



WHAT THE HECK IS DENSITY?



Density is something that often confuses students, because they think that it is the same as mass or volume. Density is a very important measurement, because regardless of how big or small a substance is, its density will not change. A watch made of gold and a brick made of gold have different masses and volumes, but they have the same density. How can that be?



← **SAME DENSITY!** →



Mass: 20,000 grams
Volume: 1040 cm³

Mass: 550 grams
Volume: 28.5 cm³

If you were to take the mass of the gold brick, and divide by its volume, you would get the same number as if you took the mass of the gold watch, and divided by its volume.

Density is a ratio of mass divided by volume:

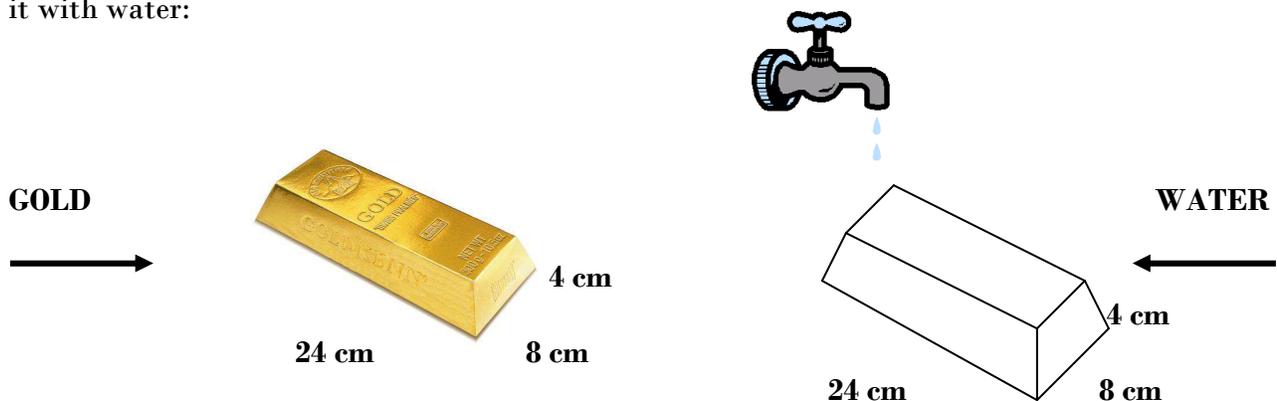
$$D = \frac{m}{V}$$

In both cases, you get 19.2 g! Even though they are different shapes and weights, they have 1 cm³

the same density.

In simple terms, density is how much something weighs, compares to how much space it takes up. A very dense object weighs a lot, but doesn't take up much space! This can be very confusing, so look at the following example:

Take the same gold brick from above. Let's build a box the exact same size, or VOLUME, but fill it with water:



Both are the same **SIZE, or volume, correct?** We could calculate the volume of both:

$$\text{Volume} = \text{length} \times \text{width} \times \text{height} = 24 \text{ cm} \times 8 \text{ cm} \times 4 \text{ cm} = 768 \text{ cm}^3$$

Are they going to **weigh** the same, though? Of course not! Why? They have **different densities!** One is going to weigh more!

The density of gold is $\frac{19.2 \text{ g}}{1 \text{ cm}^3}$, and the density of water is $\frac{1 \text{ g}}{1 \text{ cm}^3}$. That means that when you have

objects made of gold and water, and they are the same size, that the gold one will weigh **19.2 times more!** So in this case, the gold brick would weigh 14,745.6 grams, and the water brick would weigh 768 grams. That can be figured out with some basic math, if you were wondering! But we will get to that later!

Wow! That small gold brick would be about 40 pounds, where the water one would only be about a pound! How can that be? **Gold is more dense than water!** There's more stuff packed into the same amount of space!

So you can understand, a 2 liter bottle filled with soda (mostly water) would weigh about 5 pounds. The same 2 liter bottle, if filled with gold, would weigh almost 100 pounds! Even though they take up the same space, the gold bottle would weigh so much more, because there are so many more atoms packed into that space!



The entire density scale is based around water, which has a density of 1 – 1 gram of water occupies a volume of 1 cm³. It is often written as 1g/1 cm³. The amazing thing is this – gold has a density of 19.3 g/1 cm³, which means it is 19.3 times as dense as water!

Because density is a ratio that doesn't change, we can use it to identify substances. For example, the famous Greek scientist, Archimedes, was hired by a king to prove that a gold crown that was made for the king was not made of gold. It appeared to be gold – but how does one know? It appeared to have the same size and shape as the other crowns as well. Archimedes knew that if it were gold, it would have the same density as the other crowns. So he went about finding the mass and volume of the crown. The mass was easy – a scale was used to determine this. How would one find out its volume, though? This can be done through **water displacement** – an idea Archimedes discovered! An object placed in water will displace, or push aside, as much water as its own volume. Archimedes took the volume of the crown this way. He then took the mass and the volume of the supposed gold crown, calculated its density, and found out it was not made of gold. The crown maker was then beheaded. In today's times, there are more accurate ways of determining density. It can still be used, however, to identify the nature of a substance.

In summary, here are some things I want you to remember about density -

1. The density of an object will never change, no matter of how much or how little of that substance you have!
2. Because density does not change, no matter the size of an object, it can be used to identify what a substance is made of!
3. In practical terms, density means that you can have two objects that take up the same space, but have very different weights. For example, a 2-L bottle filled with soda would weigh about 5 pounds, where a 2-L bottle filled with gold would weigh 100 lbs!
4. Certain objects will float or sink in water, based on their density compared to water, and due to their buoyancy – that means their ability to float if they have air trapped inside!
5. The density scale is based around water, which has a density of $1\text{g}/1\text{ cm}^3$.