A workshop on the motor effect of an electric current

A guide for group leaders

Hello to you, the group leader!

These notes are designed to help you run a special kind of science teacher group meeting, using the video ***The Electric Motor Effect*** from the Science Teaching Alive DVD, or from the website www.scienceteachingalive.com .

This kind of meeting helps teachers to feel comfortable with doing practical work, and organising their own lessons so that their students do the activities.

If your participants want a workshop on the science content knowledge, you will find another document, *Notes for teachers*, on the website. That document will help you prepare a workshop on the subject matter.

Suggestions for your workshop programme

A. **Welcome the people** and remind them that in workshops things get produced – the thing might be a new understanding, or an issue resolved, or a physical thing made or a document written. They have to produce, not just listen.

Here are three products that could come out of this workshop:

1. A diagram showing the magnetic field lines crossing the aluminium conductor and showing how the left-hand rule is applied
2. A small electric motor like the one in the video
3. A student worksheet that the teachers have written

B. **Introduce the workshop**. You could ask the group to name all the devices they can think of, that use electric motors.

Take them through the various spaces they know, where they could find electric motors: cars, garage workshops, kitchens, lounges, farms, factories, trains, and so on.

Answers should include these examples: In a car, you have wiper motors, starter motors, cooling fans, windscreen washers, power-steering. In the garage, workshop or factory there are alarm sirens, electric drills, grinders, saws and screw-drivers. Around the house there are air-conditioners, household fans, food-mixers, tape drives, CD drives, computer hard drives, fans in computers, in microwave ovens, fridge motors, children's toys like cars . . . . Outside and on farms there are gate openers, borehole pumps, ...

C. **Do a swift review of the theory of magnetic fields** Include the way field direction is defined and the left-hand rule for the motor effect. Keep it short, about 5 minutes, otherwise the workshop becomes a lecture session.

(The video assumes that teachers know the basics of the topic. If they don't, teachers can and should study the topic for themselves. On the website you'll find some internet links that explain electromagnetism at a simple level or in much more depth. Teachers can choose how deep to go.)

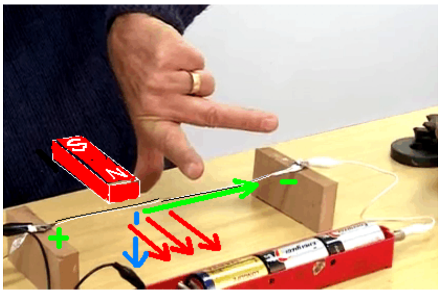
D. **Show the video right through**. It takes about 9 minutes.

E. **Remind the groups of the three workshop products** you are aiming for. Hand out the equipment that they will need; try to keep the groups small – two or three participants. On the next page you'll see a list of what things to get.

F. **The demonstration of the motor rule, using a strip of aluminium foil (0:48 to 2:40)**

Ask the groups to set up the foil strip, the battery pack and magnet as you see in this section. Check that everyone knows how to apply the left-hand rule for the motor effect and can predict which way the aluminium foil will move: upwards or downwards. **Figure 1** shows you how the left-hand rule is used.

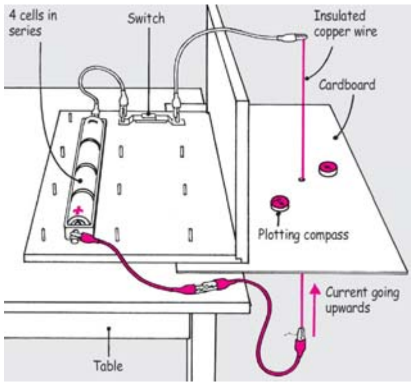
Figure 1 *This is how you apply the left-hand rule to the motion of the foil. Green shows* ***C****urrent direction (****C****entre finger), red shows* ***F****ield direction (****F****orefinger), blue shows* ***T****hrust on the conductor (****T****humb)*



G. **Demonstrating the shape of the field around a straight conductor**.

You can actually demonstrate the shape of the field around a straight conductor using a single wire, about 6 plotting compasses and a battery that can produce a strong current; see **Figure 2**.

