Density – Tutorial Script

What makes warm air rise and oil float on water? And how can you distinguish pure gold from fake gold? Density!

Density is the ratio of an object's mass to its volume. It is not simply mass or weight. It's mass per unit of volume (grams per cubic centimeter or kilograms per liter).

Yes, density is a fraction. And we know that to make a fraction bigger (increase density) we increase its numerator (mass) or decrease its denominator (volume).

Imagine two objects of the same volume but with different masses. (Same denominator, different numerators.) Which object is denser? The object with the greater mass (numerator) is the denser one.

Now imagine two objects of the same mass, but different volumes. (Same numerator, different denominators.) Which is denser? The object with the smaller volume (denominator) is the denser one.

For example, here is a gold nugget that is the same volume as this quartz crystal. Which is densest?
Because the gold nugget is almost 5 times more massive for the same volume, it's denser.

Now let's compare this gold nugget with an equal mass of quartz. The quartz would have to be 5 times greater in volume to have the same mass as the gold. Now that they are present in the same mass, are they the same density?
No! With the same mass, the material that is smallest in volume is the most dense. The gold nugget is still densest.

Pause now.

Quartz is always 1/5 the density of the gold, and if both were molten and floating in a bucket together, the quartz would rise to the top, and the gold sink to the bottom.

We see this really clearly when we mix oil and water. The denser water sinks under the less dense oil.

So how do we use density to determine the purity of gold? Pure gold has a density 20 times greater than water. So weigh your gold sample and compare it to the weight of 20 times the gold nugget's volume in water. If they aren't the same, the gold isn't pure.

Where do we see objects rising and sinking on our planet as density changes? In the oceans, when water cools, it contracts, becomes smaller in volume and thus becomes denser and sinks. If water becomes saltier, it adds mass without changing its volume. It becomes denser and sinks. In the atmosphere, when air warms, it expands, takes up more volume and becomes less dense and rises. If an air mass doesn't change temperature but instead adds evaporated water vapor, it becomes less massive (Why? The same volume, but the water kicks out one of the other heavier gas molecules and replaces it with itself which is less massive, thereby making the total mass less). The less massive air is now less dense and rises. In the asthenosphere and outer core, heat at the base of the layer causes the plastic or liquid material above it to expand and take up more volume, thus becoming less dense. This material rises upwards and displaces cooler material that is now denser than its surroundings, and sinks. This transfer of heat in a plastic or liquid medium is called convection and is the main cause of plate tectonics (convection of the asthenosphere) and the Earth's Magnetic Field (convection of the outer core).

Want to know your own density? Jump in a pool! If you sink, you're denser than the water. If you float, you're less dense. Try it yourself. But only if you know how to swim.

Pause now.

For more information and more detail, continue on to the next video in this series.

[end credits]

Earth Formation Series:
Part I: Earth Formation
Part II: Radiometric Dating
Part III: Density
Part IV: Early Earth
Part V: Life on Earth

Density
Geosciences Video Tutorial
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