

## Magnetism

Three metallic elements show strong magnetic properties. They are iron, cobalt and nickel. Steel is a metal alloy which can show magnetic properties. It is made from iron and carbon. Steel can also be mixed with other metals to make an alloy which does not show magnetic properties. For example, stainless steel is made from steel, chromium and nickel and it does not show magnetic properties.

Materials that show magnetic properties may not show it all the time. When a material is showing magnetic properties it is said to be magnetised and is known as a magnet. The most widely used magnets are now made from mixtures of the magnetic metals. Alnico is an example.

The word magnet comes from the name of the ancient country of Magnesia which is now part of Turkey. In this region large number of black stones were found which had the power to draw pieces of iron to them. The black stone became known as lodestone or leading stone because of the way it could be used to find direction. Today it is known as the mineral magnetite.

### **Behaviour of magnets**

Magnets can attract or repel other magnets and attract any magnetic material even if it is not magnetised. When suspended from a thread, a bar magnet aligns itself in a north –south direction.

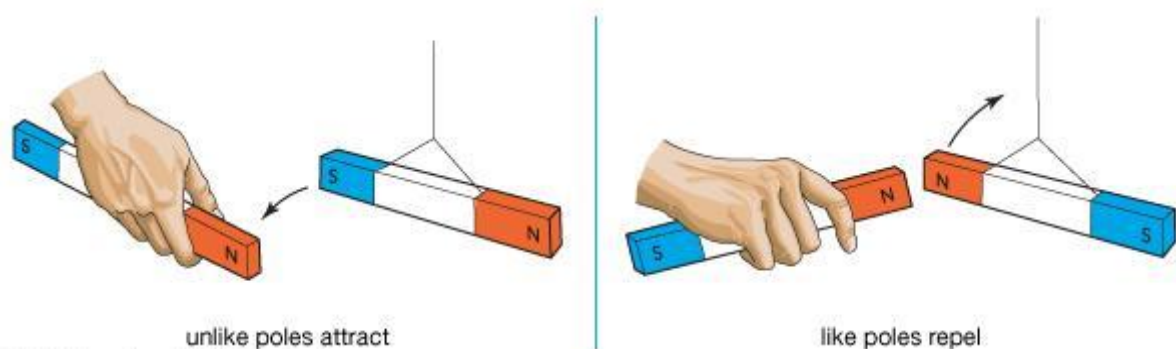
Non –magnetic materials, such as wood, paper, plastic and most metals, cannot be magnetised and so can do none of these things. Some, such as paper and water, can let the force of magnetism pass through them while other materials, such as a steel sheet, do not let the force of magnetism pass through them.

### **Strength of the magnetic force**

At each end of a bar magnet is a place where the magnetic force is stronger than at other places in the magnet. These places where the magnetic force is strongest are called poles of the magnet. The end of the magnet which points towards north when the magnet is free to move is called the north seeking

pole or North Pole. At the other end of the magnet is the south –seeking pole or South Pole.

When the north pole of one magnet is brought close to the south pole of another magnet that is free to move, the south pole moves towards the north pole and the north pole moves towards the north pole. Similarly, a north pole is attracted to a south pole. However, two south poles repel each other, as do two north poles. We can summarise these observation as different poles attract and similar poles repel.



When a material that can show magnetic properties, such as steel paper clip is attracted to the end of a magnet it also becomes a magnet and can attract other magnetic materials to it. The paper clip has been made into a magnet by a process called magnetic induction. When the paper clip is moved away from the magnet it loses its magnetism.

### Inside a magnet

Groups of particles from which a magnetic material is made, form tiny regions called domains. Each domain behaves like a tiny magnet. If the domains are arranged at random the material does not attract other magnetic materials although it can be attracted to a magnet. It also does not point north-south when it is free to move.

Magnetic domains can be made to arrange themselves in line. Then all their north poles face in one direction and all their south poles face in the opposite direction. This arrangement produces a north and a south pole in the



material as a whole. When the material is in this condition it has been magnetised and so is now a magnet.

