Charged materials and forces

Paul Chambers outlines some simple and engaging activities to introduce electrical charge and prevent misconceptions arising

It can be a continual struggle to develop interesting and engaging experiments for use in primary schools, especially when related to electrical phenomena. We are tied to the curriculum as it relates to our various stages, and the development of experiments and strategies to exemplify the relevant outcomes or aims is sometimes not straightforward. There are a number of reasons why this may be the case:

- the materials required might not lend themselves to primary schools for reasons of cost or technical complexity;
- the science underlying the experiments may be misunderstood or riddled with misconceptions;
- It may be overlooked in the syllabus or not taught in our teacher education programmes.

I feel we are missing an opportunity with the science and activities relating to electrical charge. Most people are familiar with the phenomenon of charged objects picking up paper or attracting hair, but there are number of simple and highly engaging activities within this area that are seldom used. They can provide an effective focus for early years, introduce children and teachers to the topic, and prevent misconceptions arising and repetition of incorrect explanations.

The science background knowledge

All matter is composed of charged particles, consisting of protons (positive) and electrons (negative). Most materials are electrically neutral, in that the amount of positive and negative charge is the same and they balance each other out. When we separate positive and negative charge the effects can be noticed.

When certain materials, insulators mainly, come into contact with each other, charge is transferred from one material to the other. This leaves one material with more 'negative' charge and the other material with more 'positive' charge. When we separate the materials we have two charged objects. Electrons can transfer from one surface when it is contact with another. This happens all the time when we go about our everyday lives. We are only aware of it when a lot of charge has separated and we perhaps get a small shock or our hair may 'stand up'.

A charged object, such as a balloon, has essentially a charge imbalance. We generally refer to an object like this as *charged*. The key idea for me is that we have separated the existing charge.

How can we create charged materials?

The charge separation occurs by the surface contact of two materials. When they are in contact, charge will separate and pass from one to the other. The effect is referred to as a 'triboelectric' effect. In general, more charge will separate if a larger area is in contact.

Materials can be ranked in order of their ability to gain or lose charge. It is referred to as the 'triboelectric series'. You can theoretically determine in which way the charge will be transferred by using this series, but I have never managed it. Too many other variables, such as relative roughness of the materials and humidity of the room, can come into play.

You do not separate charge by rubbing or friction per se. Materials do become more charged by rubbing, but that is because we are moving the materials more frequently across each other – in effect putting them in contact over a larger area. Rubbing a balloon across your sleeve will separate charge. Doing this repeatedly will separate more charge because it has been in contact with a greater area – essentially the area of your sleeve but done again and again.

Many books and websites refer to charging by *friction* but this is not exactly correct. Charging by *contact* would be better but they are confusing the rubbing of the rods and increasing the area of contact with friction. Rolls of cling film are charged when you tear off a strip and they have definitely *not* been rubbing together. It is perhaps being pedantic but the surface area of contact is the key.

Key words: Electricity Materials Charge

Where did the term 'static' originate?

I interpret the term 'static' as stationary or not moving. If I charge a balloon at point X that area is the 'charged' area. The charges do not move or spread to other areas of the balloon. In that sense they are static. When we charge a plastic straw at one end, that end is charged; the other end is neutral. In these examples, describing the charge on the balloon or straw as static is correct. It describes the examples correctly but does not really offer an explanation.

Engaging and involving primary children

There is quite a lot we can do to engage primary children. The experiments described below are best done on dry days where there is little moisture in the air.

Investigating which materials can be 'charged'

Introduce the concept of charging an object, such as a balloon, by rubbing it on, for example, a cloth, your hair or a piece of nylon carpet. Then hold it above some small pieces of paper. The paper will rise to the balloon and attach to it (Figure 1, see *Weblinks* for a video clip). Some will use the term 'stick' which is acceptable but may introduce the concept of stickiness, as with adhesive tape.

Using a range of materials such as a plastic pen, pencil, ruler, straw, piece of metal or rolled-up paper, allow the children to investigate whether, when rubbed and charged, the materials can attract pieces of paper. Get the children to rub the materials against hair or cloth, etc., and note which materials can attract the paper.

