Investigating Velcro - Teacher Notes

About this Activity

In this experiment the children measure the force needed to pull two strips of Velcro apart. They do this by finding out how much you can lift with a piece of Velcro.

This activity involves:

- Measuring forces (without using a force meter);
- Thinking about what makes a 'fair test';
- Finding out how Velcro works – and why old Velcro does not work as well as new Velcro.

Before You Start

Equipment needed:

- Large plastic container with screw-top lid – supplied in the Fun with Forces pack.
- Short strip of Velcro – supplied in the Fun with Forces pack.
- Approx 1kg uncooked rice.
- Weighing scales (with a measuring accuracy of about 10 grams).
- Magnifying glass (optional).

Preparation:

Before you do this experiment for the first time, you need to stick a piece of Velcro to the lid of the plastic container. You will see that one of the strips of Velcro has a self-adhesive side. Cut a length about 2-3cm long from this side and stick it to the middle of the lid. (If possible I would suggest using a blob of strong glue to help it to stick. If you do this, make sure you leave it for 24 hours before trying the experiment.)

Worksheets:

For the standard experiment you need to print out the following **Investigating Velcro** worksheets:

- **p1**, **p2** and
- either **p3A** OR **p3B**.

Worksheet **p3A** is for children who are not familiar with the distinction between 'mass' and 'weight' – so they will simply record the maximum mass that can be lifted by the Velcro. Worksheet **p3B** is for children who are able to convert the mass (measured in grams or kilograms) into a force (measured in Newtons).

There is also a further optional worksheet, **Investigating Velcro p4**, in which the children investigate how Velcro works – and why new Velcro works better than old Velcro. This worksheet is suitable for children of all abilities.

Lifting with Velcro

The aim of this part of the experiment is to find out how much weight* a strip of Velcro can lift.

The procedure is simple:

- Start by pouring a small amount of rice into the container. Screw the lid tightly onto the container, then weigh the container – and write the reading in the table on worksheet **p1**.
- Press a strip of Velcro onto the one on the lid of the container, and try to lift the container using the Velcro.
- If you can lift the container, write 'YES' in the right hand column of the table. Add some more rice and try again.
- If you can't lift it, write 'NO' in the table. Pour out some rice and try again.
- The aim is to keep adding or removing rice until you get a reasonably accurate measurement of the maximum weight that you can lift. (If you are working with a small group of children, allow them to take it in turns to add or remove rice – and then try to lift it.)
- After trying the experiment with a few different amounts of rice, you may want to tackle the questions on worksheet **p2**. (These are described below.)
- Once you have tried the experiment a sufficient number of times (10 or 12 times is fine), you will have a rather jumbled set of results. For example, you may have started with 200g, then 700g, 600g, 450g, 550g, etc. Using the table on Worksheet **p3A** or **p3B**, rewrite your results in order – starting with the smallest mass. Once you have done this you will easily be able to identify the largest mass that you managed to lift. (Note – you may occasionally find that the Velcro does lift one mass, but fails to lift a slightly smaller mass. Do not worry if this happens – see the section below: 'How accurate are your measurements'.)

***** When we lift the container with the Velcro we are finding the force required to pull the Velcro apart. This depends on the **weight** of the container, which is measured in Newtons. However, when we 'weigh' the container on the scales, the reading is in grams or kilograms – so the figure recorded in the table is the **mass** of the container. (If you repeated this experiment on another planet where gravity is weaker than on Earth, the Velcro would exert the same force as on Earth – but you would be able to lift more mass.)

What did they need to do to make sure it was a 'fair test'? (Worksheet **p2**)
(It might be a good idea to ask this question to the group once they have tried lifting the container a few times – but before they finish the experiment so that they can put the ideas into practice for the rest of the experiment.)
There are several things to consider:

- Did they press the pieces of Velcro together each time before they tried to lift it?
- Did they check that the two pieces of Velcro overlap completely? Otherwise they are not using all the Velcro to lift with.
- How slowly or carefully did they try to lift the container? If you lift it slowly there is a better chance of success than if you pull the Velcro up quickly. (This is because lifting quickly produces a large **impulsive force**. This is discussed in more detail in the Magic Flag experiment.)

