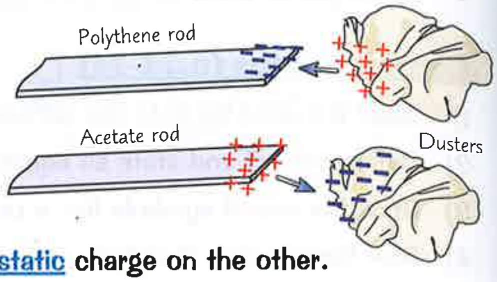
Static Electricity

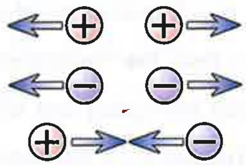
Static electricity builds up on insulating materials and often ends with a spark or a shock.

Build-up of Static is Caused by Friction



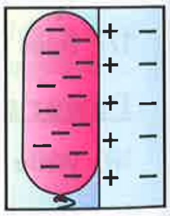
1) When certain insulating materials are rubbed together, negatively charged electrons will be scraped off one and dumped on the other.
2) As the materials are insulators, these electrons are not free to move — this build up of charge is static electricity. The materials become electrically charged, with a positive static charge on the one that has lost electrons and an equal negative static charge on the other.
3) Which way the electrons are transferred depends on the two materials involved. But whether an object has a positive or negative charge, it's always the negative electrons that have moved.
4) The classic examples are polythene and acetate rods being rubbed with a cloth duster (shown above).

Like Charges Repel, Opposite Charges Attract



1) Electrically charged objects exert a force on one another.
2) Two things with opposite electric charges are attracted to each other, while two things with the same electric charge will repel each other.
3) These forces get weaker the further apart the two things are.
4) One way to see these forces is to suspend a rod with a known charge from a piece of string (so it is free to move). Placing an object with the same charge nearby will repel the rod — the rod will move away from the object. An oppositely-charged object will attract the rod, causing it to move towards the object.

Electrically Charged Objects can Attract Uncharged Objects



1) Rubbing a balloon against your hair or clothes transfers electrons to the balloon, leaving it with a negative charge. If you then hold the balloon against a wall it will stick, even though the wall isn't charged.
2) That's because the charges on the surface of the wall can move a little — the negative charges on the balloon repel the negative charges on the surface of the wall.
3) This leaves a positive charge on the surface, which attracts the negatively charged balloon. This is called attraction by induction. And there are plenty more examples of it, too...
4) If you run a comb through your hair, electrons will be transferred to the comb making it negatively charged. It can then be used to pick up little pieces of uncharged paper — holding it near the little pieces of paper causes induction in the paper, which means they jump up and stick to the comb.

Too Much Static Causes Sparks

For more on how sparks actually jump across gaps, see page 84.

1) As electric charge builds on an object, the potential difference between the object and the earth (which is at 0 V) increases.
2) If the potential difference gets large enough, electrons can jump across the gap between the charged object and the earth — this is the spark.
3) They can also jump to any earthed conductor that is nearby — which is why you can get static shocks from clothes, or getting out of a car.
4) This usually happens when the gap is fairly small. (But not always — lightning is just a really big spark.)

Stay away from electrons — they're a negative influence...

Electrons jumping about the place and giving us all shocks, the cheeky so-and-sos.

Q1 Jade removes her jumper in a dark room. As she does so, she hears a crackling noise and sees tiny sparks of light between her jumper and her shirt. Explain the cause of this. [3 marks]

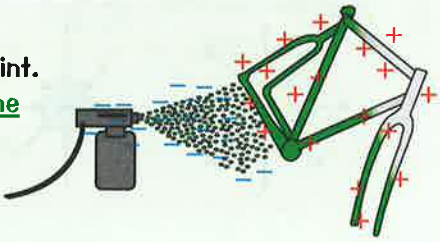
Uses and Dangers of Static Electricity

Static electricity can be a bit of a nuisance sometimes, but it also has some good uses, e.g. in industry. But don't get too happy clappy about how wonderful static electricity is — it can be pretty dangerous too.

Static Electricity Is Used in Electrostatic Sprayers

1) Photocopiers use static electricity to copy images onto a charged plate before printing them.
2) Static electricity can be used to reduce the dust and smoke that rises out of industrial chimneys.
3) Another use of static electricity is electrostatic sprayers:

- Electrostatic sprayers are used in various industries to give a fine, even coat of whatever's being sprayed. The classic examples are insecticide sprayers and paint sprayers.
- Bikes and cars are painted using electrostatic paint sprayers.
- The spray gun is charged, which charges up the small drops of paint. Each paint drop repels all the others, since they've all got the same charge, so you get a very fine, even spray.
- The object to be painted is given an opposite charge to the gun. This attracts the fine spray of paint.

