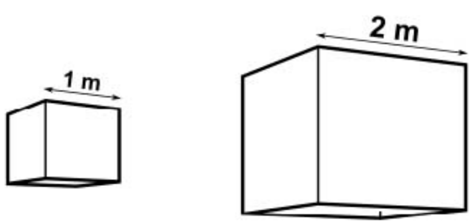
A Bigger Balloon Is Always Better

Somewhere in every project in this book it says that to make the balloon fly better you should make it bigger. But why does a bigger balloon fly better? And is it always the case? You might think that although a bigger envelope has more air and so more lift, it also has more weight and this would cancel out the extra lift.

In fact, bigger balloons have a lot more lift, much more than the extra weight of a bigger envelope. This is because the volume of a three-dimensional shape grows faster than its surface area as the shape gets bigger. Because the lift depends on the volume of the shape, and the weight depends on the surface area, more lift is left over as the shape gets bigger. The best way to understand how this works is to look at an example.

Imagine you have two hot air balloons each shaped like a cube. One balloon has sides that are 1 meter along each edge, and the other has sides that are 2 meters along each edge. Both balloons have four tissue paper sides and a top, with the bottom face left open to allow the hot air in.



If you want to calculate the volume of each balloon, multiply the width by the depth by the height. As they are both cubes, this is easy.

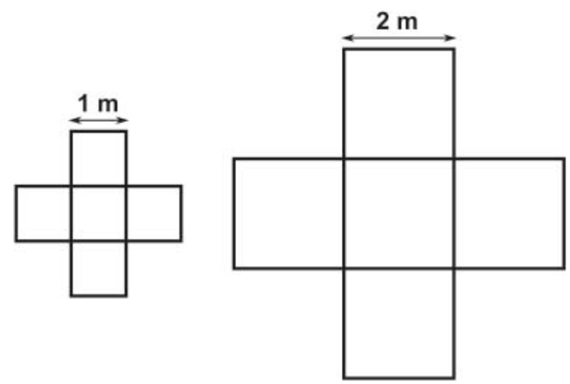
The volume for the smaller balloon is $1 \times 1 \times 1 =$ ***1 m³.***

The volume for the larger balloon is $2 \times 2 \times 2 =$ ***8 m³.***

So the volume has increased eight times by making the sides twice as long. How much has the *weight* of the envelope increased?

The weight of the balloon is made up of the weight of paper needed to make a cube-shaped envelope.

That is just the area of paper you need to make five square faces multiplied by how much the paper weighs per square meter. (Assume each square meter of tissue paper weighs about 15 grams.) The area of a square face is easy to work out—you multiply the width by the height:



For the smaller balloon, the area of one side is $1 \times 1 = 1\ m^2$.

The area for five square faces is $5 \times 1 = 5\ m^2$.

So the smaller envelope weighs $15 \times 5 =$ ***75 grams.***

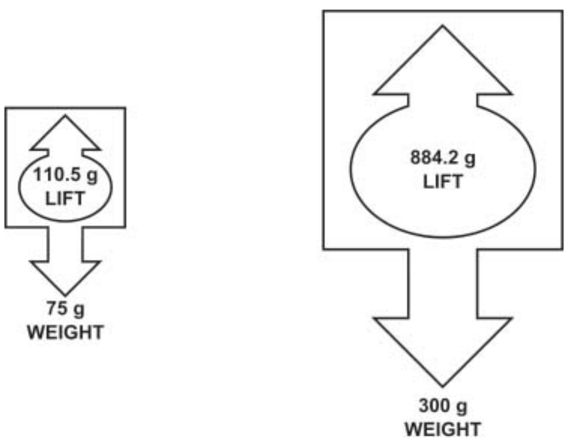
For the larger balloon, the area of one side is $2 \times 2 = 4\ m^2$.

The area for five square faces is $5 \times 4 = 20\ m^2$.

So the larger envelope weighs 15 × 20 = ***300grams.***

Overall, this means that the volume of the larger balloon is *eight times* that of the smaller balloon, and so it has eight times the lift. The weight of the larger balloon is only *four times* bigger than the weight of the smaller balloon. Since the larger balloon has eight times the lift, it's no surprise that the larger balloon flies better!

But things get even more interesting if we look at the lift available to carry a payload at the end of a flight as the burner flame gets smaller. If the air inside both balloons is heated to only 30°C above the surrounding air:



Smaller balloon lift from the heated air = 110.5 grams

Lift available for payload = lift - envelope weight = 110.5 - 75 = ***35.5grams***

Larger balloon lift from the heated air = 884.2 grams

Lift available for payload = 884.2 - 300 = ***584.2 grams***

So the larger balloon can lift a payload that is more than *16 times* bigger. This means that the larger balloon will continue flying well even as the burner starts to run out.

If you make balloons bigger, they fly better. But what happens if you make a smaller balloon? Obviously they don't fly as well because they have less lift. In fact, if you make a tissue paper balloon too small, it won't fly at all.

Stop reading here…although, if you'd like to read the next section, you may. It is a little tricky to understand, but who knows, you may just get it! :)