**Lesson 4 – Measuring Volume**

**Storyline Summary:**

Review with students that the stuff inside the Lava Lamp is made of matter that has a certain mass based on the atoms and molecules it’s made from. (From Lesson 3)

For this lesson, students now focus their attention on the size of the blobs, or their **volume**. Students investigate the amount of space that matter takes up by measuring the volume of liquids. Students also measure the volume of solids using the water displacement method. The EXTEND offers students a chance to measure the volume of larger rectangular solids with a ruler.

Students see that multiple trials and averaging data are important, especially when sharing data as a class to determine patterns. A class discussion reveals that while evidence of mass and volume alone don’t explain the behavior of the matter in the Lava Lamp, they help to think about and discover next steps.

**Note:** This lesson covers three different activities and will take more than one class period.

**What Students Do**

**Part 1:** Students review and practice measuring the volume of a liquid.

**Part 2:** Students measure the volume of three solid cylinders from the previous lesson using the water displacement method.

**Part 3:** Students measure the volume of large rectangular solids, such as books or boxes, using a metric ruler to practice using the units cm3. If available, students use small rectangular solids to measure volume with a ruler and with the water displacement method to see that one milliliter equals one cubic centimeter.

**What Students Learn**

* Volume is the amount of space that matter takes up.
* Volume can be measured by water displacement or by direct measurement of length x width x height.
* The unit for volume is cubic centimeters (cm3).

**Materials & Preparation:**

* [DQB](file://CNOCMF04/Staff_M%24/ecmosko/My%20Documents/My%20Pictures/Untitled%20picture.png)

**Part 1**

**Materials for Each Group**

* Each Student: “Measuring Volume with a Graduated Cylinder” worksheet
* 1 Test Tube Rack
* 6 25ml Test Tubes
* 3 disposable pipettes (one for each color of water)
* 100 mL or 25 mL Graduated Cylinder
* 10 ml Graduated Cylinder
* 1 container each of 100 mL blue, red and yellow dyed water
* Access to water and a sink

**Part 2**

**Materials for Each Group**

* Flinn Density and Slope Set used in Lesson 3. (Each set contains 3 plastic tubes. Each tube contains 4 cylinders of different sizes but the same material (12 cylinders per set). You may need 2 or 3 sets.
* Graduated cylinders
* Water
* Metric ruler

**Part 3**

**Materials for Each Group**

* Large rectangular solids such as textbooks or boxes
* Small rectangular solids\*

**\*Note**: **Small Rectangular Solids**

A nice addition to this lesson is to find the volume of small regularly shaped objects by *both* the water displacement method *and* by direct measurement with a metric ruler. By measuring the same object in these two different ways you can help students see the connection and equivalence between milliliters and cubic centimeters as units of volume. This would be done at the end of Step 5.

You will need small cubes or rectangular solids that can fit into the opening of a graduated cylinder. One option is to use cubes that are 2cm x 2cm x 2cm if that is small enough for your cylinders. You could use wood glue and make some rectangular solids from 2 cubes, 3 cubes, and 4 cubes. If you can’t find 2 cm wooden cubes, you could try ¾ inch wooden cubes which are very close to 2 cm (about 1.9 cm). So the volume of these cubes is close to 2cm x 2cm x 2cm = 8 cm3.

One issue with rectangular solids made from wood is that they float, and their entire volume won’t be submerged using the water displacement method. Students will need to push them into the water with their finger or pencil just until the top of the solid is barely submerged. Students should try not to have their finger or pencil go much below the surface or it will make the volume measurement inaccurate.

**Part 1 – Measuring the Volume of a Liquid**

**ENGAGE**

* 1. **Discuss the idea that if matter has mass, it must also take up space.**

Remind students that they have established that all matter has mass, and that mass can be measured. Remind students from their last discussion that to figure out why the stuff in the Lava Lamp does what it does, they may need to consider not only the mass but the amount of space it takes up. The idea is to move toward a discussion of **volume**.

Discuss how volume could be measured. Ask what tools could be used.

