
Magnetism

Introduction

Activities using magnets can feature at all levels. Students will have some knowledge of magnets, since they are common around homes, but students often expect magnets to attract any metal object rather than only iron and steel. Magnets have no effect on aluminium, brass, silver or copper. Students will often not know what metal common objects are made of, and, in fact, some substances that look like metal are coated plastic, and some plastic-coated objects such as paperclips have metal within them.

Magnetic effects involve transformation of energy. Energy, however, is a difficult concept and it may well be worthwhile considering using magnetism to illustrate the concept of force. A force can be defined as ‘anything which can cause an object to start moving, stop moving or change its direction’.

A force cannot exist by itself: it can only be exerted by one object on another, for example:

- Earth attracting a stone (force of gravity)
- a magnet attracting a ferrous metal (magnetism)
- a child pushing a block or kicking a ball.

Key concepts of magnetism

The activities in this topic are designed to explore the following key concepts:

Early years

- Magnets push and pull some matter.
- Magnets do not push and pull all matter.
- Many toys contain magnets.
- Some magnets exert more force than others.
- Magnets have many different shapes.
- Magnets are used in many ways.
- Magnets are strongest at their ends.
- Ends of magnets may push or pull other ends of magnets.

Middle years

- Magnets act on objects made of iron or steel only.
- A magnet is surrounded by a magnetic field, of definite shape.
- Magnetic force extends into the space surrounding the magnet.
- Magnets push and pull through some types of matter but not others.
- Temporary magnets can be made from permanent magnets.
- Magnetism can be destroyed by rough handling or heating.
- Some rocks are natural magnets.
- A freely suspended magnet lines up in a north–south direction. A compass needle is a small magnet.
- Like poles of a magnet repel; unlike poles attract.
- Earth has a magnetic field.
- Electric currents have a magnetic field.

Students' alternative conceptions of magnetism

Research into students' ideas about this topic has identified the following non-scientific conceptions:

- Magnets are attracted to all objects made of metal.
- Big magnets are stronger than little ones.
- The magnetic and geographic poles of Earth are located at the same place.
- Magnetic poles are only at the ends of magnets.

Activities

Properties of magnets

ACTIVITY:
INTRODUCING
MAGNETS

Teaching note: This activity enables the teacher to find out what prior experiences and ideas students have about magnets.

Key idea: A range of ideas may come up in discussion.

You will need:

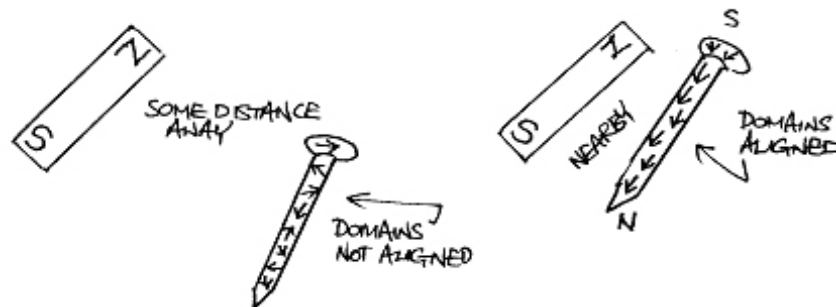
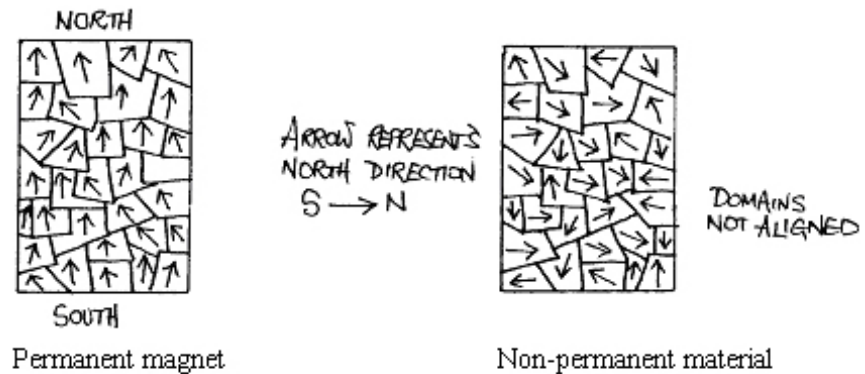
- a number of magnetic gadgets (e.g. fridge magnets, small electric motors).

