WORKSHEET: DENSITY FUNDAMENTALS

Floating in Air

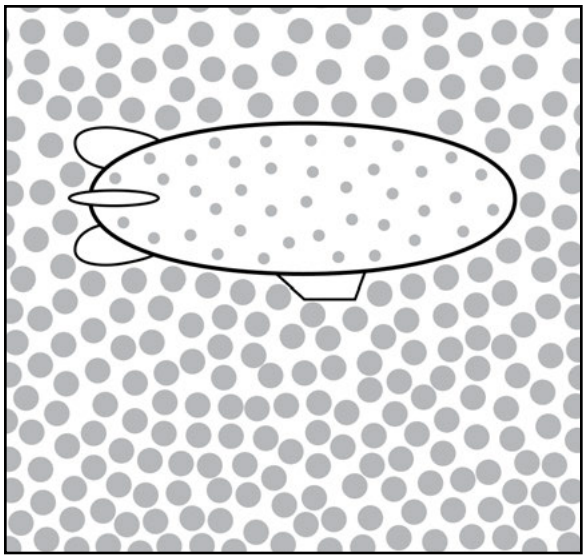
As you've seen with iron, the **density** of a substance can change with its temperature. But different materials at the same temperature also have different **densities**. If you have a cubic foot of lead, a cubic foot of water, and a cubic foot of Styrofoam all at the same temperature, they'll have very different masses, because they have very different **densities**.

Two ways to float in the air

An object placed in a **fluid** will float if it's less dense than the **fluid**, and sink if it's more dense than the **fluid**. Remember, a **fluid** can be either a liquid or a gas. The typical cases we see around us are things that float or sink in air, and things that float or sink in water. Iron is so dense that it sinks in water, whereas helium floats in air because it is less dense than air. Cork is less dense than water but more dense than air, so it floats on water but not in air.

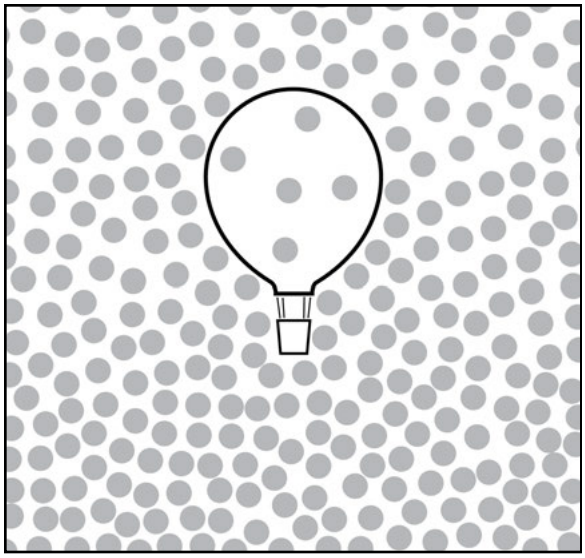
Remember, **density** is the ratio of mass to volume. So at a particulate level, the **density** of a substance is determined by two things: *how massive* the particles of the substance are, and *how closely packed or spread out* those particles are. These two aspects of **density** lead to two basic strategies for making lighter-than-air vehicles work.

Helium blimp



Helium-filled blimps and hot air balloons both float in the air by holding large volumes of low **density** gases. In a helium blimp, the gas is helium (He). At the same temperature and pressure as the surrounding air, helium has just as many atoms as the surrounding air has molecules. But the helium atoms are much less massive than the air molecules, so the helium is less dense.

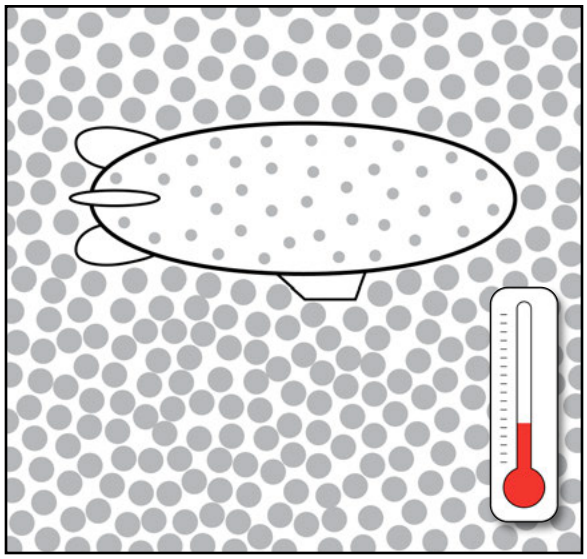
Hot air balloon



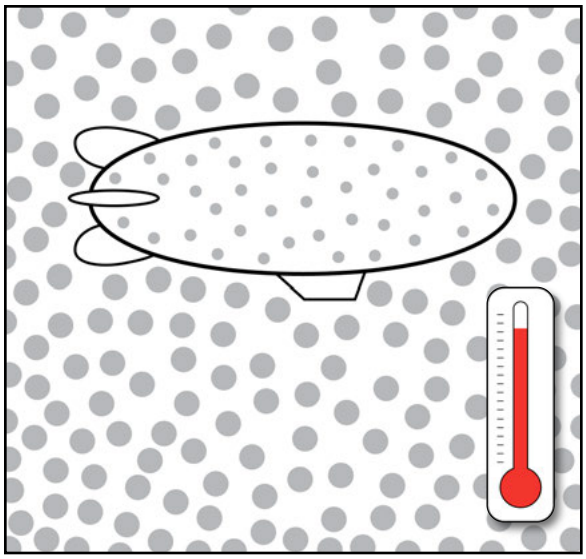
In a hot air balloon, the air inside the balloon has pretty much the same kinds of molecules as the surrounding air. Compared to helium atoms, the nitrogen molecules (N_2) and oxygen molecules (O_2) that make up most of the air both inside and outside the balloon are pretty massive. But the molecules of heated air move fast and spread out more. Many of them are pushed out of the opening at the bottom of the hot air balloon, leaving the hot air inside the balloon less dense than the surrounding air.

It's not just what's inside the blimp or balloon that matters. The **density** of the air outside changes in different weather conditions. When the air is cold, it is denser because its molecules stay relatively close to each other. When the air heats up, its molecules move faster and spread out so that the air becomes less dense. Compare the two illustrations below. One shows the blimp in cooler, denser air, and the other shows the same blimp in warmer, less dense air.

Cooler, denser air



Warmer, less dense air



In both cases, the helium in the blimp is less dense than the surrounding air. But the blimp will rise more quickly and float more easily in one case than in the other. The air temperature might affect how much weight the blimp can lift—how many passengers or how much cargo it can carry.

TURN, TALK, AND WRITE

Do you think the blimp can carry more weight in cooler air or warmer air? Explain.