

How can gravity make something go up?

A laboratory experiment from the Little Shop of Physics at Colorado State University



Overview

If you warm the air in a balloon, it will rise. But why?

Theory

When you warm up air, the molecules move faster. If they can, they will also move farther apart—reducing the density.

One cubic meter of air in Colorado has a mass of about 1.0 kg; if you warm air up by 30°C (not so hard to do) one cubic meter will only have a mass of 0.9 kg.

The balloon that you will build has a volume of about a cubic meter. So, when cold, the air in the balloon has a mass of 1.0 kg. Now,

suppose you put the balloon in the sun. It will heat up. The

molecules will move faster, and some will escape. The balloon will have the same size, but the air inside will only have a mass of about 0.9 kg.

Now, here's the cool part: The balloon itself has a mass of less than 0.1 kg. So the mass of the balloon plus the air inside it is less than the mass of one cubic meter of air.

Because the balloon is where it is, there's one cubic meter of air, which has a mass of 1.0 kg, that has to be someplace else. This is what we call *displacement*.

If you were to raise the hot air balloon up, a larger mass of air could fall down to take its place. Suppose you had a pulley and a rope with a large mass on one end and a small mass on the other... If you let go of the rope, the large mass will fall and the small mass will rise.

The same thing happens here. Gravity will pull the denser, cooler air down, causing the warmer, less dense air (and the balloon containing it!) to rise!

Necessary materials:

- Cheap, thin (.5 mil, at most!) black plastic garbage bags
- Masking tape or transparent tape

The most important thing is to make the bag really, really light. So use cheap thin bags and the lightest strongest tape you can find!



The 16-bag version of this balloon is bigger and liftier.

Doing the Experiment

Step 1: Building it. (Adapted from wikiHow)

The key thing is to use the cheapest, thinnest, cheesiest black plastic garbage bags you can find. Your final balloon will have a vaguely tetrahedral shape; this is the easiest solar hot air balloon we have ever made. You could whip one up in 15 minutes.

It uses 4 black plastic bags. You can easily scale it up to the 16-bag version illustrated in the picture, but this is quite a bit trickier.

1. Remove 4 trash bags from the roll.
2. Cut off the sealed end (as close to the seal as possible).
3. Find the long edge of the folded bag that is folded several times over.
4. Insert the blade of a pair of scissors into one of the folds and cut all the way to the other end. You should be able to spread the bag open into a 3ft x 5ft sheet of plastic.
5. Repeat this procedure for all 4 bags.
6. Join 2 bags together with masking tape, along the long (5ft) side of the sheets.
7. You should have a 5x6ft sheet of plastic. Attach another bag to one of the 5ft sides, and then the last bag. You should have a long, 12x5ft sheet of plastic.
8. Join the two shorter (5ft) ends with the masking tape.
9. You will now have a flat tube that measures 6ft x 5ft.
10. Seal one of the open ends with masking tape. This is Seam A. There should be a seam at the center of the new seam.
11. At the other end of this seam, take the remaining open end and pull it open.
12. Seal this opening, so the seam is perpendicular to seam A.
13. Cut about 5 inches off of one of the corners, and invert the entire balloon like a sock.
14. When the balloon is inflated, it should be a tetrahedron, similar to a pyramid.

Step 2: Flying it.

If you can, give yourself a head start by filling the balloon up with a hair dryer. If you do so, and you seal it off, it will rise and keep on rising. Tie it to a string or you'll need to make another...

Summing Up

This experiment is a good one to illustrate what happens to air masses in the atmosphere: Warm ones rise, cool ones sink. Both happen here; the balloon is the one we see, but the falling cool air is the key. The pull of gravity on this denser air causes the less dense air to rise!

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: <http://cmmmap.colostate.edu>

Little Shop of Physics: <http://littleshop.physics.colostate.edu>