

4.3

Mass and Volume

LEARNING TIP

The word “matter” comes from the Latin word *materia*, which means “material” or “stuff.”

In this chapter, you are investigating some of the properties of matter. Everything in the world, including you, is made of matter. What exactly is matter? **Matter** is anything that has mass and occupies space. In this section, you will learn about mass and volume.

Mass

The **mass** of an object is a measure of the amount of matter in the object. An object’s mass stays constant everywhere in the universe.

Mass is used to measure many things, from food to people (Figure 1). For example, when you buy a bag of potato chips, you are buying a certain mass of potato chips. Small masses, such as the mass of a bag of potato chips, are often measured in grams. Larger masses, such as the mass of people or vehicles, are often measured in kilograms (*kilo* means “1000”). Very small masses, such as the amounts of some medicines, are measured in milligrams (*milli* means “one-thousandth,” or “ $\frac{1}{1000}$ ”).

$$1 \text{ mg} = \frac{1}{1000} \text{ g}$$

$$1 \text{ kg} = 1000 \text{ g}$$



Figure 1

The mass of objects with different amounts of matter can be measured in different units.

Prefix	kilo		centi	milli
Multiple	1000		$\frac{1}{100}$	$\frac{1}{1000}$
Length	kilometre (km)	metre (m)	centimetre (cm)	millimetre (mm)
Mass	kilogram (kg)	gram (g)	centigram (cg)	milligram (mg)
Volume		litre (L)		millilitre (mL)

LEARNING TIP

The International System of Units, or metric system, is commonly referred to as SI. SI comes from the French name, *Le Système internationale d'unités*.

Measuring Mass

When you measure the mass of an object on a balance or a scale, you are measuring the mass directly. Therefore, this is an example of direct measurement.

Sometimes, you need to use a more complicated method to measure mass. For example, to find the mass of a quantity of water, you first need to find the mass of an empty, dry container. Then you pour the water into the container and find the mass of the container and the water. Finally, you subtract the mass of the empty container from the mass of the container with the water in it. The formula is

$$\text{Mass of water} = (\text{mass of container} + \text{water}) - \text{mass of container}$$

This is an example of indirect measurement.

Volume

As well as having mass, matter occupies space. **Volume** is a measure of the amount of space that is occupied by matter.

Measuring the Volume of a Liquid

You can measure a small volume of a liquid directly in a graduated cylinder. A graduated cylinder is a tall, narrow container with a scale of numbers on the side (**Figure 2**).

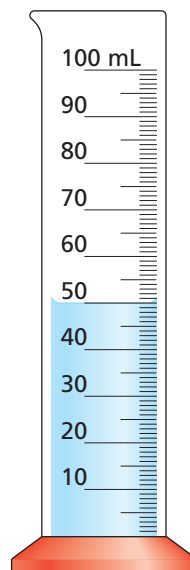


Figure 2

A graduated cylinder is marked out in steps (graduations) to enable measurement.



To measure the volume of a liquid in a graduated cylinder, you read the scale of numbers. When you look at a liquid in a graduated cylinder from the side, you will notice that the top surface has a slight curve where the liquid touches the cylinder. This curved surface is called the meniscus. For an accurate measurement, you should have your eye level with the meniscus, as shown in **Figure 3**. Then you read the volume at the bottom of the meniscus.

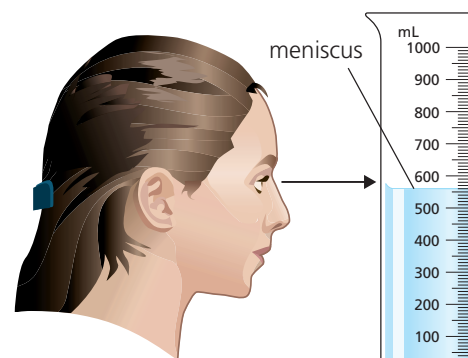


Figure 3

Read the volume of a liquid from the bottom of the meniscus.

