"Okay. Let's figure something out and ask Mrs. Dewey if we can work on it before we play the game again," said Nicholas. "Whatever we do, we'll have to do two experiments, one for each size of marble."

Here are Frank and Nicholas's data tables:

Experiment 1
Small Marbles

N Number of Marbles	*V* Volume in cc	Ordered Pairs *(N, V)*
2		
4		
8		

Experiment 2
Large Marbles

N Number of Marbles	*V* Volume in cc	Ordered Pairs *(N, V)*

Mrs. Dewey thought Frank and Nicholas had such a good idea that she encouraged all the teams to design experiments to help them make predictions: "If you use the TIMS Laboratory Method, it will help you organize your thinking."

You are going to do the experiments Mrs. Dewey's class is working on. The results of the experiments should help you make predictions when you play the game Fill It First.

You will collect and organize data that will help you make predictions about the volume of marbles when you know the number of marbles. You will investigate two sizes of marbles, so you will need to do two experiments.

1. What are the two main variables in the experiments?
2. **A.** Which of the two main variables is the manipulated variable? Justify your answer.
   B. Which is the responding variable? Justify your answer.
   C. What letters will you use to stand for the two main variables?
3. Frank and Nicholas want to look for patterns in the data to help them make predictions about the volume of the marbles when they know the number of marbles. What important variable should be held fixed in each experiment so they can do this?

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4. **A.** What values for the number of small marbles did Frank and Nicholas choose?
   B. How will these values help them see patterns?
   C. What values will you choose?

Make a plan for your experiments. Draw a picture of your plan.

- Identify the variables in your pictures and label them with letters.
- Your teacher will help you choose at least three values for the manipulated variable. The largest value will be no more than 8 marbles.

Conducting the Experiment

Collect your data on the tables on the *Volume vs. Number Data Tables* pages in the *Student Activity Book*.

- Label the first two columns of each data table with the manipulated and responding variables and include units. You will record an ordered pair in the third column.
- List the values you choose for the manipulated variable in the first column of each table.
- Use a 250-cc graduated cylinder to measure the volume of the marbles.
- Choose a convenient amount of water to use in your cylinder, but use at least 140 cc.

Volume vs. Number Data Tables

Experiment 1
Small Marbles

Experiment 2
Large Marbles

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Student Guide

Questions 1–18 (SG pp. 561–565)

1.* *N,* Number of Marbles and *V,* Volume

2. **A.*** Number of Marbles; The values for the number of marbles are chosen at the beginning of the experiments.
   B.* Volume; Students find the volume as a result of the experiments.
   C. Possible response: *N* for Number of Marbles and *V* for Volume.

3.* size of marble

4. **A.*** 2, 4, and 8 marbles
   B.* These values show doubling patterns.
   C.* Answers will vary.

***Answers and/or discussion are included in the lesson.**

5.* See Figure 3 in Lesson 3 for a sample graph.

6.* 0 cc. See the graph in Figure 3.

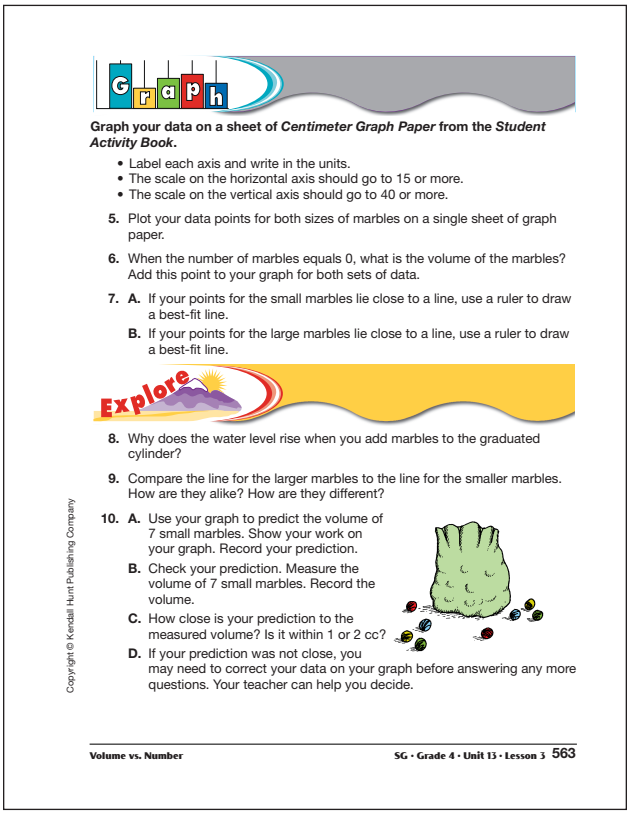
7. A.–B.* See Figure 3 in Lesson 3 for a sample graph.

