Electromagnetism

Magnets have a magnetic field around them. They have two opposite poles which exerts forces on other magnets. Like poles repel and unlike poles attract. Magnets will attract magnetic materials by inducing magnetism in them. However they will exert little or no force on a nonmagnetic material.

As said before, magnets can induce magnetism in other materials. For example, when steel and iron are placed near to a magnet, they become magnetised and are attracted to the magnet. When pulled away, the iron loses its magnetism but the steel stays permanently magnetised.

Ferrous materials are magnetic. These include iron, nickel or cobalt. Nonferrous materials are nonmagnetic such as copper and aluminium.

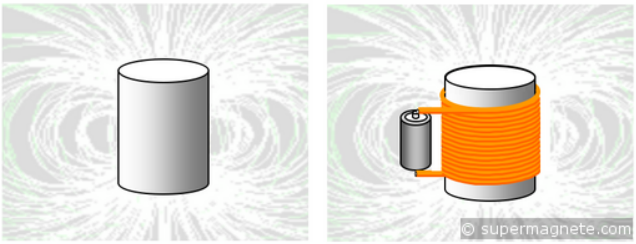
A method of making a magnet (**magnetisation**) is by inducing magnetism. This can be done very strongly if you stroke the material with one end of the magnet in one direction. The most effective way of making a metal is placing the material in a long coil of wire (a solenoid) and passing a large direct current (one way) through the coil.

To **demagnetise** the material, you can hammer it which will throw the atomic particles/atoms out of line. You can also heat it to a high temperature or repeat the solenoid method but with an alternating current.

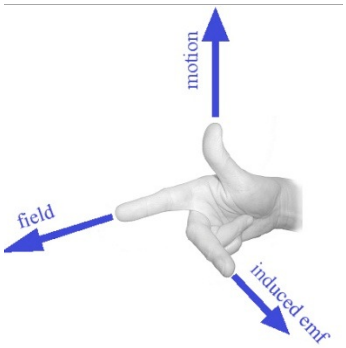
To identify the pattern of field lines around a bar magnet, you can either use a compass or iron filings. The iron filings will become tiny magnets when a magnet is placed near them and will be pulled into position by forces from the poles of the magnet.

Iron is a soft ferromagnetic material, which will magnetise and demagnetise easily. Hence it is used to create temporary magnets. **Steel** is a hard ferromagnetic material, thus it is more hard to magnetise and demagnetise. Hence it is used to create permanent magnets.

In an electromagnet the magnetic field is created through electric current in a wire-wound coil and strengthened by a soft-iron core. As soon as you turn off the power, the soft-iron core loses its magnetisation. A permanent magnet is made of ferromagnetic material, which is magnetised by a strong external magnetic field. The magnetically hard material that is used, keeps part of its magnetisation after the external magnetic field is turned off.

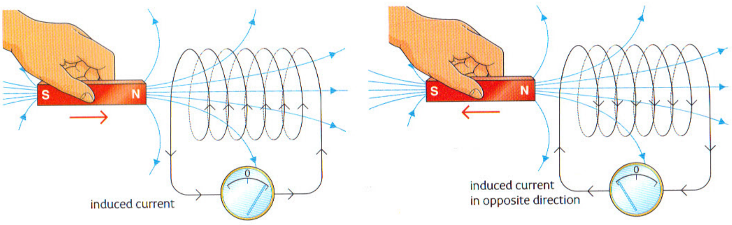


Electromagnetic induction is where a current is produced in a wire by a magnetic field. For this, the wire must be moving through and cutting the field lines of the magnet. When this happens a small e.m.f. is produced which causes a current to flow.



You can increase the e.m.f. by moving the wire faster, using a stronger magnet or increasing the length of the wire in a magnetic field. The current and e.m.f. direction can be reversed by moving the wire in the opposite direction or turning the magnet around so that the field direction is reversed.

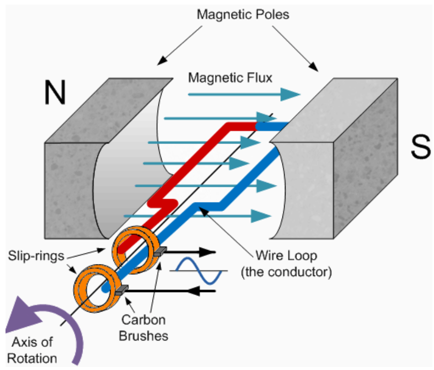
To find the field direction, you use Fleming's right hand rule. Grip the wire so that your thumb is pointing in the direction of the conventional current. Your other fingers will point in the direction of the field lines (which are circles).



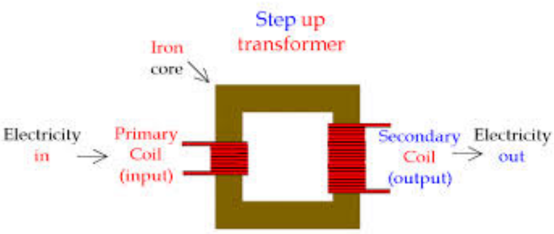
Another example of induced e.m.f. is placing a bar magnet into a coil of wire, which is part of a circuit, thus produces a current. This induced e.m.f. can be increased by moving the magnet faster, using a stronger magnet or increasing the number of turns on the coil. If the magnet is pulled away, the direction of the induced e.m.f. is reversed.

In an **A.C**. **generator**, the coil is made of insulated copper wire and is rotated by turning the shaft. The slip rings are fixed to the coil and rotate with it. The brushes are two contacts which rub against the slip rings and keep the coil connected to the outside part of the circuit.

