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Physics Topic P15 Waves, electromagnetism & space – Electromagnetism

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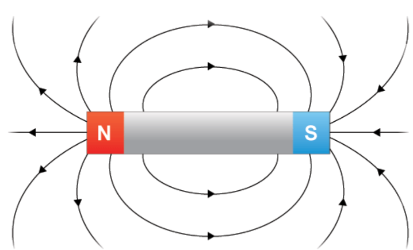
Section 1: Electromagnetism Key Terms

Pole	The **places** on a magnet where the **magnetic forces** are **strongest**.
Magnetic Field	The **area** around a magnet where a **force acts** on another magnet or magnetic material.
Repel	Occurs when two **like poles** are brought close together. The magnets **push apart**.
Attract	Occurs when two **opposite poles** are brought close together. The magnets **move together**.
Permanent magnet	A magnet that produces its **own magnetic field**.
Induced magnet	A magnetic material that **becomes a magnet** when it is placed in a **magnetic field**. When **removed** from the **field** it **quickly loses its magnetism**.
Magnetic material	There are four magnetic materials: **iron**, **steel**, **cobalt** and **nickel**.
Compass	Compasses contain small bar magnets which **points** to the **north pole** of the **Earth's magnetic field**.
Solenoid	A solenoid is a long **coil of wire** that produces a controlled magnetic field.
Electromagnet	A **solenoid containing an iron core** which increases its strength.
Motor effect (HT)	The **force produced** between a **conductor** carrying a current **within a magnetic field** and **the magnet producing the field**.
Magnetic flux density (HT)	A measure of the strength of a magnetic field.

Section 2: Magnetic fields

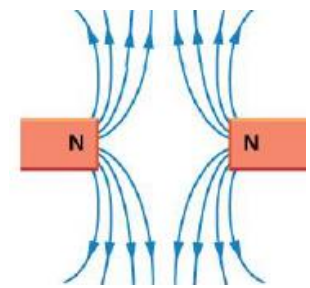
The **magnetic field lines** of a bar magnet curve around from the **north** pole of the bar magnet to the **south pole**.
The **field lines** always go from **north** to **south** and **never touch**.



Section 2: Magnetic fields (continued)

Like poles repel.

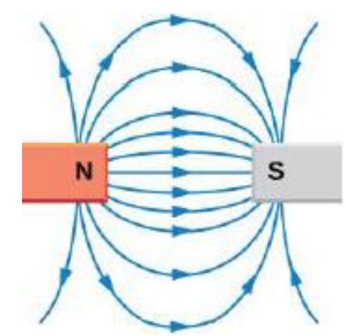
When **two north poles** (or two south poles) are placed together, they will **repel** each other.



Unlike poles attract.

When a **north pole** and a **south pole** are placed together, they will **attract**.

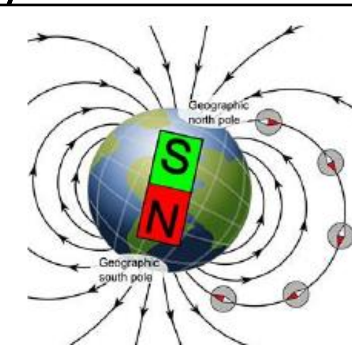
Attraction and repulsion between
two magnetic poles are examples of **non-contact forces**.



Induced magnetism is **magnetism** created in an **unmagnetised magnetic material** when the material is **placed in a magnetic field**.

Steel is used **instead** of **iron** to make **permanent magnets** because steel **does not lose** its **magnetism easily** but **iron does**.

The **Earth** behaves as if there is a **bar magnet** inside it. The geographic north pole is a **magnetic south pole**. A **compass** will point towards **geographical north** and is the **north-seeking pole**.
We know it is the **core** of the Earth that is magnetic(not the whole thing) because a compass at the **north pole** points below your feet.



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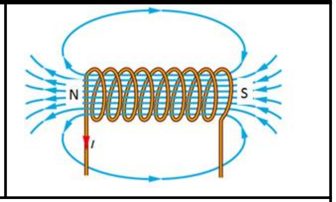
Section 3: Magnetic fields of electric currents

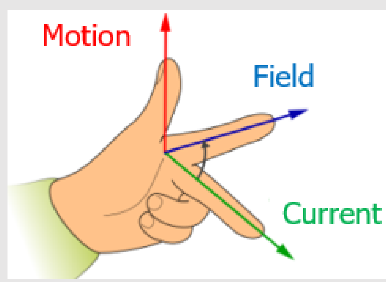
We can increase the strength of the magnetic field by putting a **magnetic** (e.g. iron) **core** in the **solenoid** (long coil of wire.) The magnetic field in a **solenoid** is concentrated **inside the coil in a uniform direction**, otherwise it acts in the same way as a bar magnet.



