

WJEC (Eduqas) Physics GCSE

8.2: Magnetic Effects of Currents

Detailed Notes

(Content in **bold** is for higher tier **only**)

This work by [PMT Education](https://www.pmt.education) is licensed under [CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)

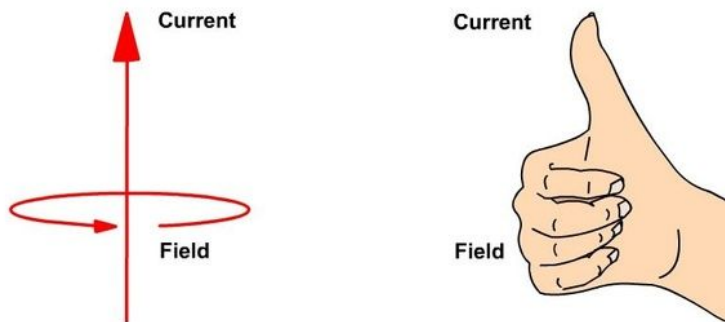




Current & Magnetic Fields

Straight Wire

Current flowing in a wire produces a circular **magnetic field** around the wire. The direction of this field is dictated by the '**Right-hand Grip Rule**'. Plotting compasses on a piece of paper with a wire running through it will demonstrate this rule.

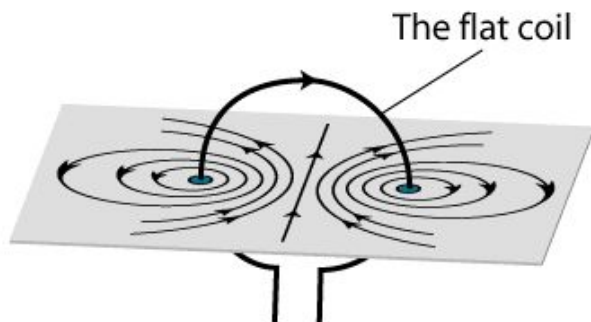


Right-hand Grip Rule for the magnetic field around a wire (Quora.com).

The strength of the field is **greater** when **closer** to the wire. Its strength can also be increased if the size of the **current** flowing through the wire is **increased**.

Plane Coil

A plane coil is a **single loop** of wire that **current** can flow through. When it does, **two opposing magnetic fields** are produced on either side of the loops that **point away** from its center. This is due to the different directions of current on either side of the loop and the **right-hand grip rule** for the direction of force.



Electromagnetic field around a plane coil (one-school.net).

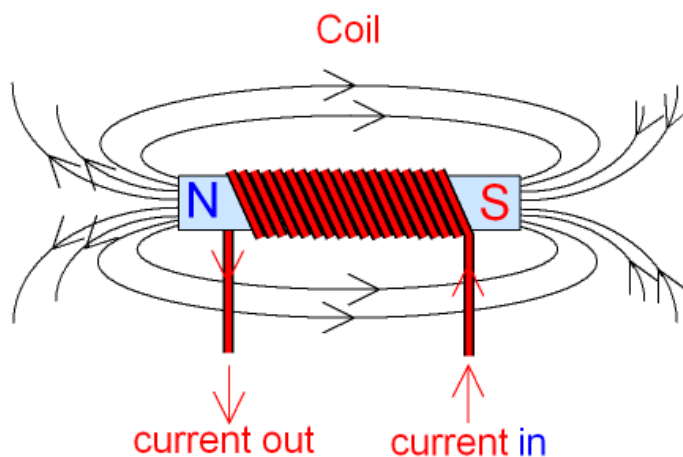
The field is **strongest inside the loop** where both magnetic fields are **concentrated** and act in the same direction.

Solenoids

A solenoid is a **coil of wire** with current flowing through. The shape of the magnetic field around it is similar to that of a bar magnet. The magnetic effect is **enhanced** as coiling the wire causes the field to align and form a giant single field, rather than lots of smaller perpendicular fields.



