Chapter 13: Electromagnetism 1

Knowledge organiser

Magnets

Magnets have a north (N) and a south (S) pole.

When two magnets are brought close together, they exert a non-contact force on each other.

Repulsion – If the poles are the same (N and N or S and S), they will repel each other.

Attraction – If the poles are different (N and S or S and N), they will attract each other.

The force between a magnet and a magnetic material (iron, steel, cobalt, or nickel) is always attractive.

Magnetic fields

A **magnetic field** is the region around a magnet where another magnet or magnetic material will experience a force due to the magnet.

A magnetic field can be represented by magnetic field lines.

Field lines show the direction of the force that would act on a north pole at that point.

Field lines always point from the north pole of a magnet to its south pole.

A magnetic field's strength is greatest at the poles and decreases as distance from the magnet increases.

The closer together the field lines are, the stronger the field.

Induced and permanent magnets

A **permanent** magnet produces its own magnetic field which is always there.

An **induced** magnet is an object that becomes magnetic when it is placed in a magnetic field.

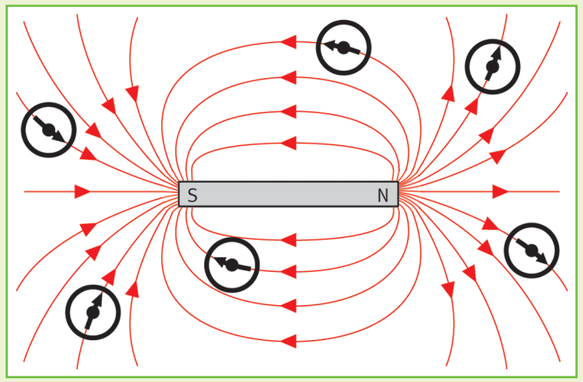
The force between an induced magnet and a permanent magnet is *always attractive* (it doesn't matter which pole of the permanent magnet the induced magnet is near).

If the induced magnet is removed from the magnetic field it will quickly lose most or all of its magnetism.

Plotting magnetic fields

A magnetic compass contains a small bar magnet that will line up with magnetic field lines pointing from north to south.

A compass can be used to plot the magnetic field around a magnet or an **electromagnet**:



If it is not near a magnet, a compass will line up with the Earth's magnetic field, providing evidence that the Earth's core is magnetic.

As a compass points towards a south pole, the magnetic pole near the Earth's geographic North Pole is actually a south pole.

Electromagnetism

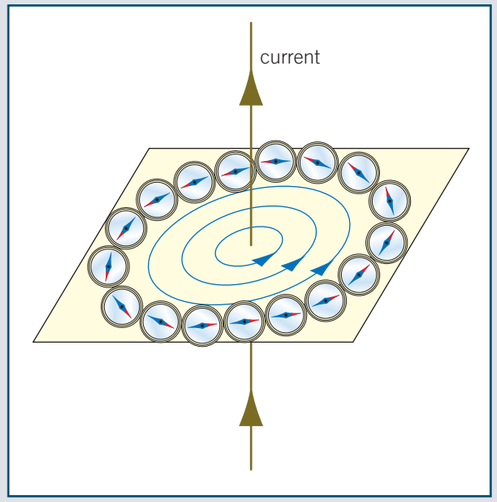
If an electric current flows through a wire (or other conductor), it will produce a magnetic field around the wire.

The field strength increases:

- with greater current
- closer to the wire.

Reversing the direction of the current reverses the direction of the field.

The field around a straight wire takes the shape of concentric circles at right angles to the wire:



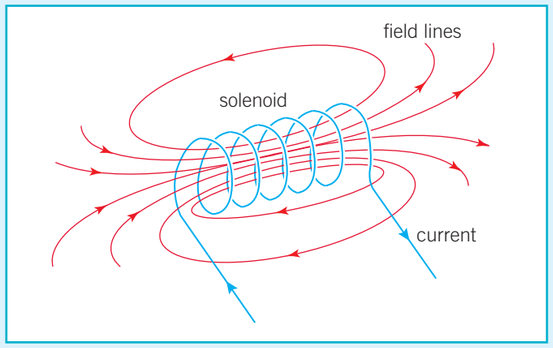
If the wire was gripped by someone's right hand so that the thumb pointed in the direction of the current, the fingers would curl in the direction of the magnetic field.

Solenoids

A **solenoid** is a cylindrical coil of wire.

Bending a current-carrying wire into a solenoid increases the strength of the magnetic field produced.

The shape of the magnetic field around a solenoid is similar to a magnetic field around a bar magnet.



Inside a solenoid the magnetic field is *strong* and *uniform*, which means it has the same strength and direction at all points.

The strength of the magnetic field around a solenoid can be increased by putting an iron core inside it.

If the wire was gripped by someone's right hand so that the fingers curl in the direction of the current in the coil, the thumb will point towards the north pole of the field.

Electromagnets are often solenoids with an iron core.

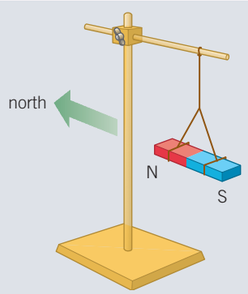
Advantages of electromagnets

- An electromagnet can be turned on and off.
- The strength of an electromagnet can be increased or decreased by adjusting the current.

Magnetic materials

Iron or steel objects, and some nickel and cobalt materials can be magnetised or demagnetised. Magnets made of steel tend to be more permanent as it does not lose its magnetism easily.

N-pole and S-pole can be identified by suspending a bar magnet, and using a second magnet to identify each pole.



