- Triple Science Content only in purple
- Triple Science and Higher Content Only in blue

GCSE AQA Physics Topic 7

7 Magnetism and Electromagnetism

7.1 Permanent and Induced Magnetism, Magnetic Forces, and Fields

7.1.1 Poles of a Magnet

- **Poles of a Magnet**: The points where the magnetic forces are strongest.
- **Interactions**:
  - Like poles repel each other.
  - Unlike poles attract each other.
- **Types of Magnets**:
  - **Permanent Magnet**: Produces its magnetic field.
  - **Induced Magnet**: Becomes a magnet when placed in a magnetic field; loses magnetism quickly when removed from the field.
- **Forces**: Attraction and repulsion between magnetic poles are examples of non-contact forces.

7.1.2 Magnetic Fields

- **Magnetic Field**: The region around a magnet where it exerts a force on another magnet or magnetic material (e.g., iron, steel, cobalt, nickel).
- **Field Strength**:
  - Strongest at the poles of the magnet.
  - Decreases with distance from the magnet.
- **Direction of Field**: From the north-seeking pole to the south-seeking pole.
- **Magnetic Compass**: Contains a small bar magnet; aligns with Earth's magnetic field.
- **Earth's Magnetic Field**: Causes the compass needle to point north.

7.1.3 Earth's Core

Seismic Waves and the Earth's Interior

- **Seismic waves** generated by earthquakes help us understand the structure of the Earth's interior.
  - There are two main types of seismic waves:
    1. **P-waves (Primary waves):**

        - **Longitudinal** waves.
        - Can travel through both **solids** and **liquids**.
        - Travel faster than S-waves.
    2. **S-waves (Secondary waves)**:
        - **Transverse** waves.
        - Can travel only through **solids**, not liquids.

Evidence for the Structure of Earth's Core:

- When seismic waves travel through the Earth, they change speed and direction depending on the materials they pass through.
- **P-waves** slow down when they enter the **liquid outer core**, but they can still pass through it.
- **S-waves** do not travel through the outer core at all, providing strong evidence that the outer core is **liquid**.
- By studying how seismic waves behave, scientists have inferred that:
    - The **inner core** is **solid**, composed mainly of **iron** and **nickel**.
    - The **outer core** is **liquid**, also composed of **iron** and **nickel**.
    - The **mantle** above the core is solid but behaves like a very slow-moving liquid over geological time.

Summary of Earth's Structure:

1. **Crust**: Solid outer layer.
2. **Mantle**: Semi-solid, flows very slowly.
3. **Outer core**: Liquid, made of iron and nickel.
4. **Inner core**: Solid, also made of iron and nickel.

7.1.4 Solenoids and Electromagnets

What is a Solenoid?

- A **solenoid** is a long coil of wire wound in a cylindrical shape. When an electric current passes through the wire, it creates a magnetic field.
- The magnetic field inside a solenoid is **strong and uniform**, resembling the field of a bar magnet, with clearly defined **north** and **south poles**.

Electromagnets:

- When a **solenoid** is wrapped around an **iron core**, it becomes an **electromagnet**. The iron core increases the strength of the magnetic field produced.
    - **Electromagnets** are useful because:
        - They can be **turned on and off** by controlling the electric current.

- The strength of the magnetic field can be **varied** by changing the current or the number of coils.

Solenoids and Electromagnets

A **solenoid** is a **coil of wire** with a current flowing through it.
It produces a **magnetic field similar to a bar magnet**.

Magnetic field of a solenoid

- Strong and **almost uniform** inside the coil.
- Direction depends on current flow (use the right-hand grip rule).

Making electromagnets stronger:

- Increase **number of turns** on the coil.
- Increase **current**.
- Add a **soft iron core** inside the solenoid.

Uses of electromagnets:

- Electric bells
- Relays
- Motors
- Scrap yard cranes

The Motor Effect

When a **current-carrying wire** is placed in a **magnetic field**, it experiences a **force** — this is called the **motor effect**.

⚙️ Factors affecting the force:

1. **Magnetic field strength (B)**
2. **Current (I)**
3. **Length of wire in field (L)**
4. **Angle** — maximum force when the wire is **at 90°** to the magnetic field.

