Grade 7 Science

Week of November 23– November 27

Density

Density Introduction

Which is more dense? A rock or a foam ball? How do you know? What's your weight? What's your mass? What's the difference?

Good measurements are fundamental to good science, and this section will have you measuring and recording and calculating. So grab your ruler and calculator and let's get started!

The main focus of this lesson is to define **density** and learn how to calculate it. A large box drops on your foot. Would you prefer that box to be full of rocks or popped popcorn? Why? The obvious answer is the box of popcorn because it isn't as heavy and won't hurt as much. Let's look at this as scientists.

Density Principles

Try these activities to discover two of the principles of density.

A. Same Mass + Less Space = More Density!

1. Gather some friends or family members in the same room.
2. Have everyone move slowly around the room.
3. Now move all those people into a smaller room—the bathroom or a closet—and ask them to move around again.

Questions:

1. In which room were the people packed more densely?
2. Did the total mass of the people change?
3. What was different?

So, what happened? Think of each person as a particle of matter in a substance. With less space (less volume), the substance is denser because the particles are closer together. You have just demonstrated a principle of density. **Density of a given mass will increase if placed in a smaller space.**

B. More Mass + Same Space = More Density!

1. Fill a container—a jar or bowl with a lid works best—with marshmallows and close the lid.
2. Now check the mass of the container by using a scale or by picking it up and getting a sense of how heavy it feels.
3. Keep adding marshmallows to the container and compact them as you go. Squish as many marshmallows into the container as possible.
4. Check its mass again, either on a scale or by feel. If you need to judge the mass by feel, it would help to have two equal containers to compare—one filled with un-squished marshmallows and the other with squished ones.

Questions:

1. Did the size of the container change?
2. Did the mass change?

What happened? You've just demonstrated a second principle of density. **More mass in the same volume has a greater density.**

Think about a bag of popped popcorn. We can use it to demonstrate a third principle of density. Compare the bag of popped popcorn and a penny. Which is heavier? The bag of popcorn, because it has more mass. Which do you think is denser? If you said the penny, you are correct. So, more mass doesn't mean greater density.

Density is a ratio of mass to volume, or how much matter there is in a given space. The scientific definition of density is the amount of mass contained in a known volume.

We can usually identify the densest substance in a group of objects by simply picking up each item. From experience, we can often predict how heavy something will be from its size, but sometimes we can be surprised by how heavy or how light an object is. Imagine that you have two similar-sized bags—one is full of rocks and the other is full of feathers. If you weren't familiar with the contents of the bags, you might assume the bags have the same mass. But as soon as you lift the two bags, you know that's not the case.

Solutions: Part A – 1. The smaller room, 2. No, 3. The volume or space; Part B – 1. No, therefore the volume remained the same., 2. Yes, the more marshmallows the greater the mass.

Density

When you compare masses of two objects with the same volume, you are considering **density**.

$$\text{Density} = \text{mass} \div \text{volume}$$

or

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Although density and mass are closely related, they are NOT the same. Something with a large mass may not be very dense, and visa versa. The amount of mass in a unit volume of a substance is its density.

Have you ever seen oil floating on top of a puddle of water? That's because oil is less dense than water. Anything less dense than water will float in it. Anything more dense will sink.

If you know the mass and volume of an object you can calculate the density by dividing.

If the mass of an object is 28 g and the volume is 18 mL, the density will be

$$28\ g \div 18\ \text{mL}$$

or

$$\frac{28\ g}{18\ \text{mL}} = 1.56\ \frac{g}{\text{mL}}$$

Sink or Float?

Will an object float?

This depends strictly on the density of the object and the density of the fluid you want it to float in (eg. water). How well an object will float is called its **buoyancy**. Water has a density of 1.0 g/mL so liquids and solids that float have a density of less than 1.0 g/mL and liquids and solids that sink have a greater density.

Automobile oil has a density of about 0.87 g/mL so it will float on top of water. What would the density of an item have to be in order to sink in oil, but float in water?

Gases also have density and are usually compared to the density of air. A gas that has less density than air will rise. Can you think of a gas that is less dense than air? Helium is one. A few gases are more dense than air and will actually sink to the ground if released into the air.

Note: Water is uncommon in that its solid form is less dense than its liquid form, which is why icebergs float.

Egg Density Experiment: https://youtu.be/fqLCwuKMBMA

Density for Identification

To study and compare substances, you must be able to list their characteristics. The boiling and melting points of a substance are defining characteristics, as is its density. Defining characteristics of substances can be used to identify an unknown sample. Scientists know the characteristics of many substances. Once we calculate the density of an unknown material, we can compare that to a list of known densities to find out what our unknown material is.