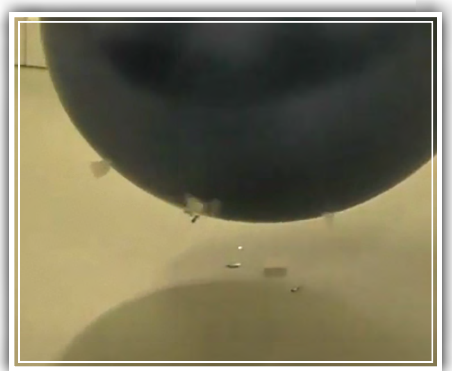

Figure 1 Attracting paper to a charged balloon

When explaining why this happens, use the concept that a charged material will attract an uncharged material. I would suggest not using the terms 'oppositely charged' or 'opposites attract'. This leads to the question of what 'opposite charge' means and is difficult to explain without making things too complex.

Can we do more?

The principle that a charged object will attract an uncharged object applies everywhere. The difficulty is that the sizes of the forces involved are small. They can only move small or lightweight things. Balloons are particularly good for these experiments.

Charge a balloon and bring it close to the face of a pupil. Ask the pupil to close their eyes but tell you when the balloon gets near. They will be able to tell by a strange, possibly tickly, feeling around their nose or eyelashes. Why? The charged balloon is attracting their little facial hairs. The hairs move, giving their owner a ticklish feeling. This experiment may also make the hairs on your arm move towards the balloon.

Attracting running water and bubbles

A charged balloon can even attract uncharged running water or bubbles (see Figures 2 and 3 and *Weblinks*). The bubbles experiment requires a reasonable amount of practice!

Moving larger objects

Place an empty drinks can on its side on a flat smooth surface and hold the charged balloon close (Figure 4). The balloon will attract the can and it will roll along the desk (see *Weblinks*).

An attractive face

Inflate a balloon and draw a face on it with someone's name. Hang it from the ceiling so that it is at face height to you. Rub the area of the balloon where the face is and allow it to fall. Perhaps say to the class you have been described as 'dangerously attractive'. Walk slowly to near to the balloon and the charged face will be attracted to your 'uncharged' face. It will rotate towards your face and then swing towards you and appear to kiss you!

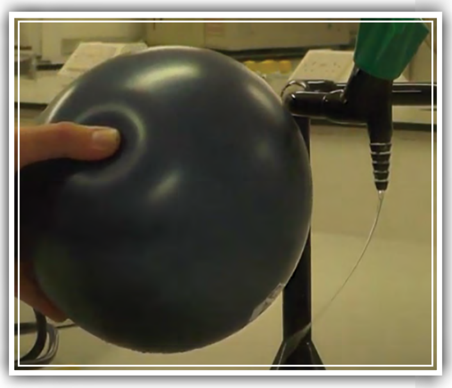

Figure 2 Running water turning towards a charged balloon

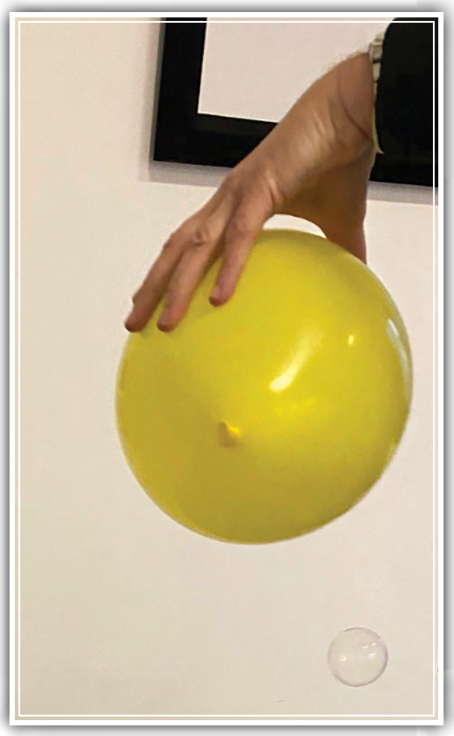

Figure 3 Even bubbles can be attracted

Key teaching points

Don't use the word 'static' as an explanation. Ever! The term 'static' has become a coverall term to describe and explain a series of different phenomena.

