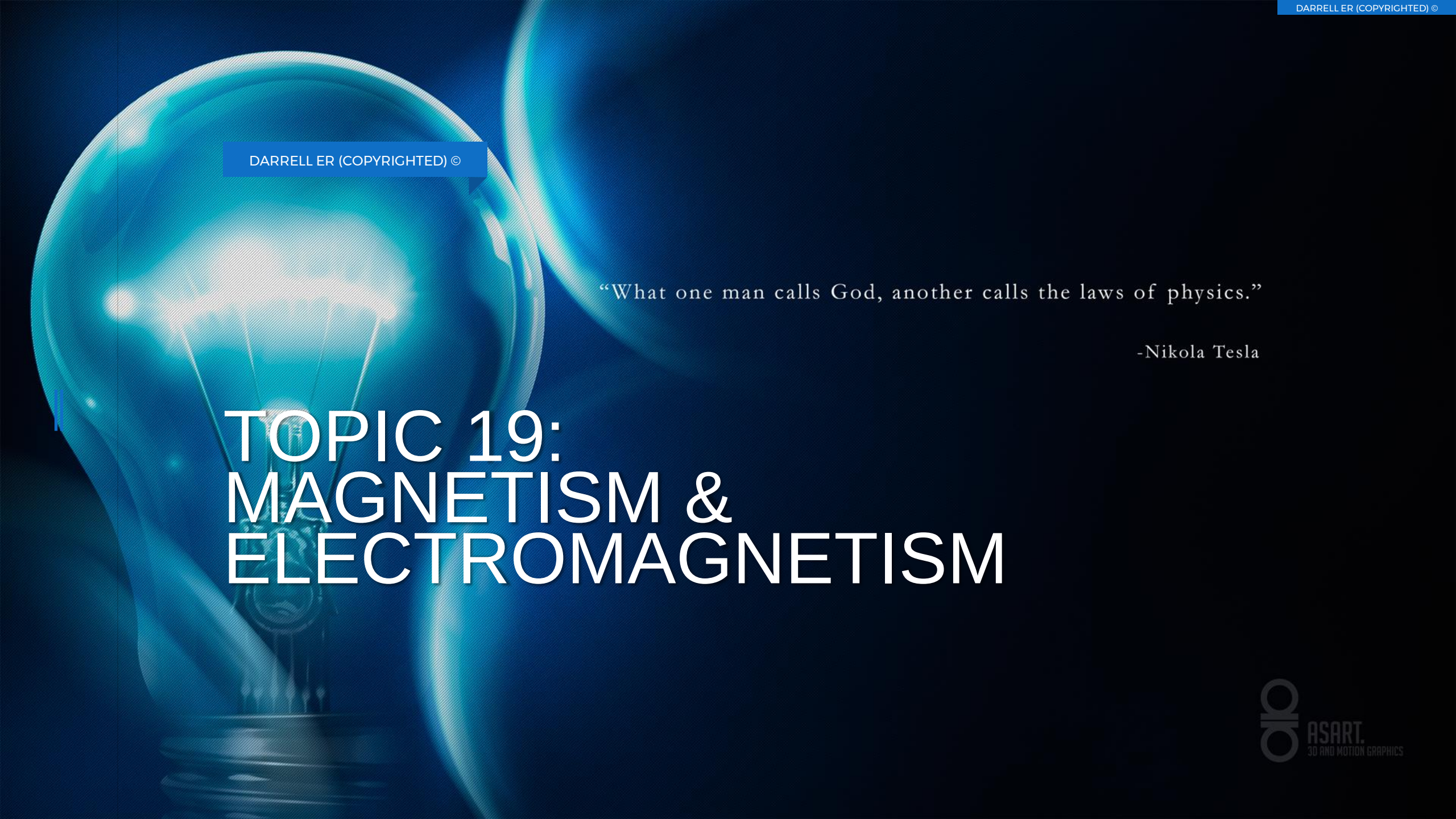

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"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 19: MAGNETISM & ELECTROMAGNETISM

THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Most difficult topic in combined Physics
- Need to be clear about the ‘Right hand grip rule’ & ‘Fleming’s left hand rule’

EXAM

- Will always be tested
- Usually appears in Section A & B

WEIGHTAGE

- Heavy overall weightage
- Constitute to around **7%** of marks for past 5 year papers