Introduce a number of magnetic gadgets to the students and get them to explain what they know about them, for example, names of places where magnets can be found, uses of magnets.

Explanatory note: To understand the properties of magnets we need to understand what is happening on a microscopic scale. All matter is composed of tiny particles called atoms. Every one of these atoms is a tiny magnet in itself. Therefore, each atom has a north pole and a south pole. The power of these tiny magnets is extremely small but magnetic power (size of the magnetic field) can increase if the atoms align themselves so that their north poles point in the same direction. In permanent magnets many of the atoms have aligned themselves; the greater the alignment, the stronger the magnet. This explains why, if a

magnet is cut in half, you will obtain two magnets. Further cutting creates more magnets.

Most materials do not act like magnets as their atoms are not aligned in terms of magnetic poles. In magnets and other magnetic materials the atoms arrange themselves into groups, called 'domains'. The atoms in each domain have their magnetic poles aligned. In a magnet many of these domains are aligned, but in a piece of iron these domains are not aligned. However, if you bring a magnet near a piece of iron, such as a nail, the domains in the nail will become aligned. This turns the nail into a temporary magnet and it will be attracted to the permanent magnet. Refer to the figure below.



ACTIVITY:
THINGS THAT
ARE
ATTRACTED TO
A MAGNET

Key idea: Magnets only act on objects made of iron or steel.

You will need:

- a bar magnet for each student
- a record sheet for each student
- two wire coathangers
- some fishing line.

Move around the classroom quietly, selecting objects to test with your magnet. Name and describe the objects on your record sheet. Predict whether or not the object will 'stick' to the magnet. Test your prediction. When you have completed the record sheet, write down your conclusions about what things are attracted to a magnet.

You can then form groups to make a mobile of things that are attracted to magnets and another one of things that are not attracted.



ACTIVITY:
INTERACTIONS
BETWEEN
MAGNETS

Key ideas: Like poles repel; unlike poles attract. Magnets are strongest at their ends. Ends of magnets may push or pull other ends of magnets.

You will need:

- two bar magnets
- a horseshoe magnet
- a record sheet
- butcher's paper or cardboard
- a watch glass (optional).

Arrange the magnets so that the two north ends are facing each other. Slowly bring them closer together. What happens? Do they attract or repel one another? Record your findings.

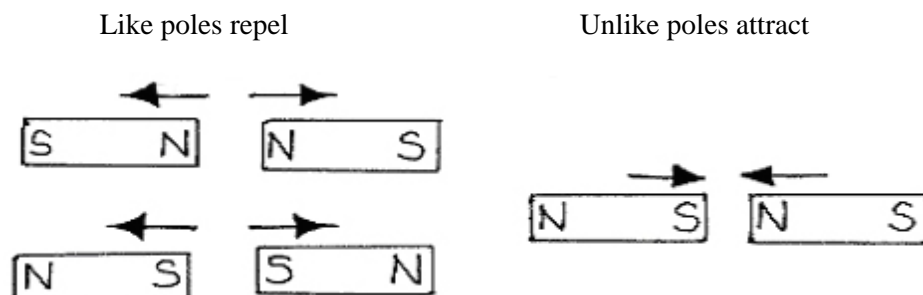
Now try putting the south ends together. What if the north and south ends are facing each other? What happens if a horseshoe magnet and a bar magnet are used? Record your results.

Finally, write down your conclusions.

If you have a watch glass, you can place a bar magnet across it and the magnetic interactions will be even more interesting.

Make up a chart to go on the wall, showing the arrangements of magnets and a sentence to tell what happens in each case.

Explanatory note: Magnets can vary in strength, size and shape. The most common types are bar magnets, discs and horseshoe magnets, although many new fridge magnets are flat strips. All these magnets have poles at either end. Two magnets interact with each other so that 'like poles repel' and 'unlike poles attract'. This is shown in the figure below.