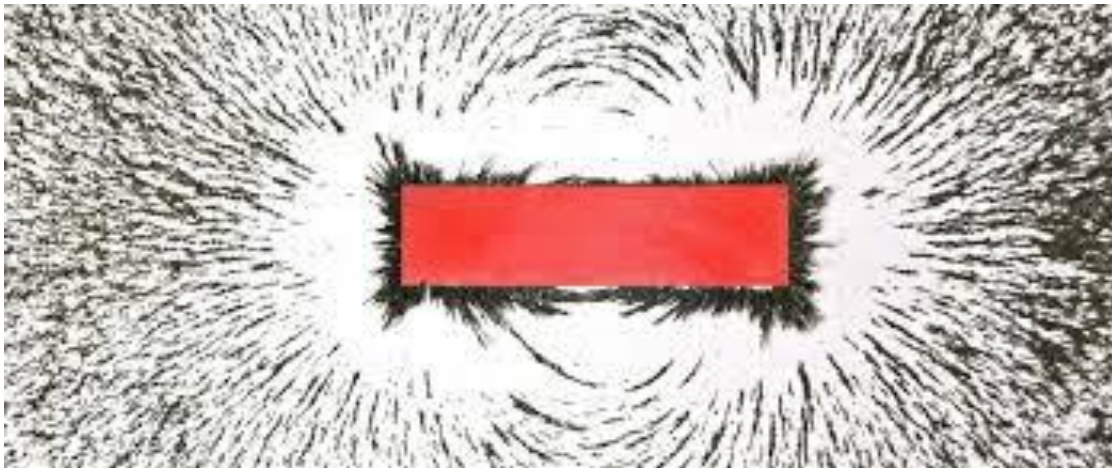
Some materials, such as steel are magnetically hard and once domains have been aligned they tend to stay aligned. Others, such as iron are magnetically soft and domains soon rotate again to random positions, so the material loses its magnetism.

### **The magnetic field**

The region around a magnet in which the pull of the magnetic force acts on magnetic materials is called the magnetic field.

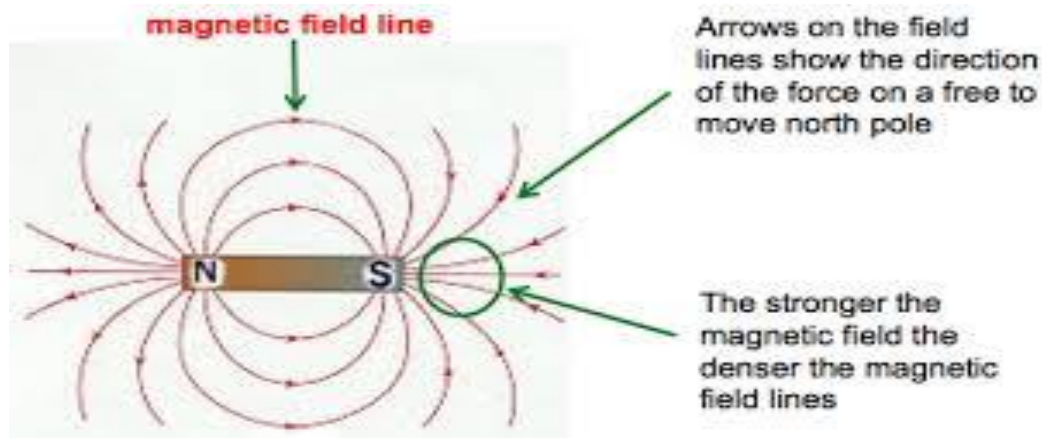
The field around a magnet can be shown by using a piece of card and iron filings. The card is laid over the magnet and the iron filings are sprinkled over the paper.

Each iron filing has such a small mass that it can be moved by the magnetic force of the magnet if the paper is gently tapped. The iron filings line up as shown in the figure.