8. Marbles have a volume as does the water. The marbles displace or push up the water, which causes the water level to rise.

9. Answers will vary. The line for the larger marbles goes uphill faster than the line for the smaller marbles. They both include the point for $N=0$ and $V=0$ and slant uphill.

10.* A. Based on the graph in Figure 3 of the lesson, about 12 cc.

B–D. Answers will vary.



Graph

Graph your data on a sheet of *Centimeter Graph Paper* from the *Student Activity Book*.

- Label each axis and write in the units.
- The scale on the horizontal axis should go to 15 or more.
- The scale on the vertical axis should go to 40 or more.

5. Plot your data points for both sizes of marbles on a single sheet of graph paper.

6. When the number of marbles equals 0, what is the volume of the marbles? Add this point to your graph for both sets of data.

7. **A.** If your points for the small marbles lie close to a line, use a ruler to draw a best-fit line.
   B. If your points for the large marbles lie close to a line, use a ruler to draw a best-fit line.

Explore

8. Why does the water level rise when you add marbles to the graduated cylinder?

9. Compare the line for the larger marbles to the line for the smaller marbles. How are they alike? How are they different?

10. **A.** Use your graph to predict the volume of 7 small marbles. Show your work on your graph. Record your prediction.
    B. Check your prediction. Measure the volume of 7 small marbles. Record the volume.
    C. How close is your prediction to the measured volume? Is it within 1 or 2 cc?
    D. If your prediction was not close, you may need to correct your data on your graph before answering any more questions. Your teacher can help you decide.

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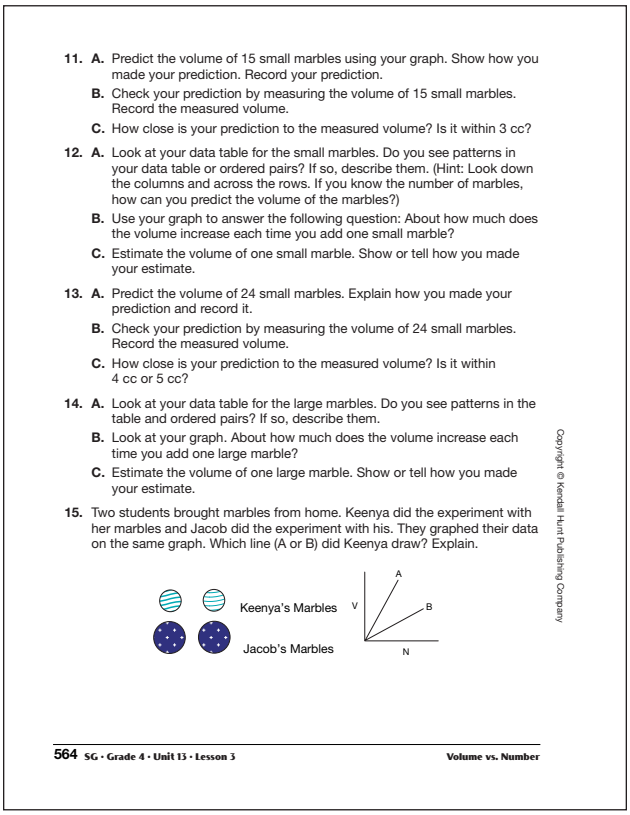
***Answers and/or discussion are included in the lesson.**