ACTIVITY:
INDIAN ROPE
TRICK

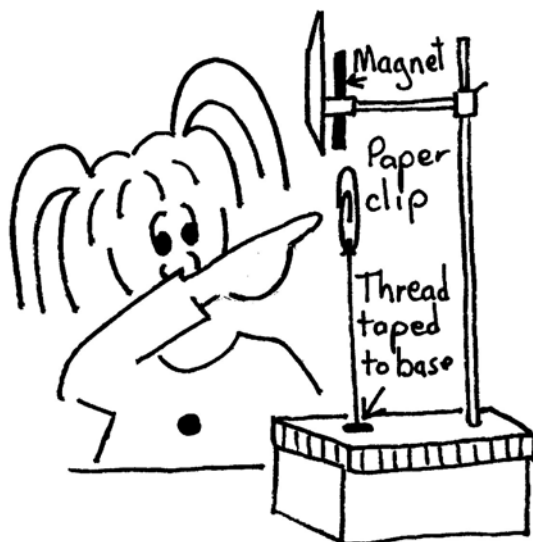
Teaching note: This activity involves a visual illusion, and can be quite compelling if set up in a room for students to discover. The paperclip floating is indeed a surprising sight. It turns out that only iron or steel objects (e.g. a pair of scissors you can use to cut the ‘invisible thread’) will affect the force, and not paper or plastic or aluminium or copper. Iron and steel objects are attracted by magnets also.

Key ideas: Magnetic force extends into the space surrounding the magnet. Magnets push and pull through some types of matter but not others.

You will need:

- cotton
- a strong magnet
- tape
- a paperclip
- paper
- cardboard
- plastic
- aluminium foil
- copper, brass, iron or steel
- an adjustable stand such as a retort stand and clamp.

You can make a paperclip float in midair by attaching it to a piece of cotton thread taped to a bench, and placing a magnet above so that the clip is almost touching the magnet but is held by the cotton. The magnet needs to be quite strong to make this work. The magnet can be covered by a card with a sign—‘Indian rope trick’.



You could also do the same trick by having the cotton stretch horizontally across the gap between two benches.

What do you think might break the magnet’s influence? Test by pushing different materials between the magnet and paperclip. Try paper, cardboard, plastic, aluminium foil, copper, brass, iron or steel.

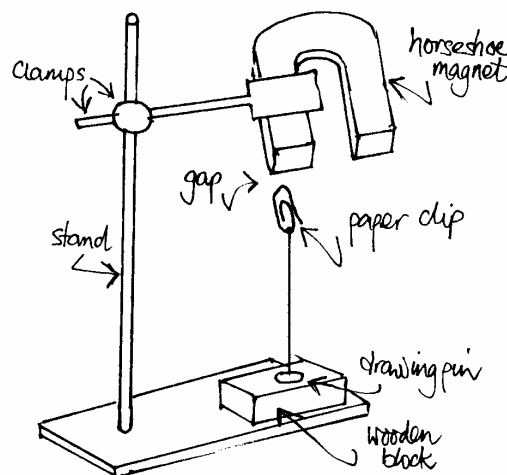
ACTIVITY:
MATERIALS A
MAGNETIC
FIELD WILL
PASS THROUGH

Key ideas: Magnetic force extends into the space surrounding the magnet. Magnets push and pull through some types of matter but not others.

You will need:

- a horseshoe magnet
- thin sheets of various materials (e.g. paper, plastic, aluminium foil, copper, brass, iron or steel)
- a paperclip
- cotton thread
- a small block of wood
- a drawing pin
- a retort stand and clamps
- two large sheets of paper
- a record sheet.

See the figure below for how to set up the equipment.



Select a sheet of some material. Record its name and describe it. Predict whether the magnetic field will pass through the material.

Test your prediction by passing the material through the gap between the magnet and the paperclip. If the paperclip does not fall then the magnetic field has passed through the material. When you have completed your record sheet, write your conclusions on the bottom of it.

As a further exercise, get two large sheets of paper, and head these: 'Materials through which a magnetic field will pass' and 'Materials through which a magnetic field will not pass'. Collect items that belong on each sheet and place them on it.

ACTIVITY:
STRENGTH OF
MAGNETS

Key ideas: Magnets are strongest at their ends. Magnets have different shapes and strengths.

You will need:

- three or more different magnets
- a spring balance
- a set of small masses (preferably made of iron)

- paperclips
- graph paper
- a record sheet.

Touch the hook of a spring balance to a magnet. Carefully pull the magnet away from the spring balance until it just lets go. Record the reading on the spring balance at the point of 'letting go'.

Try another method. Starting with the smallest, test which masses you can lift with the magnet. Record the maximum mass each magnet can lift. Or see how many paperclips you can pick up, end-to-end, with each magnet. Record your findings for each magnet on your record sheet.