The pattern made by the iron filings is called magnetic field pattern. The iron filings appear to form lines around the magnet. This phenomenon can be checked by using a plotting compass and a piece of paper and pencil. The magnet is placed in the centre of the paper and the plotting compass is placed on one side of the magnet close to its north pole. The north pole of the magnet will point away from it. The position of the north pole of the compass is marked on the paper and the plotting compass is then moved so that its south pole is over the mark made on the paper. The position of the north pole is

marked again with the plotting compass in the new position and the process is repeated until the plotting compass reaches the south pole of the magnet. The points marking the positions of the north pole of the compass are joined together by a line running from the north pole to the south pole of the magnet. This line represents one of the magnetic lines of force forming the field patterns. Arrows should be drawn on the lines, pointing from north pole to its south pole.



### Characteristics of magnetic field lines

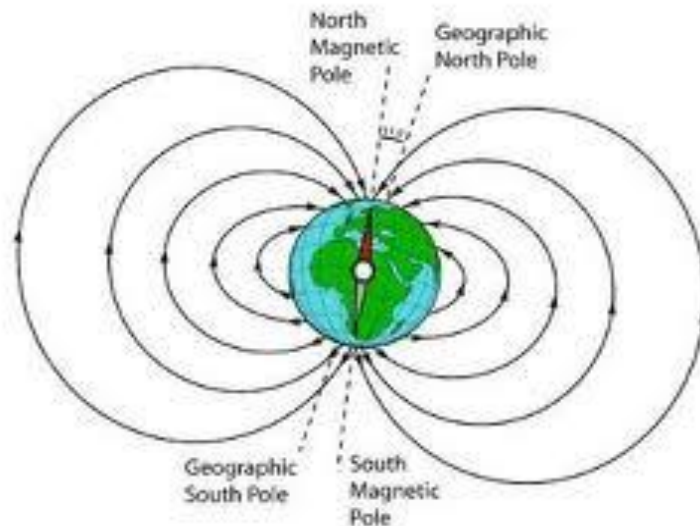
- Lines of force NEVER cross.
- Lines of force are CONTINUOUS.
- Lines of force always form individual CLOSED LOOPS around the magnet.
- Lines of force have a definite DIRECTION from North to South.
- Lines of force that are close together indicate a STRONG magnetic field.
- Lines of force that are farther apart indicate a WEAK magnetic field.

### The Earth's magnetic field

At the centre of the Earth is the Earth's core. It is made from iron and nickel and is divided into two parts- The inner core made of solid metal and the outer core made of liquid metal. As the Earth spins the two parts of the core move at different speeds and this is thought to generate the magnetic field around the earth and make the earth seem to have a large bar magnet inside it.

The Earth spins on its axis which is an imaginary line that runs through the centre of the planet. The ends of the line are called the geographic North and South poles. Their positions on the surface of the Earth are fixed.

Magnetic north- towards which the free north pole of a magnet points is not at the same place as the geographic North Pole and it changes position slightly every year.



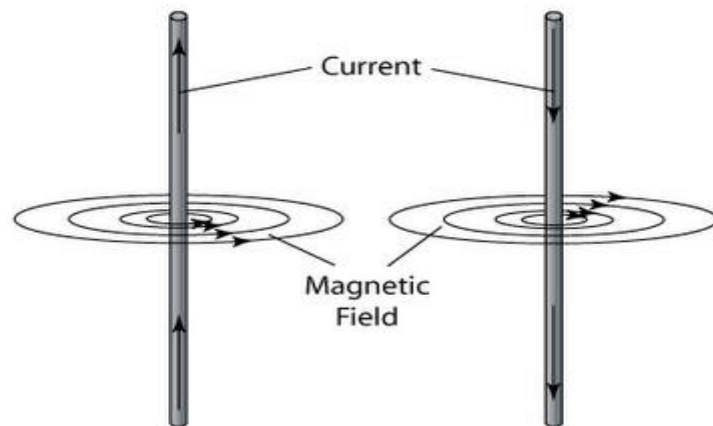
The magnetic north pole originally got its name because it is place to which the north poles of bar magnets point. In reality it is the earth's south magnetic pole because it attracts the north poles of magnets. Similarly the magnetic south pole is really the Earth's north magnetic pole because it attracts the south poles of bar magnets.

