

5th Grade - Lesson 2.4

Density and Sinking and Floating

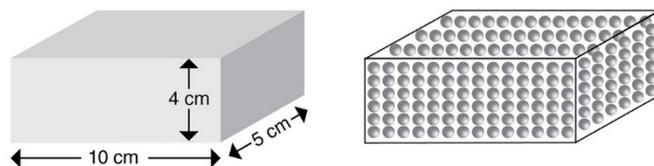
Teacher Background

Density = Mass/Volume

The density of a substance, like aluminum, quartz, or oak, is a characteristic property of that material. So if you measured the density of an unknown material that looks like aluminum and the density matched with the density of aluminum, the material is most likely aluminum.

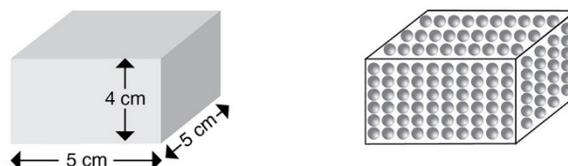
The reason substances have a characteristic density has to do with the atoms they are made from and how these atoms are arranged in the substance. The atoms of a substance have a certain mass, size, and arrangement that gives the substance a certain mass per unit of volume which is a measure of its *density*.

The density of an object, like a clay ball or wooden block, is measured by the *mass* of the object divided by its *volume* ($D=m/v$). Here's an example: Let's say this block is 10 cm long, 4 cm tall, and 5 cm wide. The volume of the block is $10\text{ cm} \times 4\text{ cm} \times 5\text{ cm} = 200\text{ cm}^3$. Let's say its mass is 1000 grams. So the density of the block is $1000\text{ g}/200\text{ cm}^3 = 5\text{ g/cm}^3$.



Density of a Piece Equals Density of the Whole

If the material that makes up the object is consistent throughout, any size piece of the object will have the same density. So if you cut the object in half, for example, so that it is 5 cm long, 4 cm tall, and 5 cm wide, the volume will be $5\text{ cm} \times 4\text{ cm} \times 5\text{ cm} = 100\text{ cm}^3$ and the mass of this $\frac{1}{2}$ -piece will be 500 g. The density is $500\text{ g}/100\text{ cm}^3 = 5\text{ g/cm}^3$.



So the density of the half is the same as the density of the whole. This makes sense because half the volume has half the mass, so the ratio of the mass and the volume stays the same so the density stays the same.

This also works the other way around. If you had a small piece of oak wood and compared it to a giant piece of oak that was 100 times the volume, they would have the same density. This is because the larger piece would be 100 times the mass and the ratio of the mass to the volume would be the same, so the density would be the same.

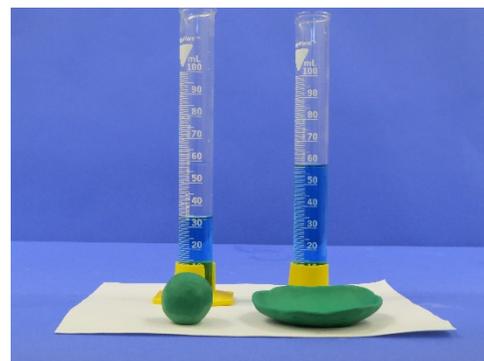
How Can a Ship Made of Steel Float?

An object sinks if it has a density greater than the density of water. An object floats if its density is less than the density of water. A common question is how can an object that is made of a material more dense than water, such as metal, be made to float.

Shaped to Displace

To understand how this works, you have to look at sinking and floating in a related but different way. This explanation is based on the principle that: *an object floats when the mass of water the object displaces is equal to the mass of the object*. So the more water an object can displace, while the object's mass stays the same, the better its chances are of floating.

For example, two solid balls of clay that are the same volume would displace the same volume and mass of water, but if one ball is flattened and shaped into a large enough bowl shape and placed in water, the clay bowl displaces a larger volume of water. The clay's mass hasn't changed, but the displaced water's volume (and mass) has increased.



Volume of water displaced by the clay sphere and clay bowl

When the weight of water displaced by the clay bowl equals the weight of the bowl, the clay bowl floats.



Boats displace a mass of water equal to the mass of the boat

Boats take advantage of these same principles and are built large enough to displace a mass of water equal to the mass of the boat.



Bowl shape displaces more water and floats