Cool Reaction! The Reaction of Baking Soda and Vinegar

Have you ever mixed vinegar and baking soda? It's fun to watch, but did you know that the reaction between the two is actually a chemical reaction that produces gas and changes temperature, too? The gas it produces is carbon dioxide, CO_2, and the temperature changes. Does the temperature go up or down? We will soon find out!

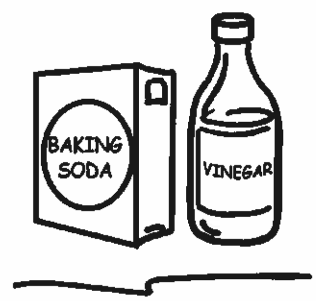
OBJECTIVES

In this activity, you will

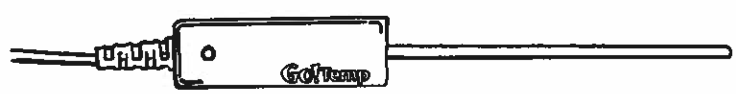
- Produce a reaction between baking soda and vinegar.
- Measure the changing temperature of a reaction.
- Make observations.

MATERIALS

computer with Logger Lite software installed
Go!Temp temperature probe
goggles
cup with fill-level marking
plastic spoon
baking soda
vinegar
paper towels or rags to clean up spills
tray



PROCEDURE



1. Get goggles and wear them.
2. Make sure the Go!Temp is connected to the computer.
3. Start Logger Lite on your computer.

10. Data collection will last 40 seconds. During this time, you should make observations about the temperature changes displayed on the screen, and about what is happening in the cup.

11. Record your observations on the Observations Sheet about the change in temperature and what happened in the cup during the reaction.

12. When data collection is complete, dispose of your materials as directed by your teacher.

Observations Sheet
Write observations about the reaction and the change in temperature of the mixture.

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Elementary Science with Vernier* lab manual includes 43 labs and essential teacher information. The full lab book is available for purchase at: http://www.vernier.com/cmat/ewv.html

Vernier

Vernier Software & Technology

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Cold as Ice

Ice water can be pretty cold. Is it always the same temperature? Is there anything you can do to make it even colder?

OBJECTIVES

In this activity, you will

- See how salt affects the temperature of freezing water.
- See how low you can decrease the temperature of liquid water.

MATERIALS

computer with Logger Lite software installed
Go!Temp temperature probe
cup
tap water
ice cubes
plastic spoon
2 spoonfuls of table salt
paper towels or rags to clean up spills
tray (if available)

KEY QUESTION

How low can you drop the temperature of water while still keeping it liquid?

PREDICTION

I predict I can drop the temperature of water to ______________°C by adding

____ to the water.

PROCEDURE

1. Make sure the Go!Temp is connected to the computer.
2. Start Logger Lite on your computer.

b. Repeat Steps 5-6 to collect ice water data.

c. When you write down the temperature, write it under the heading: Ice water temperature, and when you label your data, type: Ice water.

8. Collect data with salt and ice in the water by doing the following:

   a. Add 2 spoonfuls of salt to the ice water.

   b. Repeat Steps 5-6 to collect data for the ice water with salt. When you write down the temperature, write it under the heading: Ice water with salt temperature, and when you label your data, type: Ice water with salt.

ANALYZE YOUR DATA

1. What happened to the temperature of the water as you added ice?

____

____

2. What do you think would happen if you continued to add ice cubes to the water? Could you ever drop the temperature below zero degrees Celsius?

____

____

3. What surprised you about the addition of salt?

____

____

4. What could you do to drop the temperature even more?

____

____

Good job!!

LabQuest
35
Graphing Your Motion

Graphs made using a Motion Detector can be used to study motion. A Motion Detector measures the distance to the nearest object in front of it by emitting and receiving pulses of ultrasound. A calculator can use distance and time measurements to calculate velocity. In this experiment, you will use a LabQuest and a Motion Detector to produce graphs of your own motion.

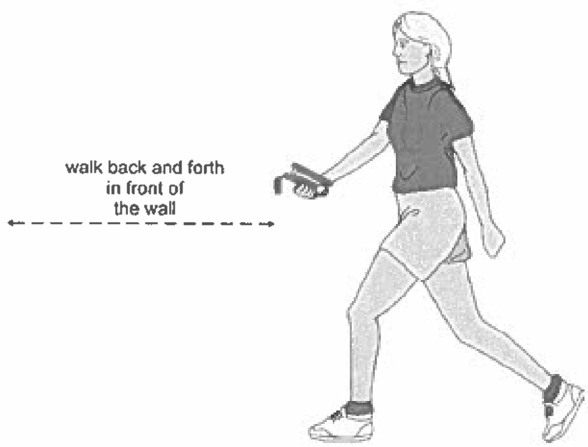
OBJECTIVES

In this experiment, you will

- Use a LabQuest and a Motion Detector to measure distance and velocity.
- Use a LabQuest to produce graphs of your motion.
- Analyze and interpret graphs of your motion.

MATERIALS

LabQuest
LabQuest App
Vernier Motion Detector
meter stick
masking tape

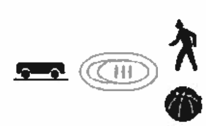


PROCEDURE

Part A Position

1. Find an open area at least 4 m long in front of a wall. Use short strips of masking tape on the floor to mark distances of 1 m, 2 m, and 3 m from the wall. You will be measuring your position from the Motion Detector in your hands to the wall.

2. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to DIG 1 of LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.



3. On the Meter screen, tap Length, then change the data-collection length to 10 seconds. Select OK.

4. Open the hinge on the Motion Detector. When you collect data, hold the Motion Detector so the round, metal detector is always pointed directly at the wall. Sometimes you will have to walk backwards.

5. Explore data collection for a position *vs.* time graph.
   a. Take a starting position one meter in front of the wall.
   b. Signal your partner to start data collection.
   c. When the fast clicking begins, walk to a distance of two meters and stop.
   d. After data collection is complete, a graph of position *vs.* time will be displayed. Discuss the results with your partners.

6. Repeat Step 5 walking more quickly this time.

7. Match a position *vs.* time graph.
   a. Choose Motion Match ▶ New Position Match from the Analyze menu. A target graph will be displayed for you to match.
   b. Examine the graph and plan what you will do to match it.
   c. Take your starting position in front of the Motion Detector.
   d. Have your partner start data collection.
   e. Move according to your plan.
   f. Examine the graph of the results.
   g. In Processing the Data (Part A), sketch a graph of your results in the space provided. **Important:** Your sketch should show *both* the target line produced by LabQuest *and* the graph of your motion. Then, in the space provided, describe what you had to do to match the first graph.
   h. If you would like to try matching the same graph, start data collection again when you are ready to stalk walking. If you are ready to match another graph, proceed to Step 8.

8. Repeat Step 7 so everyone in your group has a chance to match a position vs. time graph. **Note:** When you choose Motion Match ▶ New Position Match again, a new target graph will be displayed.

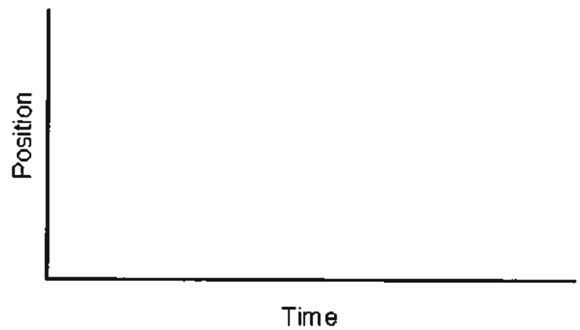
PROCESSING THE DATA (PART A)

1. Describe the difference between the two lines on your graph made in Steps 5–6. Explain why the lines are different.

2. How would the graph change if you walked toward the Motion Detector rather than away from it? Test your answer using the Motion Detector.

3. What did you have to do to match the graph you were given in Step 7?

4. Sketch a position *vs.* time graph for a car that starts slowly, moves down the street, stops at a stop sign, and then starts slowly again.



Part B Velocity

9. Choose Motion Match ▶ Remove Match from the Analyze menu. Change the y-axis to velocity. To do this, tap the y-axis label and select Velocity.

10. Make a graph of your motion when you walk away from the detector with constant velocity. To do this, stand about 1 m from the wall. Have your lab partner start data collection, then walk slowly away from the Motion Detector. After data collection is complete, a graph of velocity *vs.* time will be displayed. Discuss the results with your partners.

11. Repeat Step 10 walking more quickly this time.

12. LabQuest can also generate random target velocity graphs for you to match. Choose Motion Match ▶ New Velocity Match from the Analyze menu to view a velocity target graph.

13. Write down how you would walk to produce this target graph. Sketch or print a copy of the graph.

14. To test your prediction, choose a starting position and stand at that point. Have your partner start data collection. When you hear the Motion Detector begin to click rapidly, walk in such a way that the graph of your motion matches the target graph on the screen. It will be more difficult to match the velocity graph than it was for the position graph.

15. If you were not successful and want to match the same target graph again, start data collection when you are ready to start walking. Repeat this process until your motion closely matches the graph on the screen. Print or sketch the graph with your best attempt.

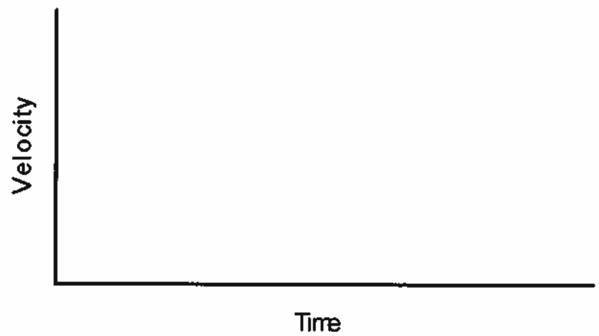
16. Repeat Steps 12–15 so everyone in your group has a chance to match a velocity vs. time graph. **Note:** When you choose Motion Match ▶ New Velocity Match again, a new target graph will be displayed.

PROCESSING THE DATA (PART B)

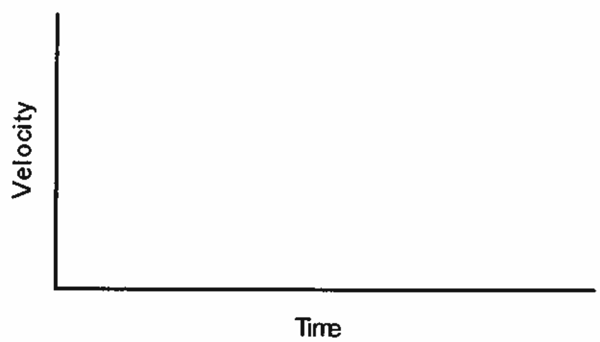
5. Describe the difference between the two lines on the graph made in Step 10–11. Explain why the lines are different.