### **The link between magnetism and electricity**

Hans Christian Oersted was a Danish physicist who studied electricity. In one of his experiments he was passing an electric current along a wire from a battery when he noticed the movement of a compass needle which had been left near the wire. This chance observation led to many discoveries about how magnetism and electricity are linked together and has many modern applications.

When an electric current passes through a wire it generates a magnetic field around the wire and the lines of force can be plotted.

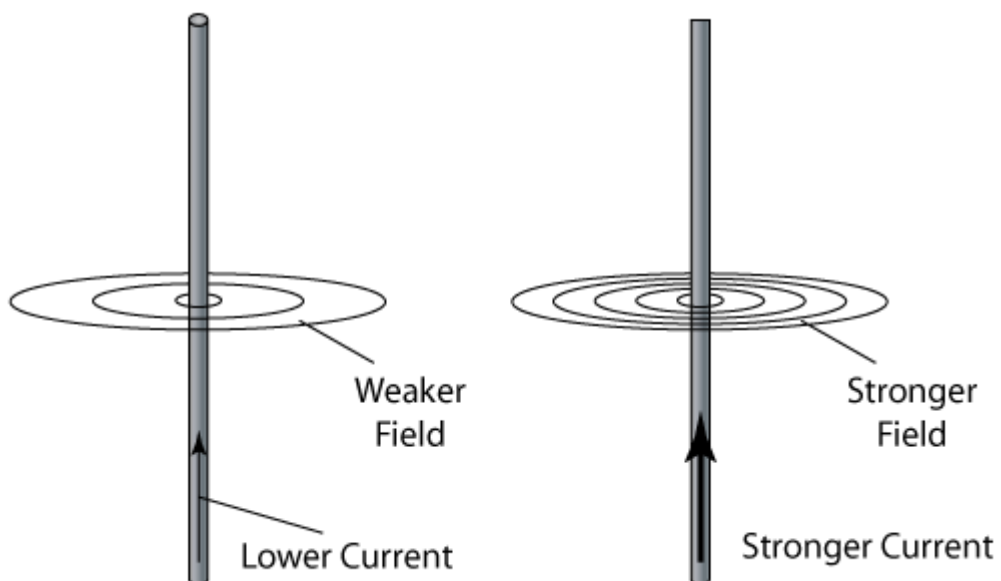
When the current flows up through the card, the field lines move in the anticlockwise direction and when the current flows down wards the field lines move in the clockwise direction.



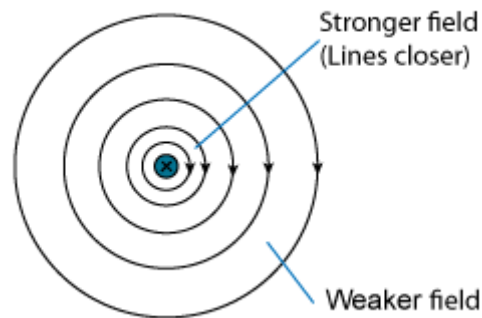
Field Pattern of Straight Wire

### Characteristics of the field lines around a straight conductor

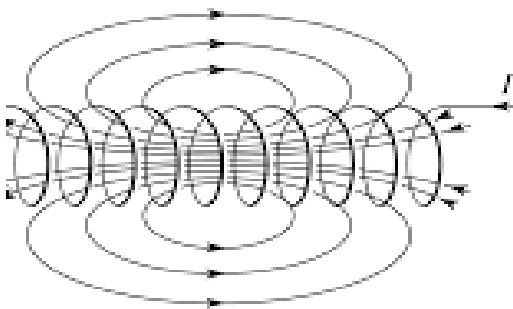
- The magnetic field forms by straight wire are concentric circles around the wire as shown in figure above. Take notes that when the direction of the current is inversed, the direction of the magnetic field line is also inversed.
- The strength of the magnetic field form by a current carrying conductor depends on the magnitude of the current. A stronger current will produce a stronger magnetic field around the wire as shown in the figure below.



