Teacher Tune-up

Quick Content Refresher for Busy Professionals

How is liquid displacement used in density measurement?

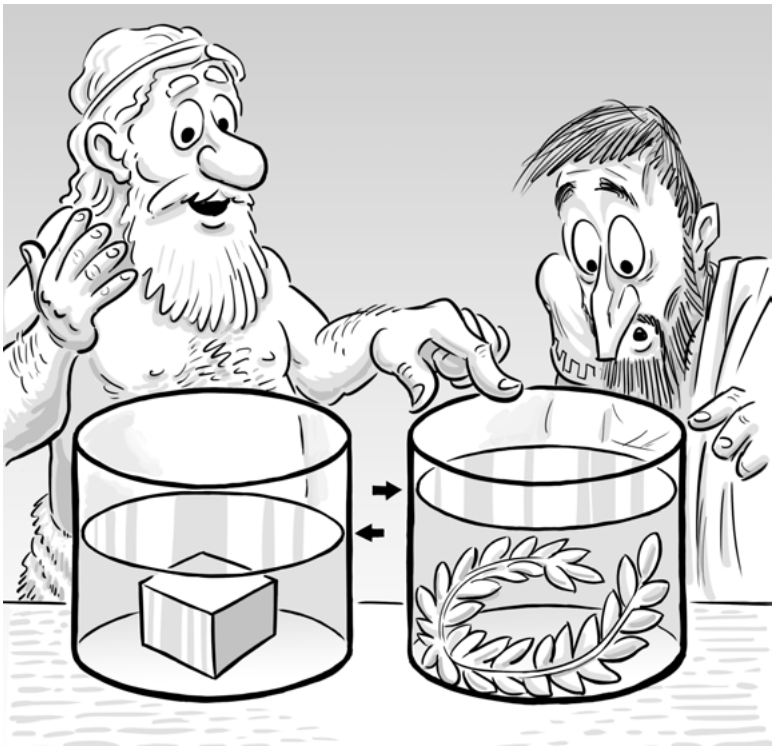
How much liquid an object displaces helps us calculate volume, mass, or both.

The density of an object is measured by determining the ratio of its mass to its volume. It is generally straightforward to find an object's mass by weighing it. Volume can be calculated easily for simple geometric shapes like cubes, prisms, cylinders, cones, and spheres; but if an object's shape is complex, its volume may not be as simple to figure out. For example, how would you calculate the volume of a porcelain cup with a handle?

The first recorded solution to this problem came from Archimedes over 2,000 years ago. He was asked by a king to determine whether a crown was made of pure gold (density 19.3 g/cm^3) or whether the gold had been mixed with less-valuable silver (density 10.5 g/cm^3). Determining the crown's density would answer the question. Its weight was easy to measure, but the shape of the crown was so elaborate that it was not possible to determine its volume by directly measuring its size. Legend has it that the solution occurred to Archimedes while he was taking a bath, when he noticed that the water level in the tub rose as his body submerged.

The volume of the crown could be calculated in the following way.

1. Fill a container to the brim, then submerge the crown in it and catch the overflow.
2. Do the same thing with a piece of pure gold that has the same weight as the crown.
3. If the crown overflow is greater, then silver has been substituted, since the volume that silver occupies is 1.8 times as much as the volume occupied by the same weight of gold.



Modern glassware makes it easier than it would have been in Archimedes' time to measure rising water level, rather than starting with a full-to-the-brim container and taking the extra step of catching and measuring overflow. To introduce students to the idea of measuring volume by displacement, most teachers use a graduated cylinder. Students note an amount of water prior to submerging an object and then note the new reading of the water level when the object is submerged. When students subtract the initial measurement from the final measurement, they are left with the volume of the submerged object. Here is a simple animation showing this process. Link: http://serpmedia.org/scigen/m2.4a.html