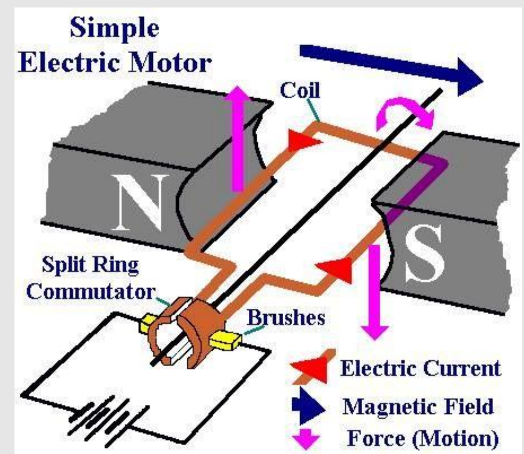
Increasing current	**Increasing current** makes the **magnetic field stronger**. **Reversing** the **direction** of the current **reverses the magnetic field lines**.
Electromagnet	An electromagnet is a **solenoid** that has an **iron core.** It consists of an **insulated wire** wrapped around an iron bar.
Increasing the force of a solenoid	• Add an **iron core** • Increase the **number of coils** of wire • Increase the **current** • Move the magnetic material **closer** to the solenoid.

Section 4: The motor effect (HT)

When a **conductor carrying a current is placed in a magnetic field, the magnet producing the field and the conductor exert a force on each othe**r. This can be used to create a motor.

Fleming's left hand rule	• Fleming's left hand rule shows the various **directions of actions** in an **electric motor.** • Thumb – direction of the **magnetic force** • First finger – direction of the **magnetic field** • Second finger – direction of the **current** in the wire.	
Flux density	**Magnetic flux density** is a **measure** of the **strength** of a **magnetic field**. It is the number of lines of magnetic flux in a given area. F=B x I x L Force = magnetic flux density x current x length	Force - newtons, N Magnetic flux density – tesla,T Current – amps, A Length – metres, m

Section 5: An electric motor (HT)

Electric motor	An electric motor is a device that makes use of the **motor effect.** The following statements explain how the electric motor creates a **turning force**: • The power supply applies a **potential difference** across the coil • A **current flows** through the coil • A **magnetic field** is created around the coil • The magnetic field **interacts** with the **magnetic field** of the **permanent magnets** • This creates a force that makes the **coil spin**. 
Increasing size of the turning force by:	• Increasing the **current** • Increasing **strength** of **magnetic field** • Increase the **number of turns** on the **coil** of wire • Adding an **iron core** inside the **coil.**
Reverse direction of force by:	• Reverse **poles** of **magnet** • Reverse **current**

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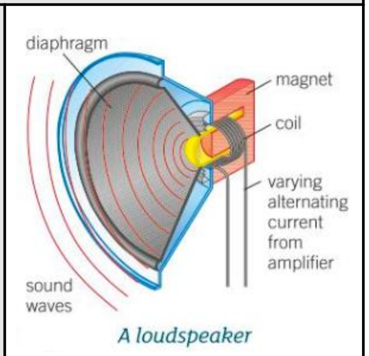
Section 6: Loudspeakers and headphones (triple HT)

Loudspeakers and headphones **use the motor effect** to convert variations in current in electrical circuits to **pressure variations** in **sound waves**. They are known as **moving coil sound devices**.

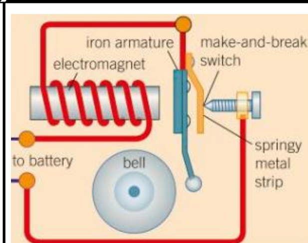
- A coil that experiences a current in a magnetic field experiences a force (**the motor effect**)
- The **current** from the **amplifier varies**, so the **current** in the **coil varies**, and so **the force exerted** on the **coil varies**
- The **force moves the coil**
- The coil moves the **diaphragm** making it vibrate.
- The **vibrating** diaphragm sets up **compressions** and **rarefactions** in the **surrounding air** which **produces sound** waves.



A loudspeaker

Section 7: Electromagnets in devices (triple)

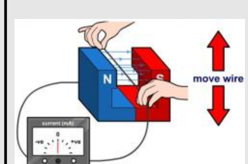
Electromagnets used in many devices	• Scrapyard crane • Circuit breaker • Electric bell (see diagram) • Relays



An electromagnet works in a circuit breaker, electric bell or relay by attracting an **iron armature** which **opens a switch**.

Section 8: The generator effect (triple HT)

The **generator effect** is the effect of **inducing** a **potential difference** using a **magnetic field**. When a **conductor** crosses **through** the **lines of a magnetic field**, a **potential difference** is **induced** across the **ends of** the **conductor**. If the conductor is part of a complete circuit, **the induced potential difference** makes an **electric current** pass around the circuit.



Section 8: The generator effect (triple HT) continued

The wire and magnetic field must **move perpendicular** to each other to **induce a current**. If they move parallel to each other, **no current** is induced.