KEY CONCEPT

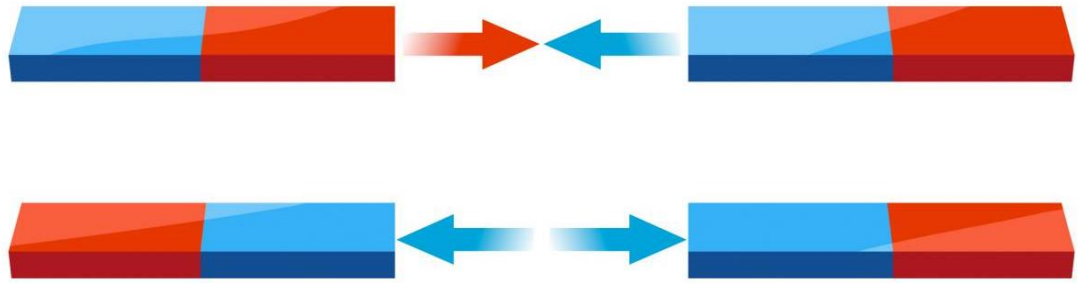
LAW OF MAGNETISM
MAGNETISATION METHODS
MAGNETIC FIELD

LAW OF MAGNETISM

MAGNETS

Like poles repel, unlike poles attract.

Only 2 magnets can repel each other. (true test for magnets)

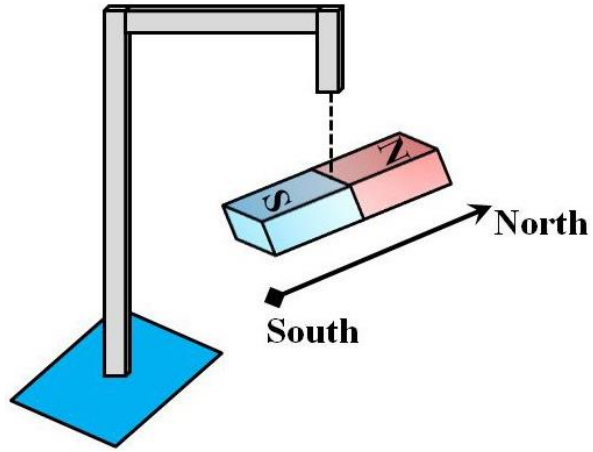


EARTH'S MAGNETIC FIELD

The earth has a magnetic field, with its magnetic south pole at the geographic north pole.

North pole (red) of a compass will be attracted to the geographic north pole and point there.

A freely suspended magnet will point in the north-south direction.



Hard & soft magnetic materials

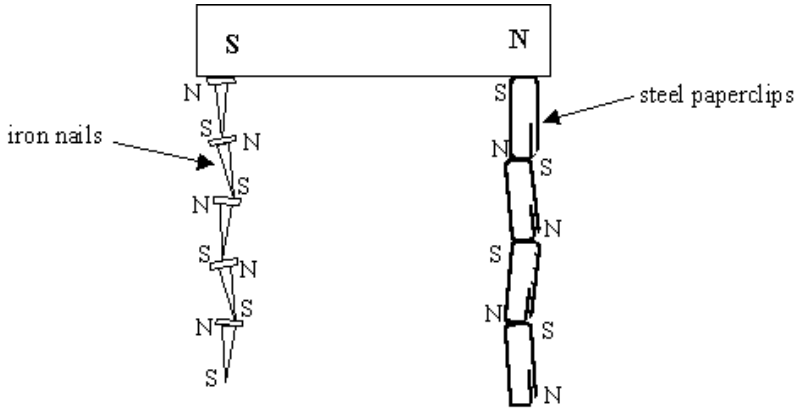
Soft magnetic materials are easy to magnetise and demagnetise and are thus used as temporary magnets.
(eg: iron)

Hard magnetic materials are difficult to magnetise and demagnetise are used as permanent magnets.
(eg: steel)

MAGNETISATION

INDUCED MAGNETISM

When a piece of unmagnetised magnetic material touches or is brought near to the pole of a permanent magnet, it becomes a magnet itself.



This explains why a magnet can attract an unmagnetised magnetic material as the material becomes an induced magnet.

The end nearer the original magnet has an opposite polarity to the magnet and possesses induced magnetism to attract magnetic objects.