6. What is the definition of velocity?

7. What did you have to do to match the graph you were given in Step 12? How well does your graph agree with the graph provided?



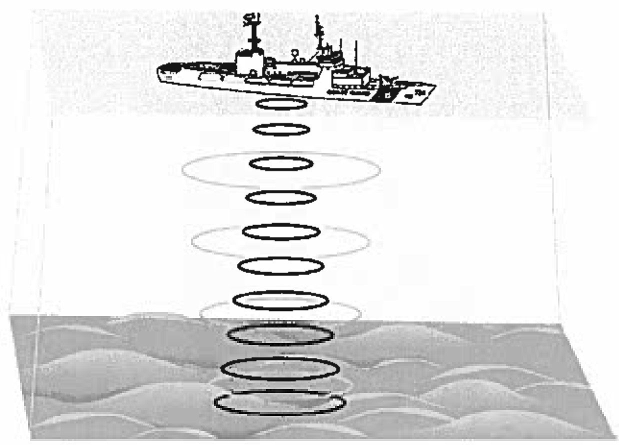
8. Sketch a velocity *vs*. time graph for a person who walks, stops for a few seconds, and then starts to run.



LabQuest
19

Mapping the Ocean Floor

Oceanographers, marine geologists, and archeologists use echo sounders to investigate objects below the surfaces of bodies of water. An echo sounder consists of a transducer that sends out and receives sound waves. A signal is sent out and bounces back from a submerged surface. Scientists use the speed of sound in water and the time it takes for the signal to bounce back to calculate the depth of the object. The deeper the object, the longer it takes for the sound to return. A map of the ocean floor is made by sending out a series of "pings" in a grid pattern and recording the depths. Echo sounders use different frequencies to map different things on the ocean floor.



Sonar, which is short for *so*und *na*vigation *r*anging, is the name given to this echo sounding system. It was invented during World War I to detect submarines. The Vernier Motion Detector works in a similar manner. In this activity, you will use a Motion Detector to map objects on a simulated ocean floor.

OBJECTIVES

In this experiment, you will

- Use a Motion Detector to measure distances.
- Map simulated ocean floors.

MATERIALS

LabQuest	1 m board
LabQuest App	masking tape
Motion Detector	2 or more boxes

PRE-LAB QUESTIONS

1. What else can you think of that measures distance by sending out a sound signal?

2. What factors make it difficult to study the ocean floor directly?

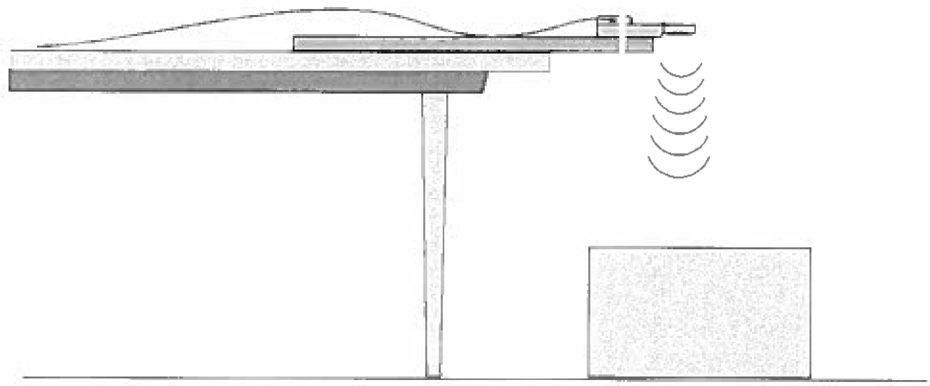


Figure 1

PROCEDURE

Part I Ocean Floor 1

1. Prepare the Motion Detector for data collection.
   a. Get the board that will act as the support for your Motion Detector.
   b. Tape or clamp the Motion Detector to one end of the board. Make sure that the round screen of the Motion Detector is not covered and is pointing downward.
   c. Place the board with the Motion Detector flat on your table as shown in Figure 1.

2. Prepare the ocean floor for data collection.
   a. Place the box on the floor underneath the Motion Detector. **Note:** The Motion Detector must be at least 40 cm from the top of the box.
   b. Line up the Motion Detector so that when it is moved along the table edge it will pass over the box.

3. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to DIG 1 of LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.

4. On the Meter screen, tap Rate. Change the data-collection rate to 4 samples/second and the data-collection length to 15 seconds.

5. Collect distance data.
   a. Move the board to position the Motion Detector to the left of the box.
   b. When everything is ready, start data collection. Then, slowly slide the board across the tabletop so that the Motion Detector passes over and past the box.

6. Determine and record the distance to the floor.
   a. Identify a flat portion of the graph that represents the floor. Tap and drag your stylus across the region that represents the floor to select the region.
   b. Choose Statistics▶Position from the Analyze menu.
   c. Record the mean (average) distance to the floor in meters.
   d. Choose Statistics▶Position from the Analyze menu to turn off the statistics.

7. Determine and record the distance to the box.
   a. Identify the flat portion of the graph that represents the box.
   b. Tap and drag your stylus across the region that represents the box to select the region.
   c. Choose Statistics▶Position from the Analyze menu.
   d. Record the mean (average) distance to the box in meters.
8. Sketch and label your graph.

Part II Ocean Floor 2

9. Prepare Ocean Floor 2.
   a. Set up two boxes in the shape of steps. The tallest box must be at least 40 cm from the Motion Detector.
   b. Repeat Steps 5–8. Be sure to record all three distances.

Part III Hidden Ocean Floor

10. Your teacher will have a hidden ocean floor for you to measure. Repeat Steps 5–8 for the concealed object or objects

Graph Sketches

Ocean Floor 1 **Ocean Floor 2** **Hidden Ocean Floor**

DATA

	Distance to floor (m)	Distance to box (m)	Box height (m)
Ocean floor 1 single box			
Ocean floor 2 box 1			
Ocean floor 2 box 2			
Hidden ocean floor box 1			
Hidden ocean floor box 2			
Hidden ocean floor box 3 (if detected)			

PROCESSING THE DATA

1. In the space provided in the data table above, find the height of each box. Do this by subtracting the distance to the box from the distance to the floor.

2. Which was your best result? Why do you think it was better than your other results?

3. How did the shape of your graph compare to the actual object(s) in each case? Explain.

EXTENSIONS

1. Try other hidden ocean-floor arrangements.

2. Research the sonar process and compare it to what you did in this activity.

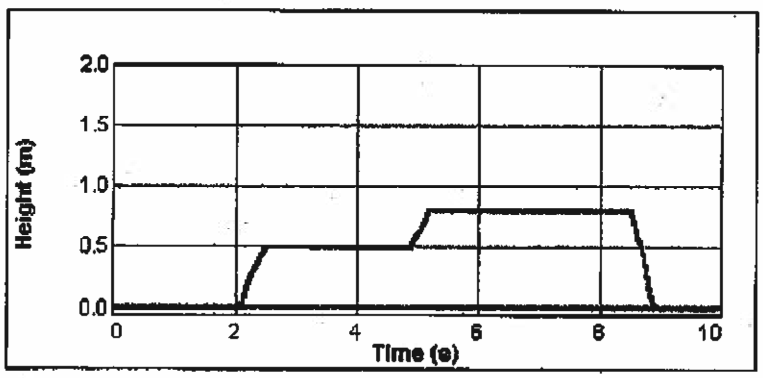
Experiment
19

TEACHER INFORMATION

Mapping the Ocean Floor

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. The boxes should be at least 50 cm wide.
3. Best results are obtained when the boxes are located touching each other or at least 50 cm apart.
4. The tabletops should be smooth and flat.
5. Boards longer than one meter can be used. They should provide rigid support for the Motion Detector.
6. The hidden arrangement can be located behind a counter or demonstration table.

