Objective: To reinforce the relationships among the liter, milliliter, and cubic centimeter.

Key Concepts and Skills
- Explore relationships between units of length and units of capacity. Investigate relationships and conversions between units of capacity and volume. Describe patterns in relationships between the dimensions and volume of rectangular prisms.
  [Measurement and Reference Frames Goal 3]

Key Activities
Students verify that 1 L = 1,000 mL, a 1 L box actually holds 1 L, and 1 L = 1,000 cm$^3$. They convert among units of volume and capacity and relate the dimensions of a prism to its volume.

Ongoing Assessment: Recognizing Student Achievement
Use an Exit Slip (Math Masters, p. 414).
[Measurement and Reference Frames Goal 3]

Ongoing Assessment: Informing Instruction
See page 763.

Key Vocabulary
- liter (L)
- capacity
- quart (qt)
- cup (c)
- milliliter (mL)
- cubic centimeter
- volume of a container

Materials
- Math Journal 2, pp. 327–329
- Study Link 9-9
- Student Reference Book, pp. 196 and 197
- Math Masters, pp. 414 and 436
- Class Data Pad (optional)
- scissors
- transparent tape
- slate
- for demonstration:
  - 1-liter cube
  - water-tight liter box
  - 1-liter pitcher
  - measuring cup
  - base-10 flats or longs

Advance Preparation
For Part 1, you will need a 1-liter cube, a water-tight liter box, a 1-liter pitcher, and a measuring cup that shows 1 cup and 250 mL. Gather a 1-liter bottle and other containers labeled with metric units of capacity. Make 2–4 copies of Math Masters, page 436 for each partnership. For the optional Extra Practice activity in Part 3, obtain a copy of Room for Ripley by Stuart J. Murphy (HarperCollins, 1999).

Finding Areas of Rectangles with Fractional Measures
- Math Journal 2, p. 330
- Students find the areas of rectangles with fractional side lengths.

Math Boxes 9-10
- Math Journal 2, p. 331
- Students practice and maintain skills through Math Box problems.

Study Link 9-10
- Math Masters, p. 289
- Students practice and maintain skills through Study Link activities.

Comparing the Capacity of Containers
- per group: 5 different-sized containers;
- 5 volume-measuring tools; macaroni, centimeter cubes, or other small items to fill containers
- Students explore the concept of capacity by comparing five different-sized containers.

Reading a Story about Volume
- Room for Ripley
- Students explain how they would calculate the volume of water needed to fill a fish tank.

Using Metric Prefix Multipliers
- Student Reference Book, p. 396
- Students use metric prefix multipliers to name quantities.
Getting Started

Math Message
Which holds more, a 1-quart bottle or a 1-liter bottle? Be prepared to explain your answer.

Math Message Follow-Up
Survey students for their answers to the Math Message problem. Ask volunteers to explain their solution strategies. Then show students the 1-liter bottle, and remind them that the liter (L) is a metric unit of capacity. Ask volunteers to define capacity. Capacity is the amount a container can hold. Demonstrate that 1 liter is a little more than 1 quart (qt):

- Remind students that 1 quart equals 4 cups (c).
- Measure 1 cup of water with a measuring cup and pour it into the 1-liter pitcher. Do this four times. Show students that 4 cups or 1 quart of water does not reach the 1-liter level.

To support English language learners and students new to the United States who might not be familiar with the U.S. customary units of capacity, show the appropriate containers as these units are discussed.

Demonstrating That 1 Liter Equals 1,000 Milliliters
Liquids such as water, soft drinks, and fuel are often measured in liters. Smaller amounts of liquids are often measured in milliliters. Show students several containers whose labels give the capacity in milliliters (mL). Review the symbols for liter (L) and milliliter (mL). To support English language learners, distinguish between the use of a single letter to indicate a unit such as L for liter and the use of a single letter as a variable, such as in the formula $A = l \times w$. 