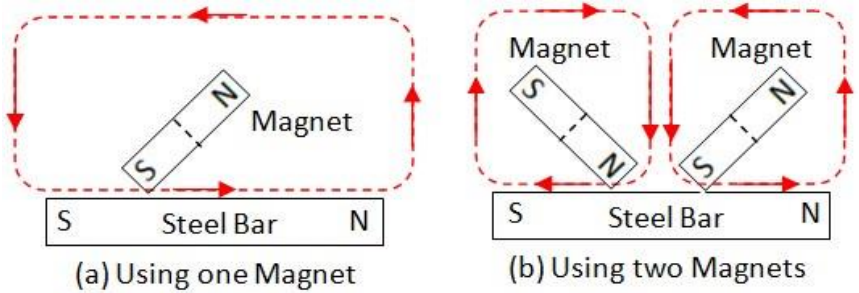
The strength of magnetism decreases as distance from the magnet increases.

***Demagnetism methods:**

- Alternating current in a solenoid
- Heating
- Hammering

MAGNETISM BY STROKING

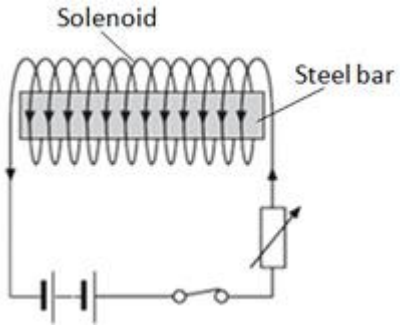
Magnetic material is stroked several times in the same direction along its length.



MAGNETISM BY DIRECT CURRENT

When the current passes through the solenoid, it creates a strong magnetic field, causing the magnetic domains to align and eventually creating a new magnet.

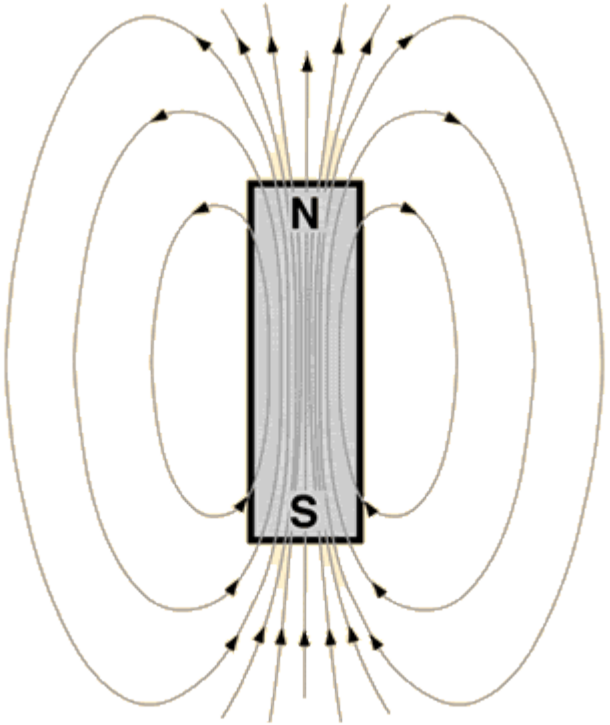
The **strength of the electromagnet** depends on the **current & the number of coils**.

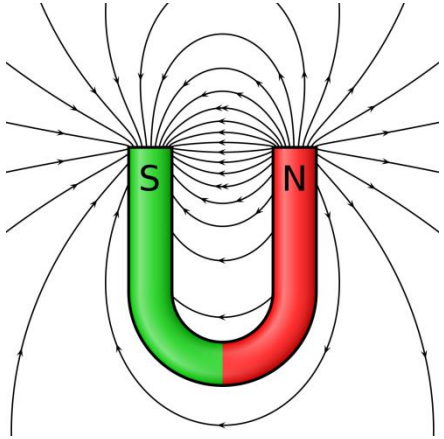


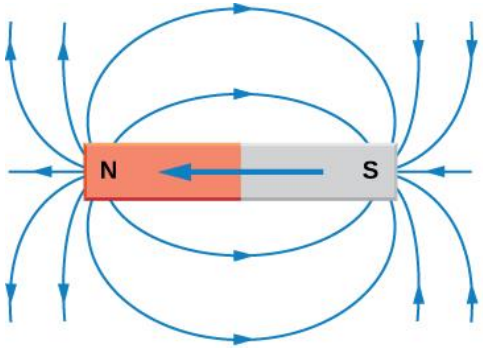
MAGNETIC FIELD

MAGNETIC FIELD

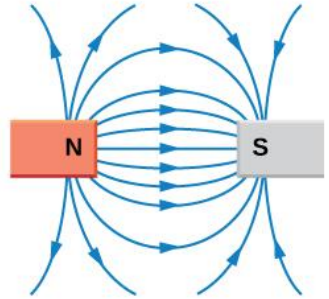
Magnetic field is a **region where a magnet will experience a magnetic force.**