SAMPLE RESULTS



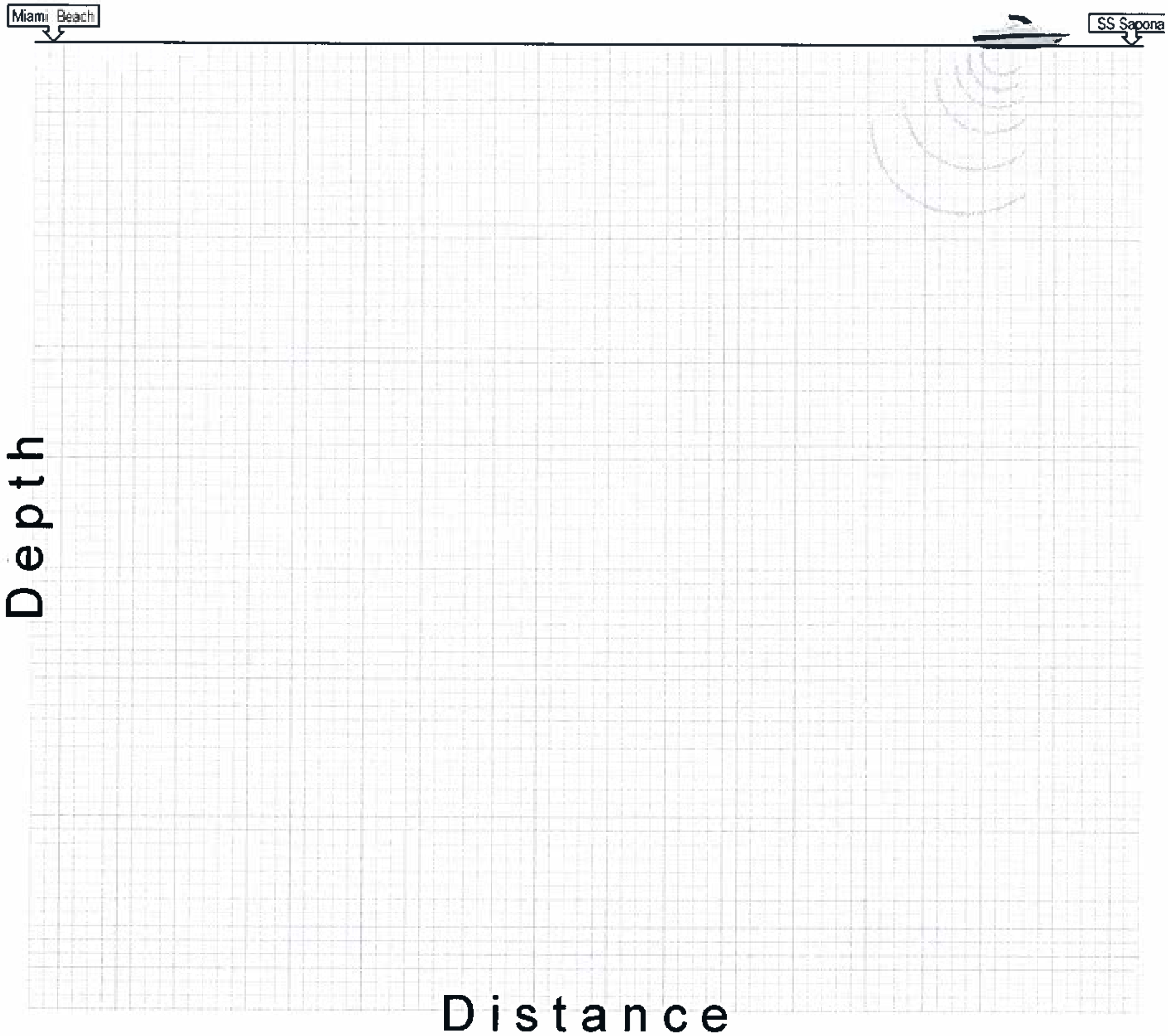
A Two-Box Simulated Ocean Floor

ANSWERS TO QUESTIONS

1. See the Sample Results.
2. The shape of the graph is similar to the shape of the objects.
3. Real ocean-floor mapping is affected by the water, water temperature, ocean currents, weather, and interfering objects.

ACKNOWLEDGEMENT

We wish to thank Don Volz and Sandy Sapatka for their help in developing and testing this experiment.


Miami Beach
SS Sapona
Depth
Distance

Mapping the Ocean Floor

Name: ______________________________

Instructions and data sheet

Background:

The surface of the oceans covers an area of more than 12 million square km! Did you ever wonder what was below the surface of all that water? Many early explorers did, and they used several methods to try to determine the shape of the ocean floor. At one time, sailors tied weights to the end of ropes and lowered them to the ocean floor, marked the distance when the rope hit bottom, and then measured that distance. You can imagine what a slow process this was!

In the early 1900s, sonar was invented by a French scientist. He used this technology to get sound wave readings of the ocean floor. This was a great discovery because it allowed scientists to get faster and more accurate readings. A device called an "echo sounder" is simply aimed downward, at which point it gives off a sound signal. The sound signal travels to the ocean floor and bounces, or "echoes", off the surface. The device picks up the echo and then computes the ocean depth at that point. To do this calculation yourself, all you need to know is the speed of sound in water (1,500 m/s), and the time it took for the sound signal to echo.

During this activity, you will use this method to construct a map for two different regions of the ocean floor.

Procedures:

Atlantic Profile:

1. Compute the *Total Distance Traveled by the Sound* by multiplying the *Time for the Signal to Return* by the Speed of Sound (1,500 m/s).
2. Record this distance on the Data Table on the back of this sheet.
3. Divide your *Total Distance Traveled* by 2 to get your *Ocean Depth* in meters.
4. Record this depth on the Data Table.
5. Plot the *Distance from Beach* (x-axis) and the *Ocean Depth* (y-axis) in meters using the **Atlantic Profile** graph on the "Mapping the Ocean Floor Lab" handout. **Sea level (Depth = 0 meters) is the line already shown on the graph.**
6. Once the points are plotted, connect the points and shade in the profile of the ocean floor.
7. **Label the following ocean floor features on your graph.** Use page 48 and 49 as a reference.

Continental Shelf, Continental Slope, Continental Rise, Island, Mid-ocean ridge, Abyssal Plain

Pacific Profile:

1. Using the **Pacific Profile** data on the "Mapping the Ocean Floor Lab" Lab Sheet Plot the *Distance from Beach* on the x-axis and the *Ocean Depth* on the y-axis. **For this set of data, the depth has already been calculated for you.**
2. Once the points are plotted, connect the points and shade in the profile of the ocean floor.
3. **Label the following ocean floor features on your graph.** Use page 48 and 49 as a reference.

Continental Slope (directly next to shore), Seamount, Trench (the deep one)

4. This map shows both the Philippine Plate and Pacific Plate. Within the oceanic crust beneath the ocean floor, **sketch what you think the subduction zone would look like. (Show one plate going under the other.)**

5. In this activity you created two different ocean floor profiles. One major difference between the two profiles is the scale of the distance from the shore. Even though both of your profile pictures cover the width of your paper, they do NOT represent the same distance. You need to get a sense of how each of the two profiles compare to each other. **Determine how much of your Atlantic Profile would be "covered" by the Pacific Profile. To do this, draw a bracket [bracket] at the bottom of your Atlantic profile representing the width of your Pacific Profile.**

*** When finished graphing both profiles, answer all discussion questions on the back of your * graph sheet using <u>complete sentences</u>.**

Data for Atlantic Profile

Distance from Beach (km)	Time for Signal to Return (seconds)	Total Distance Traveled (meters) (Time x 1500 m/s)	Ocean Depth (meters) (Total Distance ÷ 2)
50	0.4		
100	0.5		
150	0.6		
200	0.7		
250	1.1		
300	1.4		
350	2.1		
400	3.2		
450	3.7		
500	4.3		
550	4.9		
600	5.4		
650	5.4		
700	5.7		
750	5.7		
800	5.6		
850	5.7		
900	5.7		
950	5.7		
1000	5.7		
1050	5.4		
1100	5.4		
1150	4.3		
1200	3.2		
1250	0.7		
1300	above sea level		
1350	1.4		
1400	4.3		
1450	4.9		
1500	4.9		
1550	5.4		
1600	5.7		
1650	5.7		
1700	5.6		
1750	5.7		
1800	5.4		
1850	5.4		
1900	4.9		
1950	4		
2000	3.7		
2050	4.6		
2100	6		
2150	4.3		
2200	3.2		
2250	4.3		
2300	5.4		
2350	6		
2400	6		

Data for Pacific Profile

Distance from Beach (km)	Ocean Depth (meters)
0	400 above level
8	1300
16	1000
24	30
32	1000
40	3000
48	4000
56	4500
64	3000
72	2800
80	3000
88	2800
96	3700
104	3000
112	3200
120	2500
128	3100
136	4200
144	7100
152	8200
160	11000
168	10000
176	9000
184	8000
192	7000
200	6000
208	5100
216	4500
224	4200
232	3840
240	3800

Name: ______________________________ Period: ________ Date: __________

Mapping the Ocean Floor Lab

Atlantic Profile

Pacific Profile

Discussion Questions:

Answer in complete sentences.

Atlantic Profile

1. What two pieces of information are needed to determine ocean depth?

2. Describe how a seamount could become an island. **ALSO,** describe how an island could become a seamount.

3. The island on your graph for the **Atlantic Profile** is part of a chain of islands located near 26°W and 38°N latitude. Use a globe or world map to locate and identify this island chain.

4. For the first data table, once you have found the total distance traveled by the sound wave, why is it necessary to divide it by 2? (**HINT: Think about where the sound signal has to travel.*)

Pacific Profile

5. This profile shows the seafloor at the Marianas Trench, the deepest known point in any of the world's oceans. Describe what's happening in this area to create this trench. Please write the name of the trench on your profile.

6. Explain how the seamount (between 72km and 128 km from the shore) may have formed near this trench.

Comparing the two:

7. How do the two profiles differ from one another? Be descriptive of each region of ocean floor.

8. In oceanography, the edges of the continents are referred to as "margins". Depending on what type of plate activity is occurring, a margin may be considered an active margin or a passive margin. Based on your knowledge of plate tectonics, which of the two profiles would you consider to be "active", and which would be "passive". Explain your reasoning **in detail**, referring to each profile. **Then, label each profile as either "passive" or "active" on each graph.**

LabQuest
23

Reflectivity of Light

Light is reflected differently from various surfaces and colors. An understanding of these differences is useful in choosing colors and materials for clothing, in choosing colors for cars, and in city planning. Astronomers use reflectivity differences to help determine characteristics of planets. In this experiment, you will be measuring the percent reflectivity (*albedo*) of various colors. You will measure reflection values from paper of various colors using a Light Sensor and then compare these values to the reflection value of aluminum foil. The aluminum foil will arbitrarily be assigned a reflectivity of 100 percent. You will then calculate percent reflectivity using the relationship

$$\% \text{ Reflectivity} = \frac{\text{value for paper}}{\text{value for aluminum}} \times 100$$

OBJECTIVES

In this experiment, you will

- Use a LabQuest and a Light Sensor to measure reflected light.
- Calculate percent reflectivity of various colors.
- Make conclusions using the results of the experiment.

MATERIALS

LabQuest
LabQuest App
Light Sensor
ring stand and utility clamp
white paper
black paper
2 other pieces of colored paper
aluminum foil

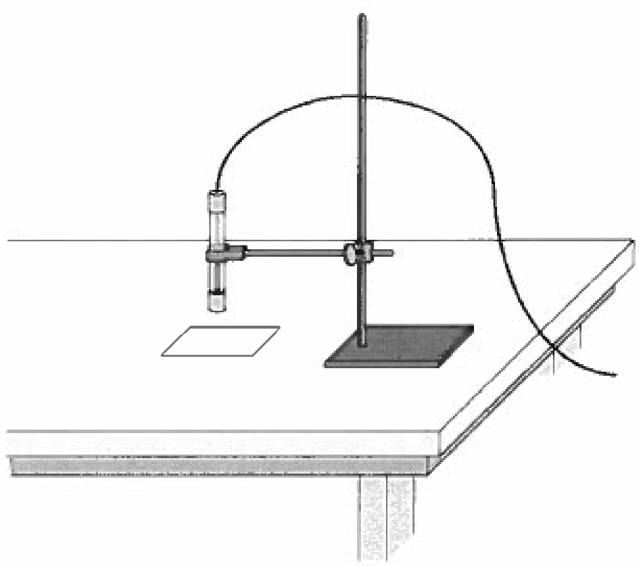


Figure 1

PROCEDURE

1. If your Light Sensor has a switch, set it to 600 lux. Connect the sensor to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
2. Set up the mode.
   a. On the Meter screen, tap Mode. Change the mode to Selected Events.
   b. Select Average over 10 seconds and select OK.
3. Start data collection.
4. Use a utility clamp and ring stand to fasten the Light Sensor 5 cm from and perpendicular to a piece of colored paper as shown in Figure 1. The classroom lights should be on.
5. When the light reading displayed on the screen is stable, tap Keep. **Note:** LabQuest will be taking data for the next 10 seconds.
6. Obtain a second piece of colored paper. Repeat Steps 4–5. Continue with this method to collect and record readings for aluminum, black, white, and two other colors.
7. Stop data collection and tap Table to view the data. Record the reflection values in your data table.