Invent another method to compare the strength of different magnets. Try it out. Describe your method and record the results on the bottom of your record sheet.

In addition, draw up some bar graphs to compare the different magnets. Create one bar graph for the spring balance readings, another one to show the heaviest masses lifted and another for the number of pins or paperclips supported. You can also create a graph to show the results using your own method of testing magnets.

ACTIVITY:
EXTENDING
THE REACH OF
A MAGNET

Key idea: Temporary magnets can be made from permanent magnets.

You will need:

- a strong magnet
- paperclips
- a large nail.

Hold a nail against one pole of a strong magnet. The nail is itself magnetised while it is in contact with the magnet and can pick up paperclips or other objects.

Check whether the nail retains its magnetism when no longer in contact with the magnet.



ACTIVITY:
MAKING
MAGNETS

Key idea: Temporary magnets can be made from permanent magnets.

You will need:

- large nails
- a bar magnet
- paperclips (or pins)
- a hammer
- insulated copper wire
- a battery
- a record sheet.


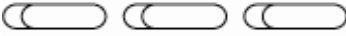

Stroke a nail with a magnet in one direction only. Test how many paperclips you can pick up after ten strokes, twenty strokes, and thirty strokes. Record your findings. Hit the nail with a hammer a few times. Test the nail with the paperclips again. Record your results. What happened? Why?

Wind some insulated copper wire around a nail, leaving about 10 cm of wire at each end. Attach the bare ends of the wire to the terminals on the battery. After a minute or two, test the nail to see if it will pick up paperclips. You have made an electromagnet!

Test to see if the number of coils around the nail makes any difference to the strength of the magnet.

Recording:

Make up a wall chart to show your results (see the table below). Make a similar graph for the number of coils on your electromagnet and the number of paperclips it will hold.

Number of strokes	Number of paperclips
10	
20	
30	

ACTIVITY:
MAKE A
TEMPORARY
COMPASS

Key idea: Temporary magnets can be made from permanent magnets.

You will need:

- a darning needle
- a polystyrene cube
- a bar magnet
- a shallow dish of water.

Stroke a darning needle until it is magnetised. Push the needle through a cube of polystyrene and float it in a shallow dish of water. It should point north-south. (Keep it away from magnets!)

Explanatory note: Permanent magnets have domains that have their poles permanently aligned. However, if magnets are heated or dropped, the domains may be knocked out of alignment. This destroys the magnet's magnetic ability.

Therefore, magnets must not be handled roughly. A magnetic material, such as an iron nail, can be made into a permanent magnet by placing it in the magnetic field of a permanent magnet over an extended period of time. This can also be achieved by continually rubbing a pole of a permanent magnet down the side of the nail, ensuring that you always rub in the same direction. This realigns the domains in the magnetic material.

Temporary magnets can be made from an iron nail, a long piece of wire and a battery. After winding the wire around the nail many times, connect it up to a battery. An electric current runs down the wire and causes a magnetic field in the iron nail. The result is a temporary magnet called an 'electromagnet'. Disconnecting the wire ceases the magnetic power of the nail.

ACTIVITY:
MAGNETIC
LEVITATION

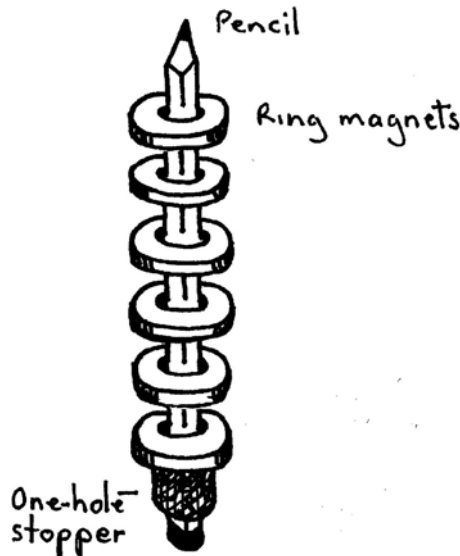
Key idea: Unlike poles of magnets repel each other.

You will need:

- six or so small ring magnets
- a pencil.

Slot the ring magnets one at a time onto an upright pencil.

The magnets either stick together or are suspended in midair, depending which side they are dropped on. The poles of a ring magnet are on the flat faces.



ACTIVITY:
MAGNETIC
TRANSPORT

Key idea: Unlike poles of a magnet repel each other.