Take care with the direction of questioning. **The intent is to guide the conversation towards volume, and *not* density at this time.**

**EVALUATE**

* 1. **Use the “Measuring Volume” Student Activity Sheet as a formative assessment.**

Assess student participation and understanding formatively to guide teaching opportunities along the way. Note which students with more developed ideas may be able to coach others with emergent ideas as the learning community develops their understanding together.

**Give each student an Activity Sheet for Part 1.**

The activity sheet will serve as the “Evaluate” component of the 5-E lesson plan. The activity sheets are formative assessments of student progress and understanding. Students will record their observations and answer questions about the activity on the activity sheet. Sections of the activity sheet will either be completed as a class, in groups, or individually, depending on your instructions.

**EXPLORE**

* 1. **Have students practice measuring the volume of a liquid using the activity on the Student Activity Sheet.**

Explain to students that they will measure the volume of the same 3 cylinders from the last lesson using a method called the “water displacement” method. But to do this, they will need to accurately measure the volume of water in a graduated cylinder. Remind students that for accuracy, they will need to take the *meniscus* at the surface of the water into consideration.

Tell students that they can practice their accuracy by measuring the volume of colored water by following the directions on the Student Activity Sheet.

**Materials for Each Group**

* Each Student: “Measuring Volume With a Graduated Cylinder” worksheet
* 1 Test Tube Rack
* 6 25ml Test Tubes
* 3 disposable pipettes (one for each color of water)
* 100 mL or 25 mL Graduated Cylinder
* 10 ml Graduated Cylinder
* 1 container each of 100 mL blue, red and yellow dyed water
* Access to water and a sink

**Teacher Preparation**

* Prepare **blue, red and yellow dyed water** in large containers (Plastic 2 L bottles work well) for refilling throughout the day. Add enough food coloring to the water to make sure the color is “intense” enough so that when mixed they will produce each of the colors of the rainbow. In particular, the red colored water needs to be a **deep** red for students to successfully see “orange” and “purple”.
* Using a permanent marker to label pipettes “blue”, “red” and “yellow” will help prevent cross contamination
* Ensure that each test tube within a set of 6 is *exactly* the same. If they are different, students may assume that the volume in each test tube is different because the diameter of the test tubes is different.
* Arrange the materials for quick pick-up and return by lab groups.**NOTE:**
* Remind students about cross contamination and attention to directions.
* You can quickly determine if students are able to use a graduated cylinder and their ability to follow directions by looking at the level of liquid in each test tube. They should all be 11mL and arranged in ROYGBV order. Small differences in the level may indicate error in observing the meniscus.
* Be sure to save time for rinsing out test tubes.
* Saving 2 sets of test tubes, one as an example of accuracy and one to show minor errors, is helpful in discussing their results the next day if you would like to discuss human error in using graduated cylinders.

**Procedure:**

1. Make sure your graduated cylinder and your test tubes are clean.
2. Set up the six test tubes in the test tube rack and label them A,B,C,D,E, and F using a piece of second chance paper/or your science journal.
3. Measure 19 ml of Red solution. Use a clean pipette for accurate measuring. Put into test tube **A**. **RINSE GRADUATED CYLINDER!**
4. Measure 18 ml of Yellow solution. Use a clean pipette for accurate measuring. Put into test tube **C**, **RINSE GRADUATED CYLINDER!**
5. Measure 18 ml of Blue solution. Use a clean pipette for accurate measuring. **Put i**nto test tube **E**, **RINSE GRADUATED CYLINDER!**
6. From **Test Tube C**, **remove** 4 ml and add it to test tube **D**. **RINSE GRADUATED CYLINDER!**
7. From **Test Tube E**, **remove** 7 ml and add it to test tube **D**. Mix by swirling GENTLY. **RINSE GRADUATED CYLINDER!**
8. From the **Beaker** of Blue solution, measure 4 ml and pour into test tube **F**. **RINSE GRADUATED CYLINDER!**
9. From the **Beaker** of Red solution, measure 7 ml and pour into test tube **F**.Mix by swirling GENTLY. **RINSE GRADUATED CYLINDER!**
10. From **Test Tube A**, remove 8 ml and pour into to test tube **B**. **RINSE GRADUATED CYLINDER!**
11. From **Test Tube C**, remove 3 ml and add it to test tube **B**. Mix by swirling GENTLY. **RINSE GRADUATED CYLINDER!**
12. Draw and color what you observe in the test tubes. Under each test tube drawing record the volume contained in the represented test tube.