DATA

Color	Aluminum	Black	White	________	________
Reflection Value	________	________	________	________	________

PROCESSING THE DATA

1. Calculate the percent reflectivity (albedo) of each color using the formula given in the introduction. Show your work and record the results in the table below.

Color	Aluminum	Black	White	________	________
Percent Reflectivity	100%	________	________	________	________

2. Which color, other than aluminum, has the highest reflectivity?

3. Which color has the lowest reflectivity?

4. What materials might give a planet a high reflectivity or albedo? Explain.

5. Does the planet Earth have high reflectivity? Why?

EXTENSION

1. Design an experiment to determine if there is a relationship between reflected light and heat absorbed by various colors or materials.

Name ______________________________ Date ______________

Computer
25

Heart Rate and Body Position

Does the position of your body affect your heart rate? In this experiment, you will use a Heart Rate Monitor to measure your heart rate while sitting, lying, and standing. You will then use your results to answer the question.

OBJECTIVES

In this experiment, you will

- Use a Hand-Grip Heart Rate Monitor or Exercise Heart Rate Monitor to measure your heart rate while sitting, lying, and standing.
- Analyze the results of your experiment.
- Compare your results with those of other students.
- Answer the question posed in the introduction.

MATERIALS

computer
Vernier computer interface
saline solution in dropper bottle
(for use with Exercise HR Monitor)
Vernier Hand-Grip Heart Rate Monitor **or**
Vernier Exercise Heart Rate Monitor

PROCEDURE

1. Plug the receiver module of the Heart Rate Monitor into the Vernier computer interface.

2. Start the Vernier data-collection program and open the file "25 Heart Rate Position" from the *Middle School Science with Vernier* folder.

Using a Hand-Grip Heart Rate Monitor

Use the following instructions if you are using a Hand-Grip Heart Rate Monitor.

3. Stand facing your table or lab bench. Grasp the handles of the Hand-Grip Heart Rate Monitor your hands. The fingertips of each hand should be placed on the reference areas of the handles. The left hand grip and the receiver are both marked with an alignment arrow. When collecting data, be sure that the arrow labels on each of these devices are in alignment (see Figure 1). The reception range of the plug-in receiver is 80–100 cm, or about 3 feet.

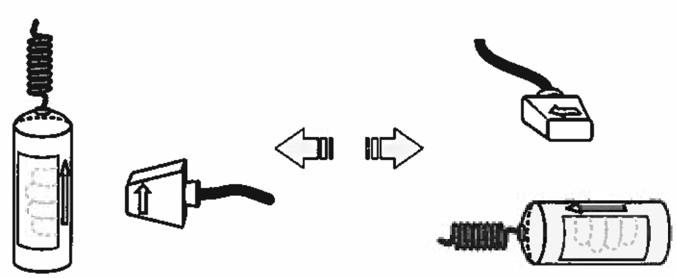


Figure 1

4. Click [▶ Collect] to determine that the sensor is functioning correctly. There will be a 15 second delay while data are collected before the first point is plotted on the upper graph. Thereafter, a point will be plotted every 5 seconds. The readings should be consistent and within the normal range of the individual, usually between 55 and 90 beats per minute.

5. If the readings appear unreasonable, reposition your fingers and check the sensor and receiver alignment.

6. Once it is apparent that the sensor is functioning correctly, click [■ Stop] and continue with Step 11.

Using an Exercise Heart Rate Monitor

Use the following instructions if you are using an Exercise Heart Rate Monitor.

7. Depending upon your size, select a small or large size elastic strap. Secure one of the plastic ends of the elastic strap to the transmitter belt. It is important that the strap provide a snug fit of the transmitter belt.

8. Wet each of the electrodes (the two textured oval areas on the underside of the transmitter belt) with 3 drops of saline solution.

9. Secure the transmitter belt against the skin directly over the base of the rib cage. The POLAR logo on the front of the belt should be centered. Adjust the elastic strap to ensure a tight fit.

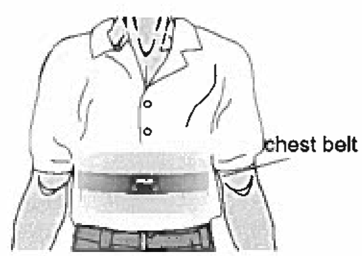


Figure 2

10. Take the receiver module of the Heart Rate Monitor in your right hand and have a seat well away from the computer monitor. Face away from the computer monitor and your classmates. Sit quietly. Remember that the receiver must be within 80 cm of the transmitter in the Heart Rate Monitor belt.

Part I Sitting Heart Rate

11. Once the subject has been seated quietly for about a minute, a partner should click [▶ Collect] to begin monitoring heart rate.

Part II Reclining Heart Rate

12. After 4 minutes of data collection have gone by, the subject should recline on a clean surface or table and facing away from the computer monitor and all classmates. Note: A partner should tell the subject when it is time to recline.

Part III Standing Heart Rate

13. After 8 minutes of data collection have gone by, the subject should stand facing away from the computer monitor and all classmates. A partner should again tell the subject when it is time to stand. Data collection will automatically stop after 12 minutes.

Name ____ Date ____________________________

Part IV Recording Data

14. Determine the subject's sitting heart rate.
    a. Move the mouse pointer to the 2 minute line.
    b. Press the mouse button and hold it down as you drag across the graph to the 4 minute line to *select* this part of the graph.
    c. Click the Statistics button, . Record the Mean (average) sitting heart rate (in bpm).

15. Determine the subject's reclining heart rate.
    a. Move the mouse pointer to the 6 minute line.
    b. Press the mouse button and hold it down as you drag across the graph to the 8-minute line to *select* this part of the graph.
    c. Click the Statistics button, . Record the Mean (average) reclining heart rate (in bpm).

16. Determine the subject's standing heart rate.
    a. Move the mouse pointer to the 10 minute line.
    b. Press the mouse button and hold it down as you drag across the graph to the 12-minute line to *select* this part of the graph.
    c. Click the Statistics button, . Record the Mean (average) standing heart rate (in bpm).
    d. Close all of the Statistics boxes.

17. Print copies of the graph as directed by your teacher.

18. Repeat Steps 3–17 with other members of the team serving as subjects.

DATA

Subject's name			
Sitting heart rate (beats/min)			
Reclining heart rate (beats/min)			
Standing heart rate (beats/min)			
Difference between sitting and reclining heart rates (beats/min)			
Difference between standing and sitting heart rates (beats/min)			
Difference between standing and reclining heart rates (beats/min)			

PROCESSING THE DATA

1. In the space provided in the data table, subtract to calculate the difference between the sitting and reclining heart rates for each subject.
2. Subtract to find the difference between the standing and sitting heart rates for each subject.
3. Subtract to find the difference between the standing and reclining heart rates for each subject.
4. Does the position of your body affect your heart rate?
5. Compare your results with those of other students.
6. Try to explain the results of the experiment.

EXTENSION

1. Measure your heart rate while standing on your head. Compare the results with your other results.

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Middle School Science with Vernier* lab manual includes 38 labs and essential teacher information. The full lab book is available for purchase at: http://www.vernier.com/cmat/msv.html

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Activity
40

Learning to Use a Voltage Probe

A Voltage Probe can measure the voltage of a battery. This is one way of checking whether a battery is good. In this activity, you will learn about the Voltage Probe by working with a battery.

OBJECTIVES

In this activity, you will

- Learn to use the Voltage Probe.
- Measure the voltage of a battery.
- Match patterns on LabQuest.

MATERIALS

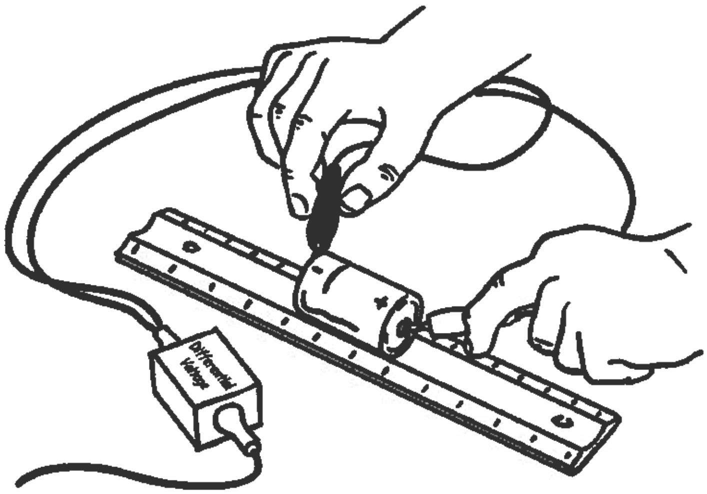
LabQuest
Vernier Differential Voltage Probe
battery
ruler with center groove

PROCEDURE

Part I Learn About the Voltage Probe

1. Make sure the Voltage Probe is connected to LabQuest.
2. Choose New from the File menu.
3. On the Meter screen, tap Length. Change the data-collection length to 20 seconds. Select OK.
4. Look at the materials you will be using in this activity.
   a. Pick up the battery. Do you know which end is the positive end and which is the negative? Make sure everyone in your group agrees upon which is positive and which is negative and put the battery in the groove in the ruler.
   b. Now, look at the clips of the Voltage Probe. You will be touching the metal tips of these clips to the ends of the batteries later on.

5. Zero the Voltage Probe.
   a. Clip together the ends of the red and black wires coming from the Voltage Probe.
   b. Look at the screen and choose Zero from the Sensors menu to zero the Voltage Probe. The voltage readings should be at or near 0 V.
   c. Disconnect the clips.