What happens if the container is lifted for a few seconds, but then falls off? (Worksheet **p2**)
(The best time to discuss this is when it happens!)
As you add more and more rice, you may find that the container is lifted for a moment – but then falls. Does this count as a successful lift? Ask the children to think of a rule to decide what counts as a successful lift, for example, 'It has to hold for 5 seconds without

falling off'.
This is really another instance of ensuring that we have a 'fair test'. It does not really matter what we decide to use as our rule, the important point is that we have to apply the same rule each time.
You can also ask the children to think about other 'rules' that they could introduce. For example, you may have noticed that sometimes when you try to lift it, the Velcro comes unstuck straightaway, but if you press the Velcro on and try again, it works! So a suitable rule would be that you could try to lift it three times before you decide that the Velcro does not lift that amount.

How accurate are your measurements?
(This question is not on the worksheets, but is something which you might like to discuss – particularly with more able pupils.)
Velcro works because thousands of tiny loops in one side of the fastener catch on the tiny hooks on the other strip (see below). So the amount that you can lift on any particular attempt depends on how many loops and hooks are connected – and how well they are connected.
In some instances, this may lead to apparently contradictory results. For example, you may find that the Velcro manages to lift a mass of 650g, but fails to lift 640g.
This does not mean that the experiment has failed, or that you have done anything incorrectly, it is just a reflection on the fact that the Velcro may work better on some occasions than others. (This is something that many people – adults and children – fail to recognise: Often the accuracy of an experiment is limited by something other than the accuracy of our measuring equipment. For instance, in this case you may have weighing scales which are accurate to 1 gram, but the uncertainty in our final measurement may be much greater than this.)

Exploring how Velcro Works

What does Velcro feel like? What is different about the two pieces of Velcro?
Cut a short length of each side of Velcro fastener. Pass the two pieces around the group of children – and ask them to comment on what each piece feels like. In particular, ask them to comment on any differences between the two pieces.
They should notice that one piece feels soft, whereas the other is hard and spiky.

If you have a magnifying glass, use it to examine each piece. Notice that the soft piece of Velcro appears to be covered in lots of fine threads. In fact, if you look really carefully you will see that each of these actually forms a tiny loop. The other piece of Velcro is covered in small rigid hooks.

How does Velcro work?
When you press two pieces of Velcro together, some of the loops catch around the hooks – which makes it difficult to pull the two surfaces apart again.

Some types of plants produce seed heads which work in a similar way to Velcro – they are covered in tiny hooks or barbs which stick to our clothes – or to the fur of passing animals. The inventor of Velcro, George de Mestral, came up with the idea after taking his dog for a walk – and finding that his clothes and the dog's coat were covered in these seed heads.

Why does the Velcro on new shoes work better than that on old ones?
The best way to answer this is to have an old piece of Velcro fastener that the children can examine. Even without a magnifying glass they will be able to see that the old Velcro is covered in foreign matter – such as hair, fluff and other rubbish. (This is particularly true of the side with the hooks.) So when you press two old pieces of Velcro together, the hair and fluff gets in the way and stops the hooks and loops from connecting so effectively.

If you want to demonstrate this effect quantitatively, you could repeat the experiment with the container using a length of old dirty Velcro. Compare how much weight you can lift in comparison with the nice clean Velcro.

Further Ideas

An interesting puzzle.
Place the middle of the soft strip of Velcro onto the piece on the lid of the container – and then lift using **both** of the free ends of the Velcro strip. You should find that you can lift considerably more than with the original method. How does this work?

When we lift the container one end of the Velcro strip (as we did in the original experiment), this allows the loops and hooks to be pulled apart one at a time. (Scientists would call this a **shear** force.) In comparison, if we use both ends of the Velcro strip to lift (as in this instance), we are trying to pull all of the hooks and loops apart at the same time. (This is called a **tensile** force.) Since it requires a much larger force to pull all of the hooks and loops apart at the same time, – this means that we can lift a much larger weight using the latter technique.

Children can also see how this relates to the Velcro fasteners on their shoes. They unfasten their shoes by pulling the Velcro off from one side, pulling each pair of hooks and loops apart one at a time. It is much more difficult if you grab hold of the Velcro strip and try to pull it directly upwards.

Does the lifting force of Velcro depend on the area of the Velcro strips?
One way to answer this question is to stick a second piece of Velcro fastener on the lid of the container – then use two of the soft pieces of Velcro to try to lift the container. Can you lift more than you did the first time?
Alternatively, you could place a short length of masking tape so that it covers half of the Velcro on the lid. Can you lift as much as you did the first time?