11. **A.** Predict the volume of 15 small marbles using your graph. Show how you made your prediction. Record your prediction.
    B. Check your prediction by measuring the volume of 15 small marbles. Record the measured volume.
    C. How close is your prediction to the measured volume? Is it within 3 cc?
12. **A.** Look at your data table for the small marbles. Do you see patterns in your data table or ordered pairs? If so, describe them. (Hint: Look down the columns and across the rows. If you know the number of marbles, how can you predict the volume of the marbles?)
    B. Use your graph to answer the following question: About how much does the volume increase each time you add one small marble?
    C. Estimate the volume of one small marble. Show or tell how you made your estimate.
13. **A.** Predict the volume of 24 small marbles. Explain how you made your prediction and record it.
    B. Check your prediction by measuring the volume of 24 small marbles. Record the measured volume.
    C. How close is your prediction to the measured volume? Is it within 4 cc or 5 cc?
14. **A.** Look at your data table for the large marbles. Do you see patterns in the table and ordered pairs? If so, describe them.
    B. Look at your graph. About how much does the volume increase each time you add one large marble?
    C. Estimate the volume of one large marble. Show or tell how you made your estimate.
15. Two students brought marbles from home. Keenya did the experiment with her marbles and Jacob did the experiment with his. They graphed their data on the same graph. Which line (A or B) did Keenya draw? Explain.

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11. A.* Answers will vary. Based on the graph in Figure 3 of the lesson, about 28 cc.

B–C. Answers will vary.

12. A.* Answers will vary. Possible responses using the data tables in Figure 2: Going down the columns, the numbers in the first column double and the numbers in the second column almost double (7 is almost twice 4). If you look across the rows the numbers in the second column are almost twice the numbers in the first column. If you know the number of marbles, you can predict that the volume will be almost twice the number.

B.* On the graph, adding a marble is the same as going over one space to the right. When you go one space to the right, the volume on the vertical axis goes up by about 2 cc.

C.* About 2 cc.

13. A.* Answers will vary. Possible response: Using the graph in Figure 3, the volume of 24 marbles is about 44 cc. Since the volume of 12 marbles is 22 cc, the volume of 24 marbles will be about double that.

B–C.* Answers will vary.

14. A.* Answers will vary. Possible responses using the data tables in Figure 2: Going down the columns, the numbers in the first column double and the numbers in the second column almost double. Going across the rows, the numbers in the second column are between three and four times the numbers in the first column.

B.* Answers will vary. Using the graph in Figure 3, the volume increases between 3 and 4 cc each time you move over one.

C.* Answers will vary. Using the data in Figures 2 and 3, reasonable estimates are 3.5 cc or between 3 and 4 cc.

15.* Keenya drew line B. Her marbles have less volume than Jacob's marbles, so her line will not be as steep. Every time she adds one marble, the volume does not go up as much as if she used the larger marbles.

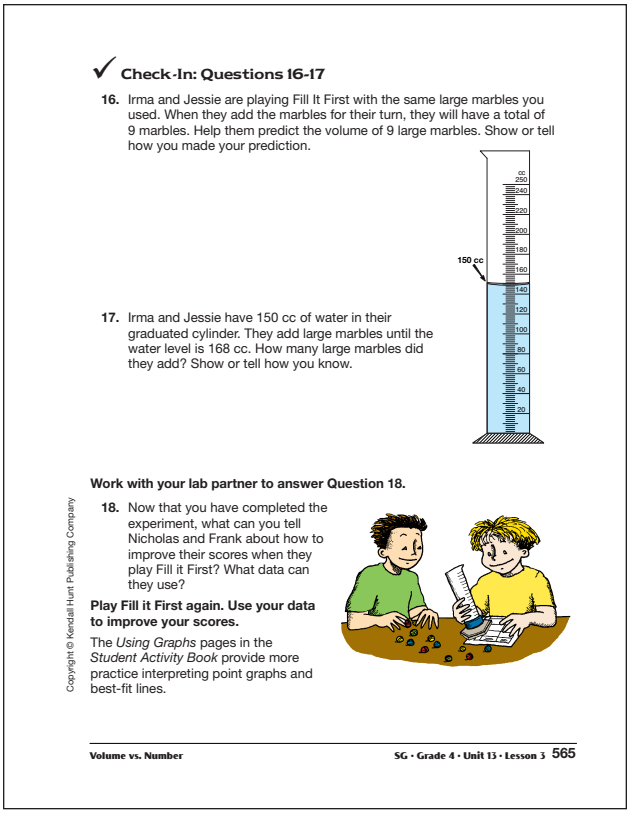
***Answers and/or discussion are included in the lesson.**

16.* Answers will vary. Based on the sample graph, 33 cc. See Figure 3 in Lesson 3.

17.* Answers will vary. See Figure 3 in Lesson 3. The volume of the marbles is 168 − 150=18 cc. Using the sample graph, the number of marbles is 5.

18.* Answers will vary. Possible responses: We can draw lines and arrows on our graph to find the volume of the number of marbles we spin.