Mental Math and Reflexes
Have students record measurement equivalencies for units of capacity and volume on their slates. Suggestions:

- 3 gallons equals how many pints? 24 pints
- 40 cups equals how many gallons? $2\frac{1}{2}$ gallons
- 3 quarts equals how many fluid ounces? 96 fluid ounces
- 5 liters equals how many milliliters? 5,000 milliliters
- 700 cm$^3$ equals how many milliliters? 700 milliliters
- 650 milliliters equals how many cubic centimeters? 650 cm$^3$

Math Message Follow-Up
Have partners compare their answers and resolve any differences.
Demonstrate that there are 1,000 milliliters in 1 liter. Measure 250 milliliters of water with a measuring cup, and pour it into the 1-liter pitcher. Do this four times. Show students that the water reaches the 1-liter level.

Since \(4 \times 250 \text{ mL} = 1,000 \text{ mL}\), then 1 liter = 1,000 milliliters.

**Demonstrating That 1 Liter Equals 1,000 cm\(^3\)**

Model the relationship between 1 liter and 1,000 cubic centimeters:

- Demonstrate that a liter box actually holds 1 liter. Fill the 1-liter pitcher with water to the 1-liter level, and pour this into the liter box. Show students that the water is level with the top edge of the liter box. The liter box holds 1 liter of liquid.
- Demonstrate that a liter box holds 1,000 cubic centimeters. Count out and stack 10 flats (each 10 cm by 10 cm by 1 cm), or combine available flats with groups of 10 longs (each 1 cm by 1 cm by 1 cm) equivalent to 10 flats. Ask: *What is the volume of the cube structure? 1,000 cm\(^3\)* Next, fill the 1-liter box with the cube structure. Ask: *How much does the 1-liter box hold? 1,000 cm\(^3\)*

Clarify that volume is the amount of space that a 3-dimensional object takes up. The *volume of a container* is a measure of how much the container will hold. The volume of a container that is filled with a liquid or a solid that can be poured is often called its capacity.

Capacity is usually measured in units such as gallons, quarts, pints, cups, fluid ounces, liters, and milliliters. These units of capacity are not cubic units, but liters and milliliters easily convert to cubic units.

Use questions similar to the following to summarize the discussions:

- 1 liter is equivalent to how many cubic centimeters? 1,000 cm\(^3\)
- 1 liter is equivalent to how many milliliters? 1,000 milliliters
- What is the relationship between milliliters and cubic centimeters? 1 milliliter is equivalent to 1 cubic centimeter.

Write the following equivalencies on the board or on the Class Data Pad:

- \(1 \text{ L} = 1,000 \text{ mL}\)
- \(1 \text{ mL} = \frac{1}{1,000} \text{ liter}\)
- \(1 \text{ L} = 1,000 \text{ cm}^3\)
- \(1 \text{ mL} = 1 \text{ cm}^3\)
Assign journal pages 327 and 328. Students convert between metric units of volume and capacity and between U.S. customary units of capacity.

**Ongoing Assessment:**

**Recognizing Student Achievement**

Use an Exit Slip (Math Masters, page 414) to assess students’ understanding of the distinction between volume and capacity. Have students explain the difference between volume and capacity, and have them list several examples of things that would be measured in cubic centimeters and several examples of things that would be measured in milliliters. Students are making adequate progress if they reference liquids that can be poured as being measured in milliliters, or a unit of capacity, and cubic centimeters as the measure of nonliquids, or the measure of how much space is taken up or enclosed. [Measurement and Reference Frames Goal 3]

**Exploring Volume**

(Math Journal 2, p. 329; Student Reference Book, pp. 196 and 197; Math Masters, p. 436)

Ask students to refer to the formulas for finding the volumes of rectangular prisms on pages 196 and 197 of the Student Reference Book, as needed. Ask volunteers to record the two formulas for finding the volume of a rectangular prism on the board.

\[
V = l \times w \times h \\
V = B \times h
\]

Pass out several copies of Math Masters, page 436 (1 cm Grid Paper) to each partnership. Partners first cut out a 16 cm by 22 cm section of grid paper. Then on journal page 329 they try to find the dimensions of the open box with the greatest possible volume that can be made out of that section of grid paper. Remind students of the open-box patterns they used on Activity Sheet 8 in Lesson 9-8 and the nets they made in the Part 3 activities of Lesson 9-9. Finally, they record their discovery in Problem 2.

