



# Cambridge (CIE) IGCSE Physics



Your notes

## Simple Phenomena of Magnetism

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## Magnetism

### Forces between magnetic poles

- The ends of a magnet are called **poles**
- Magnets have two poles: a **north** and a **south**
- Magnetic forces are **strongest** at the poles

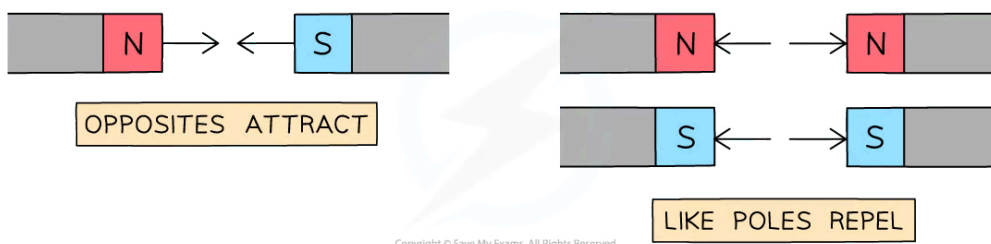
### North and south poles of a magnet



#### *Poles of a Magnet*

- When two magnets are held close together, there will be a force between the magnets
  - **Like poles repel** (push each other apart)
    - A north pole will repel a north pole
    - A south pole will repel a south pole
  - **Opposite poles attract** (are pulled toward each other)
    - A north pole will be attracted to a south pole

### Magnet attraction and repulsion



#### *Opposite poles attract and like poles repel*

- The attraction or repulsion between two magnetic poles is an example of a **non-contact force**



#### Examiner Tips and Tricks

In your exam, you need to be able to predict the interaction that will occur between magnets when given their physical arrangement.



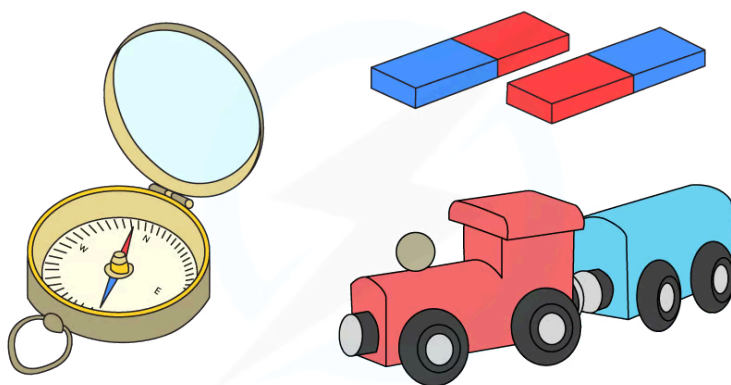
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# Uses of magnets

## Uses of permanent magnets

- Uses of permanent magnets include:
  - **Compasses:** for thousands of years humans have used compasses for navigation, since the needle always points north
  - **School lab experiments:** the magnets used in school science demonstrations are permanent magnets
  - **Toys:** toy trains and trucks often have magnets which attach the carriages or trailers to the engine or cab
  - **Fridge magnets:** these are made either of flexible magnetic material or by sticking a magnet to the back of something

## Some uses of magnets



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*Compasses and toy trains are two examples of the use of permanent magnets*

## Uses of electromagnets

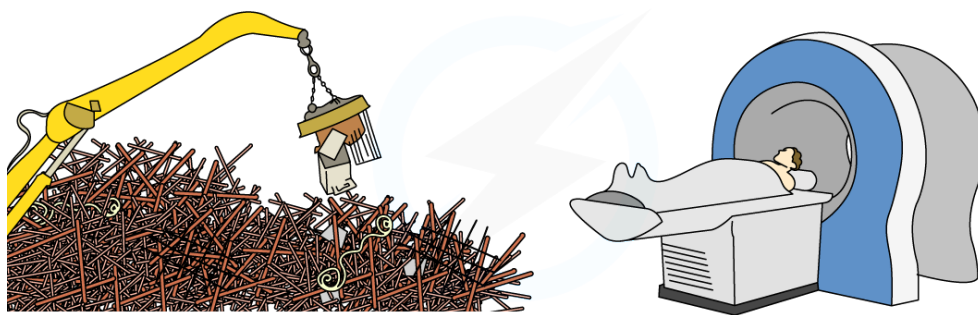
- Electromagnets have many uses including
  - **MRI scanners:** in hospitals, an MRI scanner is a large, cylindrical machine using powerful electromagnets to produce diagnostic images of the organs of the body
  - **Speakers and earphones:** the loudspeakers, microphones and earphones used in phones and laptops use electromagnets to sense or send soundwaves
  - **Recycling:** because steel is a magnetic material it can be easily separated from other metals and materials using electromagnets. Once recovered the steel is re-used and recycled, reducing mining for iron ore and processing ore into steel

- **Mag-Lev Trains:** the ability of Mag-Lev trains to hover above the rails is due to them being repelled by large electromagnets on the train and track. This reduces friction and allows speeds of nearly 400 miles per hour

## Some uses of electromagnets



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*Picking and sorting scrap metal and an MRI scanner are two examples of the uses of electromagnets*