The strength of the field decreases out as you move further out. This is illustrated in figure below. Thus, you must be very careful when you are asked to draw the magnetic field in your exam. The distance of the field lines must increase as it is further out from the wire.



If the wire is made into a coil and connected into a circuit, a magnetic field is produced around the coil as shown in the figure below



If a piece of steel is placed inside the wire coil and the current is switched on, the magnetism of the coil and the steel is stronger than that of the coil alone. The current flowing through the coil induces magnetism in the steel. When the current is switched off the steel keeps some of the magnetism it acquired because it is magnetically hard.

If a piece of iron is placed inside the coil it makes an even stronger magnet when the current is switched on than the steel did. When the current is switched off the iron loses its magnetism completely because it is magnetically soft.

### The Electromagnet

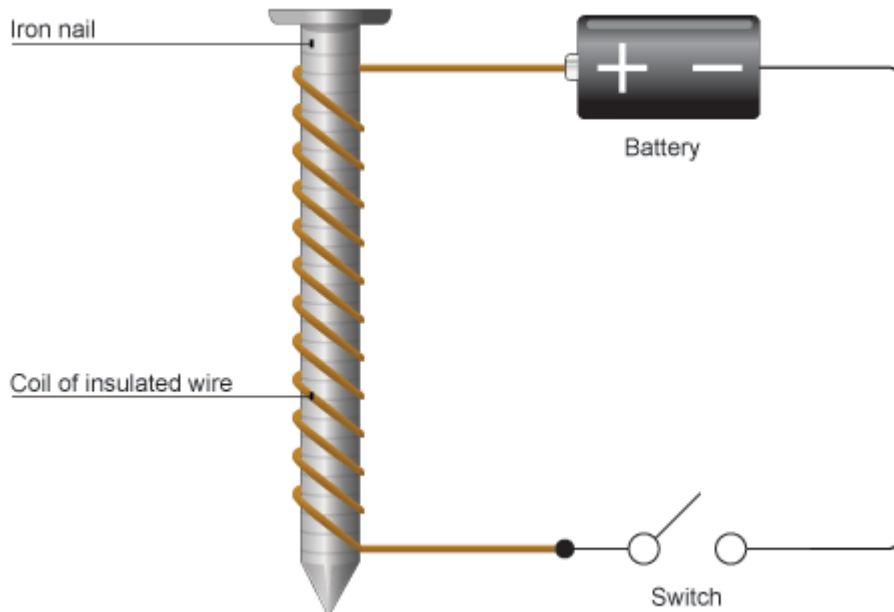
When an electric current flows in a wire it creates a magnetic field around the wire.

By winding the wire into a **coil** we can strengthen the magnetic field. Electromagnets are made from coils like this.

## Making an electromagnet stronger

We can make an electromagnet stronger by doing these things:

- wrapping the coil around an iron core
- adding more turns to the coil
- increasing the current flowing through the coil.



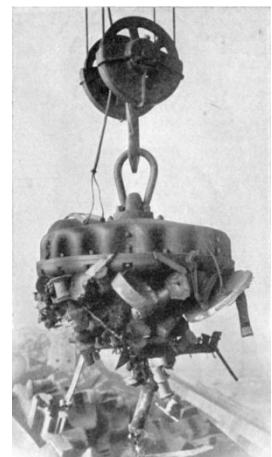
## The magnetic field of an electromagnet

The magnetic field around an electromagnet is just the same as the one around a bar magnet. It can, however, be reversed by turning the battery around.

Unlike bar magnets, which are permanent magnets, the magnetism of electromagnets can be turned on and off just by closing or opening the switch.

