Name: _____ Date: _____

Student Exploration: Measuring Volume

Vocabulary: cubic centimeter, diameter, graduated cylinder, meniscus, milliliter, pipette, radius, rectangular prism, sphere, volume, water displacement

Prior Knowledge Question (Do this BEFORE using the Gizmo.) Albert plays football. His sister Juliana plays volleyball. While walking home from practice one day, Albert and Juliana argue about which is bigger, a football or volleyball.

How would you measure and compare the sizes of the two balls? _____

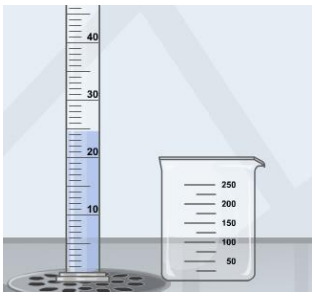
_____

_____

_____

Gizmo Warm-up

When scientists talk about how big something is, they are really talking about its **volume**, or the amount of space it takes up. The *Measuring Volume* Gizmo™ allows you to measure the volumes of liquids and solids using a variety of tools.



To begin, remove the **50-mL graduated cylinder** from the cabinet and place it below the faucet. To turn on the faucet, click on the faucet handle. Fill the cylinder about halfway, as shown.

1. Place the **magnifier** over the waterline. Draw a sketch of what you see in the area at right. Label the large tick marks on your sketch.

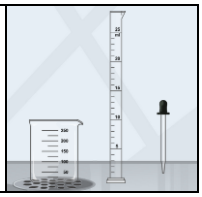
   What volume is represented by each small tick mark?

   _____

2. What is the shape of the waterline? _____

   This curved shape is called the **meniscus**. Always read the volume at the bottom of the meniscus.

3. What is the volume of water in the graduated cylinder? _____

Activity A: **Volume of liquids**	Get the Gizmo ready: • Drag all objects to the cabinet. • Move the **25-mL graduated cylinder**, the **250-mL beaker**, and the **2-mL pipette** to the counter.	

Introduction: **Graduated cylinders** are precise tools for measuring volume. Most graduated cylinders are marked in **milliliters**. There are 1,000 milliliters in 1 liter (about two cups).

Goal: Fill a graduated cylinder with a given amount of water.

1. Prepare: Place the **250-mL beaker** below the faucet and fill it with water. (Move the faucet handle up to pour faster.) You will use the beaker as a source of water in your experiments.

2. Measure: To pour water from the beaker to the graduated cylinder, move the beaker over the graduated cylinder. Add about 15 mL of water to the graduated cylinder (does not have to be exact).

   Place the **magnifier** over the waterline, and sketch what you see in the space at right. Label the large tick marks on your sketch.

   A. How many medium tick marks lie between two labeled tick marks? _____

   B. How much volume does each medium tick mark represent? _____

   C. How much volume does each small tick mark represent? _____

   D. Estimate the water volume in the graduated cylinder to the nearest 0.1 mL.

      (Remember to read from the bottom of the curved meniscus.) _____

3. Measure: Scientists use **pipettes**, also known as eyedroppers, to add or remove small amounts of water. To fill the **pipette**, place its tip in the beaker water and click the black bulb once.

   To release a small amount of water, place the pipette above the graduated cylinder and click the bulb. Do this until the graduated cylinder contains exactly 17.5 mL of water. (Remember to read the volume at the *bottom* of the meniscus.)

4. Show your work: Open the **Tools** tab at lower left and click the **camera** (). Right-click the screen shot, click **Copy**, and then paste the image into a blank document. Label the image "17.5 mL." When you are finished, print out this document and turn it in with this worksheet.

(Activity A continued on next page)

Activity A (continued from previous page)

5. Practice: Use the Gizmo to complete each of the following challenges. When you have finished each one, take a screen shot and add it to your document. Label each image with the volume.

   A. Fill the **25-mL graduated cylinder** with 11.5 mL of water.

   B. Fill the **100-mL graduated cylinder** with 76.0 mL of water.

   C. Fill the **50-mL graduated cylinder** with 38.5 mL of water.

6. Think and discuss: Suppose you needed to measure exactly 15.0 mL of water for an experiment. Which graduated cylinder would be the best one to use, and why?

   _____

   _____

   _____

   _____

7. Further practice: Select the **Practice** button. In this mode, the Gizmo will give you a series of challenges. When you complete a challenge, click **Submit**. Click **Reset** if you would like to start over or try a problem again. As you practice, the Gizmo will keep a tally of right and wrong answers in the green and red circles.

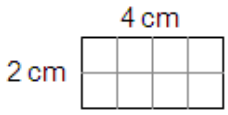
   Complete the first six challenges. Stop when you see the **ruler** and **sphere** (ball) on the screen.

Activity B: **Regular solids**	Get the Gizmo ready: • Select the **Free Exploration** mode. • Return all items to the cabinet. • Drag the **block** and the **ruler** to the counter. • You will need a calculator for this activity.	

Introduction: The volumes of regular solids, such as spheres (balls) and **rectangular prisms** (blocks), can be determined by measuring their dimensions. The volume of a solid is usually expressed in **cubic centimeters** (cm^3). One cubic centimeter is exactly the same volume as 1 milliliter.

Goal: Measure and calculate the volume of a rectangular prism and a sphere.