F=BI

Where:

- **F** = force (N)
- **B** = magnetic flux density (T)
- **I** = current (A)
- **L** = length (m)

Fleming’s Left-Hand Rule (for motors)

Use your **left hand** to find the direction of **force** on a conductor:

Finger	Represents
First finger	Field (magnetic field – north to south)
Second finger	Current (positive to negative)
Thumb	Motion / Force direction

The rule helps predict which way the wire will move in the field.

Electric Motors

How a simple motor works

1. A **coil of wire** carrying a **current** sits in a **magnetic field**.
2. Each side of the coil experiences an **opposite force** (motor effect).
3. The forces cause the coil to **rotate**.
4. A **split-ring commutator** reverses the current every half turn → keeps the coil spinning in the same direction.

Uses

Electric motors are found in fans, drills, car wipers, and many everyday devices.

Electromagnetic Induction

Induction = producing a **potential difference (voltage)** across a conductor when it **moves through a magnetic field**.

How to induce a potential difference:

- Move a **magnet in and out of a coil**, or
- Move a **coil near a magnet**, or
- Move a **wire** through a **magnetic field**.

If the conductor is part of a **complete circuit**, a **current flows** — this is an **induced current**.

To increase the induced potential difference:

- Move the magnet **faster**.
- Use a **stronger magnetic field**.
- Add **more turns** to the coil.

Direction of induced current

- Determined by **Fleming's Right-Hand Rule** (for generators):
  - **Thumb** = motion (movement)
  - **First finger** = field (north to south)
  - **Second finger** = current (from positive to negative)

Alternating Current (AC) and Direct Current (DC)

- **AC (Alternating Current)**:
  Current **reverses direction repeatedly** (used in mains electricity).
  Produced by **alternators** or **AC generators**.

- **DC (Direct Current)**:
  Current flows **in one direction only**.
  Produced by **cells, batteries, and dynamos**.

Electric Generators

AC Generator (Alternator)

- A **coil rotates** in a magnetic field.
- As the coil turns, the **magnetic field through it changes**, inducing a **potential difference**.
- Because the coil keeps rotating, the **direction of current reverses every half turn**, producing **AC**.
- Uses **slip rings** to maintain continuous contact with the circuit.

DC Generator (Dynamo)

- Works like an alternator but uses a **split-ring commutator** instead of slip rings.
- The commutator **reverses the connection** every half turn → keeps the current **flowing in one direction (DC)**.

Transformers

Transformers **change the potential difference (voltage)** of an alternating current.

How they work:

- An **alternating current** in the **primary coil** produces a **changing magnetic field** in the **iron core**.
- This changing field **induces a voltage** in the **secondary coil**.

🔌 Types:

- **Step-up transformer:** Increases voltage (more turns on secondary).

- **Step-down transformer:** Decreases voltage (fewer turns on secondary).

Transformers only work with **AC**, because DC doesn't produce a changing magnetic field.

Loudspeakers and Microphones

Loudspeakers

- Convert **electrical signals (current)** into **sound waves**.

How they work:

1. A **coil of wire** is attached to a **cone**.
2. The coil sits in a **permanent magnetic field**.
3. When a current passes through the coil, it experiences a **force** (motor effect).
4. The direction of current changes repeatedly (AC), causing the coil (and cone) to **vibrate**.
5. The vibrating cone **creates sound waves** in the air.

🎙️ Dynamic Microphones

- Work the **opposite way** to a loudspeaker.

- Convert **sound waves** into **electrical signals**.

How they work:

1. Sound waves cause a **diaphragm** to vibrate.
2. The diaphragm moves a **coil** within a **magnetic field**.
3. This movement **induces a potential difference** in the coil (electromagnetic induction).
4. The changing voltage represents the **sound wave**.

   The magnetic field inside a solenoid is **parallel** and **evenly spaced**.

- **Outside the solenoid**, the magnetic field is similar to that of a **bar magnet**, with field lines exiting from the **north pole** and entering the **south pole**.

Practical Uses of Electromagnets:

1. **Electric motors**: Electromagnets are used to generate movement in motors.
2. **Relays**: Used in switches to turn circuits on and off remotely.
3. **Magnetic cranes**: Used to lift heavy iron or steel objects in junkyards and factories.

4. **Loudspeakers**: Use electromagnets to convert electrical signals into sound by vibrating a diaphragm..