 **A B C D E F**

Volume: Volume: Volume: Volume: Volume: Volume:

**Part 2 - Measuring the Volume of a Solid Using the Water Displacement Method**

(From Middle School Chemistry, Chapter 3, Lesson 2)

**ENGAGE**

1. **Show an animation and demonstrate how to measure volume using the water displacement method.**

Finding Volume by Water Displacement: [www.acs.org/middleschoolchemistry/simulations/chapter3/lesson2.html](http://www.acs.org/middleschoolchemistry/simulations/chapter3/lesson2.html)

Students should measure the volume of the same ***Density and Slope Set*** rods students used for measuring mass in Lesson 3.

**EXPLORE**

**2. Give each student an Activity Sheet for Part 2 and have them measure the volume of 3 solid rods using the water displacement method.**

****Have students measure the volume of the 3 rods of the same material but different lengths using the water displacement method. (These are the same rods that they measured the mass of in Lesson 3.)

Be sure students measure the volume of the rods they used in the last lesson and that they record their results in the Student Activity Sheet.

**Note:**

When measuring the volume of a rod using the water displacement method,students should be as accurate as possible when reading the volume of water in their graduated cylinder. Reading the meniscus a little high or a little low can cause an inaccurate measurement for the volume of the rod.

This will result in the biggest problem when measuring the orange rods. If the volume is read slightly too high, the density calculated in the next lesson (Lesson 5) may be the same or even slightly less than the density of water. This cannot be since the orange rods sink in water. If this problem does occur, it can be discussed and dealt with by remeasuring the volume of orange rods as accurately as possible.

**Part 3 - Measuring the Volume of Solids with a Ruler**

**ENGAGE**

**1. Show students that the volume of an object can also be measured with a ruler.**

Demonstrate using any box or thick book you have in the classroom. Use a metric ruler to measure the length, width, and height in centimeters. Have students do the calculation to find the volume of the object in cubic centimeters.

**EXPLORE**

 **2. Have students measure the volume of two rectangular solids, such as a box or textbook.**

Hand out the Student Activity Sheet (Bottom Part only) and have students measure the volume of 2 different solids using a ruler.

Students can practice the concept of measuring volume by calculating the volume of each of the blocks in the drawing.

**\*Small Rectangular Solids**

If you were able to find or make small enough rectangular solids that fit into a graduated cylinder, have students use the water displacement method to measure the volume of two different solids in milliliters. Then have them use a ruler to measure the length, width, and height and calculate the volume in cubic centimeters. Their results should be very similar. You want students to realize that as a measure of volume, 1 milliliter (1 mL) = 1 cubic centimeter (cm3).

**EXPLAIN**

**3. The blobs in the Lava Lamp have both mass and volume.**

Return to the DQB. Students now understand that matter has both mass and volume and that the mass and volume of the blobs are both determined by the atoms and molecules that make up the matter in the blobs. Let students know that the relationship between mass and volume is important in figuring out why the blobs move up and down in the Lava Lamp.

**EXTEND**

* 1. **Have a class discussion about how mass and volume work together as *density*.**

Tell students that the amount of mass in a certain volume is a quantity that has its own name. A brick has a lot of mass for its volume, but a block of wood has much less mass for the same volume. Ask if any student knows what the relationship between mass and volume is called.

The answer is in the next lesson: **density**!

Ask students if they think the density of a material helps determine whether it sinks or floats. Students should say that it does.

Tell students that they will need to learn about density to better understand the behavior of the rising and sinking blobs in the Lava Lamp.