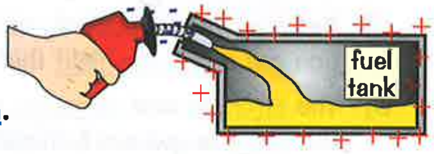


- This method gives an even coat and hardly any paint is wasted. In addition, parts of the bicycle or car pointing away from the spray gun still receive paint, i.e. there are no paint shadows.
- Insecticide sprayers work in a similar way, except the crops to be sprayed aren't given an opposite charge — the plants charge by induction as the insecticide droplets come near them (see p.82).

Static Electricity Can be Dangerous

Whilst there are some uses of static electricity, it can be inconvenient and sometimes even dangerous.

1) Refueling cars — as fuel flows out of a filler pipe, e.g. into an aircraft or tanker, then static can build up. This can easily lead to a spark (p.82) which might cause an explosion in dusty or fumey places — like when filling up a car with fuel at a petrol station.

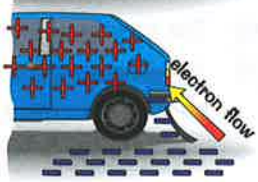


2) Static on airplanes — as planes fly through the air, friction between the air and the plane causes the plane to become charged. This build up of static charge can interfere with communication equipment.
3) Lightning — raindrops and ice bump together inside storm clouds, leaving the top of the cloud positively charged and the bottom of the cloud negative. This creates a huge voltage and a big spark, which can damage homes or start fires when it strikes the ground.
4) You can reduce some of these dangers by earthing charged objects (see below).

Objects Can be Earthed to Stop Electrostatic Charge Building Up

1) Dangerous sparks can be prevented by connecting a charged object to the ground using a conductor (e.g. a copper wire) — this is called earthing.
2) Earthing provides an easy route for the static charges to travel into the ground. This means no charge can build up to give you a shock or make a spark.

3) The electrons flow down the conductor to the ground if the charge is negative and flow up the conductor from the ground if the charge is positive.
4) Fuel tankers must be earthed to prevent any sparks that might cause the fuel to explode.



I know, I know — yet another shocking joke...

As useful as static electricity can be, you've got to be aware of the dangers — and how to prevent them.

Q1 Give two uses of static electricity. [2 marks]

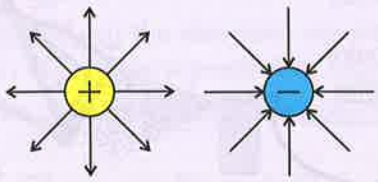
Electric Fields

Electric fields — much less green and much more shocking than the fields you're used to.

Electric Charges Create an Electric Field

1) An electric field is created around any electrically charged object.
It's the region around a charged object where, if a second charged object was placed inside it, a force would be exerted on both of the charges (see below).
2) The closer to the object you get, the stronger the field is. (And the further from it, the weaker it is.)
3) You can show an electric field around an object using field lines. For example, you can draw the field lines for an isolated (i.e. not interacting with anything) point charge:

Draw at least eight equally spaced field lines.

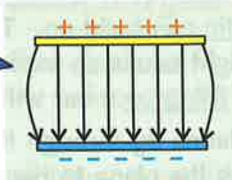


- Electric field lines go from positive to negative.
- They're always at a right angle to the surface.
- The closer together the lines are, the stronger the field is — you can see that the further from a charge you go, the further apart the lines are and so the weaker the field is.

Electric Fields Cause Electrostatic Forces

1) When a charged object is placed in an electric field, it feels a force.
This force is caused by the electric fields around two charged objects interacting.
2) If the field lines between the charged objects point in the same direction, the field lines 'join up' and the objects are attracted to each other.
3) When the field lines between the charged objects point in opposite directions, the field lines 'push against' each other and the objects repel each other.
4) Between two oppositely-charged parallel plates, you get a uniform field that looks like this.
5) The strength and direction of the field is the same anywhere between the two plates (it's only different at the very ends).

If you need to draw electric fields, don't forget the arrows on your field lines.



When you're drawing a uniform field, you need to show at least three field lines, parallel and all the same distance apart.

Sparking Can Be Explained By Electric Fields

1) When an object becomes statically charged, it generates its own electric field.
2) Interactions between this field and other objects are the cause of events like sparking.
3) For example, for the comb from p.82 — after it's been run through your hair, it's charged and so produces an electric field. This electric field interacts with the pieces of paper (without touching them) and so they feel a force.
4) This force causes them to move towards the comb (and some will even stick to it).
5) Sparks are caused when there is a high enough potential difference between a charged object and the earth (or an earthed object). A high potential difference causes a strong electric field between the charged object and the earthed object.
6) The strong electric field causes electrons in the air particles to be removed (known as ionisation).
7) Air is normally an insulator, but when it is ionised it is much more conductive, so a current can flow through it. This is the spark.

Electric felines — lines between charged cats...

Electric fields may seem a bit weird at first — but the good news is they're very similar to magnetic fields (which are over on the next page), so if you understand one of them, you can understand them both.

Q1 Draw the field lines surrounding an isolated, uniform, positively-charged sphere. [3 marks]