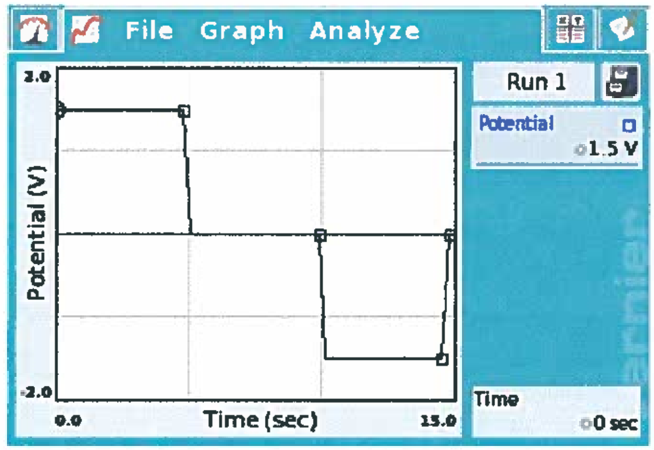


6. Collect data using the Voltage Probe by following the steps below. After you collect data, you will record your observations, so be sure to pay close attention!
   a. Look at the screen and start data collection.
   b. Touch the two Voltage Probe clips together. Notice if anything happens to the voltage values.
   c. Now, touch the black clip to the positive end of the battery (the side with the bump) and the red clip to the other end, and hold them for a few seconds. Are the voltage values negative?
   d. Finally, switch the clips around so the red clip touches the positive end of the battery and the black clip touches the negative end. Are the voltage values negative now?
   e. Stop data collection if it has not stopped already.

7. On the Observations Sheet below, write down what happened when you were collecting data.

Observations Sheet
1. When I touched the two clips together, the voltage
2. When I touched the black clip to the positive end of the battery and the red clip to the negative end of the battery, the voltage
3. When I touched the red clip to the positive end of the battery and the black clip to the negative end of the battery, the voltage

Part II Matching Patterns with the Voltage Probe



8. In this part of the activity, you will complete writing the steps necessary to match the pattern on the graph. Think about how you would do this and fill in the blanks below. **Note:** Your voltage readings might not match the pattern, exactly. It is most important to make the pattern similar to that on the graph, rather than reach the same voltages.

   a. Start with the red clip touching the ________________ (positive or negative) end and the black clip touching the ________________ (positive or negative) end of the battery.

   b. Keep the clips in this position for ____________ seconds.

   c. Quickly, touch the clips together and hold them there for __________ seconds.

   d. Quickly, touch the red clip to the ____________ (positive or negative) end and the black clip to the other end and hold them there for ________________ seconds.

   e. Quickly, touch the clips together and hold them there for __________ seconds until data collection ends.

9. Start data collection and follow the steps you wrote in Step 8.

10. If your data matches the original pattern, congratulations! If you want to try again, repeat the steps you wrote in Step 8.

Good job!!

Are All Batteries the Same?

Why are there so many kinds and sizes of batteries? Does the size of the battery determine the voltage of the battery? In this activity, you will set up an electrical circuit and investigate some of the properties of batteries.

OBJECTIVES

In this activity, you will

- Make observations about the size of different batteries.
- Use a probe to measure the voltage of various batteries.
- Make simple circuits with batteries and bulbs.

MATERIALS

LabQuest
Vernier Differential Voltage Probe
TI Light Probe
1 AAA battery
2 AA batteries
1 C battery
2 D batteries
small light bulb in socket
ruler with groove for holding batteries
2 jumper wires with alligator clips on each end
masking tape

PROCEDURE

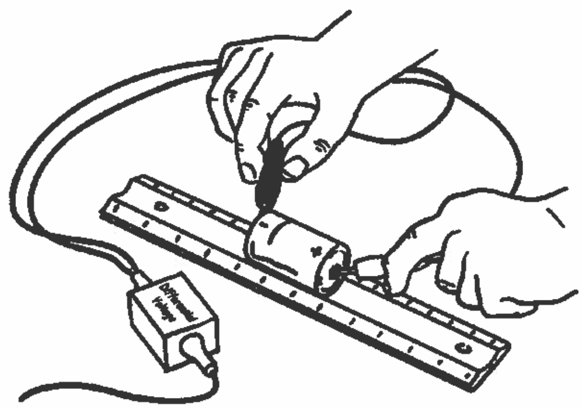
Part I Looking at Batteries and Measuring Voltages

1. Your teacher is going to hold up different batteries. The voltage of the AAA battery is 1.5 volts.

2. Predict the voltages of the other batteries and record your predictions in the Predicted voltage column of the Part I Data Table on the next page. The first one has been filled in for you.

Part I Data Table			
Battery type	**Predicted voltage**	**Measured voltage**	**Voltage printed on battery**
AAA battery	**1.5 V**	**V**	**V**
AA battery	**V**	**V**	**V**
C battery	**V**	**V**	**V**
D battery	**V**	**V**	**V**

3. Make sure the Voltage Probe is connected to LabQuest.
4. Choose New from the File menu.
5. Zero the Voltage Probe:
   a. Clip together the ends of the red and black wires coming from the Voltage Probe.
   b. Look at the screen and choose Zero from the Sensors menu to zero the Voltage Probe. The voltage reading on the screen should be at or near 0 V.

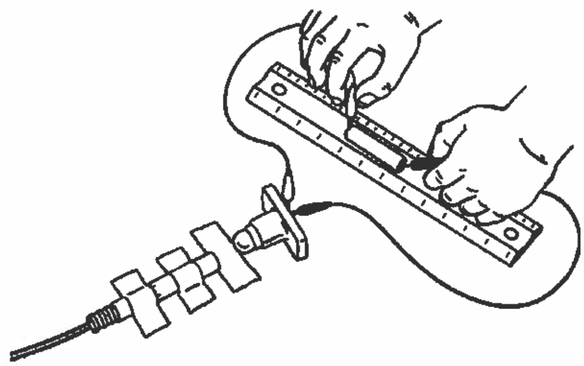


6. Measure the voltage of each battery:
   a. Place the red clip of the Voltage Probe on the positive (+) end of the battery and the black clip on the negative (-) end of the battery.
   b. Look at the voltage displayed on the screen.
   c. Record the value in the Part I Data Table above in the Measured voltage column.
7. Repeat Step 6 for each of the batteries. Do not forget to record your values in the Part I Data Table.
8. Now, read the voltage listed on the side of each battery (you may need a magnifying glass for some batteries). Record the voltage values in the Part I Data Table under Voltage printed on battery.

Part II Using Batteries to Light up a Light Bulb

9. Do the following to get the sensor ready for this part of the activity.
   a. Disconnect the Voltage Probe and connect the Light Probe.
   b. Choose New from the File menu.
   c. Lay the Light Probe on the table and tape it down.
   d. Put a piece of tape on the table, with one edge right under the tip of the probe.

10. Set up the circuit pictured here using the AAA battery, wires, and the light bulb. Place the tip of the light bulb on the edge of the tape so it is pointing straight at the Light Probe. Someone in your group should hold the socket of the bulb in place during data collection. **Careful:** Do not put your finger between the Light Probe and the bulb when you are collecting data!



11. Now follow these steps to find out how bright the light bulb is:
    a. Touch one of the jumper wire cables to the positive end of the battery.
    b. Touch the other jumper wire cable to the negative end of the battery.
    c. Look at the Light Level values on the screen. When the number stays the same for a few seconds, record the value in the Part II Data Table.

Part II Data Table			
Type of battery in circuit	**Light Level**	**Type of battery in circuit**	**Light Level**
AAA battery		**C battery**	
AA battery		**D battery**	

12. Repeat Step 11 using a different battery in the circuit each time. Make sure the light bulb is in the right place and don't forget to record the Light Level in the Part II Data Table!

ANALYZE YOUR DATA

1. Look at the values for the voltages for the different batteries in the Part I Data Table. How do the voltages you measured compare to your predictions? Why did you make your prediction as you did?

2. What did you notice about the brightness of the bulbs when using the different batteries to light them in Part II? Did the size of the bulb seem to make a difference in how bright the bulb was? Look at your data to help you answer these questions.

Good job!!

Stacked Batteries

Did you ever wonder why it takes two batteries stacked together to run a flashlight or why your video game player takes four batteries? Why do they need to be put into these devices a certain way? This activity will allow you to explore how all this works by measuring the voltages across different numbers of batteries stacked together.

OBJECTIVES

In this activity, you will

- Measure the voltages of batteries as they are stacked together.
- Compare the voltages of different types of stacked batteries.
- Draw conclusions about batteries in electronic devices.

MATERIALS

LabQuest
Vernier Differential Voltage Probe
4 D batteries
4 AA batteries
ruler with groove for holding batteries

KEY QUESTION

What do you think will happen to the voltage as you add more D batteries together and measure the voltages from the end of the first battery to the opposite end of the last battery?

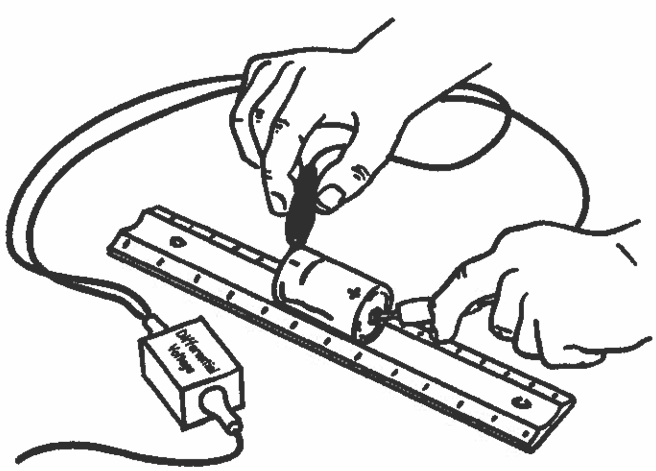
HYPOTHESIS

The voltage will ______________ by ______________ volts every time an additional D battery is added to the stack.