**Exit Slip**

**Open Boxes**

What are the dimensions of an open box—having the greatest possible volume—that can be made out of a single sheet of centimeter grid paper?

1. Use centimeter grid paper to experiment until you discover a pattern. Record your results in the table below.

<table>
<thead>
<tr>
<th>Height of box</th>
<th>Length of base</th>
<th>Width of base</th>
<th>Volume of box</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cm</td>
<td>20 cm</td>
<td>7 cm</td>
<td>280 cm³</td>
</tr>
<tr>
<td>2 cm</td>
<td>18 cm</td>
<td>12 cm</td>
<td>432 cm³</td>
</tr>
<tr>
<td>3 cm</td>
<td>16 cm</td>
<td>10 cm</td>
<td>480 cm³</td>
</tr>
<tr>
<td>4 cm</td>
<td>14 cm</td>
<td>8 cm</td>
<td>448 cm³</td>
</tr>
<tr>
<td>5 cm</td>
<td>12 cm</td>
<td>6 cm</td>
<td>360 cm³</td>
</tr>
<tr>
<td>6 cm</td>
<td>10 cm</td>
<td>4 cm</td>
<td>240 cm³</td>
</tr>
<tr>
<td>7 cm</td>
<td>8 cm</td>
<td>2 cm</td>
<td>112 cm³</td>
</tr>
</tbody>
</table>

**Math Journal 2, p. 329**

**Ongoing Assessment:**

**Informing Instruction**

Watch for students who have difficulty deciding how to cut the grid paper correctly to make boxes. Suggest that they cut a 1 cm by 1 cm square out of each of the four corners of the grid to make a pattern for an open box that is 1 centimeter in height, then cut a 2 cm by 2 cm square at each corner to make a pattern for an open box that is 2 cm in height, and so on.

Students use Math Masters, page 436 to find the greatest possible volume of an open box.
2 Ongoing Learning & Practice

Finding Areas of Rectangles with Fractional Measures
(Math Journal 2, p. 330)

Students find the areas of rectangles with fractional side lengths.

Math Boxes 9-10
(Math Journal 2, p. 331)

Mixed Practice Math Boxes in this lesson are paired with Math Boxes in Lesson 9-8. The skills in Problems 2 and 5 preview Unit 10 content.

Writing/Reasoning Have students write a response to the following: Explain how you found the least common denominator for Problem 3. Sample answer: I wrote the multiples for 20 (20, 40, 60, and so on) until I found a number that was divisible by 3 (60).

Writing/Reasoning Have students write a response to the following: Explain the strategy you used to solve Problem 1d and the reasoning used. Answers vary.

Study Link 9-10
(Math Masters, p. 289)

Home Connection Students complete a page that reviews plotting points and calculating area.

3 Differentiation Options

Comparing the Capacity of Containers

To explore the concept of capacity, have students compare the capacity of five different-sized containers. Ask students to predict which containers have the largest and smallest capacities. Then have students use fill material (macaroni, centimeter cubes) to compare the capacities of the five containers and to determine if their predictions were correct. Encourage students to continue to develop their personal references as they make and check their predictions.
Reading a Story about Volume

**Literature Link**
To explore volume, read the following book to the class. Explore the following question: How much water does the fish tank hold? Discuss how students would calculate the volume of water in the fish tank.

**Room for Ripley**

**Summary:** This book follows a boy’s adventure to buy a fish and figure out how much water is needed in the fish tank.

---

**Using Metric Prefix Multipliers**

*(Student Reference Book, p. 396)*

To support language development for metric measurement, have students look at the prefixes table on *Student Reference Book*, page 396. Ask questions similar to the following:

- If a cycle is a wheel, how many wheels does a unicycle have? A bicycle? A tricycle? **One wheel; two wheels; three wheels**
- How many angles does a quadrangle have? **Four**
- How many sides does a pentagon have? A hexagon? A heptagon? A nonagon? **5 sides; 6 sides; 7 sides; 9 sides**
- How many liters are in a kiloliter? A milliliter? **1,000 liters; 1/1,000 liter**

Encourage students to look for the prefixes in number names. Consider having students illustrate some of the words and prefixes that they discuss.