Density is the measure of how closely packed the particles (atoms and molecules) are. The density of a substance at a given temperature is always the same. When you study chemistry in later years, you will investigate why some types of matter are denser than others. For now, all you need to know is that it involves the arrangements of the atoms. Here are the densities of some common substances:

Substance	Known Density (g/cm^3)
hydrogen	0.00009
helium	0.0002
air	0.0013
oxygen	0.0014
carbon dioxide	0.002
ice	0.92
water	1.00
aluminum	2.70
table salt	2.16
copper	8.96
silver	10.50
lead	11.34
gold	19.30

Once we calculate a density of an unknown material, we can compare that to a list of known densities to find out what the material is. For example, the density of water at room temperature is always 1.0 g/mL

Calculating Density

Let's do a quick review.

mass = how much matter is in a sample (usually measured in grams)

volume = how much space the sample takes up (liquids are usually measured in litres or millilitres and solids are measured in cubic metres or cubic centimetres)

Given this, the density of liquids will have units of grams per millilitre (g/mL) and the density of solids will be in grams per cubic centimetre (g/cm^3). For practical purposes, one millilitre is the same volume as a cubic centimetre, and the two are often interchanged. Remember to always include units when you record measurements and perform calculations. That is part of the scientific method, and it helps to ensure your calculations are correct.

The formula for calculating density is:

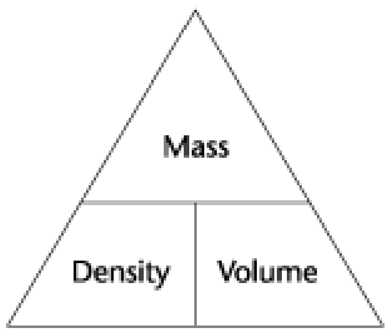
$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Calculating Density from Mass and Volume: https://youtu.be/-TMs7oJWdYQ

Calculating Mass from Density and Volume: https://youtu.be/tJ0CLvuhzpU

Calculating Volume from Density and Mass: https://youtu.be/45d8C-tFfEw

Note:



Looking for density? $\text{density} = \frac{\text{mass}}{\text{volume}}$

Looking for mass? $\text{mass} = \text{density} \times \text{volume}$

Looking for volume? $\text{volume} = \frac{\text{mass}}{\text{density}}$

How Temperature Affect Density

Temperature has a direct impact on the density of materials. In this lesson we'll review what you have learned about the movement of the particles in a substance in response to heat to explore the effect that temperature has on the density of materials.

Recall that as the temperature of a substance increases, the particles move faster and the spaces between them expand. This process is called **thermal expansion**. The particles in the substance become spread out over a greater volume. By definition, the substance becomes less dense.

$$(\text{density} = \frac{\text{mass}}{\text{volume}}).$$

When the temperature of a substance decreases, the particles move slower and the spaces between the particles contract, or get smaller. This process is called **thermal contraction**. The object still has the same number of particles but those particles take up less volume, resulting in increased density.

Practical Applications

The unique visual effect of a lava lamp is created by flowing globs of material. But how does it work? The light at the bottom of the lamp heats the solid material, causing the particles to vibrate and move apart. As the material expands, the globs are less dense than the surrounding material and they rise.

At the top of the lamp the material cools (heat is removed) and the particles slow down and move closer together. As the glob contracts, its density increases and it sinks to the bottom of the lamp.

How Does it Work? – Lava Lamps: https://youtu.be/DL3Ez9bxMTo

Different materials expand and contract at different rates. Scientists and engineers must understand the expansion and contraction of the material with which they work. You'll see an example of how engineers deal with expansion and contraction when you cross a bridge. Every few metres there are gaps in the surface of the bridge deck. In the summer, you may not notice these gaps but during a cold winter, the gaps will feel like big cracks that cause the car to bump as it drives over them.

Why? The bridge is fixed to either side of the river bank. In the summer, the bridge deck will expand in the heat. The gaps allow for this expansion, preventing the surface materials from pushing together and crumbling. In the winter, the bridge deck contracts, pulling the sections apart and preventing the surface of the bridge deck from cracking.

You may notice the same principle when you look at telephone lines. In the heat of summer, the lines hang very low but in winter, they are much tighter and therefore higher. The extreme temperature differences in Canadian climates create challenges for those who design and build buildings, bridges, roads, and other infrastructure.

Complete the following.

1) Use the table of known densities in the “Density for Identification” lesson to identify the objects below.

Density of Unknown Object	Identity
0.002 g/cm^3	
0.092 g/cm^3	
0.0013 g/mL (1mL = 1cm^3	

2) Watch the video for calculating density, then copy down the equation you would use to calculate its value.

3) Perform the following density calculations by solving for the missing values. Show your equations and work below the table.

Object	Mass	Volume	Density
Sugar cube	12.5 grams	2.5 cm^3	
Gold nugget	72.7 grams		19.3 g/cm^3
Ice cube		12 cm^3	0.92 g/cm^3
Hot air balloon		2 800 m^3	0.95 kg/m^3
Cedar log	5852 kg		380 kg/m^3
Osmium crystal	2112.44 grams	9.4 cm^3	

4) Fool's Gold. Do a serarch to find the physical properties of pyrite and fill in the table below so you will never be fooled.

Property	Gold	Pyrite
Colour	Yellow	
Density	19.3 g/cm^3	
Boiling point	2 807 Celsius degrees	
Conductivity	conducts	2 800 m^3

5) True or False. Solids are denser than liquids. Explain your choice below.