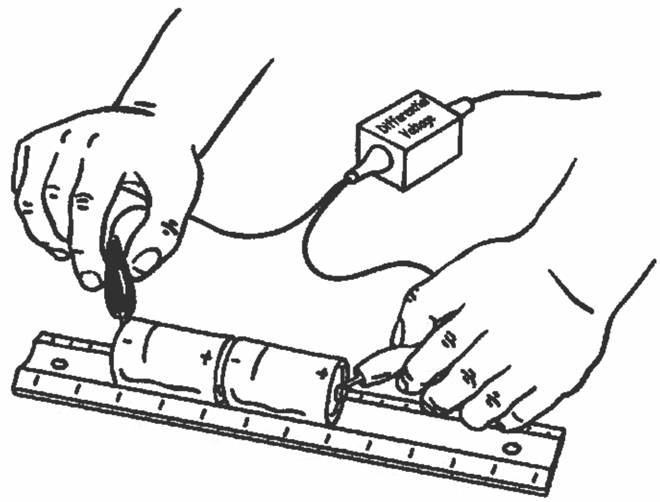
PROCEDURE

Part I Measure the Voltage of Stacked D Batteries

1. Make sure the Voltage Probe is connected to LabQuest.
2. Choose New from the File menu.
3. Set up the data-collection mode.
   a. On the Meter screen, tap Mode. Change the mode to Events with Entry.
   b. Enter the Name (Batteries) and leave the Units field blank. Select OK.
4. Zero the sensor and begin data collection by doing the following:
   a. Clip together the ends of the red and black wires coming from the Voltage Probe.
   b. Look at the screen and choose Zero from the Sensors menu to zero the Voltage Probe. The voltage reading on the screen should be at or near 0 volts.
5. Collect data by following these steps:
   a. Start data collection.
   b. Tap Keep and enter **0** for 0 batteries. Select OK.
   c. Put the ruler on the table and put one D battery in the groove of the ruler.
   d. Now press the red clip to the positive end of the battery, and press the black clip to the negative end of the battery.
   e. When the voltage reading stays the same for a few seconds, tap Keep.
   f. Enter **1** for 1 battery, then select OK.



6. Collect data for 2 stacked batteries.
   a. Place a second battery on the ruler with the negative end of this battery touching the positive end of the first battery.
   b. Hold the red clip against the positive end of the first battery and the black clip against the negative end of the second battery.
   c. When the readings are the same for a few seconds, tap Keep.
   d. Enter **2** for 2 stacked batteries and then select OK.



7. Collect data for the 3rd and 4th batteries by doing the following:
   a. Place another battery on the ruler with the negative end of this battery touching the positive end of the battery before it.
   b. Hold the red clip against the positive end of the first battery in the row and the black clip against the negative end of the last battery in the row.
   c. When the readings are the same for a few seconds, tap Keep.
   d. Enter **3** for 3 stacked batteries and then select OK.
   e. Repeat this step with 4 batteries in the stack.
8. When you have collected data for 4 batteries, stop data collection.
9. Tap the Table tab. Look at the voltage values in the Potential column and record the voltages in the Part I Data Table, below.

Part I Data Table	
Number of D batteries	**Potential**
1 battery	**V**
2 batteries	**V**
3 batteries	**V**
4 batteries	**V**

Part II How Do AA Batteries Stack Up?

Key Question

What do you think will happen to the voltage as you add AA batteries together and measure the voltage? Will the voltage of AA batteries change the same amount as the voltage changed when you stacked D batteries? Why or why not?

Hypothesis

The voltage will ______________ by ___________ volts every time another AA battery is added to the stack.

Prediction

Tap the Graph tab. Choose Draw Prediction from the Analyze menu. Draw what you think will happen to the voltages as you add more AA batteries. Select OK.

10. Tap the File Cabinet icon to store your data and repeat Steps 5–9, using the AA batteries in place of the D batteries. This time, write down your data in the table below.

Part II Data Table	
Number of AA batteries	**Potential**
1 battery	**V**
2 batteries	**V**
3 batteries	**V**
4 batteries	**V**

ANALYZE YOUR DATA

1. How did your prediction from Part II match your data?

____

____

____

____

____

2. What do you think the voltage would be if you added together 10 batteries? Why?

3. Compare your data from Parts I and II of this activity. Describe how they are the same and different. Do the similarities and differences surprise you?

Good job!!

An Inclined Plane

An inclined plane is a slanted surface used to raise objects. The sloping floor of a theater, a road over a mountain, and a ramp into a building are examples of inclined planes. In this experiment, you will use a Force Sensor to measure the force needed to lift an object and the force needed to pull the same object up an inclined plane. You will then calculate and compare work done in raising the object to the same height by lifting it and pulling it up an inclined plane.

OBJECTIVES

In this experiment, you will

- Use a LabQuest and a Force Sensor to measure force.
- Compare forces.
- Calculate work and efficiency.
- Make conclusions using the results of the experiment.

MATERIALS

LabQuest
LabQuest App
Vernier Force Sensor
smooth board (at least 0.5 m long)
wooden block with a hook
books
metric ruler
paper clip

Figure 1: Using the Dual-Range Force Sensor

PROCEDURE

Using an Inclined Plane

1. Set up a stack of books as shown in Figures 1.
2. Get a board and set up an inclined plane as shown in Figures 1. Measure the length of the board (in meters) and record this value in the data table. Measure and record the height of the inclined plane (in meters).
3. Get a wooden block with a hook on one end. Partly straighten a paper clip—leaving a hook at each end. Use the paper clip to attach the wooden block to your Force Sensor.
4. Set the range switch on the Force Sensor to 10 N. Connect the Force Sensor to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.

5. Slowly pull the wooden block up the inclined plane. The Force Sensor should be held parallel to, and about 2 cm above, the surface of the inclined plane, as shown in Figure 1. Once the wooden block is moving at a steady rate, start data collection. Continue pulling the wooden block until data collection is complete (5.0 seconds).
6. Determine the mean (average) force (in N).
   a. After data collection is complete, choose Statistics from the Analyze menu.
   b. Record the mean (average) force (in N).

Without an Inclined Plane

7. Now determine the force needed to lift the wooden block.
   a. Repeat Step 5 as you slowly lift the block the same height as the inclined plane.
   b. Repeat Step 6 and record the value of the force (in N) needed to lift the wooden block.

DATA TABLE

Length of inclined plane	________	m
Height of inclined plane	________	m
Force (average) to pull the block up the inclined plane	________	N
Force (average) to lift the block	________	N

PROCESSING THE DATA

1. Does it take more or less force to move the block using the inclined plane? Explain.

2. A formula for calculating work is

$$W = F \times d$$

where W = work (in N•m), F = force (in N), and d = distance (in m). Use this formula to calculate work done using the inclined plane. Here, F = the average force needed to pull the block up the inclined plane and d = the **length** of the inclined plane.

3. Calculate work done in lifting the block. Here, F = the average force needed to lift the block and d = the **height** of the inclined plane.

4. Does it take more or less work to move the block using the inclined plane?

5. A formula for calculating the efficiency of a machine is

$$\text{efficiency} = \frac{\text{work output}}{\text{work input}} \times 100$$

Use this formula to calculate the efficiency of the inclined plane. Here, work output = the work done lifting the block, and work input = the work done pulling the block up the inclined plane.

6. What causes the difference between the work needed to pull the block up the inclined plane and the work to lift it to the same height? Discuss ways to decrease this difference.

EXTENSIONS

1. Study how changing the inclined plane slope changes force.
2. Design an experiment to study your answer to Question 6.
3. Determine the mechanical advantage of the inclined plane.

Experiment

22

TEACHER INFORMATION

An Inclined Plane

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. We suggest that you include one of the extension ideas in the required part of this experiment.

3. The smooth-surface boards used for the inclined plane should be at least 0.5 m long. We use boards that are 1.2 × 0.25 m.

4. A 5 cm × 10 cm × 15 cm piece of wood works well. Insert a hook in the center of one end. Other flat-surface objects can be substituted.

5. The Dual-Range Force Sensor has a low range, –10 to 10 N, and a high range, –50 to +50 N. Students will use the low range for this experiment.

6. For even better results, you can have students *zero* the Force Sensor. They should position their Force Sensor horizontally on the inclined plane, as shown in Figure 1 of the student procedure.

7. Illustrate proper technique for pulling an object up an inclined plane with the force sensor before the experiment. Remind your students not to pull the object too fast.

8. Your students should get better results using the Force Sensor and average force values than with spring scales.

SAMPLE RESULTS

Length of inclined plane	1.20 m
Height of inclined plane	0.24 m
Force (average) to pull object	1.58 N
Force (average) to lift object	4.90 N

ANSWERS TO QUESTIONS

1. It takes less force to move the object using the inclined plane.

2. W = F × d = 1.58 N × 1.20 m = 1.90 N•m

3. W = F × d = 4.90 N × 0.24 m = 1.18 N•m

4. It takes more work to move the object using the inclined plane.

5. Efficiency = 1.18 N•m/1.90 N•m = 62.1%

6. Friction causes the work to move the object with the inclined plane to be greater than the work needed to lift it the same vertical distance.

Bubbles in Your Bread

Baking bread is something many people all over the world do every day. Have you ever baked bread using yeast? Did you know that yeast are living organisms? In a water environment, yeast use sugar and oxygen to produce a gas called carbon dioxide, CO_2. The carbon dioxide makes the dough rise and creates the bubbles or air pockets that you can see in the bread that you eat.

OBJECTIVES

In this activity you will

- Use a Pressure Sensor to measure the pressure caused by the production of CO_2.
- Make observations about how temperature affects rising dough.

MATERIALS

computer with Logger Lite software installed
Go! Link interface
Vernier Gas Pressure Sensor
plastic tubing and stopper assembly
large bowl
warm water (approximately 30-35°C)
cold water (approximately 5-10°C)
bread dough
plastic bottle
paper towels or rags to clean up spills
tray (if available)

KEY QUESTION

Does temperature make a difference in the amount of time it takes for bread to rise?

HYPOTHESIS

I think that the __________ (warm or cold) bread dough will rise faster because ________

____

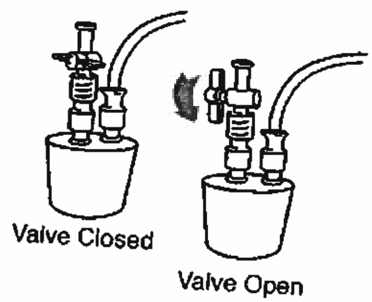
PREDICTION

In the first part of this activity, you will test cold dough. Click the Predict button, [icon], and draw a line that shows your prediction for how the pressure will change when the dough is in cold water.