You will need:

- six to ten strong magnets
- wood or cardboard
- construction tools.

You can make a transport system with magnets where vehicles are suspended in the air as they move along the system. Make a track out of wood or cardboard and magnets whereby the magnets are secured in a line on the track in such a way that their north poles lie face up. You can then make a small cart with two magnets with their north poles faces down. It will float along the track. To keep the vehicle on the track you may need to construct guiding rails to the track.

Explanatory note: The observations in this activity, and in both *Magnetic levitation* and *Lively dancer*, can be explained by magnetic repulsion. Magnets need to be arranged so that unlike poles repel each other.

ACTIVITY:
MAPPING
MAGNETIC
FIELDS

Key idea: Magnetic fields are regions in space which apply a force to magnetic materials.

You will need:

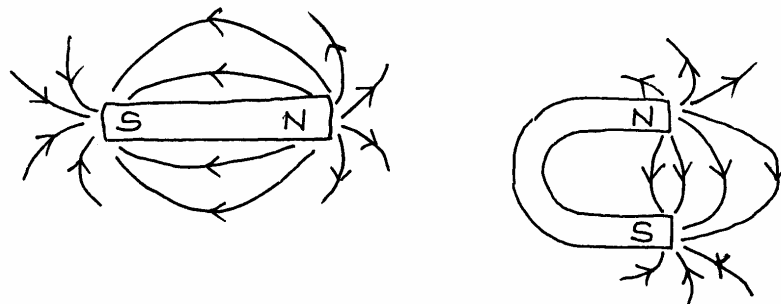
- a sheet of cardboard (e.g. cover paper)
- a shaker of iron filings
- two bar magnets
- a horseshoe magnet
- a funnel
- a newspaper
- spray paint
- a container of turpentine
- paper towel
- a record sheet.

Arrange the magnets and place the cardboard *on top of* the magnets. Carefully sprinkle the iron filings onto the cardboard until you see a clear pattern of lines. Draw these lines accurately on your record sheet. Take the 'holey' lid from the shaker, insert the funnel, then carefully return the iron filings to the jar. Repeat this for the arrangements shown in the figure *Magnetic fields*.

Another way to record this activity is to select a favourite arrangement. Lay out the newspaper on the floor, set up the arrangement and sprinkle it with iron filings. The *teacher* should then spray paint the arrangement. After about 10 minutes, brush the filings onto another piece of card and then soak them in turpentine to remove the paint. Later you can dry them on paper towel and tip them back into the jar.

Explanatory note: A magnetic field is the area surrounding a magnet that will affect another magnet or an object made of magnetic material. The lines drawn on the simple bar magnet and horseshoe magnet in the figure *Magnetic fields* shows the patterns formed by sprinkling iron filings around these magnets. The arrows indicate the direction of these lines; the direction is defined as the direction a small compass would point if placed near the magnet.

FIGURE:
MAGNETIC FIELDS



ACTIVITY:
MAGNETS AND
COMPASSES

Key idea: A compass needle is a magnet.

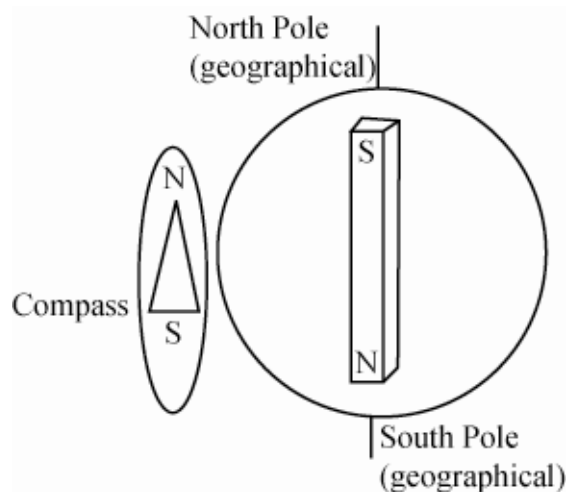
You will need:

- a magnet
- a piece of iron
- a compass.

Investigate what happens when a magnet or piece of iron is brought near a compass. Why is the case of the compass made of brass or aluminium?

