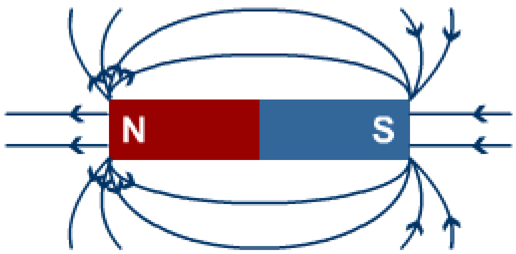
Magnetism is an effect that we cannot see, hear or touch. Magnetic fields can be detected when they produce forces. For instance, if you put two magnets close together, they will either push apart or pull together.

Magnetic fields



A magnet has a magnetic field around it. This field is strongest at its poles, which are at the ends of the magnet. A magnet has two poles, a North-seeking pole and a South-seeking pole. These names are often shortened to North pole and South pole.

The field around a magnet can be represented on a diagram by lines with arrows on. These are called **field lines**. The closer together the lines are, the stronger the field.

The arrows always point from the North pole to the South pole.

- Opposite poles will attract.
- Similar poles will repel.

Magnetic materials and magnets

There are only a few natural elements that are magnetic. The main ones are iron, cobalt and nickel. Many other magnetic materials can be made, by mixing these elements with other substances. A good example is steel, which is a mixture of iron and carbon. Even some plastics are magnetic because they have magnetic substance mixed in them.

Only magnetic materials can be attracted to a magnet, or made into a magnet. Most magnets are made from iron and steel.

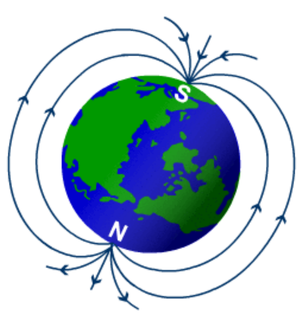
Did you know that oxygen is actually magnetic when it is frozen?

What is the difference between a magnet and a piece of magnetic material?

The easiest way to tell them apart is that ***a magnet can repel and attract another magnet***. Whereas, ***a piece of magnetic material can only attract a magnet!***

Magnetic materials do **not** have fields around them, but they are affected by near by magnetic fields.The

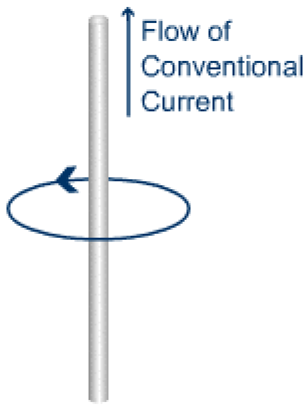
Earth's magnetism

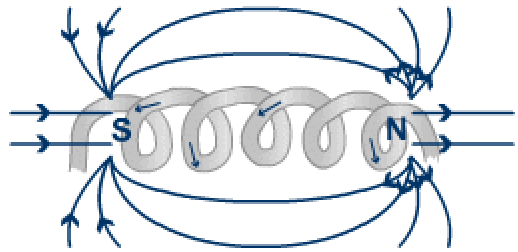


The Earth has its own magnetic field around it. The iron core inside of the Earth causes this field. Explorers have been using the Earth's magnetic field to find their way around for centuries. Magnets in compasses spin round until their North-seeking pole points to the North pole on the Earth.

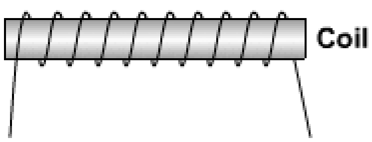
Currents and magnetic fields

All currents have a magnetic field around them. All the cables connecting electrical appliances to the mains in your home will have magnetic fields around them, and so do the large electricity power lines you can see on pylons outside. A straight wire has a circular magnetic field around it. A coil of wire has a magnetic field around it, that is the same shape as a bar magnet.





If the conventional current flows the other way, the magnetic field will be in the opposite direction. As you move further away from the wire, the magnetic field gets weaker, which is why the lines are drawn further apart.



These types of magnets are called **electromagnets.** They are **temporary magnets** as they can be turned on and off with the current. Normal bar magnets are **permanent magnets** because it is very difficult for them to lose their magnetism.

Electromagnets are far more useful than permanent magnets because:
1. They can be switched on and off.
2. The strength of the magnetic field can be changed, by altering the current.
3. They can easily be made into a variety of shapes and are less expensive to make.