Or, we can use the answer for the volume of one marble we found in ***Question 12C***. Then we can multiply that number by the number of marbles we get on the spinner.



✓ **Check-In: Questions 16-17**

16. Irma and Jessie are playing Fill It First with the same large marbles you used. When they add the marbles for their turn, they will have a total of 9 marbles. Help them predict the volume of 9 large marbles. Show or tell how you made your prediction.

17. Irma and Jessie have 150 cc of water in their graduated cylinder. They add large marbles until the water level is 168 cc. How many large marbles did they add? Show or tell how you know.

Work with your lab partner to answer Question 18.

18. Now that you have completed the experiment, what can you tell Nicholas and Frank about how to improve their scores when they play Fill it First? What data can they use?

Play Fill it First again. Use your data to improve your scores.

The *Using Graphs* pages in the *Student Activity Book* provide more practice interpreting point graphs and best-fit lines.

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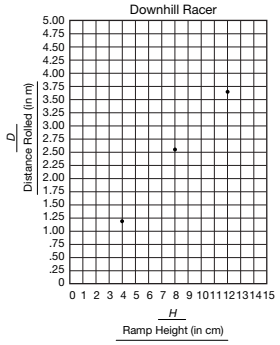
***Answers and/or discussion are included in the lesson.**

Name _____ Date _____

Using Graphs

Lee Yah tried the Downhill Racer experiment at home on her front steps. She rolled a toy car down a ramp from three different heights. Here is her graph.



1. **A.** Do the points seem to form a line? If yes, use a ruler (or something straight) to draw a best-fit line.

   B. Did the distance the car rolled increase or decrease as the height of the ramp got higher? Explain.

   C. If possible, predict how far the car would roll if Lee Yah sets the ramp height at 9 cm. Show or tell how you decided.

   D. If possible, predict how far the car would roll if the ramp height were 15 cm. Show or tell how you decided on your answer.

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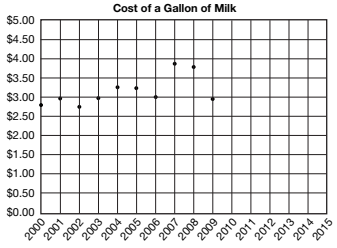
Name _____ Date _____

This graph shows the cost of a gallon of milk from 2000 to 2009 in the United States.



2. **A.** Do the points seem to form a line? If yes, use a ruler (or something straight) to draw a best-fit line.

   B. Did the cost of a gallon of milk increase or decrease from 2000 to 2009? Explain.

   C. If possible predict the price of a gallon of milk in 2015. Show or tell how you decided on your answer.

   D. What is the cost of a gallon of whole milk at a store near you today?

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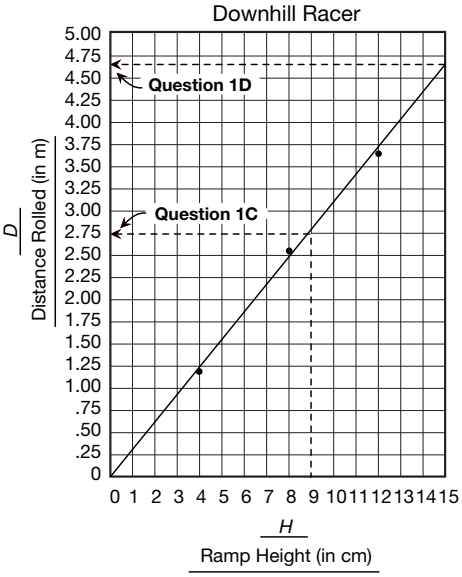
Student Activity Book

Questions 1–2 (SAB pp. 551–552)

1. **A.**



   B. Increase. Possible explanation: Each time you go one cm to the right on the graph, the distance the car rolls gets larger.

   C. About 2.75 m; See graph above.

   D. About 4.60 m; See graph above.

2. **A.** The points do not form a line.

   B. Answers will vary, but students must justify their answers. Possible response: The cost of a gallon of milk was about the same in 2009 as in 2000, but the price went up and down between those years.

   C. Answers will vary, but students must justify their answers. Students may say that the cost of a gallon of milk will stay around $3 per gallon since it was close to $3 for all the years except 2007 and 2008. Or, students may say that since the cost varied so much, it will be hard to predict the cost in 2015.

   D. Answers will vary.