**What is Matter?**

You are made of matter. **Matter** is anything that has mass and takes up space. A toaster, a glass of water, and the air around you are all made of matter.

Matter can be described by its properties. Several properties of matter are volume, mass, and weight. The liter (L) is a scientific unit of volume. The kilogram (kg) is the SI unit for mass, and the newton (N) is the SI unit of weight.

**What is Volume?**

All matter takes up space. The amount of space that an object takes up is known as the object’s **volume**.

Imagine a car driving into a full swimming pool. Some water would splash out. This happens because the car and the water have volume. Two objects can’t occupy the same space at the same time.

**Units of Volume**

The SI unit of volume is the cubic meter. The figure below shows how big a cubic meter is.

The liter (L) is used more often as the scientific unit for measuring volume. Small volumes of liquid are often given in milliliters (mL). Remember that 1 L equals 1,000 mL. Any volume of liquid can be described in liters or milliliters. For example, the volume of a small can of soda is measured as 0.355 L or 355 mL.

**STUDY TIP**

**Organize Information** In your notebook, make a table with three columns. Label the first column Property of Matter, the second column Definition, and the third column Unit of Measure. As you read, fill in the columns.

**READING CHECK**

1. **Identify** Give a unit of measure for each of the following properties:
   - volume:
   - mass:
   - weight:

2. **Define** What is volume?

3. **Convert** The volume of a one half gallon carton of milk is 1.9 L. How many milliliters is 1.9 L?
MEASURING LIQUID VOLUME
At home, you may use a measuring cup to determine a liquid's volume. In class, you may use graduated cylinders to measure volume.

When you measure an amount of liquid, you must be careful. If you look closely, you will see that the surface of water is curved in a glass container. The curve of the surface of a liquid is called a meniscus.

The meniscus may curve only a small amount, and may look flat in a large glass container. The amount of liquid in a container is measured from the lowest point of the meniscus. When you look at the figure below, you can see a meniscus.

VOLUME OF A REGULARLY SHAPED SOLID OBJECT
The volume of any regularly shaped solid object is measured in cubic units. The word cubic means that the object is not flat. The volume of an object is calculated by multiplying three measurements: length, width, and height.

It is important to see the difference between cubic measurements, which mean volume, and square measurements, which mean area. The figure below shows the difference between volume and area.

READING CHECK
4. Describe What is a meniscus?

5. Draw On the figure, draw a meniscus that would show a volume of 6.0 mL.

6. Identify What do cubic measurements measure?

7. Identify What do square measurements measure?

The cube has volume. Each face of the cube has area. The square has only area.
FINDING THE VOLUME OF A REGULARLY SHAPED OBJECT

A formula is used to calculate the volume of a regularly shaped object. An example of a regularly shaped object is a cube.

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

An example of a cube is shown below:

A cube whose length, width, and height are each 1 m has a volume of one cubic meter (1 m\(^3\)).

To find the volume (V) of a regularly shaped object, multiply the area (A) and height (h) as shown in the following formula:

\[ V = A \times h \]

Let's do a problem. What is the volume of a box that has an area of 400 cm\(^2\) and a height of 10 cm?

\[ V = A \times h \]
\[ V = 400 \text{ cm}^2 \times 10 \text{ cm} = 4,000 \text{ cm}^3 \]

VOLUME OF AN IRREGULARLY SHAPED OBJECT

One way to measure the volume of an irregularly shaped object is to put it into a known volume of water. The increase in volume is equal to the volume of the object.

Remember that objects cannot occupy the same space at the same time. The figure below shows how much water is displaced or moved after an object is dropped into it.

The irregularly shaped solid makes the total volume 2 mL larger. So, its volume is 2 mL.

Critical Thinking

8. Find What is the area of each face of the cube shown in the figure? Remember that area is length multiplied by width.

9. Describe You are given a toy metal car and asked to find its volume. Describe how you would do this.
What Is Mass?

Another property of matter is mass. Mass is a measure of the amount of matter that makes up an object. For example, both you and a penny are made of matter. You are made up of more matter than the penny, so you have a greater mass.

The mass of an object does not change when the location of the object changes. The mass of any object changes only when the amount of matter that makes up the object changes.

DIFFERENCE BETWEEN MASS AND WEIGHT

You may think that the terms mass and weight mean the same thing, but they are very different. Weight is the measure of the force of gravity on an object. Earth has a force of gravity that keeps all objects from floating into space. When you step on a scale, you are seeing how much force Earth pulls on you. This is known as your weight.

An object's weight can change depending on where the object is located. The mass of the object stays the same. For example, a penny would weigh less on the moon than here on Earth. This happens because the moon has less mass and has a lower force of gravity than Earth does. The mass, or amount of matter in the penny, stays the same. Only the force of gravity changes.

The table below shows how mass and weight differ.

<table>
<thead>
<tr>
<th></th>
<th>Mass</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>How it is measured</td>
<td>with a balance</td>
<td>with a scale</td>
</tr>
<tr>
<td>What is measured</td>
<td>the amount of matter</td>
<td>the force of gravity</td>
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<td>SI measurement units</td>
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<td>newtons</td>
</tr>
<tr>
<td>Changes with the location of the object?</td>
<td></td>
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</table>
What Is Matter?