The magnetic field around a coil electromagnet can be increased by:
1. Increasing the current in the wire.
2. Putting more loops on the coil
3. Placing an iron or steel core inside of the coil.

Iron and steel behave slightly differently as cores, because iron is **magnetically soft** and steel is **magnetically hard.**

Magnetically soft, for example, iron:
- Easy to magnetise.
- Loses its magnetism quickly when the current is switched off.

Magnetically hard, for example, steel:
- Harder to magnetise.
- Stays magnetic after the current is switched off.

Most electromagnetic devices use iron as the core, because they want the magnetism to change quickly.

The motor effect

When two magnets are close together, they affect each other and produce a force. The same happens when any two magnetic fields are close together.
If a wire carrying a current is placed in a magnetic field a force is produced. This is called the **motor effect.**
The direction of the force will depend on the direction of the magnetic field and the direction of the current in the field. The current, magnetic field and force will always be at right angles to each other, so the wire will not move towards the poles.

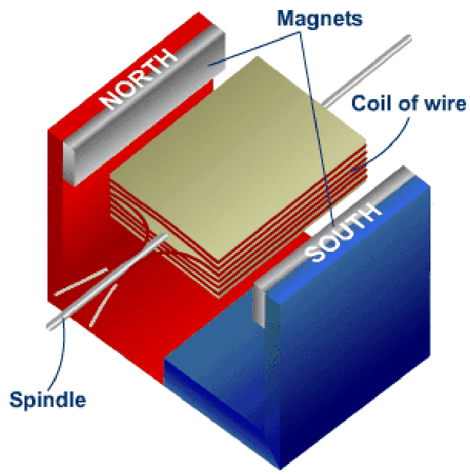
Why does this happen?
The magnetic field from the current is affected by the magnetic field from the magnet; this produces a force.

To make the force bigger:

- Increase the size of the current.
- Increase the strength of the permanent magnet.

A huge electromagnet is often used to pick up cars. When the current is switched off, the magnet loses its magnetism and the car falls back down to the ground.

Electric motors



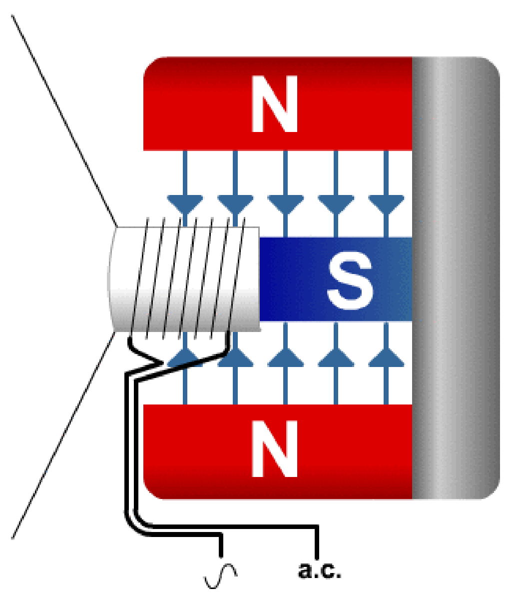
An electric motor uses the motor effect to spin a coil of wire inside a magnetic field.

To increase the speed of the motor:

- Increase the current in the coil.
- Increase the number of loops on the spinning coil.
- Increase the strength of the magnet.

If either the magnetic poles are swapped around or the current flows in the opposite direction the motor will spin in the opposite direction.

Loud speakers



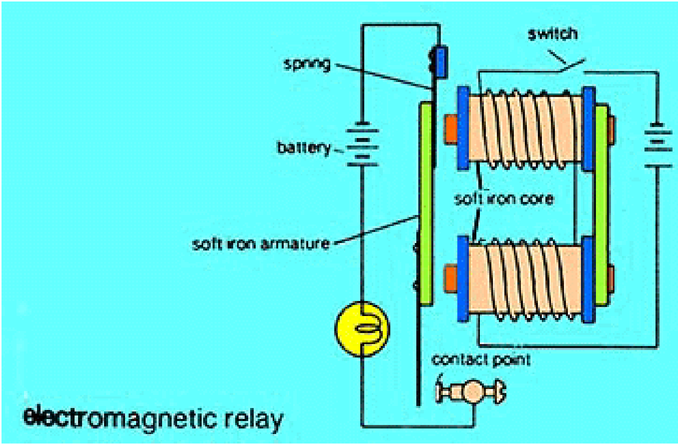
The alternating current that represents a sound wave flows through the coil. As the current carrying coil is inside a magnetic field a force is produced, which makes the coil move. This pulls the paper cone in the same direction. As the current changes direction, the force produced changes direction. This makes the paper cone move the opposite way. The backward and forward motion of the cone produces a sound wave in the air.

