THE SET UP

1. Summary
After demonstrating low-level static electricity with a balloon, build up a large electrostatic charge on the Van de Graaff’s dome and use it to perform tricks on the students. There are many different kinds of demonstrations, and you will be able to invent your own, but in this guide we will include experiments with students’ hair, flying aluminium cake cases, electron repulsion with a metal ball on a string, giving another student an electric shock and using a charged student to illuminate a light bulb.

2. Context
This experiment is crucial to effectively demonstrating electrostatics, or introducing electricity and electrical circuits. The student participation element makes it great fun for open days or an end of term activity.

3. Apparatus
- Van de Graaff Generator
- Metal ball on stick, for discharging the dome
- Fluorescent tube, ideally in a plastic shroud
- Aluminium cake cases, that mince pies are baked in
- Metallised ball, a polystyrene ball coated in metal paint
- Hairs/wool on spike (optional)
- Plastic tray to stand in, to prevent students being earthed
- Hair drier, to improve performance on a damp day

4. Preparation
- The Van de Graaff generator is notoriously unreliable and can go from creating fabulous sparks to nothing in the matter of minutes, or vice-versa
- Cleaning the dome with detergent can help to remove grease, and blowing a hairdryer to warm the dome and surrounding air can improve performance dramatically
• Holding the belt to stop it briefly can speed up the charging process
• Run the Van de Graaff, discharging it with the metal ball on the stick to check it is working
• Put the hair or wool on the dome to check it stands up due to electron repulsion
• Put a pile of inverted aluminium cases onto the dome to check they fly off one by one
• Hold a fluorescent tube by the end terminals, with the other end close to the dome and it should light up as an electrostatic current passes through you to earth.

5. Safety

• Make sure that volunteers know that they may get a shock
• Ensure none of your volunteers have heart problems or use a pacemaker
• Don’t charge up multiple people as they can hold potentially dangerous levels of charge. However you can discharge the charge between students (see the procedure below)
• Fluorescent lights should be housed in a protective plastic casing when being used for this experiment.

Please note: If a student is accidentally discharged onto the metal ball (as seen in the DVD footage), the build up of charge is not at a high enough level to be dangerous.

THE DEMONSTRATION

1. Procedure

• Inflate a balloon, rub it on some wool, invite a volunteer with floppy hair to join you and demonstrate that moving the balloon near their hair will cause it to stand on end. Explain the effect and discuss the nature of electrostatics
• Start the Van de Graaff generator and demonstrate the discharging sparks by bringing the metal sphere close to the dome. Discuss the similarities with the balloons and also with thunder and lightning
• Demonstrate the aluminium cake cases flying off the top of the dome and discuss the effect
• Warn students that if they have any heart conditions or use pacemakers it would be dangerous for them to volunteer for the student participation experiments
• Invite a volunteer with floppy hair to join you – the ideal hair is long, straight and hasn’t been conditioned (conditioners contain anti-static substances). Stand them in a plastic tray, charge them up by placing one hand on the dome and discuss the effect on their hair
• Have another volunteer join you to discharge the charged person. Pointing index fingers about 1cm apart will produce a visible spark
• Have another volunteer hold a fluorescent light tube by the end terminals, while the charged person moves their finger close to the other terminals – the bulb will flicker and illuminate.

2. Suggested Script Ideas

Today we are going to look at something that has transformed society forever and I can demonstrate it with a balloon – I would like a volunteer please.

I am simply going to rub this balloon onto my volunteer’s hair and we shall see what happens. Their hair stands on end – why?

It’s all to do with electricity, or more precisely the movement of charged particles from one place to another. Tiny little electrons are being moved from the balloon to the hair when I am rubbing, which makes the hair become negative and the balloon positive. As opposite charges attract, the hair is now attracted to the balloon and vice-versa. Each hair strand, however, is each charged negatively so they repel each other and stand on end.

I am going to use a much more efficient way of transferring electrons by using a Van de Graaff generator.

Let’s start by piling aluminium cake cases onto the dome and we’ll see what happens

(They fly off one by one.)

Just like with the hair, as they get charged with the same charge, they repel each other and fly off.

(Demonstrate earthing the dome by holding the metal ball close.)

What we are seeing here is mini-lightening. Air is usually an insulator but when the charges build up too much, a breakdown occurs and a spark leaps across the gap. In the same way, thunderclouds have huge amounts of energy causing lots of movement and rubbing and so a massive build up of charge is created.
What is thunder?
Thunder follows lightning in the same way we can hear the spark of the Van de Graaff – it heats up the air to such an extent that it causes a sound wave to be produced. The thunder follows the lightning as light travels much faster than sound so we see things before we hear them.

Please can I have another volunteer to charge up.

Stand in the tray and put your hand on the dome and I’ll switch it on.
We can see that as her hair is all being charged with the same charge that it stands on end and repels all the other hairs.

This time we are going to see if we can get a lightning discharge from you, so I need another volunteer who is as hard as nails.

Stand with your arms close to your sides and when I say “go” I’d like you to point your fingers and quickly bring them to about 1cm apart. Everyone else be very quiet and watch carefully.

(Turn the lights down to see the spark clearer)

(Spark is seen leaping the gap between them)

Can we store enough charge in someone in order to light a bulb?

Let’s try it; can I please have another volunteer? When we have charged you up I’d like you to put your finger up towards the bulb’s end terminals. It won’t hurt... much.

(Tube is seen glowing and flickering)

So you can go home and tell everyone you lit up the room at school today."

THE CONCLUSION

1. Explanation
Electricity is the process of moving charge from one place to another. Electrical energy is so useful because it is easy to convert it into other forms of energy, such as light, heat, sound and movement.
2. Useful Questions and Answers

Q) Why do objects charge up differently on different days?
A) Moisture in the air allows objects to discharge easily. The best days for electrostatics are very cold, dry days as there is little moisture in the air.

Q) Why doesn’t lightning occur on cold, dry days?
A) Lightning is caused by a massive build up of charge as water molecules rub against each other. This can only happen in thunderclouds when huge amounts of energy move the molecules around, powered by the sun.

Q) Why does a hair dryer improve the Van de Graaff’s performance?
A) It gets rid of the moisture on the dome and in the air.

Q) Which objects give up electrons and which objects gain electrons?
A) That is not a simple question to answer – it depends on the material’s position in a table called ‘The Triboelectric Series’, which is a list of materials ordered depending on how well they hold on to their electrons. If you rub two objects together, the one higher in the series becomes positive. So if you rub rubber with cotton, the rubber becomes negative as it gains electrons from the cotton, but if you rub rubber with polyester, the rubber becomes positive as it gives electrons to the polyester.