When the coil is rotated, it cuts magnetic field lines, so an e.m.f. is generated, which makes a current flow. Each side of the coil travels upwards then downwards then upwards so the current flows backwards then forwards then backwards hence it is an alternating current.



The current is maximum when the coil is horizontal since field lines are being cut at the fastest rate and 0 when the coil is vertical, since it is cutting no field lines. The e.m.f. can be increased by increasing the number of turns on the coil, increasing the area of the coil, using a stronger magnet or rotating the coil faster.



AC voltages can be increased or decreased using a transformer. This consists of a soft iron core and has two coils on each side. The iron core gets magnetised by the incoming current and this magnetism then creates a current in the leaving wire. If the purpose of the transformer is to increase the voltage, there will be more turns on the right than on the left (step up transformer). If it is supposed to decrease the voltage, the coils are the other way round (step down transformer).

Output voltage / Input voltage = Turns on output coil / Turns on input coil

$$V_2 / V_1 = n_2 / n_1$$

Input voltage × input current = output voltage × output current

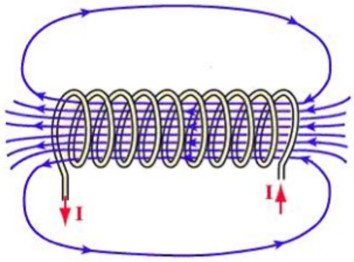
$$V_1 \times I_1 = V_2 \times I_2$$

$$Power_1 = Power_2$$

Transformers are used to make high voltage AC currents. Since power lost in a resistor = R × I^2, having a lower current will decrease the power loss. Since transmission cables are many kilometres long they have a lot of resistance, so a transformer is used to increase the voltage and decrease the current to decease power lost. The advantages of high-voltage transmission are that less power is lost and thinner, light, and cheaper cables can be used since current is reduced.

Energy losses in cable are lower when the voltage is high. Energy loss per unit time is given by P=I^2*R. Voltage is the amount of energy per unit charge, and current is the amount of charge per unit time, so for a higher voltage you can have a smaller current providing the same amount of energy to your components per unit time. Going back to P=I^2*R, for a given load resistance, a smaller value of I will result in a smaller power loss (energy loss per unit time).

4.5 (d) The magnetic effect of a current

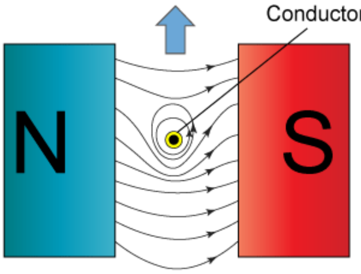


1. Increasing the current increases the strength of the field
2. Increasing the number of turns of a coil increases the strength.
3. Reversing the current direction reverses the magnetic field direction (right-hand rule).

•The magnetic effect of current is used in a relay and a circuit breaker.

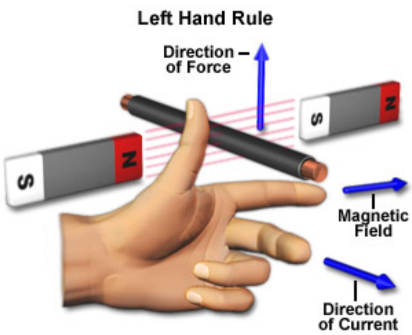
(Describe applications of the magnetic effect of current, including the action of a relay)

4.5 (e) Force on a current-carrying conductor

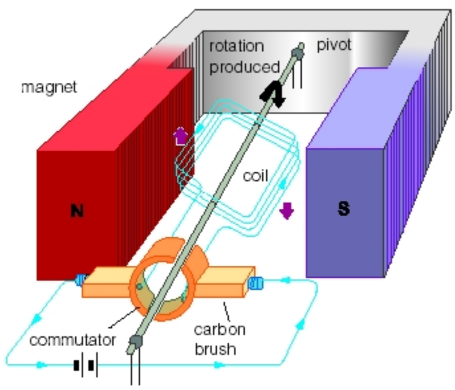


•If a current carrying conductor is in a magnetic field, it warps the field lines. The field lines from the magnet want to straighten out naturally. This causes a catapult like action on the wire creating a force. The direction of the force, current or magnetic field is given by Fleming's left-hand rule.

-if you reverse the current, you will reverse the direction of the force
-if you reverse the direction of the field, you will reverse the direction of the force.



• "Describe an experiment to show the corresponding force on beams of charged particles"
An electron gun creates a beam of electrons. The screen is coated with a fluorescent material which glows when electrons strike it. Current is passed through a pair of coils, to create a magnetic field. NOTE: the direction of the electron beam is the opposite to the conventional current direction so when using the left-hand rule you have to point in the opposite direction of the electron beam.
4.5 (f) d.c. motor



A current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing the number of turns on the coil.

DC motor runs on a direct current. The coil is made of insulated copper wire. It is free to rotate between the poles of the magnet. The commutator, or split-ring, is fixed to the coil and rotates with it. When the coil overshoots the vertical, the commutator changes the direction of the current through it, so the forces change direction and keep the coil turning. The brushes are two contacts which rub against the commutator and keep the coil connected to the battery. They are usually made of carbon. The maximum turning effect if when the coil is horizontal. There is no force when the coil is vertical (but luckily it always overshoots this position)

•The turning effect can be increased by:
-increasing the current
-using a stronger magnet
-increasing the number of coils (increases the length of coil)
-increasing the area of the coil (increases the length of coil)
•Reversing the rotation can be done by:
-reversing the battery
-reversing the poles