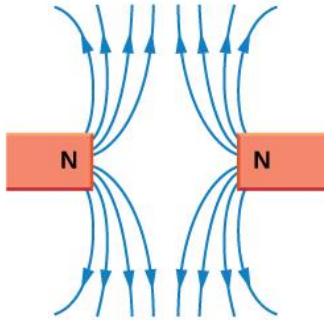




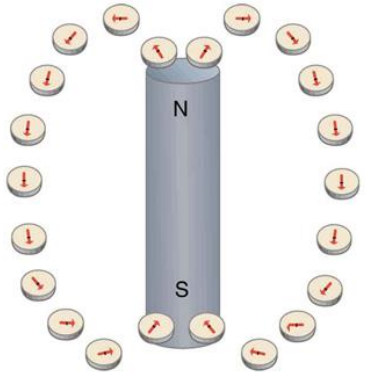
Magnetic field lines of a bar magnet

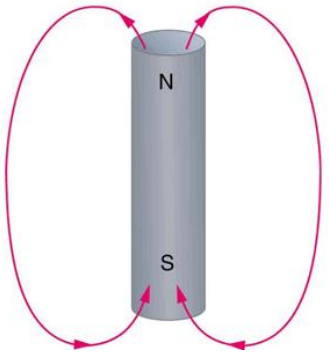


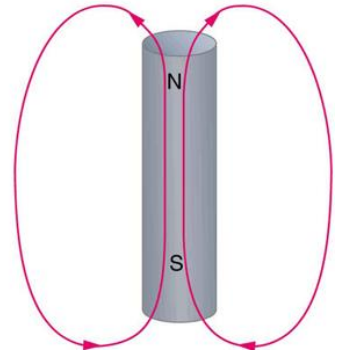
Magnetic field lines between unlike poles



Magnetic field lines between like poles







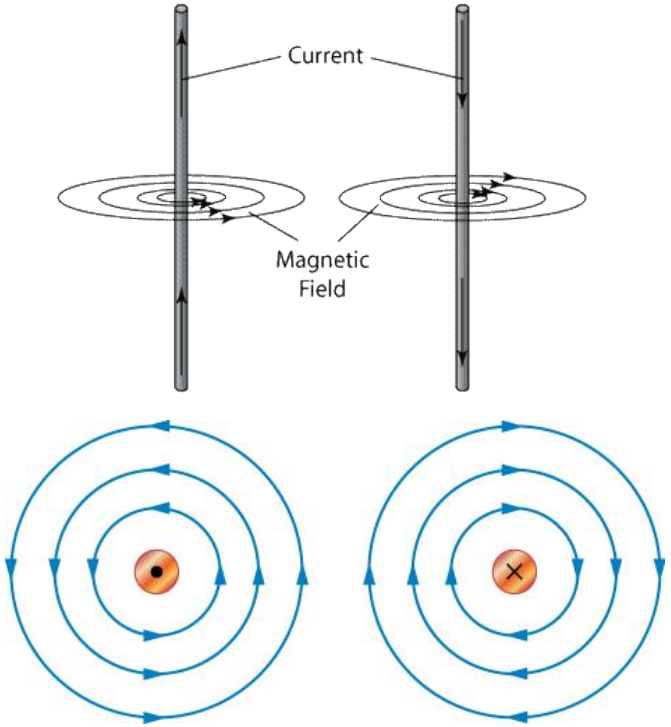
Tips:

- Magnetic field lines must never intersect or originate from the same point
- Closer magnetic field lines means the region's magnetic field strength is stronger

