

Measuring Matter: Mass and Volume**What's the Matter?**

Matter is all the “stuff” that exists in the universe. Everything you can see and touch is made of matter, including you! The only things that aren't matter are forms of energy, such as light and sound. In science, **matter** is defined as anything that has **mass** and **volume**. Mass and volume measure different aspects of matter.

Mass

Mass is a measure of the amount of matter in a substance or an object. The basic SI unit for mass is the kilogram (kg), but smaller masses may be measured in grams (g). To measure mass, you would use a balance. In the lab, mass may be measured with a triple beam balance or an electronic balance, but the old-fashioned balance pictured below may give you a better idea of what mass is. If both sides of this balance were at the same level, it would mean that the fruit in the left pan has the same mass as the iron object in the right pan. In that case, the fruit would have a mass of 1 kg, the same as the iron. As you can see, however, the fruit is at a higher level than the iron. This means that the fruit has less mass than the iron, that is, the fruit's mass is less than 1 kg.

- 1) Refer to the picture to the right. The left side contains a bowl of fruit, the right side contains a 1 kg mass. If the fruit were at a lower level than the iron object, what would be the mass of the fruit?

The mass of the fruit would be greater than the mass of the iron object (greater than 1kg)

**Mass vs. Weight**

Mass is commonly confused with weight. The two are closely related, but they measure different things. Whereas mass measures the amount of matter in an object, weight measures the force of gravity acting on an object. The force of gravity on an object depends on its mass but also on the strength of gravity. If the strength of gravity is held constant (as it is all over Earth), then an object mass is directly proportional to the objects weight, so a greater mass also has a greater weight.

- 2) With Earth's gravity, an object with a mass of 1 kg has a weight of 2.2 lb. How much does a 10 kg object weigh on Earth?

A 10 kg object has 10 times more mass than a 1kg object, so it should have 10 times the weight. Therefore, its weight would be 22 lbs on Earth.

Volume

Volume is a measure of the amount of space that a substance or an object takes up. The basic SI unit for volume is the cubic meter (m³), but smaller volumes may be measured in cm³, and liquids may be measured in liters (L) or milliliters (mL). How the volume of matter is measured depends on its state.

- The volume of a liquid is measured with a measuring container, such as a measuring cup or graduated cylinder.
- The volume of a gas depends on the volume of its container: gases expand to fill whatever space is available to them.
- The volume of a regularly shaped solid can be calculated from its dimensions. For example, the volume of a rectangular solid is the product of its length, width, and height.
- The volume of an irregularly shaped solid can be measured by the displacement method. You can read below how this method works.

Calculating Volume from Dimensions

If the shape of the object is regular, it can be calculated using a formula.

- 3) How could you find the volume of air in an otherwise empty room?

Assuming the room is a rectangular prism, you could multiply the length by the width by the height ($V = l \times w \times h$) to find the volume of the room.

Measuring Volume Using the Displacement Method

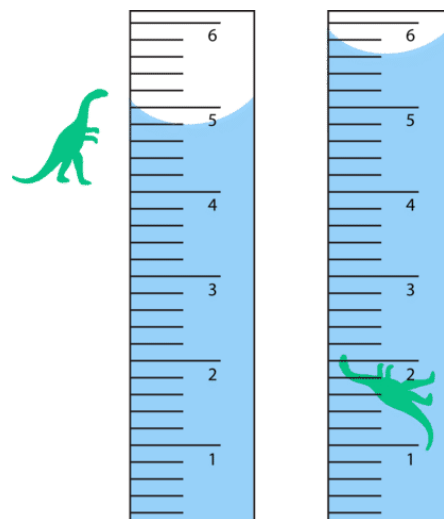
You can measure the volume of an irregularly shaped object using the **displacement method**. In this method, the object is placed in a known volume of water. The object, taking up a certain amount of space in the water, causes the water level to rise an equal amount. This change in water level can be measured to find the volume of the object.

The Displacement Method

- I. Add water to a measuring container such as a graduated cylinder. Record the volume of the water.
- II. Place the object in the water in the graduated cylinder. Measure the volume of the water with the object in it.
- III. Subtract the first volume from the second volume. The difference represents the volume of the object.

- 4) What is the volume of the dinosaur in the diagram to the right?

The water level rose from 4.8mL to 5.6mL when the dinosaur was placed in the graduated cylinder. Since it displaced 0.8 mL of water, its volume must be 0.8mL (or 0.8cm³).



Review

- 5) How do scientists define matter?

Matter is anything that has mass (is made of atoms) and volume (takes up space).

- 6) What is mass? What is the basic SI unit of mass?

Mass is a measure of the amount of matter in an object. It is measured in grams (g) or kilograms (kg).

- 7) What does volume measure? Name two different units that might be used to measure volume.

Volume is a measure of the amount of space an object takes up. Solids are usually measured in cubic centimeters (cm³), while liquids are usually measured in milliliters or liters (mL or L)

- 8) Explain how to use the displacement method to find the volume of an irregularly shaped object.

First, measure the beginning volume of the water in a graduated cylinder. Second, drop the object into the graduated cylinder. Third, measure the new volume of the water with the object inside the graduated cylinder. Finally, subtract the beginning water level from the final water level. This will tell you how much water the object displaced, which is equal to its volume.