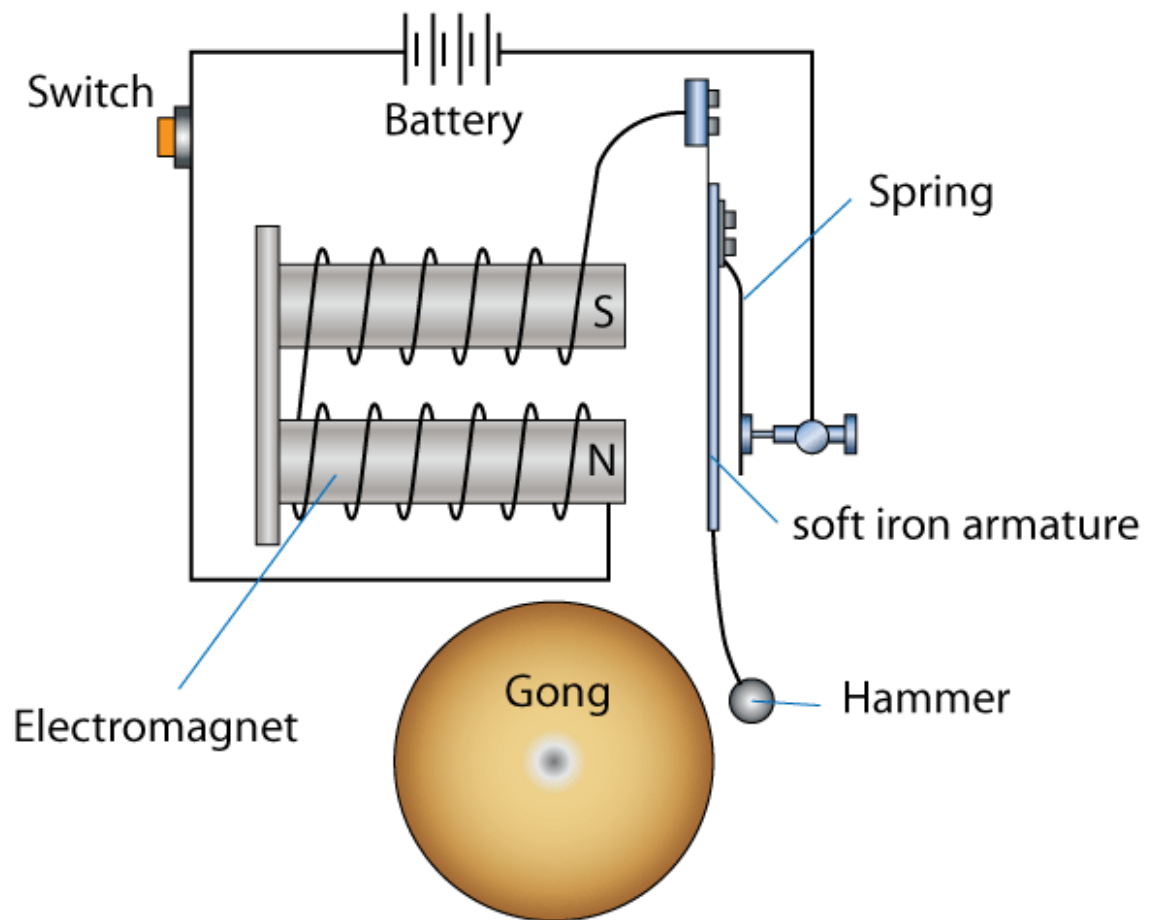
## Uses of Electromagnets

Electromagnets are widely used as components of other electrical devices, such as motors, generators, relays, loudspeakers, hard disks, MRI machines, scientific instruments, and magnetic separation equipment. Electromagnets are also employed in industry for picking up and moving heavy iron objects such as scrap iron and steel





## Electric bell



When the switch is on, the circuit is completed and current flows. The electromagnet becomes magnetised and hence attracts the soft-iron armature and at the same time pull the hammer to strike the gong. This enables the hammer to strike the gong.

As soon as the hammer moves towards the gong, the circuit is broken. The current stops flowing and the electromagnet loses its magnetism. This causes the spring to pull back the armature and reconnect the circuit again.

When the circuit is connected, the electromagnet regains its magnetism and pulls the armature and hence the hammer to strike the gong again. This cycle repeats and the bell rings continuously.