KEY CONCEPT

MAGNETIC EFFECT OF CURRENT
RIGHT HAND GRIP RULE
SOLENOID

MAGNETIC EFFECT OF CURRENT



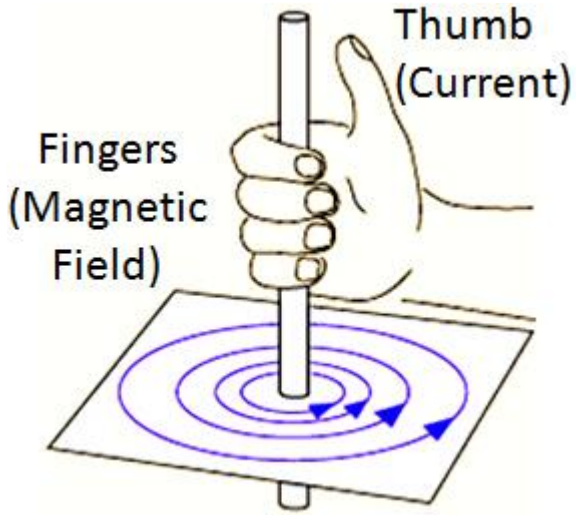
3D view

2D view

MAGNETIC EFFECT OF CURRENT

A current carrying conductor generates a magnetic field around itself.

To determine the direction of magnetic field, use the 'right hand grip rule'.

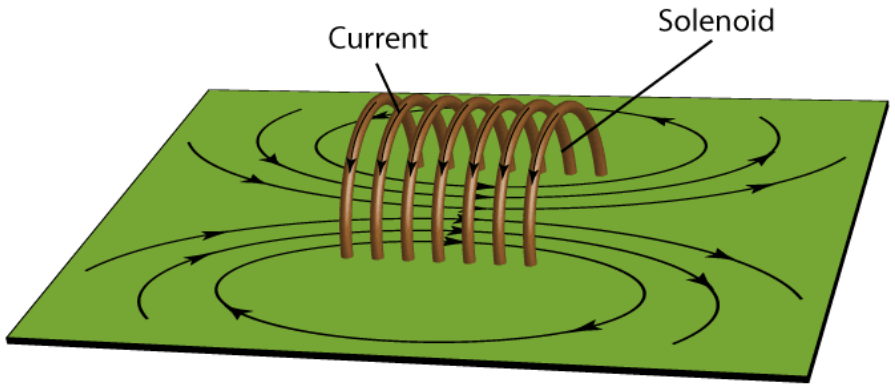


To remember, visualise an arrow.

If the arrow is **flying towards you**, it is a **'dot'**.
If the arrow is **flying away from you**, it is a **'cross'**.

Hence, 'dot' is out of the paper, towards you & 'cross' is into the paper away from you.

SOLENOID



Magnetic field generated by a solenoid. The field pattern is resemble a long bar magnet.

To increase magnetic field strength of solenoid:

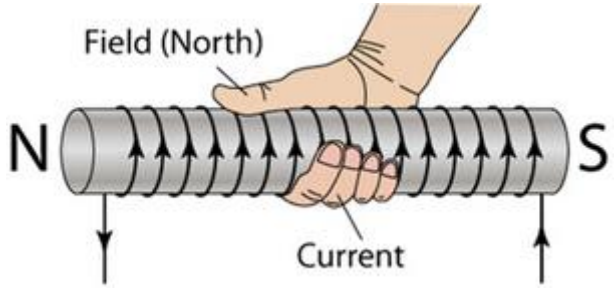
- use a larger current
- increase number of coils
- Place a soft iron core in the solenoid to concentrate the magnetic field

MAGNETIC EFFECT OF A SOLENOID

Magnetic field is stronger in the region inside the solenoid as the field lines in the region inside the solenoid are parallel. (has same strength along most of the inner part of the solenoid)

Magnetic field lines outside the solenoid are similar to those of a bar magnet because the solenoid has poles.

To determine the polarity of the solenoid, use the **right hand grip rule.**



Imagine gripping the wire with your right hand.

Your finger should curl to the direction of the current.

The direction your thumb is pointing towards is the north pole of the solenoid.

