Other physical properties

Making sense of density

“Which is heavier, a kilo of lead or a kilo of feathers?” Full marks if you answered “Neither - they have the same mass, 1 kilogram.” It’s a trick question, of course, but many people (including you, maybe) still believe that lead is heavier than feathers. Whether it’s heavier or lighter depends on how much you’ve got. A kilo of lead is heavier than 500 g of feathers, but it’s lighter than 2 kilos of feathers.

What people mean is that lead is denser than feathers. That is, it’s heavier if you have the same volume. You can have a pillow fight with a bag of feathers, but you couldn’t even lift a pillow-case filled with lead!

Working out the density of an object is quite easy. You simply use the equation:

Density = mass / volume or, in symbols, $\rho = m/v$.

All you need to know is the mass (which you can determine by weighing the object) and the volume. If you have a regular-shaped object (for example, a cube, cylinder or sphere), you can measure its dimensions and use a known equation to determine the volume. If the object has an irregular shape (for example, a lump of stone), you can use displacement to determine the volume.

But it's not quite that straightforward.

Depending on which source of information you look in, you will find densities given in different units:

- kilograms per cubic metre, kg m^{-3}
- grams per cubic centimetre, g cm^{-3}

You need to be familiar with both systems and be aware that values in kg m^{-3} are a thousand times larger: for example, the density of aluminium is 2700 kg m^{-3}, or 2.7 g cm^{-3}.

There may also be a difference between the density of an object and the density of the material it’s made from. What if the object is hollow, like a football, or is made of a porous material, with bubbles in, like plastic foam? You can determine the object's volume by measuring its dimensions, but you haven't accounted for the holes - you haven't determined the volume of the material itself.

We therefore need to distinguish between "apparent density" (the density of the object) and "real density” (the density of the material). The Standard Procedures below describe methods for determining the density of regular - and irregular-shaped objects. If the object has no holes or bubbles, the density determined will be the real density of the material that the object's made of. But if the material you're testing is porous or your sample is hollow, remember to record the fact that you've only worked out the "apparent" density.

Powders and crystals present another problem. There are tiny air gaps between the solid particles. You can pour a powder like tea, coffee or sugar into a container until it is full. If you then tap it gently, the level drops. Tapping makes the particles move closer together. The mass is the same, but the volume is less, so the apparent density has increased. The density of a powder, including the air gaps, is called its “bulk density”. British Standards specify how many times the container must be tapped (to compact the powder) when measuring bulk density. The Standard Procedures below do not cover powders and crystals.

SP 0011:2005 ***Methods of determining the density of materials***

- Part 1: Determining the density of regular-shaped objects
- Part 2: Determining the density of irregular-shaped objects (Displacement can method)
- Part 3: Determining the density of irregular-shaped objects (Buoyancy method)