The higher the frequency of the electrical signal, the higher the frequency of the sound wave produced, so making a higher pitched noise. The greater the amplitude of the electrical signal, the greater the force produced, so the further the cone will move, making a louder noise.

Relays

Relays are used as safety devices.

A large current circuit can be switched on by a small current circuit, as shown below:



When the small current in the input circuit is switched on, the electromagnet becomes magnetic and attracts the iron armature. The armature rotates towards the electromagnet, pushing the contacts together. This switches on the large current in the output circuit. This type of relay circuit is used in the ignition of a car.

Creating currents

You can see that any current in a magnetic field will produce a force, which may make something move. The opposite affect is that if a wire is moved in a magnetic field, a voltage is produced, and if there is a complete loop, a current will flow. This is how electricity is generated.

There are two main ways to generate electricity:

1. **Moving a wire in a magnetic field**
   - If the wire is moved in the opposite direction, the current will flow the other way.
   - If the wire is moved faster, a larger current will flow.
   - If the wire is stationary, no current will flow.
2. **Moving a magnet in a coil of wire**
   - If the magnet changes direction, the current will flow the other way.
   - If the magnetic poles are swapped around, the current will flow the other way.
   - If the magnet moves faster, a larger current will flow.
   - If the magnet is stationary, no current will flow.

Generating electricity

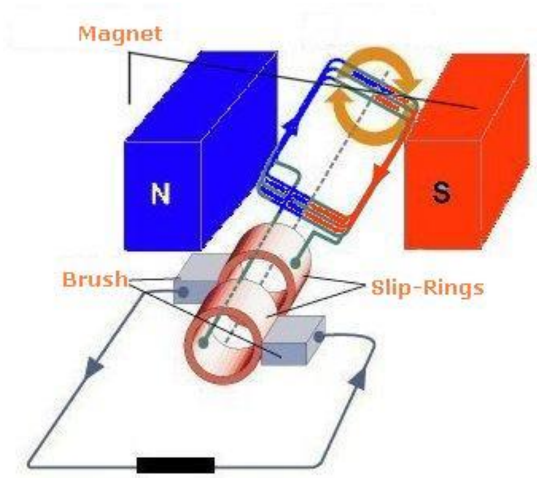
In industry, electricity is generated by spinning a coil of wire in a magnetic field.

To increase the voltage or current generated:

- Spin the coil faster.
- Put more loops on the coil.
- Use a stronger magnetic field.
- Use a coil with a larger area.

When a current is generated we say that it has been **induced** in a conductor.

Note: A voltage is always induced when a conductor moves in a magnetic field, but a current is only induced if there is a **complete circuit** for it to flow around.

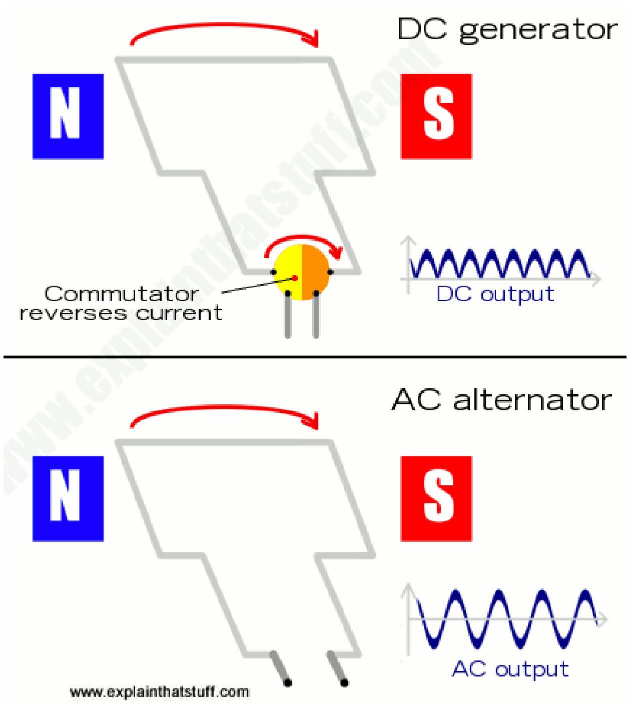


In the diagram, you can see that there are carbon brushes and slip rings.