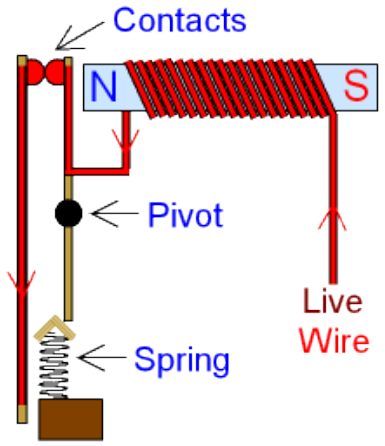
** 'Fingernails' is direction of current!*

KEY CONCEPT

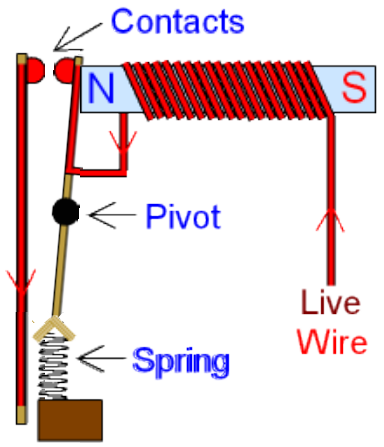
APPLICATION OF ELECTROMAGNETISM
CIRCUIT BREAKER, MAGNETIC RELAY, BELL
MOTOR EFFECT

CIRCUIT BREAKER

When current is normal:



When current exceeds:



CIRCUIT BREAKER

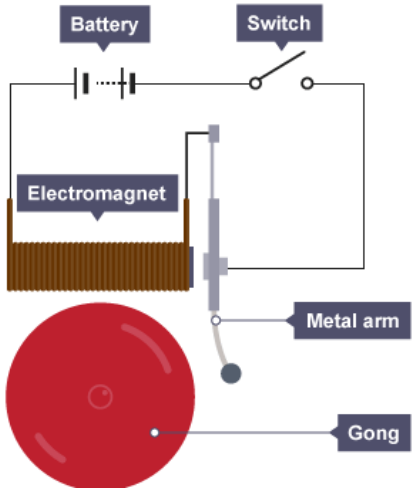
Device designed to switch off the current in a circuit when the current exceeds a certain value.

When current is too high, electromagnet will be strong sufficiently magnetised to attract the contact. This will break the circuit.

Spring will then pull the springy metal to the right and separate the contacts to stop the current from flowing.

After the fault is repaired; the contacts can be pushed back by pressing the reset button on the outside of the circuit breaker box.

ELECTRIC BELL



ELECTRIC BELL

When the switch is pushed, the circuit is closed and the soft iron cores are magnetized.

The armature is then attracted to the electromagnet and hammer strikes the bell.

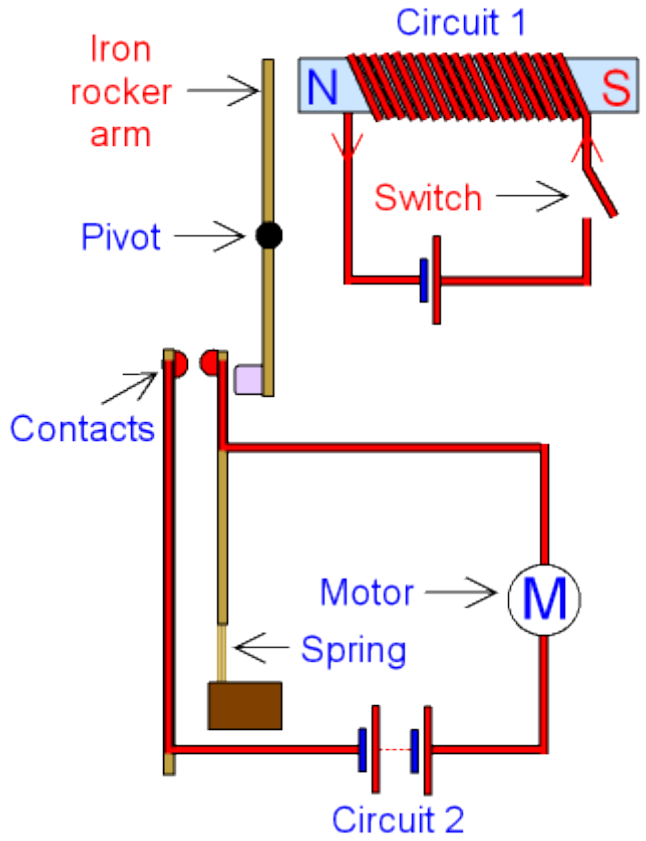
The forward movement of the armature breaks contact and cuts off current.