Chapter 13: Electromagnetism 2

Knowledge organiser

The motor effect (HT only)

When a current-carrying wire (or other conductor) is placed in a magnetic field, it experiences a force.

The force is due to the interaction between the field created by the current in the wire and the magnetic field in which the wire is placed.

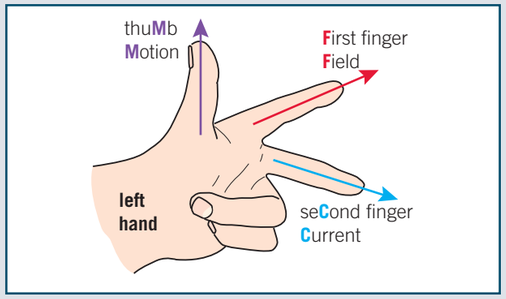
The magnet producing the field will experience an equal-sized force in the opposite direction.

The direction of the force is reversed if the current is reversed or if the direction of the magnetic field is reversed.

Fleming's left-hand rule (HT only)

The direction of the force/motion of the wire is always at right angles to both the current and the direction of the magnetic field it is within.

It can be worked out using Fleming's left-hand rule:



Magnetic flux density (HT only)

The **magnetic flux density** of a field is a measure of the strength of the magnetic field.

For a current-carrying wire at right angles to a magnetic field, the size of the force on it is given by the equation:

force (N) = magnetic flux density (T) × current (A) × length (m)

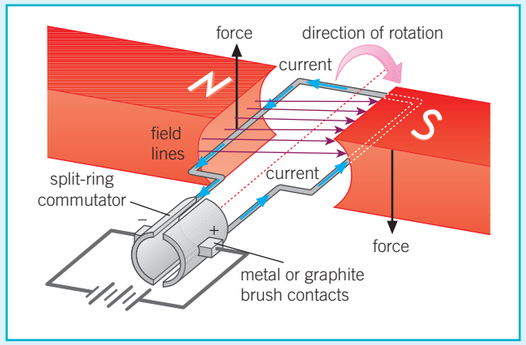
$$F = BIl$$

Electric motors (HT only)

A current-carrying coil of wire in a magnetic field will tend to rotate.

This is the basis of an electric motor.

The diagram below shows a simple motor made of one rectangular piece of wire.



When there is a current in the wire, it spins because:

- each side of the coil experiences a force due to being a current-carrying conductor in a magnetic field
- the forces on each side of the coil are in opposite directions.

The **split-ring commutator** keeps the motor spinning in the same direction.

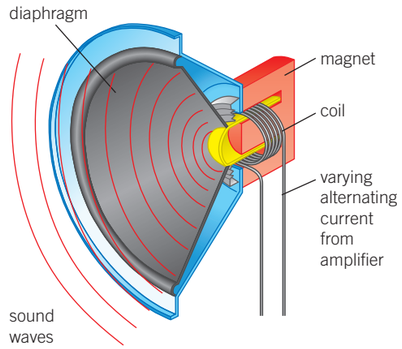
The ends of the wire swap contacts with the power supply every half turn, so current always flows in the same direction relative to the magnetic field.

The motor can be made to spin

- *faster* – by increasing the current in the coil or increasing the strength of the magnetic field.
- *in the opposite direction* – by reversing the direction of the current or reversing the direction of the magnetic field.

Loudspeakers

Moving-coil loudspeakers and headphones use the **motor effect** to convert changes of current in a coil of wire to changes of pressure in sound waves.



A coil of wire is placed inside a permanent magnet (so it is inside a magnetic field) and is attached to a diaphragm.

When a current flows through the coil, it experiences a force due to the motor effect.

This causes the diaphragm to move.

When the current changes direction, the force on the coil also changes direction, causing the diaphragm to move in the opposite direction.

Variations in the current make the coil and diaphragm vibrate.

These vibrations create variations of pressure in the air which form a sound wave.

The frequency of the sound wave produced is the same as the frequency of the alternating current supplied to the coil.

Key terms

Make sure you can write a definition for these key terms.

attraction, electromagnet, induced, magnetic field, magnetic flux density, motor effect, split-ring commutator, permanent, repulsion, solenoid

Chapter 13: Electromagnetism

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P13 questions	Answers
1	What is a magnetic field?	the region of space around a magnet where a magnetic material will experience a force
2	What happens when like and unlike poles are brought together?	like = repel, unlike = attract
3	What happens to the strength of the magnetic field as you get further away from the magnet?	decreases
4	Where is the magnetic field of a magnet strongest?	at the poles
5	In which direction do magnetic field lines always point?	north to south
6	What does the distance between magnetic field lines indicate?	strength of the field, closer together = stronger field
7	What is a permanent magnet?	material that produces its own magnetic field
8	What is an induced magnet?	material that becomes magnetic when it is put in a magnetic field
9	What does a magnetic compass contain?	small bar magnet
10	What is produced around a wire when an electric current flows through it?	magnetic field
11	What factors does the strength of the magnetic field around a straight wire depend upon?	size of current, distance from wire
12	What effect does shaping the wire into a solenoid have on the magnetic field strength?	increases strength of magnetic field
13	How can the strength of the magnetic field inside a solenoid be increased?	put an iron core inside
14	What does Fleming's left-hand rule show?	relative orientation of the force, current in the conductor, and magnetic field for the motor effect
15	What is the symbol for magnetic flux density and what unit is it measured in?	B, tesla (T)
16	What is the motor effect?	when a conductor placed in a magnetic field experiences a force
17	What causes the motor effect?	interaction between the magnetic field created by current in a wire and the magnetic field in which the wire is placed
18	What do loudspeakers and headphones do?	use the motor effect to convert variations in current in electrical circuits to pressure variations in sound waves

Put paper here