MEASURING MASS AND WEIGHT

The brick and the sponge in the figure below have the same volume. This is because the brick has larger mass, so Earth pulls on the brick more than it does on the sponge. Therefore, the brick weighs more than the sponge.

![Image of brick and sponge]

The brick and the sponge take up the same amount of space. The brick contains more matter, so its mass—and thus its weight—is greater.

The SI unit for mass is the kilogram (kg). Smaller masses are often measured in grams (g) or milligrams (mg). These units can be used to give the mass of any object. 

Weight is a measure of gravitational force. The SI unit of weight is the newton (N). One newton is equal to the weight of an object on Earth with a mass of about 100 g.

What Is Inertia?

Imagine kicking a soccer ball that has the mass of a bowling ball. It would not only be painful but also very difficult to move the ball. The reason is inertia. Inertia is the ability of an object to resist a change in its motion. Therefore, an object will stay at rest unless something causes the object to move. Also, a moving object will keep moving unless something causes it to change speed or direction.

The mass of an object tells you how much inertia an object has. An object with a large mass is harder to get moving and harder to stop than an object with less mass. The reason is that the object with the larger mass has more inertia. For example, a truck has more inertia than a bicycle. If you were trying to get a truck moving by pushing on it, you might not be able to get it moving at all. It is much easier to change the motion of a bicycle.

READING CHECK

13. Identify Name three mass units.

14. Identify What is the SI unit for force and its symbol?

15. Identify What is inertia?

16. Identify What does the mass of an object tell you about its inertia?
Section 1 Review

SECTION VOCABULARY

| **inertia** | the tendency of an object to resist being moved or, if the object is moving, to resist a change in speed or direction until an outside force acts on the object |
| **mass** | a measure of the amount of matter in an object |
| **matter** | anything that has mass and takes up space |
| **meniscus** | a curve at a liquid’s surface by which one measures the volume of a liquid |
| **volume** | a measure of the size of a body or region in three-dimensional space |
| **weight** | a measure of the gravitational force exerted on an object; its value can change with the location of the object in the universe |

1. Describe  Why is an apple an example of matter?

2. Explain  What is the difference between mass and weight?

3. Identify  In the figure below, what is the volume of water in the graduated cylinder?

![Graduated Cylinder]

4. Determine  A rock is placed into a graduated cylinder containing 80 mL of water. What is the volume of the rock if the water level rises to the 120 mL mark?

5. Calculate  One airline limits the size of carry-on luggage to a volume of 40,000 cm³. A passenger has a carry-on that has an area of 1,960 cm² and is 23 cm high. Is the passenger’s luggage OK to carry on the airplane? Show work to prove your answer.
Chapter 1 The Properties of Matter

SECTION 1 WHAT IS MATTER?
1. Volume: liter
   Mass: kilogram
   Weight: newton
2. The amount of space that an object takes up is volume.
3. 1,900 mL
4. A meniscus is the curved surface of a liquid in a container.
5. The student should draw a line that curves downward from 7 mL to the 6 mL line, then back to the 7 mL line.
6. volume
7. area
8. 1 m²
9. Put a known volume of water into a graduated cylinder. Put the car into the cylinder. Measure how much the volume increases.
10. the amount of matter in an object
11. weight

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12. kilograms, grams, milligrams
13. newton (N)
14. the ability of an object to resist a change in its motion
15. Objects with higher mass have more inertia.

Review
1. An apple has mass and takes up space.
2. Mass is a measure of how much matter is in an object. Weight is a measure of the force due to gravity on an object.
3. 19 mL
4. 40 mL
5. \( V = A \times h \)
   \[ V = 1,960 \text{ cm}^3 \times 23 \text{ cm} = 45,080 \text{ cm}^3 \]
   No, the luggage is too big.

SECTION 2 PHYSICAL PROPERTIES
1. properties that can be observed and measured without making a new substance
2. its mass or weight, its density, its compressibility
3. the amount of matter in a given volume
4. 23 times as much, or 44 g more
5. \( D = \frac{m}{V} \)
   \[ D = \frac{28 \text{ g}}{1.45 \text{ cm}^3} = 19.3 \text{ g/cm}^3 \]
6. when measured at the same temperature and pressure
7. zinc
8. If it is denser than water, it will sink.
9. The diet soda—objects less dense than water float in the water.
10. the liquid with the lowest density
11. a change that affects the physical properties of a substance
12. melting
13. a change of state
14. A gas can change into a liquid or into a solid.
15. nothing

Review
1. Divide the mass of the substance by its volume.
2. No, because all the substances are more dense than methanol.
3. \( D = \frac{m}{V} \)
   \[ D = \frac{135 \text{ g}}{50 \text{ cm}^3} = 2.7 \text{ g/cm}^3 \]
   aluminum
4. The ball with the smaller volume has the larger density.
5. Its volume must get larger.

SECTION 3 CHEMICAL PROPERTIES
1. change into new matter
2. iron
3. The identity of the substance does not change when the physical property is observed; when the chemical property is observed, the substance changes identity.