Explanatory note: Compasses are just freely moving magnets. Permanent magnets may be used as compasses if you allow them to swing freely in a horizontal plane. Magnets point north because the whole Earth may be considered to be a huge magnet. Scientists believe Earth's iron core and currents of liquid rock give rise to this magnetism. In the figure *Earth as a magnet* Earth can be viewed as having a permanent magnet inside it. The north pole of this permanent magnet is located at the geographic South Pole of Earth. At the geographic North Pole of Earth is the location of the south pole of the permanent magnet. This can be confusing, but it explains why a magnet's north pole points to geographical north as unlike poles of magnets attract one another.

FIGURE:
EARTH AS A
MAGNET



ACTIVITY:
HOW MANY
MAGNETS?

Teaching note: A number of games and toys involve magnets. For example:

- a fishing game involving magnets suspended from string, picking up small bits of metal floating in a tub
- board games involving magnetic attraction from underneath
- a mystery dip in which small objects of various materials are buried in sawdust and a magnet is used to explore what will be picked up
- a toy train that uses magnets to link the carriages
- magnetic sculptures, or levitating objects, as can be found in science toy shops
- toys of various kinds, with steel parts (drawing pins), that can be made to move with a strong magnet under the bench
- toys with battery-operated electric motors that contain magnets.

Key idea: A range of ideas may come out of discussions with the students.

You will need:

- a variety of magnets—different sizes, shapes and strengths.

Observe the variety of magnets found around the house. What similarities and differences do you find?

ACTIVITY:
THE LIVELY
DANCER

Key idea: Unlike poles of magnets repel each other.

You will need:

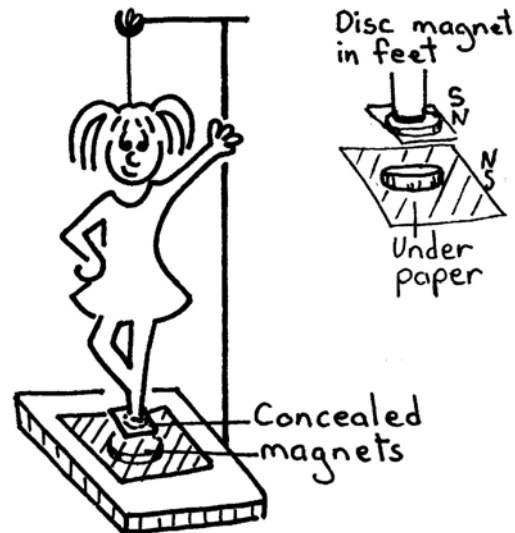
- a stand (made of wood and wire)
- cotton thread
- cardboard
- scissors
- tape
- two ring magnets.

You can make a suspended paper doll dance unexpectedly using ring magnets. Make a stand and a base out of wood and wire or anything else that comes to hand.

Cut out a cardboard dancing figure, with enough cardboard at the feet to conceal a ring magnet.

Suspend the dancer from the stand using cotton thread. Tape a ring magnet horizontally in the figure's feet, and another on the base close to where the dancer's feet would settle. Arrange the magnets so they have repelling poles.

Swing the dancer gently and observe what happens.



Key idea: Electric currents have a magnetic field.

You will need:

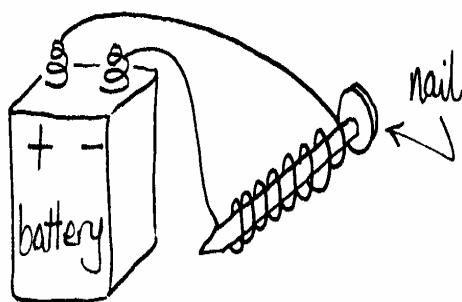
- insulated wire
- an iron nail
- a battery
- a switch.

Wind the wire several times around the nail as shown in the figure. Connecting the wires to a battery produces the electromagnet.

Explore different magnetic effects through increasing the number of turns of the wire.

Connect a switch to turn the electromagnet on and off.

ACTIVITY:
MAKING AND
TESTING AN
ELECTRO-
MAGNET



The wire will heat up quickly if left connected to the battery for too long. The battery will become flat quickly if the wire is left connected.

Explanatory note: Magnetism and electricity are very closely linked. The battery creates an electric field in the wire which in turn moves electrons (a current is produced). The current creates a magnetic field producing an electromagnet. When the current stops, the magnetic field ceases. This phenomenon also works in reverse. Moving a magnet near a wire creates an electric field in the wire which in turn moves electrons (a current is produced). This is the principle by which electric generators produce electricity.