The carbon brushes act as contacts with the slip rings, so that the current can always flow from the coil to an external circuit.

Why is alternating current produced?

The current produced is an alternating current as during each rotation, each side of the coil moves up and down in the magnetic field. This change in direction produces a change in direction of the current.



DC generators

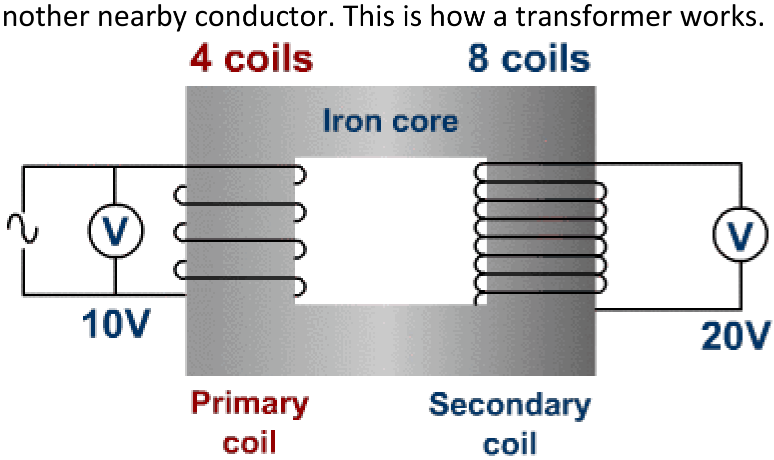
Just as a simple DC electric motor uses direct current (DC) electricity to produce continual, rotary motion, so a simple DC generator produces a steady supply of direct current electricity when it spins around. Like a DC motor, a DC generator uses a **commutator**.

AC Alternators

The simplest kind of alternator is like a DC generator without a commutator. As the coil or magnets spin past one another, the current naturally rises, falls, and reverses, giving an AC output. Just as there are AC induction motors, which use electromagnets to produce a rotating magnetic field instead of permanent magnets, so there are alternators that work by induction in a similar way.

Transformers

Transformers are able to change the voltage of an alternating current. This is used on the national grid. The larger the voltage, the lower the amount of wasted heat energy in the cables. However, these large voltages are too dangerous to use in the home, so *transformers are used to reduce the voltage to a safe level*. An alternating current has a changing magnetic field around it. This changing magnetic field can induce a current in another nearby conductor. This is how a transformer works.



The alternating current in the primary coil has a changing magnetic field around it. This changing field induces an alternating current and voltage in the secondary coil. The size of this voltage depends on the difference in the number of loops on the coils.

Calculating the size of the output voltage

You can work out the size of the voltage using the following equation:

$$\frac{\text{Voltage across the primary coil}}{\text{Voltage across the secondary coil}} = \frac{\text{Number of loops on the primary coil}}{\text{Number of loops on the secondary coil}}$$

Number of loops on primary coil	Number of loops on secondary coil	Voltage in (V)	Voltage out (V)
100	200	_____	10
25	100	1	____
100	____	10	5
____	200	50	100
200	800	60	____

MAGNETS AND CURRENTS LINKS

Force on a current carrying conductor in a magnetic field

https://www.youtube.com/watch?v=HTTA30sEv6o

Understanding Electromagnetic induction (EMI) and electromagnetic force (EMF)

https://www.youtube.com/watch?v=tC6E9J925pY

Magnetism Revision IGCSE Triple

https://www.youtube.com/watch?v=jP4ZNa_XJMU

Simple phenomena of Magnetism - IGCSE Physics/Chris Gozzard

https://www.youtube.com/watch?v=2qQeQ0PXKH4

Magnetism and Electromagnetism REVISION PODCAST

https://www.youtube.com/watch?v=qyUxAlrQgS8

Methods of Magnetisation and Demagnetisation

https://www.youtube.com/watch?v=Dka-cROHxBY