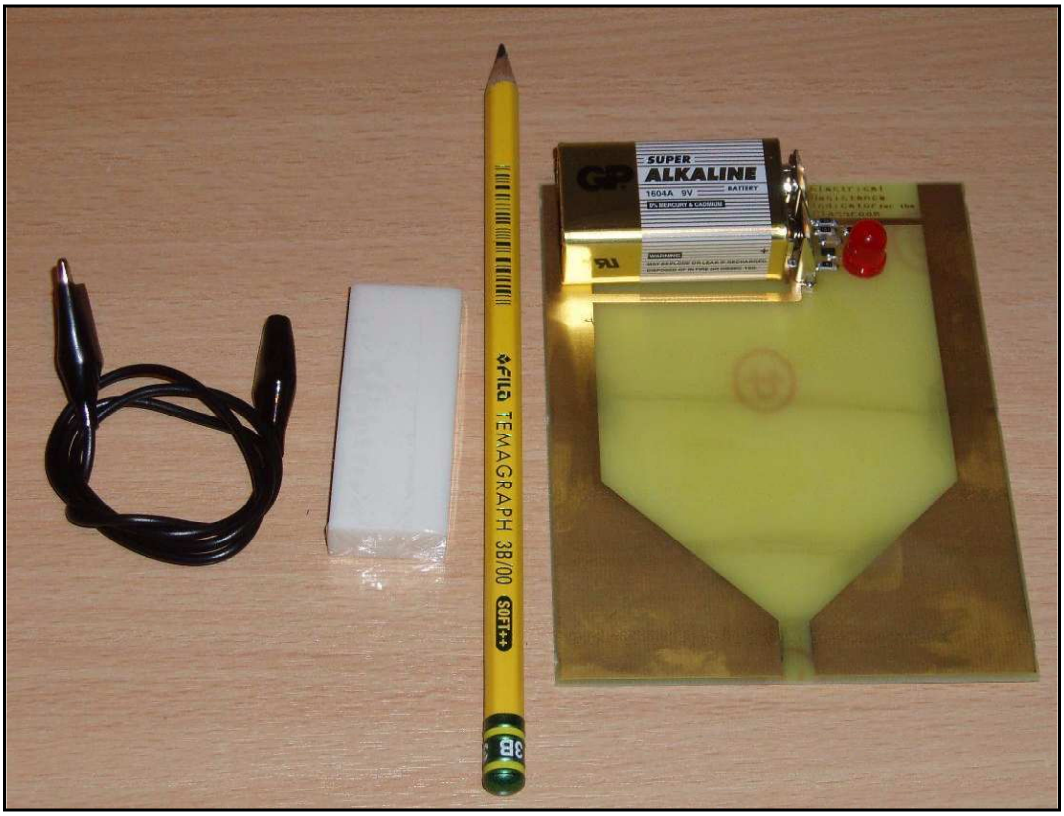

Electrical Resistance Indicator for the Classroom

Manufactured in the U.K. by:
***SWALLOW* SYSTEMS**
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History

My neighbour teaches primary science. Last year, he came round and talked to me about the problem he had had with unit 6G of the science curriculum. He had tried the recommended method using different lengths of wire, batteries and bulbs to see how the length and area of a conductor affects the resistance of a wire. For ordinary components, this simply doesn't work. You either need to use special resistance wire or you need high power bulbs such as car headlights. Ordinary wire is so low in resistance that, unless you use very long lengths, the resistance change is not visible.

We had an interesting session and I gave him some pieces of antistatic foam and some LEDs with protective resistors built-in. The resistance of the foam is high enough to work with reasonable-sized pieces and can be cut into shapes for testing. Unfortunately it doesn't wear well. He reported later that these worked fine and that the children had noticed that they themselves conducted enough electricity to light the LEDs dimly. The high point was several children connecting themselves in series and passing the current to illuminate the bulb.

We had tried experiments using pencil leads as the conductors but these failed as the resistance was too high. I spoke about the experiments with another friend who teaches electronics and week or so later he gave me a 7B pencil with instructions to try that. At that stage I decided to put all the elements together and invented the first ERIC.

We spent a considerable time trying to find a suitable name. ERIC is the best we could come up with; sorry.

Description

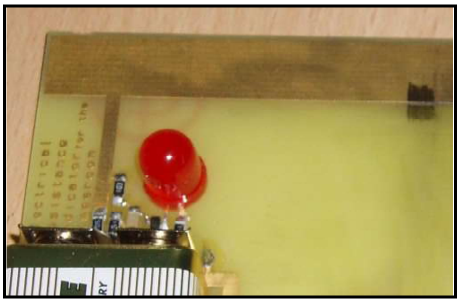
ERIC is basically a battery with a LED connected to one end and some gold-plated contacts surrounding an area of fibreglass. There is a small amount of electronics to protect the LED from short circuits and ensure that the LED lights with quite a small current.