The soft iron cores lose their magnetism and the armature is no longer attracted.

The steel spring causes armature to return to its original position and remake contact, causing the cycle to repeat again.

The bell will continue to ring as long as the switch is closed.

MAGNETIC RELAY



MAGNETIC RELAY

A magnetic relay uses an electromagnet in one circuit to switch on another circuit.

A small current in the first circuit can be used to control a second circuit that requires a large current.

How it works

1) The first circuit is a simple electromagnet which requires only a small current.

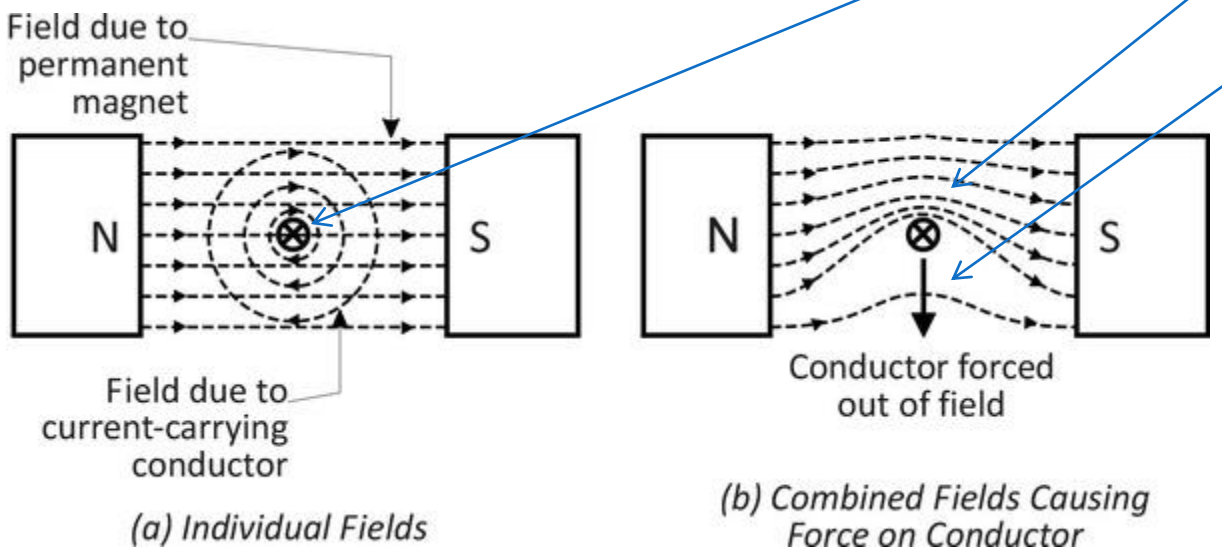
2) The current flows and magnetise the soft iron core to attract the soft iron armature.

3) The top end of the armature is raised as it swings about the pivot, closing the switch contacts of the second circuit.

4) When the switch for the first circuit is open, the soft iron core is demagnetised and the armature will return to its original position.

This device enables circuits to be constructed more efficiently. Furthermore, it can also be attached to thermistors or LDRs which can run on low current.

MAGNETIC FORCE ON A CURRENT CARRYING CONDUCTOR

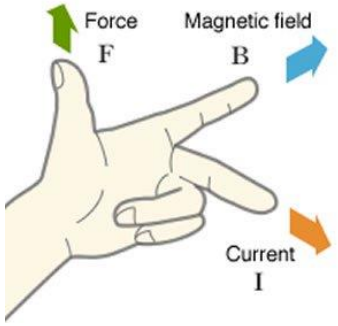


MAGNETIC FORCE ON A CURRENT CARRYING CONDUCTOR

Current + Magnetic Field → Direction of force
(motor effect)

1. A current carrying conductor will have its own magnetic field.
2. When the wire's magnetic field interacts with the external magnetic field, this will result in a stronger magnetic field on one side.
3. A **magnetic force** will act on the wire as a result of the uneven magnetic field.

