use the data from the displayed graph and record the distance for each one-second interval.
2. After all three trials, use the TI-73 to find the average distance for each time.

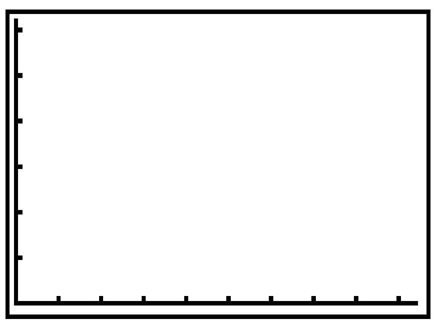
Time in Seconds (t)	Trial 1: Distance in Meters (d)	Trial 2: Distance in Meters (d)	Trial 3 Distance in Meters (d)	Average Distance in Meters (d)

Data Analysis

1. Use the average distance from the data table on the previous page and complete the table that follows. Remember that *speed is distance divided by time* ($s = \frac{d}{t}$).

Time (t)	Average Distance (d)	Average Speed (d/t)

2. Use the space below to draw a line graph of the average speed versus time or use the TI-73 to create an xyLine plot. Time is the independent variable and average speed is the dependent variable. Be sure to put the correct variable on each axis, and label the graph.



3. Look at the graph you just drew.

   a. Is the line's slope positive or negative?

   ____

   b. What does this tell you is happening to the vehicle's speed?

   ____

   ____

   c. Did the speed increase, decrease, or remain the same during the experiment?

   ____

   ____

4. Discuss how the data you collected does (or does not) support your hypothesis.

5. Why do you think the speed changed the way it did? What factors could have caused the change?

6. The formula for velocity is ______________________ .

7. How is this different from the formula for speed?

8. Can speed be a negative number? Can velocity? Explain.

9. Using the data from the experiment and the TI-73, calculate the vehicle's velocity between seconds 1 and 3 and between seconds 3 and 5 in the space below. Be sure to show all your work.

10. Acceleration measures how velocity changes during a period of time. The formula for acceleration is ______________________ .

11. Using the two values you found for velocity in question nine above, calculate the vehicle's acceleration. Is the vehicle's acceleration (positive / negative / zero)? (Circle the correct response.)

Conclusion

The vehicle’s speed (increased / decreased / stayed the same) over time.
(Circle the correct response.)

Teacher Notes

Activity 7

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Objectives

- To understand speed, velocity, and acceleration and know how to calculate them
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NSES Standards

- Physical Science: Force and motion

Preparation

- In this activity, students will use the CBL 2™ and a motion detector to measure a moving vehicle's change in distance during a five-second period of time. The graph will provide them with the information they need to calculate the average velocity of the vehicle and to reach conclusions about its instantaneous velocity at any point and its change in velocity or acceleration.
- Clear an area at least 2 meters wide and 7 meters long. At one end of the area, set up the ramp (if used), motion detector, CBL 2, and TI-73. The motion detector should be placed on the floor with the sensor as close to the floor as possible, pointing toward the opposite end of the cleared work area. If using a ramp, place the motion detector next to the bottom of the ramp approximately 0.5m from the end of the ramp. The motion detector must be pointing in the direction the vehicle will be moving. See diagram on page 57.
- Depending on the size of the vehicle and any obstructions in front of the motion detector, the students may run into problems collecting their data. You may want to have this happen on purpose to give your students practice in modifying experiments to overcome unexpected problems, but it is still recommended that you perform this experiment using the same vehicle and setup that you plan to use with your students.
- The vehicle can be any number of items, but it is recommended that it have a rear cross section at least 7 cm by 7 cm to ensure that the motion detector can track it.
- *The lab is designed for the vehicle to be rolled down a ramp*. Other options are for a student to push the vehicle when the lab starts or use a motorized car or truck if one is available. Bear in mind that the motorized vehicle will have a constant velocity, while the rolled or pushed vehicle's velocity will decrease.

Management

- Assign these student jobs for this lab:
  - Materials/setup person (sets up samples, sensor)
  - Tech person (operates CBL 2™ and TI-73)
  - Data recorder (reads distance and time readings from the TI-73 at each collection interval)
  - Runner (brings CBL 2 and TI-73 to the computer to print graphs with TI-GRAPH LINK™ or TI™ Connect and brings **Data Collection and Analysis** pages to the teacher)
- Clear covered plastic shoeboxes will hold a CBL 2™, pH sensor, cups, rinsing bottle, and other equipment neatly at each station. If students are sharing one pH sensor, representatives from each lab group should bring test beverages in the cups to the sensor. Mounting the sensor on a ring stand is an option.
- Students can record distance and time readings in their lab journals as they are displayed on the TI-73. This keeps them engaged throughout the data collection period and if they lose their data/graph later, they can still write up their lab report. Students can also access the data in the TI-73 lists after data collection. You can send the lists to all students' calculators using [APPS] **1:Link**.

  a. Press [APPS].

  b. Press [ENTER] to select **1:Link.**

  c. Select **4:List** and press [ENTER].

  d. Press [▼] to move the ▸ beside the list you wish to send. Press [ENTER].

  e. Repeat step **d** for each list you wish to send.

  f. Set the receiving unit by pressing [APPS] [ENTER] [▶] to select **RECEIVE**. Press [ENTER]. **Waiting…** displays on the TI-73 screen.

  g. On the sending unit, press [▶] to select **TRANSMIT** and press [ENTER].

  For more permanent storage of data, use TI-GRAPH LINK or TI™ Connect to save the lists in a computer folder.
- Students can assess each other using a teamwork rubric after the lab. Provide a checklist of positive and negative behaviors. Copy these on quarter sheets of paper.

Note: *Data is not collected in perfect intervals. Students will have to use their measurement skills to find the distance at one-second intervals.*

Data Analysis

The questions for this lab include calculating the vehicle's velocity and acceleration for different segments of the vehicle's run. The students then analyze the data to reach conclusions about why it changed. The following formulas apply:

$$v = \frac{\Delta d}{\Delta t} = \frac{d_f - d_i}{t_f - t_i} \qquad a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

where:

- v is velocity
- a is acceleration
- d_f is the final distance
- d_i is the initial distance
- t_f is the final time
- t_i is the initial time
- v_f is the final velocity
- v_i is the initial velocity
- Δd (delta d) is the change in distance
- Δt (delta t) is the change in time
- Δv (delta v) is the change in velocity

Note that in many cases the initial time, distance, and/or velocity may be zero. Many students get confused when they have to work with equations like this for the first time.