Figure 2 *The magnetic field around a straight conductor when a current is flowing upwards.*

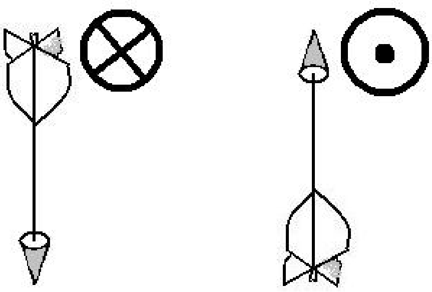


But the advantage of the coil that Brian makes is that you get 10 times the magnetic field (if you wrap the wire 10 times around the former-block) and so the iron filings show the pattern clearly.

H. **Make sure that everyone understands the symbols** ⊗

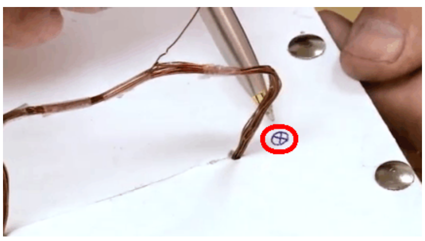
and ⊙**.** The first one represents the tail of an arrow going down into the paper and away from the reader – see **Figure 3**. The second one, ⊙, represents an arrow coming up, out

Figure 3 *The symbols for current downwards and current upwards.*



of the paper, and towards you, the reader. So the symbol in the **Figure 4** represents current going **down** into the cardboard.

Figure 4 *This cross represents the current going down into the cardboard .*



Using the right-hand rule for current and field, you point your thumb down in the direction of the current, and your fingers curl around showing the shape of the field. Of course, that is the same shape that the plotting compasses show – the needles form a circle around the current.

I. **Why does the coil of a motor turn?** This step is not in the video, but it helps people to understand why the coil of an electric motor turns.

Hang the square coil you have made so that it can turn while still having a current flowing through it. See **Figure 5**. Hold two magnets as shown and close the switch – the coil will twist, as the side with downward current feels the force at right angles to the magnetic field. If the coil could turn completely around you would have the beginnings of an electric motor.

But the coil would not turn completely around because if the other side of the coil came between the magnet poles, the current in that side would be **upwards** and so the twisting force would be in the opposite direction; this force would stop the coil and make it twist the other way.

In a real electric motor, the **commutator** ensures that the current switches direction each time the coil turns, and so the magnetic field always gives its push in the direction you want to keep the motor turning. This diagram, **Figure 6**, shows you how a motor works with a commutator

Figure 5 *Let the coil hang so that it can twist freely.*

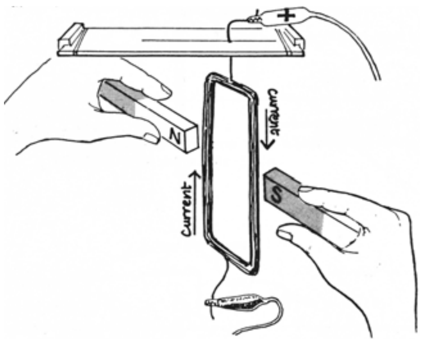
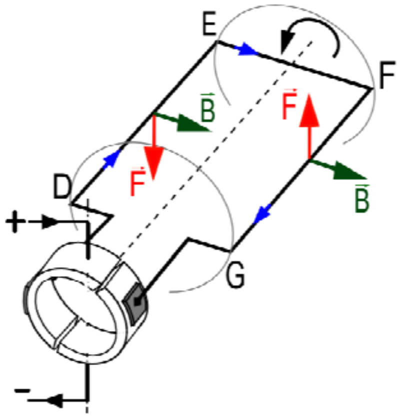