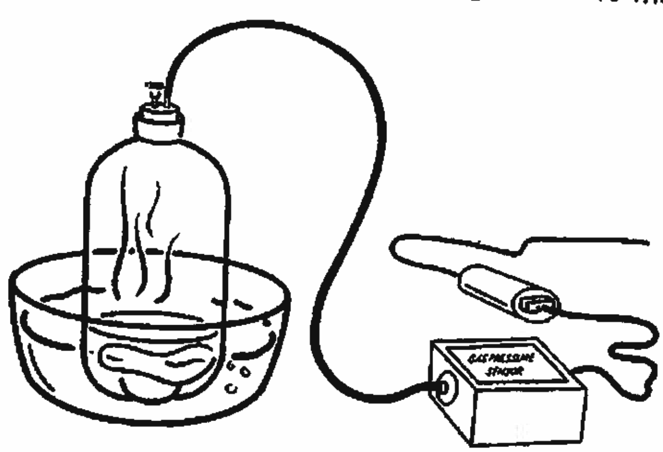
PROCEDURE

Part I Pressure Change for Dough in Cold Water

1. Do the following to get the Pressure Sensor ready to collect data.
   a. Make sure the Pressure Sensor is connected to the Go!Link and that the Go!Link is connected to the computer.
   b. Close the valve on the stopper. The handle should be sideways to the valve. Look at the drawing below to see what the valve looks like when it is closed and open.
2. Start Logger Lite on your computer.
3. Open the file for this activity by doing the following:
   a. Click the Open button, [icon].
   b. Open the file called "Elementary Science."
   c. Open the file called "19 Bubbles in Bread."



4. To prepare the dough for data collection, follow these steps:
   a. Get a ball of dough from your teacher.
   b. Put the dough in the bottle. Rolling the dough into a snake shape may help you get it in the bottle.
   c. Lightly tap the bottle on a table to help the dough settle to the bottom.



Follow these steps to get ready to collect data:

a. Twist the stopper into the mouth of the bottle so it fits tightly. **Important:** The stopper must be twisted in tightly or it may pop out.

b. Put the bottle in the bowl.

c. Have one student hold the bottle down in the bowl, or use masking tape to tape the bottle down.

d. Carefully pour the cold water into the bowl.

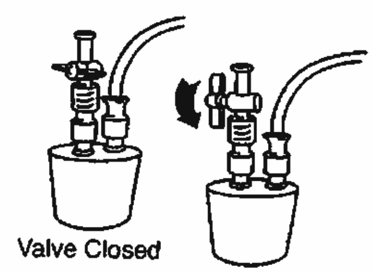
Click [Collect] to start data collection.

Data collection will last 10 minutes. During this time, watch the data and the dough to observe the changes taking place. Record your observations about the pressure and what happened in the bottle during the reaction in the Part I Observations Sheet.

Part I Observations Sheet

When data collection is over, click the Store button, , to save your data.

Open the valve on the stopper and watch what happens to the pressure. Record what you see on the Part I Observations Sheet.



Part II Pressure Change in Warm Water

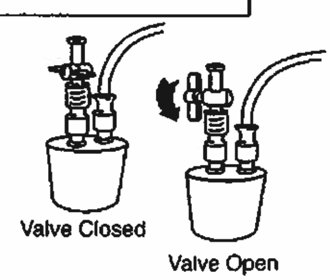
Prediction

Click the Predict button, , and draw a line that shows your prediction for how the pressure will change as the dough is warmed up.

10. Do the following to get the materials ready for data collection.
    a. Empty the cold water as directed by your teacher.
    b. Close the valve on the stopper by turning it sideways to the valve, making a plus sign (see the "Valve Closed" drawing above).
    c. Put the bottle back in the bowl.
    d. Carefully pour warm water into the bowl.
11. Click Collect to start data collection.
12. Record your observations about the pressure changes and what happens in the bottle on the Part II Observations Sheet below:

Part II Observations Sheet

13. Open the valve on the stopper and watch what happens to the dough. Record what you see on the Part II Observations Sheet.
14. Dispose of your materials as directed by your teacher.



ANALYZE YOUR DATA

1. Click the Examine button, , to find the pressure at each minute of the experiment. Record each value in its place in the Data Table.

Data Table		
	Cold water	Warm water
Beginning pressure	kPa	kPa
Pressure at 1 minute	kPa	kPa
Pressure at 2 minutes	kPa	kPa
Pressure at 3 minutes	kPa	kPa
Pressure at 4 minutes	kPa	kPa
Pressure at 5 minutes	kPa	kPa
Pressure at 6 minutes	kPa	kPa
Pressure at 7 minutes	kPa	kPa
Pressure at 8 minutes	kPa	kPa
Pressure at 9 minutes	kPa	kPa
Pressure at 10 minutes	kPa	kPa

2. Look at each of the columns in the Data Table. Do you see a pattern in the values for the warm-water dough? Is there a pattern in the values on the cold-water dough column?

____

____

3. What do you think would happen to the warm-water dough if you allowed the experiment to run much longer? How about the cold-water dough?

____

____

____

4. What effect does temperature have on the reaction? Do you think it would be easier to bake bread on a hot day or a cold day? Why do you think so?

   ____

   ____

Good job!!

TEACHER INFORMATION

Bubbles in Your Bread

BACKGROUND INFORMATION

In this activity, students will observe the pressure caused by gases that are the result of the digestive processes of yeast working in the dough. Yeast are single-cell fungi, and we tend to think of their work in bread as biological, but it is also a chemical process. These little organisms are digesting the sugar in the dough and creating carbon dioxide gas, which makes the little bubbles in bread. Creating a gas is one indication that a chemical reaction has taken place. In addition to gas, alcohol is produced, giving bread dough its characteristic smell.

As the bread dough rises, the gases created by the yeast's digestion increase the pressure. If the temperature is too cold, however, the yeast are not as active and will not create the gas needed for the dough to rise.

TIME FRAME FOR ACTIVITY

This activity can be completed in about 50 minutes after an initial 10-15 minutes for making the dough.

CURRICULAR CONNECTIONS

Social Studies - Breads from different cultures, basic needs of humans.

Math - Comparisons, graph analysis, volume measurements.

HELPFUL HINTS

1. The student pages with complete instructions for data-collection using Logger Lite or LabQuest App can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. Data can be collected using a Pressure Sensor connected to Go!Link on a computer or a Pressure Sensor connected directly to LabQuest. LabQuest does not support the use of Go! products.
3. This should probably not be the first Pressure Sensor activity your students do. Begin with Activity 16, *Learning to Use the Pressure Sensor*.
4. As a precursor to this activity, you may want to have kids examine a piece of bread to find the little bubbles that are the result of the yeast in the recipe.

5. You should attach the plastic tubing to the stopper prior to giving them to the students.

6. You will need to provide students with warm and cold water. The warm water should be about 30-35°C. You can usually obtain water of this temperature from the tap. The cold water should be about 5-10°C. If your tap water is not this cold, add a little ice.

7. Prepare the dough in front of the students or ahead of time and store it in the refrigerator until it is needed. Allow time for the dough to return to room temperature before you give it to your students. A recipe can be found on page 10 - 5 T.

   Another option for the dough is to buy it pre-made, such as the self-rising Rhodes dinner rolls. Take the dough out of the freezer about 2 hours before starting the activity. If they are out for a shorter period of time, they might not show much change because they are still cold. If they are out for too long, they may have finished rising before you give them to the students. When you take the rolls out, place them individually on a flat surface so they don't all stick together. Give each student group 3 rolls.

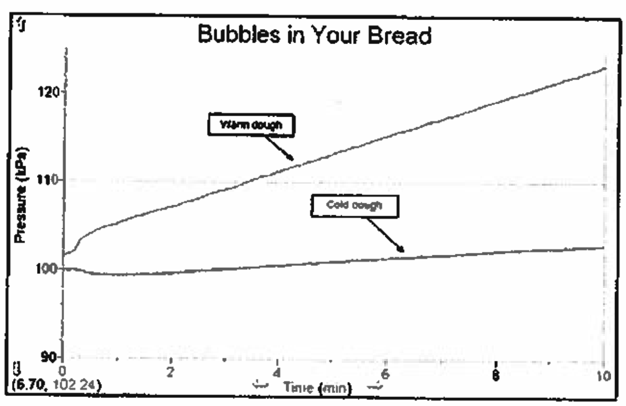
8. Rolling the dough into small "snakes" makes it easier to put in the bottles.

9. In order to compare data between the groups, try to give each group the same amount of dough.

10. If you have sufficient materials, you can do both parts of this activity at once.

SAMPLE RESULTS

The amount of dough in your bottle and the temperature of your water will greatly affect the change in pressure during data collection. It is possible that during the cold dough run, the pressure will decrease and that during the warm dough run, the pressure will not increase as much as is does in the sample data below.



Pressure change caused by the rising of dough in a bottle in warm and cold water baths

Data Table		
	Cold water	Warm water
Beginning pressure	100.0 kPa	101.6 kPa
Pressure at 1 min	99.4 kPa	105.3 kPa
Pressure at 2 min	99.7 kPa	107.3 kPa
Pressure at 3 min	100.1 kPa	109.1 kPa
Pressure at 4 min	100.6 kPa	111.2 kPa
Pressure at 5 min	101.0 kPa	113.2 kPa
Pressure at 6 min	101.4 kPa	115.5 kPa
Pressure at 7 min	102.0 kPa	117.3 kPa
Pressure at 8 min	102.2 kPa	119.3 kPa
Pressure at 9 min	102.6 kPa	121.2 kPa
Pressure at 10 min	102.9 kPa	123.3 kPa

ANSWERS TO THE ANALYZE YOUR DATA SECTION

1. Answers are based on each individual graph. Values from the sample data are displayed in the table above.

2. Answers are based on student graphs, but there should be a pattern that is evident in the numbers as well as the graph. For example, the cold water dough drops in pressure, then increases by about 0.4 kPa each minute. The warm water dough increased almost 4 kPa at the beginning, and it continued to increase about 2 kPa each minute after that.

3. If the experiment were allowed to continue, the pressure in the warm dough bottle would pop the stopper out of the bottle, and the pressure would immediately drop. The cold water dough would continue to rise very slowly, but as the water warmed, the pressure in the bottle would rise more like the warm dough.

4. Yeast are not as active in cold temperatures. Therefore, if a cold day means a cold kitchen, you might not have bread in time for dinner!

ASSESSMENT

1. Have students write a statement about the effect of temperature on the reaction of the bread dough and relate it explicitly to the data on their graph.
2. Provide students with a description of an experiment and a graph of pressure *vs.* time that is different than the warm water/cold water dough comparison. Have them write a description of the data shown on the graph.

EXTENSIONS

1. Determine other factors the might affect the way bread rises. Design an experiment to explore those ideas.
2. Use a yeast-sugar mixture alone (instead of dough) and perform the same experiment.
3. Discuss what happens when you open the valve after you take data. Why does the dough suddenly expand? (When the valve is opened, the compressed air escapes. This allows the gas in the dough to expand into the space left by the escaping air.)
4. Research types of bread from different cultures.
5. Find a bread recipe that does not use yeast and use it to perform this activity.
6. If local regulations allow, make extra bread for the entire class to eat.