FLEMING'S LEFT HAND RULE

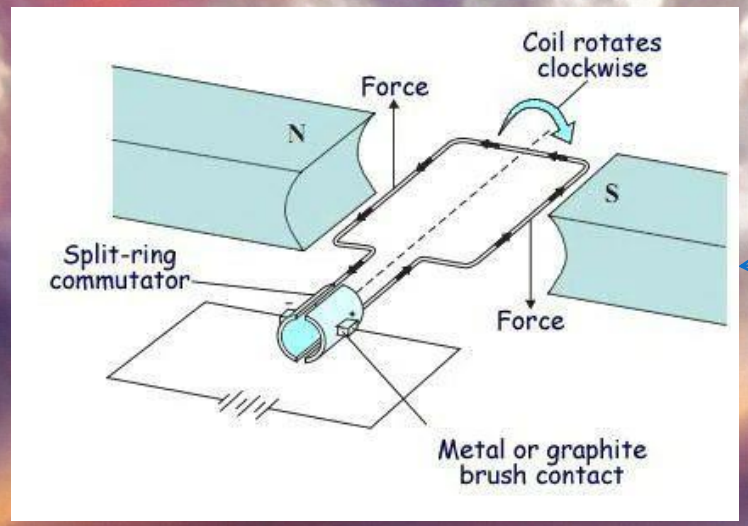


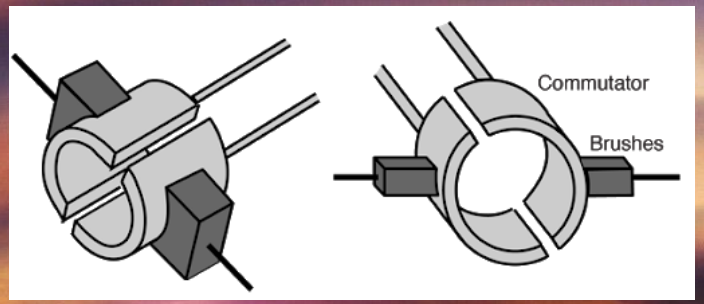
Tips to remember: Goldilocks & the 3 bears story.

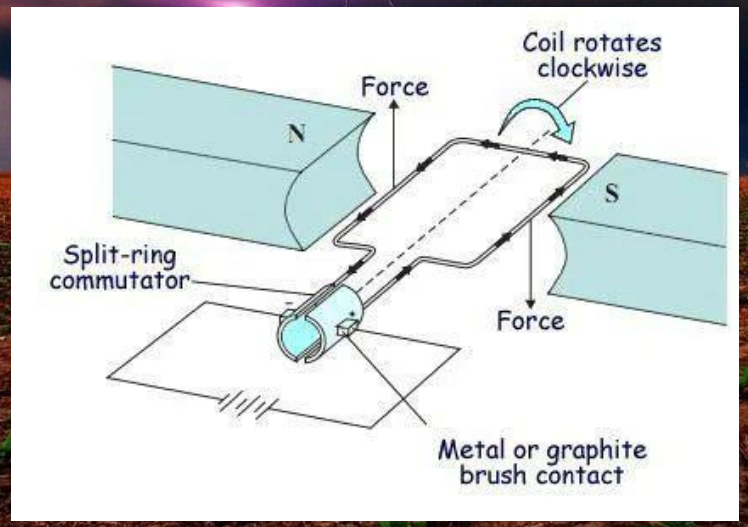
***F**orce is **f**ather, **M**agnetic field is **m**other, **C**urrent is **c**hild.*

The mother bear ownself cook but ownself eat all the porridge. So:

Father bear is like 'you good you good.' (**thumb**s up)
Mother bear is the culprit. (point at her with **index finger**)
Child is is 'FML' (**middle finger**)







DIRECT CURRENT (D.C) MOTOR

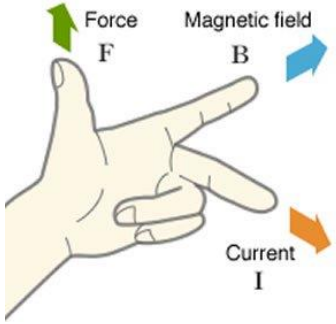
1) Using Fleming's left hand rule, the **left side of the coil** experiences an **upward force** while the **right hand side** experiences an equal **downward force**.

2) This makes the coil **rotate clockwise** until it reaches a vertical position.

At the vertical position, the current is cut off because the **split ring commutator** is not in contact with the carbon brushes, but momentum of the coil will carry it slightly beyond the vertical position.

3) The direction of current is reversed and this produces a **clockwise moment again**. The split ring commutator will be in contact with the carbon brushes and keep the coil rotating.

*Fleming's Left hand rule:



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