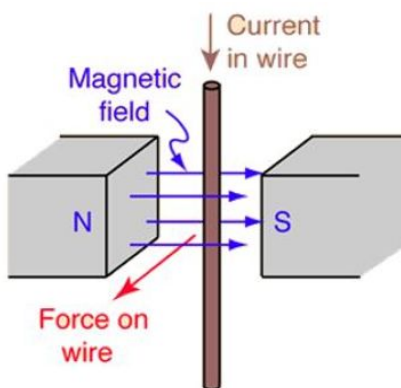
Inserting an **iron core** in the centre increases its strength as it is easier for magnetic field lines to pass through than the air. This is known as an electromagnet.



Magnetic field around a current-carrying coil of wire (gcsescience.com).

The Motor Effect

The magnetic field formed around a current-carrying wire can **exert a magnetic force** and interact with another magnetic field. This is the **motor effect**. When the wire is placed into a magnetic field so that the two fields sit at **right angles**, it will experience a **force at right angles** to the direction of current flow and the magnetic field lines.



The motor effect on a current-carrying wire (studyricket.co.uk).

The **length of the wire** exposed to the field can also change the **strength** of the force experienced around a wire. **Magnetic flux density (B)** is also a factor and it is similar to the magnetic field strength. This variable is measured in **Tesla** and is **proportional** to the **force** experienced.

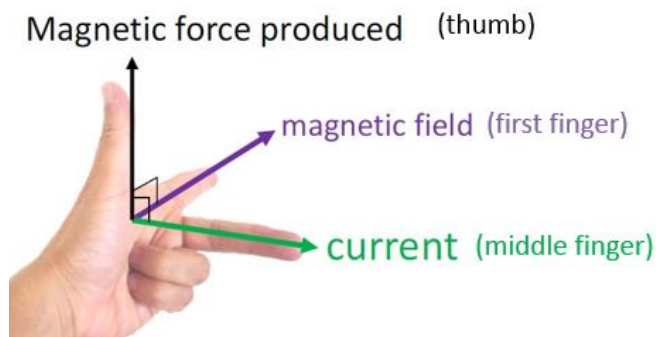


$$F = BIl$$

*F is force in Newtons (N), B is magnetic flux density in Tesla (T),
I is current in Amperes (A) and l is the length of the conductor in meters (m).*

Fleming's Left-hand Rule

The resulting motion caused by the magnetic force produced from the motor effect is shown with '**Fleming's Left-hand Rule**'. The current, magnetic field and force experienced all act at right angles to one another.

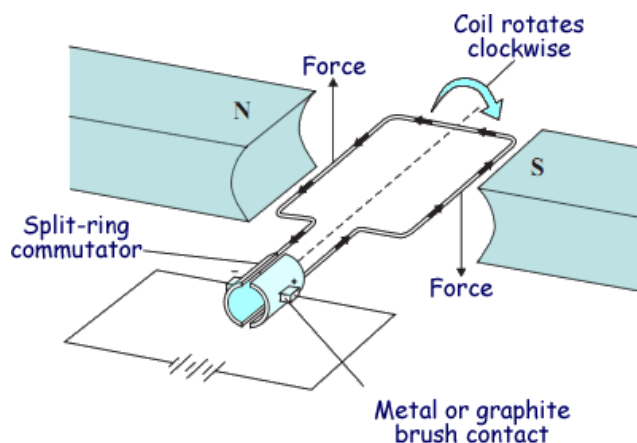


Fleming's Left-hand Rule (studyrocket.co.uk).

Using this analogy, an unknown direction of force, field or current can be found from two known directions by lining the left-hand up correctly.

Electric Motors

Using the concepts of the motor effect and Fleming's left-hand rule, simple electric motors can be built from a **loop of wire** that is free to **rotate** between two opposing, permanent magnetic poles. As current flows through the coil, it **experiences a force** away from one magnet and moves towards the second one where the process repeats, creating a **circular motion**.



Simple electric motor using the motor effect (cyberphysics.co.uk).



The direction of the current has to be **reversed** for every **half turn** of the loop, otherwise its movement will stop. A conducting split ring called a **commutator** is used to do this. If a **coil** of wire is used instead of a single loop, the effect of the magnetic field **increases** as there are more turns with current flowing through to be affected by the magnetic force.