The battery is a small 9V type. You can use any battery that is mechanically compatible with the one supplied.

ERIC comes with a 3B pencil, an eraser and a piece of wire with crocodile clips at each end. When there is a conducting path between the contacts the LED lights. The brightness depends on the resistance of the path. If the contacts are connected with the wire the LED lights with full brightness. It is designed for experiments associated with Unit 6G of the science curriculum.

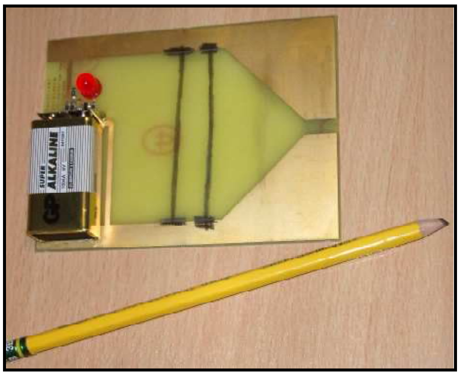
Operation

Use the pencil to draw a line across between the contacts. The LED will light according to the resistance of the connection. You will need to scribble across the join where the line meets the contact to ensure a good connection. An area 5-10 mm square is sufficient.

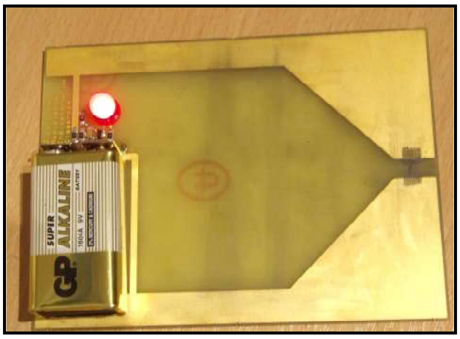


Now you can join the scribbles with a pencil line. A single stroke may have minute cracks in it that stop the current so you will probably have to go over the line several times. A continuous line as shown will light the LED fairly dimly.

If you make the line wider, the LED will become brighter. If you add a second line, there will be another path for the current and the LED will be brighter.



If you use a shorter line, between the wide contact areas, the LED will be brighter.



You can try out different shapes in the area between the contacts.

The rules are:

If there is no path between the contacts the LED will be off.

The wider the track, the brighter the LED.

The shorter the track, the brighter the LED.

The thicker the track (lots of layers of pencil), the brighter the LED.

Lower electrical resistance makes the LED brighter.

When you do the experiments, you will note the LED flashing, apparantly at random. This will be due to inadvertantly touching both contacts either with your fingers or with other conductive materials. People conduct electricity! Only observe the LED brightness when your fingers are clear of the contacts. You should also take notice of the material that ERIC is resting on. Most desktops are insulators and will give no problem. If you want to operate on a metal surface, use an insulator such as paper, plastic or cardboard, under ERIC to avoid problems.

You can remove the pencil lines using the eraser provided. Other soft erasers will also be suitable but do not use very abrasive types as you will remove the gold plating from the contacts.

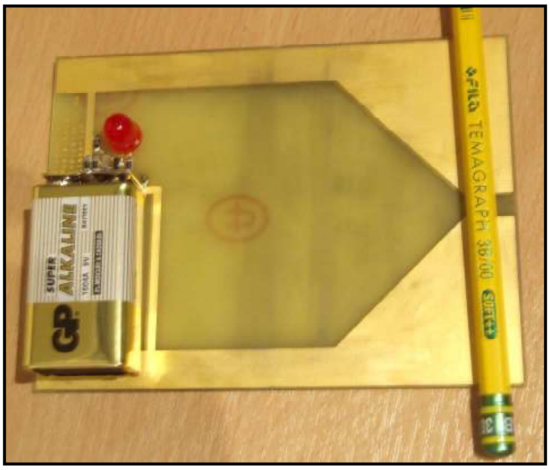
You can use other pencils apart from the one provided. In general, softer pencils (e.g. 7B) will give lower resistance (brighter LED) and harder pencils (e.g. HB or 2H) will give higher resistance (dimmer LED). Do not expect coloured pencils or crayons to conduct electricity.