Figure 4 A charged balloon 'pulling' a can

For example, consider these questions and answers:

- *Why does a rubbed balloon stick to a wall?* A: *Static.*
- *Why does the cling film cling to my hand?* A: *It is static.*

The use of the word 'static' in these answers only makes the topic more confusing. The answers are at best imprecise and essentially wrong and so make the correct science difficult to establish. I would suggest we explain or describe these events using the concept of charge separation. All materials are made of particles that are electrically charged. These particles are positively charged or negatively charged. There are only two kinds of charge.

A different answer to the first question could be, *'A charged balloon is attracted to the uncharged wall.'* For the second *'the cling film is charged and is attracted to any uncharged object nearby, sandwiches, biscuits, etc.'* would also be better.

Links to the curriculum

Current school curricula do not really give this topic much importance.

The National Curriculum in England states all pupils should:

Develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them.

In particular, is says:

Forces and magnets: Pupils should be taught to:
– notice that some forces need contact between two objects, but magnetic forces can act at a distance
– observe how magnets attract or repel each other and attract some materials and not others.

In Scotland, the Curriculum for Excellence notes:

By investigating forces on toys and other objects, I can predict the effect on the shape or motion of objects.

I have collaborated in investigations to compare magnetic, electrostatic and gravitational forces and have explored their practical applications.

Develop the skills of scientific inquiry and investigation using practical techniques.

I believe we are missing something here. The experiments described above are straightforward and easy to do in a primary school context. They require balloons, paper or plastic straws, paper, cans, etc. They allow investigation, pupil-directed learning and the exploration of physical phenomena.

I have had 10-year-olds measure a track on the floor with tape and then time a pupil 'pulling' an empty drinks can along the track using a charged balloon and then returning. The length of the track and the time it took to travel were measured. Results were presented and discussion around the idea of speed followed.

Everyday applications

The principle of a charged object attracting an uncharged object is used frequently:

- Printers and photocopiers charge areas of blank paper. These charged areas attract photocopying or printer toner and they attach to the paper in the shape you want, such as words, diagrams or photographs.
- Objects that have a complex shape, for example bikes, can be difficult to paint. Charge the frame, spray paint in its general direction and the paint will attach itself to all sides of the frame.
- People with sensitive airways can clean a room of dust by having a small device that draws in the air and passes it between charged plates. Any dust in the air is attracted to the plates and the air that passes through has been cleaned. Leave the purifier on in a room for a while and people with allergies, for example, can sleep more easily.

Further investigation

You need a straw (not metal!) and two watch glasses. Place the watch glasses as shown in the video clip (see *Weblinks*) to create a very smooth platform. Rub one end of the straw and balance it on the watch glasses. Bring your finger close to the charged end and watch what happens (Figure 5). The charged straw is attracted to your finger. As your finger is part of you and you are a large object it is easier for the straw to move towards you than you to move towards the straw. The straw will 'follow' your finger.

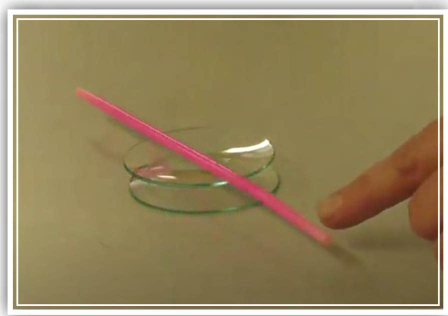

Figure 5 Finger attracting the charged end of a straw

Conclusion

These experiments are easy to undertake, highlight the principle and could also be used to introduce the idea of 'force at a distance', which some texts use when comparing magnets and gravity for example.

There are more experiments that can be done in this area, even leading to pieces of paper and foil being suspended in mid-air. This topic is ideal for primary science and can assist in the teaching of forces and electrical phenomena as we progress through the syllabus.

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Weblinks

Charged balloon picking up paper: www.youtube.com/watch?v=fBXtwh-pN0E
Charged balloon and running water: www.youtube.com/watch?v=eGntNmeJnns
Charged balloon and bubbles: www.youtube.com/watch?v=3Y4wX8dIjVo
Charged balloon and can: www.youtube.com/watch?v=CH2RjjYTscY
Charged straw on watch glass: www.youtube.com/watch?v=nusV1exo8Dg