The volume of a liquid is generally measured in litres (L) or millilitres (mL). (A millilitre is $\frac{1}{1000}$ of a litre.) You will be familiar with measurements of volume from containers of milk or soft drinks.

Calculating the Volume of a Rectangular Solid

You can measure a rectangular solid with a ruler and then calculate its volume using the following formula:

$$\text{Volume} = \text{length} \times \text{width} \times \text{height}$$

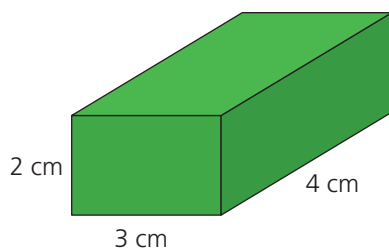


Figure 4

If you measure all the sides in centimetres, then the volume will be in cubic centimetres (cm^3). If you measure all the sides in metres, then the volume will be in cubic metres (m^3).

The volume of a rectangular solid with a length of 3 cm, a width of 4 cm, and a height of 2 cm (**Figure 4**) is calculated as follows:

$$\begin{aligned} \text{Volume} &= \text{length} \times \text{width} \times \text{height} \\ &= 3 \text{ cm} \times 4 \text{ cm} \times 2 \text{ cm} \\ &= 24 \text{ cm}^3 \end{aligned}$$

The volume of a solid is usually given in cubic centimetres (cm^3). The volume of a liquid is usually given in millilitres (mL). Recipes, however, usually use millilitres for both solid and liquid volumes. This works because 1 cm^3 is the same as 1 mL, and 1000 cm^3 is the same as 1 L. Thus, in the calculation above, the volume could also be stated as 24 mL.

Measuring the Volume of an Irregular Solid

Sometimes, you cannot measure the length, width, and height of a solid because the sides are not regular. The volume of a small, irregular solid, such as a jagged rock, must be measured by displacement. To do this, choose a container (such as a graduated cylinder) that the irregular solid will fit inside. Pour water into the empty container until it is about half full. Record the volume of water in the container, and then carefully add the solid. Make sure that the solid is completely submerged in the water. Record the volume of the water plus the solid (Figure 5). Calculate the volume of the solid using the following formula:

$$\text{Volume of solid} = (\text{volume of water} + \text{solid}) - \text{volume of water}$$

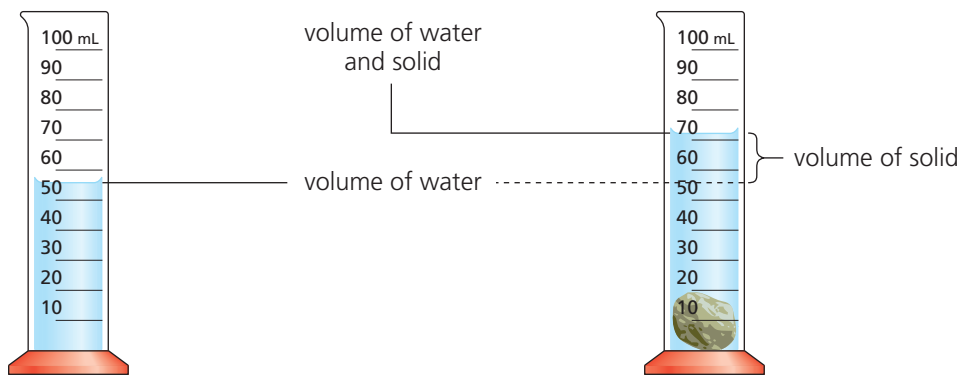


Figure 5

Measuring volume by the displacement of water

LEARNING TIP

For review in measuring mass and volume, see "Measurement and Measuring Tools" in the Skills Handbook.

CHECK YOUR UNDERSTANDING

1. Define mass and volume. State the units that are used to measure each.
2. Name two pieces of equipment that can be used to measure mass and volume. How do these pieces of equipment improve our ability to communicate with each other?
3. What is the correct way to read the volume of a liquid in a graduated cylinder?
4. Determine the volume of the following box.

