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# Unit 12 – Magnetism and Motor Effect

This unit explores the fascinating link between electricity and magnetism, known as electromagnetism. Students will learn how magnets and electric currents create magnetic fields, how to use compasses and field lines to visualise these fields, and the difference between permanent and induced magnets. We examine how wires carrying a current can experience a force in a magnetic field, leading to practical applications such as electric motors.

## What is Magnetism?

**Magnetism** is a force generated by the movement of electric charges.

Basic rule:

- **Like poles repel** (N–N or S–S)
- **Opposite poles attract** (N–S)

| Material | Magnetic? |
|---|---|
| Iron | ✅ |
| Steel | ✅ |
| Cobalt | ✅ |
| Nickel | ✅ |
| Copper, Aluminium, etc. | ❌ |

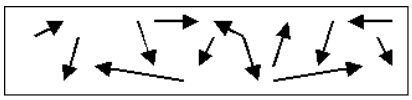
# Permanent vs Induced Magnets

## Permanent Magnets

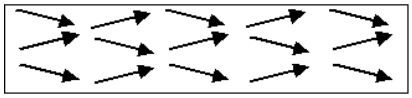
- Always magnetic
- Fixed north and south poles
- Found in:
  - Speakers
  - Compasses
  - Electric generators

## Induced Magnets

- Not naturally magnetic — must be magnetised
- Can become temporary magnets when stroked with a permanent magnet (aligns domains)
- Lose magnetism when:
  - Left alone
  - Given a knock or heated
- **Used in electromagnets**



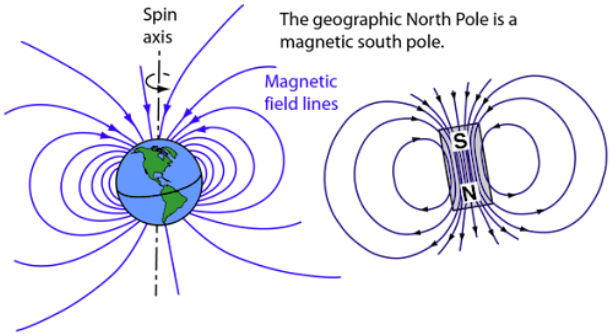
Unmagnetised



Magnetised

# Magnetic Fields

- **Magnetic field lines** show the force around a magnet:
  - Direction: **From North to South**
  - Closer lines = **stronger field**
- Use a **plotting compass** to investigate field shape and direction.



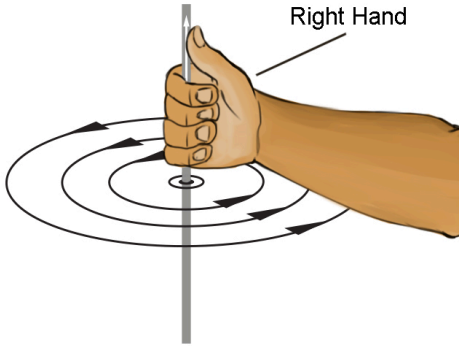
## Earth's Magnetic Field

- Earth's core is magnetic, creating a giant field.
- A compass aligns with these lines.
- **Important twist**:
  - Earth's **geographic North Pole is actually a magnetic south pole**.

# Electricity and Magnetism

## Current-Carrying Wire

- A current in a wire generates a circular magnetic field.
- Use the right-hand rule to find direction:
  - Thumb = current
  - Fingers curl = field direction




### Field Strength Depends On:

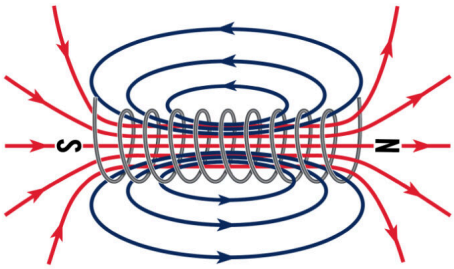
| Factor | Effect |
| --- | --- |
| Size of current | Larger current = stronger field |
| Distance from wire | Closer = stronger |

# Solenoids

**A solenoid is a coil of wire carrying a current. Its magnetic field mimics a bar magnet.**

### Features:

- The field inside is strong and uniform
- Iron core boosts strength
- Outside field is weak due to cancellation




### Factors Affecting Solenoid Strength:

- Current size
- Number of coils
- Core material (soft iron is best)
- Length and cross-sectional area

# Interactions Between Fields

### Current-Carrying Wire Near a Magnet:

- Wire's field + magnet's field = **resultant force**
- The wire is pushed in a direction **perpendicular** to both the current and the magnetic field.

### Visualising:

- If:
  - Magnet poles are on the x-axis
  - Current flows on the y-axis
- Then:
  - Force is felt along the z-axis (right angles to both)

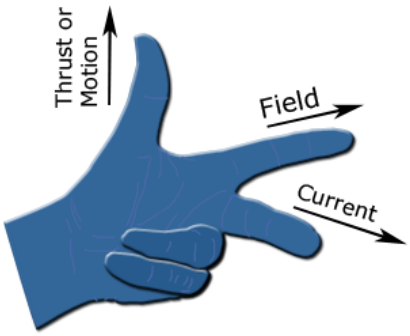
**Key Principle**: **Magnetic force is caused by the interaction of two magnetic fields.**

# Fleming's Left-Hand Rule

Used to work out the direction of:

- Force (Motion)
- Magnetic Field
- Current (Conventional)

| **Finger** | **Direction** |
|---|---|
| First | Field (North to South) |
| Second | Current (Positive to Negative) |
| Thumb | Motion (Force) |




## Equation for Force:

$$F = B \times I \times L$$

Where:

- **F** = Force (N)
- **B** = Magnetic flux density (T)
- **I** = Current (A)
- **L** = Length of wire in field (m)

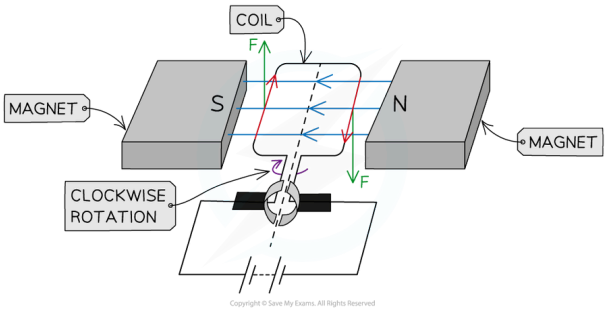
# Electric Motors

- Wire coil is placed between two magnets
- When current flows:
  - One side of the coil is pushed **up**
  - Other side pushed **down**
- The coil **rotates continuously**

🔁 Use **Fleming's Left Hand Rule** to determine which side moves in which direction.

🧰 **Motor Components**:

- Coil of wire
- Magnetic field
- Split-ring commutator (for full rotation — GCSE extension)

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