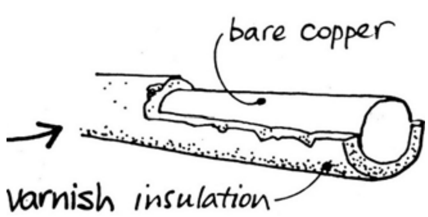
Figure 6 *A commutator changes the direction of the current every 180° of rotation.*



J. **Making the little motor (5:30 – 6:50)**

The little motor that Brian makes is great fun and students can make their own. It could have a problem – it has no commutator and so half the time the current would be the wrong direction in the loop. But it has a clever way of dealing with the problem – it has half a commutator. See **Figure 7**. The bare wire contacts the paper clips (which have 1.5 volts across them), the current flows in the coil and it feels the electromagnetic force for only half a revolution. When the varnish insulation touches the paper clips, the current stops but the coil just carries on rotating until the conducting parts of the coil make contact with the paper clips again, and current flows around the coil again.

Figure 7 *Scrape the insulation off only one half of the shaft.*



K. **Summing up** When most people have completed the activities, sum up in a discussion:

- Which of these activities can we demonstrate in our classrooms?
- Which of these can we organise as student activities?
- What questions will we use to focus the students' activities?

M. **Writing worksheet questions**

Now move to the final product of the workshop – a student worksheet. You will find a suggestion on how to design this, if you look at the menu on the website. Teachers will want to take a copy of this, so try to have a photocopier available, or provide pens and sheets of blank paper.

What to prepare

Items	Where to get them
Magnets. Mark the N and S poles of some of the magnets, but leave others un-marked if you are going to challenge people to find out which is the N and S pole.	As you see in the *Magnets* video, you can get very strong permanent magnets out of old loudspeakers, computer hard drives and microwave ovens. You can also find dealers in most cities if you go on Google and search for “magnet suppliers”.
Aluminium foil (cooking foil)	
Torch cells: about 3 per group. Test them before the workshop because they may be old or nearly “dead”	
Thin wire, insulated with varnish. You need varnish-coated wire for making the little motor, because the varnish can be scraped off one side of the wire. Thin wire such as the wire inside computer cables and telephone cables is insulated with plastic of various colours; that will work for making the rectangular loop, provided you can get pieces more than 2 m long.	You can get this from places that repair electrical equipment, such as radio and TV shops, (radios and TV sets have transformers) garages (cars have ignition coils, starter motors, alternators), appliance centres (washing machines, microwave ovens, fridges have motors and transformers).
Wooden blocks to support the cardboard or foil	
Drawing pins	Supermarket
Battery pack. Make one, if you need to, by rolling three cells in an A4 sheet of paper and holding them together with a broad rubber band around the ends	
Sticky tape to hold the rectangular coil together	
Wires with croc clips; you need at least two, but four is better	Electricity kit; electrical goods shops, hardware stores like Builder’s Express
Iron filings. Or use a hacksaw to cut some iron/steel; collect the small pieces of steel using a magnet wrapped in a plastic bag.	You can get these in chemistry kits, but you can make them too. You can use a file on some iron (that’s why they are called iron **filings**).
Plotting compasses. Try to get at least 3 per group of teachers. If you can’t find plotting compasses like those in the video, you can use steel nails and make magnetic needles like the one you see in the leader’s notes.	Steel nails are extra-hard so that they can be hammered into concrete. Some kinds are broad and flat. Use a strong permanent magnet to stroke them and magnetise them.
Old electric motor to examine. You’ll usually find that the magnets on each side of the armature (the part that spins) are electromagnets and not permanent magnets. In the video, you see two coils of copper wire on each side of the armature (= the part that spins).	Appliance repair centres. Washing machines, microwave ovens, fans, computer power supply units, fridges, tape recorders have motors and transformers.
Old loudspeakers to take apart and show how the coils fit into the ring magnets. If the loudspeaker still works, you can put a voltage on the wires from your battery pack. When you close the switch or open it, the speaker will move and make a noise, but if you just leave the current flowing in the coil, the coil will not move and you will hear no sound.	