Simple Yeast Bread Recipe

450 mL (2 cups) warm water (water too hot to keep your finger in is too hot)
10 g (2 teaspoons) sugar
7 g (1 package) fast acting active dry yeast
900 g (3 ½ cups) all purpose flour
14 g (1 tablespoon) salt

Add the sugar and yeast to about 100 g (½ cup) of warm water and dissolve. After a few minutes, the mixture should have small bubbles forming around the edge. This means the yeast is active.

Meanwhile, put the flour and salt in a large mixing bowl. Mix well and then add about 100 g (½ cup) of warm water. Stir, then add the yeast mixture and blend to make soft dough. Add as much water and flour as needed to make dough that is not sticky. This makes it easier for the "bread snakes" to fit through the mouth of the bottle without sticking.

At this point the dough is ready for the experiment. This makes enough dough for about six groups. Keep the dough cold before giving it to the students or it may begin to rise.

If you make a batch of dough for eating, at this point you would allow the dough to rise for about 20 minutes, and then bake it in small loaves or rolls on a cookie sheet at 200°C (400°F) for 30 to 45 minutes, depending on the size you choose to make.

Gas Pressure and Volume

In this simple experiment, you will use a Gas Pressure Sensor and a gas syringe to study the relationship between gas pressure and volume. Temperature and amount of gas will be kept constant. The results will be expressed in words, in a table, with a graph, and with a mathematical equation. These are four methods commonly used by scientists to communicate information.

This experiment is similar to one first done by Robert Boyle in 1662—without the use of a calculator, of course. The relationship you will discover is known as Boyle's law.

OBJECTIVES

In this experiment, you will

- Use a LabQuest, a Gas Pressure Sensor, and a gas syringe to measure the pressure of an air sample at several different volumes.
- Make a table of the results.
- Make a graph of the data.
- Predict the pressure at other volumes.
- Describe the relationship between gas pressure and volume with words and with a mathematical equation.

MATERIALS

LabQuest
LabQuest App
Vernier Gas Pressure Sensor
20 mL gas syringe

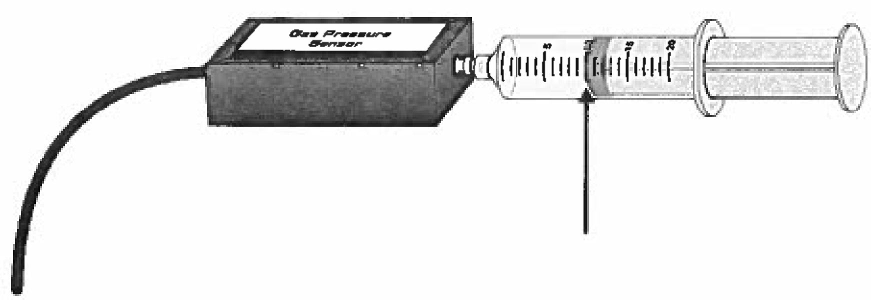


Figure 1

PROCEDURE

1. Prepare the Pressure Sensor and an air sample for data collection.
   a. Connect the Pressure Sensor to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
   b. A 20 mL syringe is already connected to the sensor and set at the 10 mL mark for you.

2. Set up the mode.
   a. On the Meter screen, tap Mode. Change the mode to Events with Entry.
   b. Enter the Name (Volume) and Units (mL). Select OK.

3. You are now ready to collect pressure and volume data. It is easiest if one person takes care of the gas syringe and another operates LabQuest.
   a. Start data collection.
   b. Move the piston so the front edge of the inside black ring is positioned at the 5.0 mL line on the syringe (see Figure 2). Hold the piston firmly in this position until the pressure value displayed on the screen stabilizes.
   c. Tap Keep and enter **5**, the gas volume (in mL). Select OK to store this pressure-volume data pair.

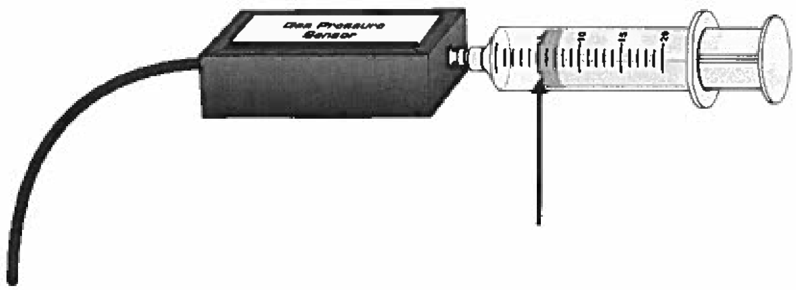


Figure 2

   d. To collect another data pair, move the syringe to 7.5 mL. When the pressure reading stabilizes, tap Keep and enter **7.5** as the volume. Select OK.
   e. Continue with this procedure using volumes of 10.0, 12.5, 15.0, 17.5, and 20.0 mL.
   f. Stop data collection.

4. To examine the data pairs on the displayed graph, tap any data point. As you tap each data point, the pressure and volume values are displayed to the right of the graph. Record the pressure (round to the nearest 0.1 kPa) and volume data values in your data table.

5. (optional) Print a graph of pressure *vs.* volume.

DATA

Volume (mL)	5.0	7.5	10.0	12.5	15.0	17.5	20.0
Pressure (kPa)	_____	_____	_____	_____	_____	_____	_____

PROCESSING THE DATA

1. See the data table and note the pressure when the volume is 10.0 mL, and when the volume is 5.0 mL. What happened to pressure when the volume was halved?

2. See the data table and note the pressure when the volume is 20.0 mL. Compare this pressure to the pressure when the volume is 10.0 mL. What happened to the pressure when the volume was doubled?

3. From your data and graph, what is the pressure when the volume is 16 mL? 8 mL? How do these values compare?

4. What would the pressure be at 40.0 mL? At 2.5 mL? Explain how you determined these values.

5. What is the relationship between gas pressure and volume (Boyle's law) in words?

6. Do gas pressure and volume vary directly or inversely? Explain.

7. Write an equation to express the relationship between gas pressure and volume. Use the symbols P, V, and k.

EXTENSIONS

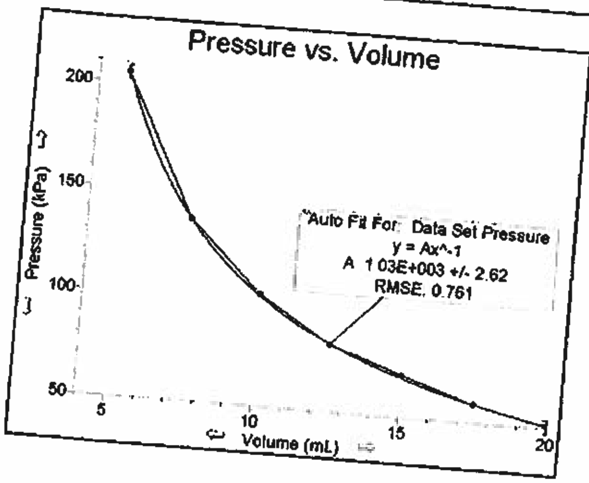
1. Repeat the experiment using a pure, noncorrosive gas, such as oxygen, butane, or carbon dioxide. Compare the results with your results for air.
2. Plot P versus $1/V$ and discuss the graph. You can do this using graph paper, Vernier Logger *Pro*.

Gas Pressure and Volume

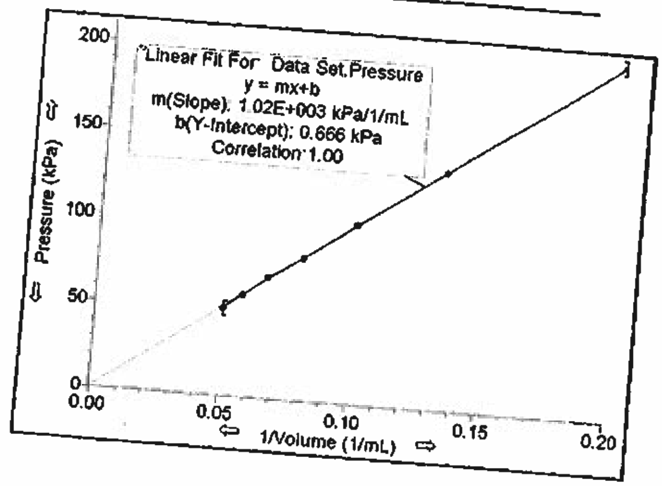
1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. In order to save time, you may prefer to do Step 1 of the student procedure prior to the start of class.
3. You should never have to perform a new calibration when using the Gas Pressure Sensor. Simply use the stored calibration in the data-collection program.
4. One error in this experiment is the small inside volume of the white stem that leads to the inside of the Gas Pressure Sensor. The volume of this space is about 0.8 mL. This means that when students enter a volume of 10 mL (as read on the syringe), the volume is really about 10.8 mL. To compensate for this error, you could have your students add 0.8 mL to each of the volumes they enter. They will get somewhat better ratios of pressures in questions 1–4, using this method.

SAMPLE RESULTS

Volume (mL)	Pressure (kPa)	Constant, k (P•V)
5.0	204.6	1023
7.5	136.8	1026
10.0	103.3	1033
12.5	82.1	1026
15.0	69.9	1048
17.5	58.8	1028
20.0	50.7	1013



Pressure vs. Volume



Pressure vs. Reciprocal of Volume

ANSWERS TO QUESTIONS

1. The pressure doubled when the volume was halved.
2. The pressure became half as great when the volume was doubled.
3. Typical results are 63 kPa when the volume is 16 mL and 126 kPa when the volume is 8 mL. The pressure corresponding to a volume of 16 mL is expected to be about half as great as the pressure when the volume is 8 mL.
4. Since the pressure reading at 20.0 mL is about 50 kPa, the pressure should be about 25 kPa at 40.0 mL, because the pressure halves when the volume doubles. The pressure reading at 5.0 mL is about 200 kPa. The pressure at 2.5 mL can be expected to be about 400 kPa because the pressure doubles when the volume is halved.
5. Answers will vary.
6. Gas pressure and volume vary inversely. Explanations will vary. A table of results, such as the one in the Sample Results table on the previous page, can be used to bring out this relationship.
7. $PV = k$ is an [illegible]ation expressing the relationship between gas pressure and volume. The Sample Resu[illegible]able helps show this.