Unit 4F

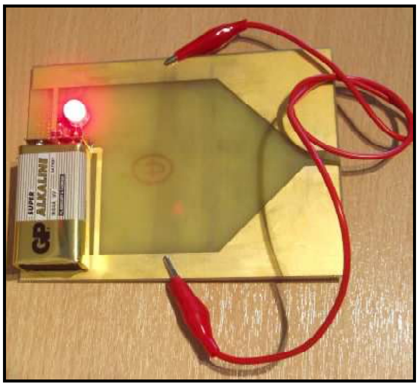
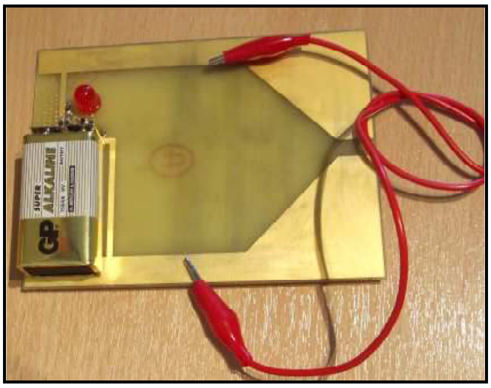
Unit 4F is about the difference between insulators and conductors. You can simply place an item to be tested across the contacts and see whether the LED lights up.

Metal things such as coins, keys, and paperclips conduct.

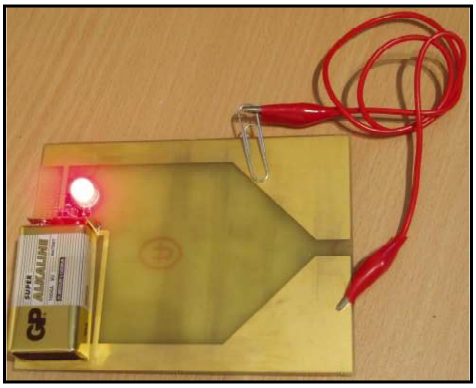
Rubber is a classic insulator.



The wooden part of a pencil is an insulator.

The lead is both a conductor (the wire down the middle) and an insulator (the plastic covering).



You can use the lead to connect various things across the contacts.

Note that people are not insulators. If you have your fingers across the contacts you will probably light the LED anyway.

Related experiments

It is worth checking unusual materials while you do 4F. In particular you should try water. You can use just a drop of water across the short gap between the contacts. This may be difficult to manage carefully without getting the entire unit wet so you might want to carry out this experiment as a demonstration instead.

A more tractable way to do this is to use a damp tissue and compare it with a dry tissue. You are less likely to spray water everywhere this way. You can also try dry cloth and wet cloth or dry sponge and wet sponge. Students can do these experiments themselves. The message is that anything wet will be conductive.

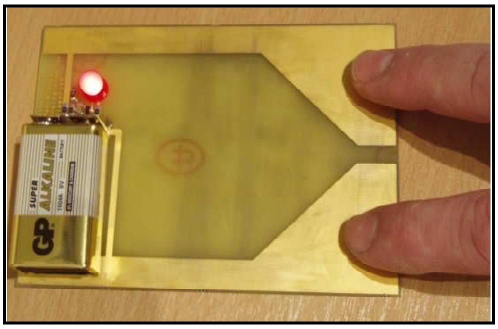
I haven't tried other liquids but my guess is that olive oil would not conduct. I have no idea about butter, margarine, salad cream etc. You could do the experiments!

When you use "sticky" liquids, make sure that you keep them away from the battery and LED. The area between the contacts is easy to clean but the rest isn't. Cleaning can be done with a small amount of soapy water and then drying with a tissue or cloth. If it looks clean and the LED is off, it is probably clean enough.

If you end up with everything wet, remove the battery and wipe it with a dry cloth. Shake excess water off ERIC and dry the rest with a hairdrier on low heat. Don't forget to dry the back.

More Ideas

ERIC is very sensitive and will light the LED, dimly, with very small currents. People conduct electricity and, typically, if you press fingers against both contacts, the LED will light.



The current flow from the 9 volt battery is so small that there will normally be no sensation caused.

If you have just washed and dried your hands very thoroughly, or you have very dry skin, you may not be able to light the LED. You can improve the contact by wetting your fingers.

There are plenty of experiments to do with this. For example, if you start with one finger on each contact, you can try touching one of the contacts with an extra finger or using two fingers on each contact. This decreases the resistance so it will increase the brightness.

You can try pushing harder with your fingers. The harder you press the lower the resistance is. You can vary the area of skin touching ERIC. In general, the lower the area the higher the resistance.

You might like to ask students to make predictions. If they have understood the physics behind the experiments, they should be able to make good predictions for some of these experiments.

