

## Water Density

If you're still in school, you've probably heard this statement in your science class: "Density is the mass per unit volume of a substance". On Earth, you can assume mass is the same as weight, if that makes it easier.

If you're not still in school, then you probably forgot you ever even heard it. The definition of density, makes a lot more sense with a little bit of explanation. As long as an object is made up of molecules, and thus has size or mass, it has a density. Density is just the weight for a chosen amount (volume) of the material. A common unit of measurement for water's density is gram per milliliter (1 g/ml) or 1 gram per cubic centimeter (1 g/cm<sup>3</sup>).

Actually, the exact density of water is not really 1 g/ml, but rather a bit less (very, very little less), at 0.9998395 g/ml at 4.0° Celsius (39.2° Fahrenheit). The rounded value of 1 g/ml is what you'll most often see, though.

## Water's density varies with temperature

Growing up with an older brother was difficult, especially when he had his friends over, for their favorite activity was thinking of ways to antagonize me. I was able to use water density once to at least play a trick on them, though. One hot summer day they climbed the huge hill next to our house to dig a hole to hide their bottle-cap collection. They got thirsty and made me go back home and bring them a gallon of water. That gallon of tap water at 70° weighed 8.329 pounds, which was a lot for a 70-pound kid to haul up a huge hill.

So, when they demanded another gallon of water, I consulted the "Internet" of that day—an encyclopedia— and found out that a gallon of water at its **boiling point** only weighed 7.996 pounds! I ran up the hill carrying my gallon of water that weighed 0.333 pounds less; and ran back down even faster than their angry voices fading behind me.

Temperature (°F/°C)	Density (grams/cm <sup>3</sup> )	Weight (pounds/ft <sup>3</sup> )
32°F/0°C	0.99987	62.416
39.2°F/4.0°C	1.00000	62.424
40°F/4.4°C	0.99999	62.423
50°F/10°C	0.99975	62.408
60°F/15.6°C	0.99907	62.366
70°F/21°C	0.99802	62.300
80°F/26.7°C	0.99669	62.217
90°F/32.2°C	0.99510	62.118
100°F/37.8°C	0.99318	61.998
120°F/48.9°C	0.98870	61.719
140°F/60°C	0.98338	61.386
160°F/71.1°C	0.97729	61.006
180°F/82.2°C	0.97056	60.586
200°F/93.3°C	0.96333	60.135
212°F/100°C	0.95865	59.843

Source: U.S. Department of the Interior, Bureau of Reclamation, 1977, *Ground Water Manual*, from

The Water Encyclopedia, Third Edition, Hydrologic Data and Internet Resources, Edited by Pedro Fierro, Jr.

and Evan K. Nyler, 2007

## Ice is less dense than water

If you look at this picture you can see that some of the iceberg is below the water level. This is not a surprise, but actually almost all of the volume of iceberg is below the water line, not above it. This is due to ice's density being less than liquid water's density. Upon freezing, the density of ice decreases by about 9 percent.



Heavy ice cubes sink to the bottom of a glass of water while the normal cubes float.

Credit: Mike Walker

The hydrometer is gently lowered into the liquid to be measured until the hydrometer floats freely. There are etched or marked lines on the device so the user can see how high or low the hydrometer is floating. In less dense liquids the hydrometer will float lower, while in more dense liquids it will float higher. Since water is the "standard" by which other liquids are measured, the mark for water is probably labeled as "1.000"; hence, the specific gravity of water at about 4°C is 1.000.

Hydrometers have many uses, not the least being to measure the salinity of water for science classes in schools. They are also used in the dairy industry to get estimates of the fat content of milk, as milk with higher fat content will be less dense than lower-fat milk. Hydrometers are often used by people who make beer and wine at home, as it offers an indication of how much sugar is in the liquid, and lets the brewer know how far along the fermentation process has gone.

Make your own hydrometer:

- [Hydrometer science-fair project](#)
- [Making and using a hydrometer](#)

The instrument to measure the density of a liquid is called a hydrometer. It is one of the simplest of scientific-measuring devices, and you can even make your own out of a plastic straws (see links below). More often, though, it is made of glass and looks a lot like a thermometer. It consists of a cylindrical stem and a weighted bulb at the bottom to make it float upright.



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A hydrometer is used to measure density of liquid.



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