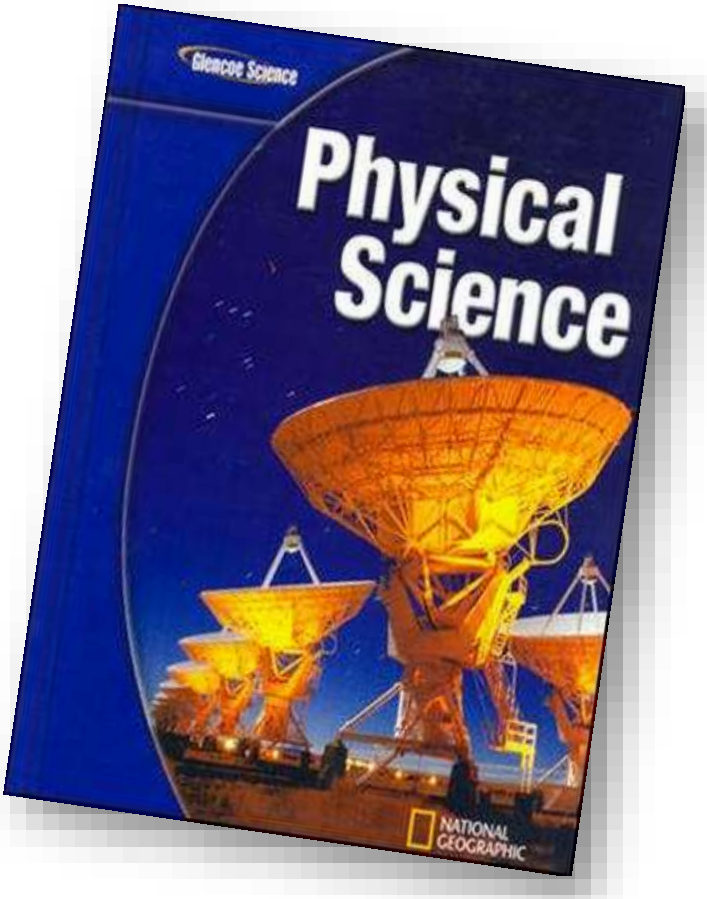
What's Density?

Mass. Volume. Density.



Matter takes up space. It is anything that has mass and volume. Your science textbook is made of matter. It takes up space on your desk, has a particular mass and volume. The amount of space an object takes up is called its volume. Volume is an important property of matter that you use every day. Many products you may buy at a store such as milk or bottled water, are sold in specific volumes. The metric units that are used to express volume are the liter (L), milliliter (mL), and cubic centimeter (cm^3). In general, liters and milliliters are used to measure the volume of liquids and cubic centimeters (cm^3) are used to measure the volume of solids. One milliliter is equal in volume to one cubic centimeter. One thousand milliliters (mL) is equal to one liter (L). How many milliliters are there in 2.5 liters?

The properties of mass and volume can be used to describe another important general property of matter called density. Density is often used to describe the characteristics of objects. For example, someone might say "this is a dense forest." Meaning there is a large amount of plants. To scientists and science students, being

Metric Volume

1 milliliter (mL) = 1 cm^3
1 Liter (L) = 1dm^3
1 Liter (L) = 1, 000 mL
1 milliliter (mL) = 0.001 Liters (L)

"dense" helps to define a very special property of matter. Density is often defined as the <u>mass per unit volume of an object</u>.

Density is an important property because it allows you to compare different types of matter. Suppose you were asked to determine which is heavier, wood or steel. How would you go about doing it? Perhaps you would suggest comparing the masses of both on a balance. You are on the right track, but there is one problem with this solution. What size pieces of wood and steel would you use? After all, a small piece of steel might have the same mass as a large piece of wood.

You probably realize that in order to compare the masses of two objects, you need to use equal volume of each. When you do, you soon discover that a piece of steel has a greater mass than a piece of wood <u>of the same volume</u> (and that is the important part of statement). So for our example we can say a cubic centimeter of steel is heavier than a cubic centimeter of wood. Or, in fact, steel is denser than wood.

All matter has density. And the density of a specific kind of matter is a property that helps to identify it and distinguish it from other kinds of matter. Because density is equal to mass per unit volume, we can write a formula for calculating the density of an object:

Density = mass / volume

Density

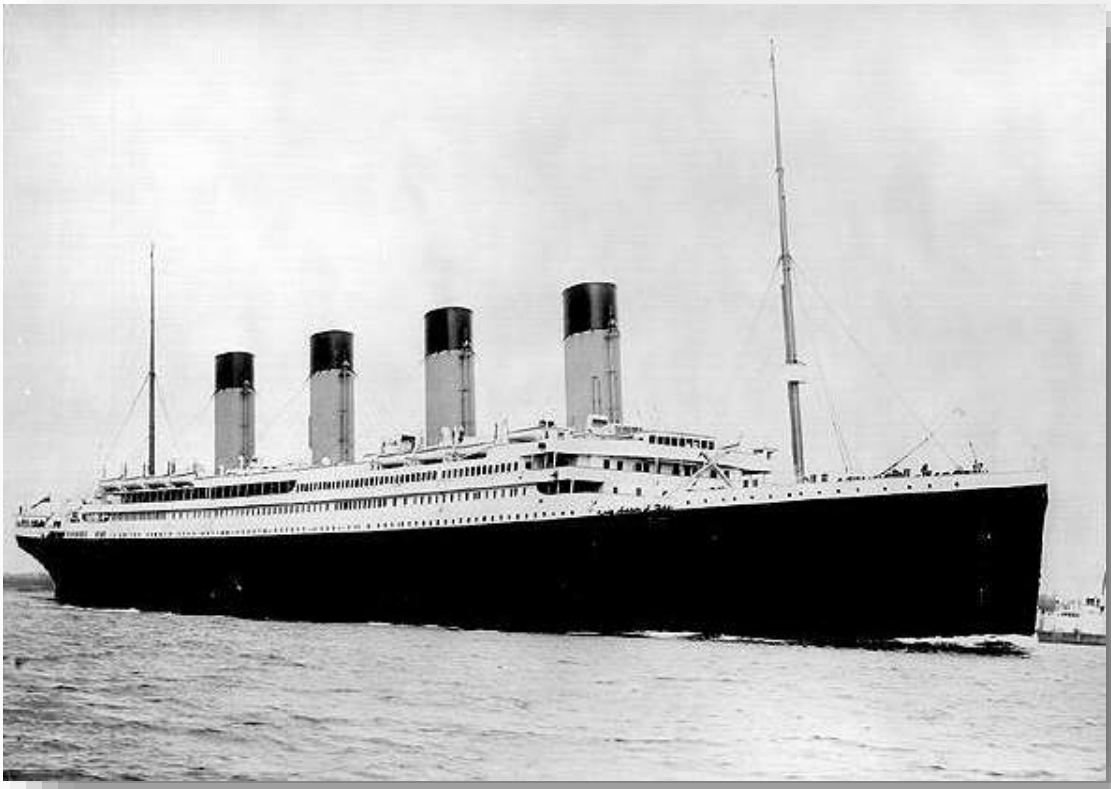
1 g/mL = 1 g/cm^3 or 1 kg/L = 1 kg/dm^3

Density is often expressed in grams per milliliter (g/mL) for a liquid or grams or cubic centimeter (g/cm^3) for a solid. The density of wood is about 0.8 g/cm^3. This means that a piece of wood one cubic centimeter

cm^3 in volume has a mass of about 0.8 gram. The density of steel is 7.8 g/cm^3. So a piece of steel has a mass about 9.75 time that of a piece of wood of the same volume. In summary, steel is much denser than a piece of wood. The density of fresh water is 1 g/mL. Objects with a density less than water float. Objects with a density greater than water sink. Thus wood floats in water because its density is less than the density of water.

What happens to a piece of flat steel when it is put in water? You can no doubt think of examples, such as ships, that are made of really

Titanic



You may have read or saw the movie about the passenger ship *Titanic*, which sank in 1912 after it struck an iceberg in the North Atlantic Ocean. The most advanced technology was used to build the *Titanic*. This included watertight doors specially designed to seal off part of the ship that had been damaged and leaked. When the *Titanic* struck an iceberg on its maiden (first) voyage, the sides of the ship were pierced. As water filled the inner parts of the ship, air was pushed out and the density of the ship increased. As the density of the ship increased to a point higher than sea water, the *Titanic* sank to the bottom of the ocean.

dense materials that can float on water. There are special attributes of ships that allow them to float despite being made of dense materials. Their shape and the open areas within the ship lower their density below that of water. If you have ever placed an ice cube in a glass of water, you know that ice floats. Frozen water, ice, must be less dense than liquid water. Actually, the density of ice is about 89 percent of cold water. Only a small portion of the ice cube is above the water level. The rest is below the surface. This fact is what makes icebergs so dangerous. For it is only the "tip of the iceberg" that is visible from the wheelhouse of a ship. Much of the ice of the iceberg is below the surface.

Sample Problem

If 96.5 grams of gold has a volume of 5 cubic centimeters, what is the density of gold?

$$Density = \frac{Mass}{Volume}$$ **1. Write the formula.**

$$Density = \frac{96.5\ g}{5\ cm^3}$$ **2. Substitute given numbers and units**

$$Density = 19.3\ \frac{g}{cm^3}$$ **3. Solve for the unknown variable, density.**

The density of water increases with depth. In other words, the density of water increases as you go deeper under the surface of the water. So the density of deep water is greater than 1 g/mL. An object that is less dense than deep water will eventually stop sinking. In comparison, air at the earth's surface is denser than air on top of a mountain. As you travel from sea level, the density of the air goes down. This is why people often refer to the "thin air" in places like Denver, Colorado. Being nearly a mile high from sea level, this city has an atmosphere considerably less dense than most other places.