You can try using two people. Each person can try putting their fingers individually across the contacts. You may find that one is "brighter" than the other. Now you can try both people together. The LED should be brighter than either of them individually. If each person has one finger on each contact, the resistance is reduced and the LED will be brighter. This is called a PARALLEL circuit. Each circuit passes its own current and the LED shows the sum of the currents.

If a person puts a finger on a contact and another person puts a finger on the other contact but they don’t touch one another, there is no circuit and the LED doesn't light. If it does light, look for accidental circuits. When I tried it, the LED lit and we traced our circuits back and found that we were both leaning on the same metal surface.

If the people hold each other’s spare hand, this will complete the circuit and the LED will light. The current passes through one person from finger to hand and then through the other person from hand to finger. The LED will be dimmer than if either had separately connected themselves across the contacts. This is a SERIES circuit.

With lots of people, you can try all of them in parallel. This can get very crowded as each one tries to touch both contacts. This gives maximum brightness. The change in brightness as each person is added may be very small. You can talk about whether everyone has applied the same pressure and if they change the contact area of their fingers. How can you ensure that this is a fair test?

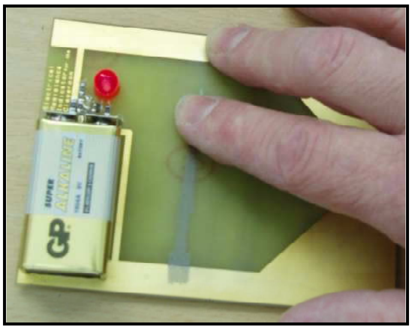
You can try all the people in series, forming a chain across the contacts. The LED may be very dim if you have enough people. You may have to shade the LED to see it. If any part of the chain is broken the LED will go out. You may be able to make the LED light with the whole class.

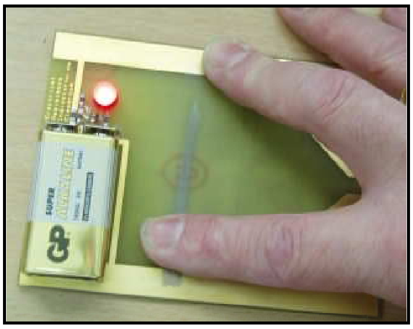
Skin conducts better if it is wet. You can try the experiment by putting your fingers across the contacts to see how bright the LED is and then repeating after you have licked them. You can make the LED light with more people in series if they have wet hands.

I have a model in my head of what I am electrically. It boils down to me being a bag of water surrounded by skin that doesn't conduct too well. I can make my skin conduct better by making it wet. The resistance drops as more of my skin is touching the contacts. The harder I press, up to a limit, the more skin touches the contact (fingerprints keep part of the skin out of contact unless squashed flat).

A friend of mine discovered that he could use his finger as a fader. He kept one finger firmly pressed against one contact and slid the other finger across the edge of the other contact. As the contact area increased the LED got brighter. It is difficult to make this a fair test as repeatability is poor. However, the direct experience of varying the contact area and observing the LED is a very immediate learning experience.

A more repeatable version of the fader is to use a pencil track that doesn't quite reach all the way across ERIC. Use your fingers to complete the connection and you can see that a short length of track gives a bright LED and a long track gives a dim LED.





When you try this, you will find that you rub the pencil off as you move your finger. The LED will get dimmer as you move your finger back and forth and rub the graphite off.

You can use the crocodile clip lead instead of your fingers. This works fine but you should ensure that the track is consistently thick as the contact area will be quite small.

Safety

Electricity can be dangerous. ERIC uses a low-voltage battery and you will not damage yourself using it. However, you should be aware that these experiments are quite fun and may give the wrong impression to young children. **Trying to repeat these experiments with mains electricity and mains light bulbs will probably be FATAL.**

You must emphasise to children that electricity can be dangerous. It is difficult to give a direct experience to show the danger without exposing children to hazard. There is a way that I like but cannot recommend as it has health and safety implications. This is to lick the terminals of a 9 volt battery. The direct sensation of electrical shock is quite unpleasant but it is entirely in the control of the child. You would need to try it yourself before suggesting it. You may find that the children try it out themselves.

This electrical shock will cause no permanent damage. The possibility of cutting the tongue or, probably more significant, passing disease from child to child would have to be considered in your risk analysis.

There are “toys” on the market whose function is to deliver an unpleasant electrical shock. These could be used to demonstrate how dangerous electricity can be.

The experiments with wet hands demonstrate that water causes electricity to be more dangerous. This is a good message to pass across.