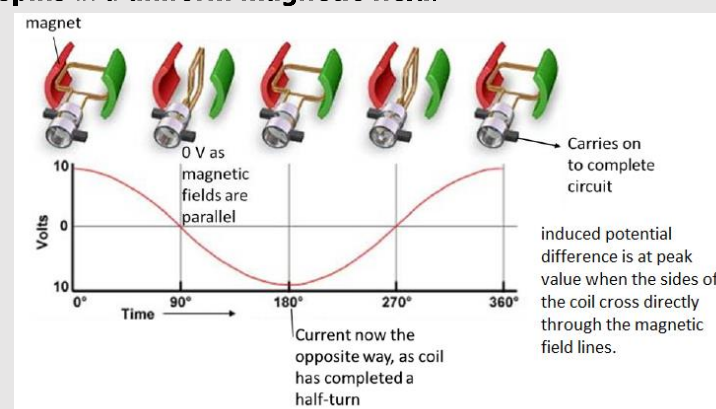
Factors **affecting size** of induced potential difference/induced current	• **Speed of movement**: Faster the conductor passes through the lines of magnetic field, the bigger the induced potential difference/current. • Use a **stronger magnet** (Stronger magnet larger induced potential.)
Factors **affecting direction** of induced potential difference/induced current	• **Reverse magnet** • **Reverse movement**

Section 9: The alternating-current generator (triple HT)

Depending on the set up, the **generator effect** can be used in an **alternator** to **generate ac** and in a **dynamo** to generate **dc**.

Alternator

ac is generated in an **alternator**. It is made up of a **coil** that **spins** in a **uniform magnetic field**.



Each end of the coil of wire spin inside, and make contact with, a complete loop of conductor that's connected to the rest of the circuit. Since every **180° turn** of the coil the **current flips direction**, you get **ac**.

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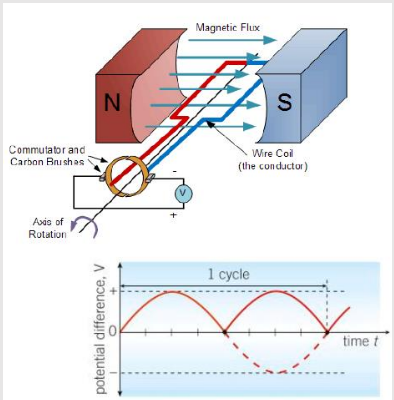
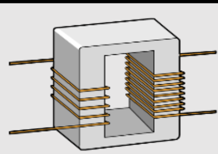
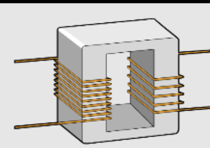
Section 9: The alternating-current generator (triple HT) cont.'

Dynamo	**dc** is generated in an **dynamo**. To prevent the current flipping direction every half-turn, a clever **split ring commutator** is used. This ensures that the **current** is **restricted** to **one direction only in the coil** – direct potential difference.



Section 10: Transformers (triple HT)

Transformers are **used to increase or decrease** the **size** of an **alternating potential difference**. It **only works** with **ac** as a **changing magnetic field** is **necessary to induce ac** in the secondary coil. Transformers have a primary coil, a secondary coil and an iron core (iron used as **easily magnetised**.)

Step-up transformer	Step-down transformer
	
More turns on secondary coil than on primary, therefore **increases voltage**. Increasing voltage **decreases the current** in the wires which means **less resistance**. Less resistance means **less energy lost as heat**, therefore it is **more efficient** to transmit electricity at high voltage.	Fewer turns on secondary coil than on primary, therefore **decreases voltage**. Reducing the voltage makes it **safer** to use in the **home**.

Section 11: Transformers in action (triple HT)

In transformers, the ratio of the potential difference across the coils is equal to the ratio of the number of turns on each coil. This is the **transformer equation**.

Transformer equation	$\frac{V_p}{V_s} = \frac{N_p}{N_s}$	V_p = potential difference across primary coil (V) V_s = potential difference across secondary coil (V) N_p = number of turns on primary coil N_s = number of turns on secondary coil

In a step-up transformer, $V_s > V_p$
In a step-down transformer $V_s < V_p$
In a step-up transformer Ns>Np
In a step-down transformer Ns<Np

Assuming Transformers are 100% efficient, the electrical power input is equal to the electrical power output. This results in a **transformer efficiency** equation.

Transformer efficiency	$V_p \times I_p = V_s \times I_s$	V_p = primary potential difference (V) I_p = primary current (A) V_s = secondary potential difference (V) I_s = secondary current (A)

The National Grid supplies electricity from power stations via a series of cables and transformers to customers at **high voltages** to **reduce energy loss**. A **high grid potential difference** reduces the **current** that is needed, so it reduces the **heating effect** and hence **reduces power loss** and makes the system more **efficient**.