1. Observe: Count the squares in the rectangle at right to find its area.



   A. What is the area of the rectangle? _____

   B. How does the area of the rectangle relate to the lengths of each side? _____

   _____

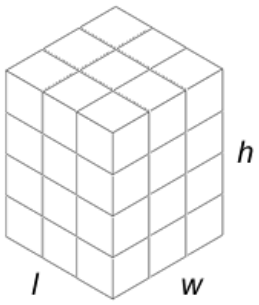
2. Observe: A block is an example of a rectangular prism. A rectangular prism has six rectangular faces. Look at the block shown below. Each cube inside the block has a 1-cm side and a volume of 1 cm^3, or 1 mL.

   A. What are the length, width, and height of the block?

      Length: _____ Width: _____ Height: _____

   B. Multiply these three dimensions. What is the product of the length, width, and height? _____

   C. How many cubic centimeters are in the block? _____



3. Measure: Just as the area of a rectangle is the product of its length and width, the volume of a rectangular prism is equal to the product of its length, width, and height. In the Gizmo, place the **ruler** over the **block**.

   A. What are the length, width, and height of the block?

      Length: _____ Width: _____ Height: _____

   B. What is the volume of the block? _____

(Activity B continued on next page)

Activity B (continued from previous page)

4. Measure: Return the **block** to the cabinet and drag out the large **sphere**. The volume of a sphere is calculated using the following formula:

$$V_{Sphere} = 4\pi r^3 / 3$$

The symbol π represents the number pi, which is about 3.14. The letter r stands for the **radius** of the sphere, which is the distance from the center of a sphere to its surface. The radius is exactly half of the **diameter**, which is the distance across the sphere. (The diameter is also equal to the length, width, and height of the sphere.)

   A. Place the ruler over the sphere. What is the diameter of the sphere? _____

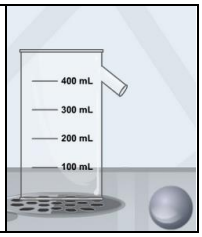
   B. What is the radius of the sphere? _____

   C. What is the volume of the sphere? _____

5. Measure: Return the large **sphere** to the cabinet and drag out the small **marble**. Use the ruler and your calculator to find the volume of the marble. Show your work.

   Volume of the marble: _____

6. Further practice: Select **Practice**. Do the next three problems, measuring the sphere, the marble, and the rectangular prism. (Note: The dimensions of each object vary slightly each time you go through the problems.)

Activity C: **Water displacement**	Get the Gizmo ready: • Select **Free Exploration**. • Return all objects to the cabinet. • Drag the large **sphere**, the **overflow cup**, the **250-mL beaker**, the **50-mL graduated cylinder**, and the **magnifier** to the counter.	

Introduction: Have you ever climbed into a tub and seen the water rise? The amount the water rises is related to your size—the bigger you are, the more the water will rise. This method, called **water displacement**, can be used to measure volume.

Goal: Use water displacement to measure the volume of an object.

1. Get the Gizmo ready: Place the **overflow cup** under the faucet. Fill it until water starts to flow out of the spout. Place the **250-mL beaker** next to the overflow cup so that the spout of the overflow cup is over the beaker. (If necessary, empty the beaker into the sink.)

2. Measure: Place the **sphere** into the overflow cup, causing water to pour into the beaker. Empty the beaker into the **50-mL graduated cylinder**. Place the **magnifier** over the waterline.

   A. What is the volume of water in the graduated cylinder? _____

   B. Recall that you used the ruler and the volume of a sphere equation to find the volume of the sphere in activity B. What is the volume of the sphere? _____

   (Recall that 1 cm^3 is the same volume as 1 mL.)

3. Explain: Why does the water volume in the graduated cylinder match the sphere's volume?

   _____

   _____

4. Practice: Using what you have learned, find the volume of the **rock**. (Hint: For a more precise measurement, use the **25-mL graduated cylinder**.)

   What is the volume of the rock? _____

   Describe how you found the rock's volume: _____

   _____

   _____

(Activity C continued on next page)

Activity C (continued from previous page)

5. Explore: You can find the volume of an object using just a graduated cylinder if you don't have access to an overflow cup. This technique works if the object you are measuring is small enough to fit into the graduated cylinder.

   Return the **overflow cup** and the **25-mL graduated cylinder** to the cabinet. Take out the **100-mL graduated cylinder** and the **pipette**. Fill the **100-mL graduated cylinder** to exactly 40.0 mL, using the **beaker** and the **pipette**.

   A. Drag the **rock** into the **100-mL graduated cylinder**. Use the **magnifier** to read the new volume.

      What is the current water volume in the graduated cylinder? _____

   B. How much has the water volume changed in the graduated cylinder? _____

      _____

   C. Based on your answers to A and B, what is the volume of the rock? _____

6. Practice: Use the same method to find the volume of the marble. Use the 25-mL graduated cylinder.

   What is the volume of the marble? _____

   Describe what you did to find the volume of the marble: _____

   _____

   _____

7. Think and discuss: When measuring the volume of the marble, why is it better to use the 25-mL graduated cylinder than the 100-mL graduated cylinder? If possible, discuss your answer with your classmates and teacher.

   _____

   _____

   _____

   _____

8. Further practice: Select **Practice**. Do the next four problems, using displacement to find the volume of the marble, rock, sphere, and rectangular prism. (Note: The dimensions of each object vary slightly each time you go through the problems.) Continue to practice as long as you like!