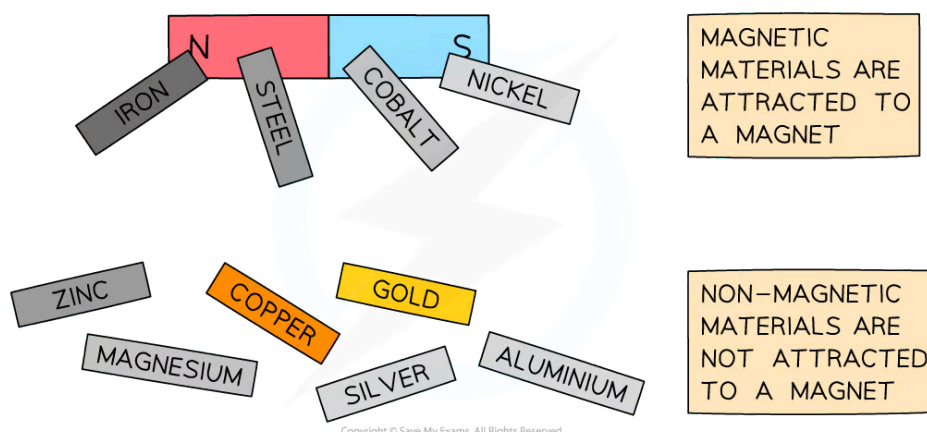


## Induced magnetism

### Magnetic materials

- Very few metals in the Periodic Table are magnetic
- The magnetic metals are:
  - Iron
  - Cobalt
  - Nickel
  - Steel is an alloy which contains iron, so it is also magnetic

### Magnetic materials



**Magnetic materials are attracted to a magnet; non-magnetic materials are not**

- Magnetic materials (which are not magnets) will always be **attracted** to the magnet, regardless of which pole is held close to it

### Magnets and magnetic materials



**Magnetic materials are attracted to both poles of a permanent magnet**

- Bringing a material close to a known magnet will determine if the material is magnetic, non-magnetic or if it is a magnet itself



- It is a **magnet** if it is **repelled** by the known magnet
- It is a **magnetic material** if it is **attracted** to the known magnet
- It is a **non-magnetic material** if it is **neither** attracted nor repelled by the known magnet

## Types of magnets

- There are two types of magnets:
  - Permanent magnets
  - Induced (also called temporary) magnets

### Permanent magnets

- Permanent magnets are made out of permanent magnetic materials, for example, **steel**
- A permanent magnet will **produce its own magnetic field**
  - It will not lose its magnetism

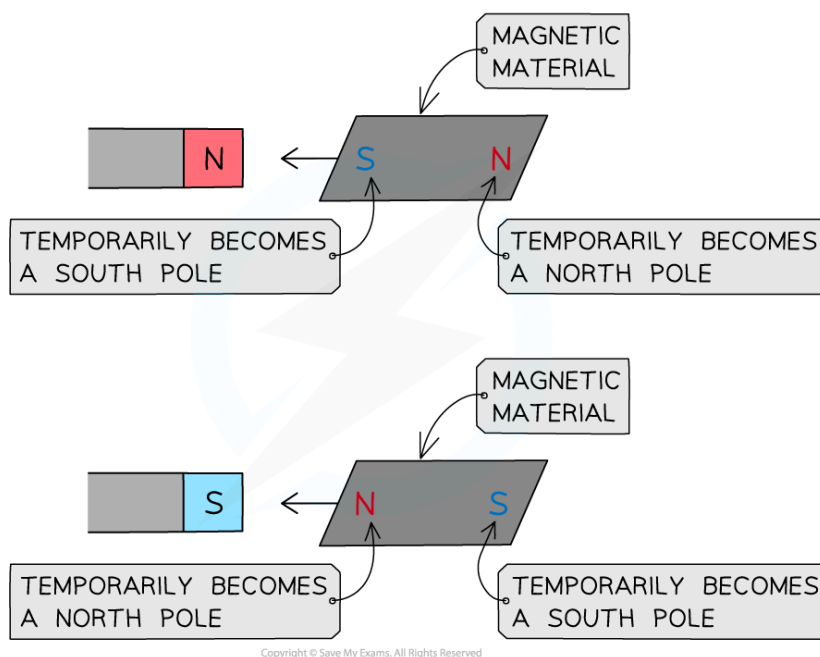
### Temporary (induced) magnetism

- An **induced magnet** is a material with a **soft iron core** that **becomes** a magnet **temporarily** when it is placed in a magnetic **field**
  - Induced magnetism always causes a force of **attraction** between the **permanent magnet** creating the magnetic field and the induced magnet
  - When this happens it is said that the material has been **magnetised**
  - This means that the end of the material closest to the magnet will have the **opposite** pole to that of the magnet pole closest to the material
- When removed from the magnetic field, the material will **lose** its induced magnetism **quickly** and become **unmagnetised**
  - Some objects such as paperclips or needles (made from steel) can be magnetised and will remain magnetic for a while
  - Other objects, such as electromagnets or transformers (which are made from **soft iron**) will be **unmagnetised** (no longer magnetised) as soon as the cause of the induced magnetism is **removed**

### Induced magnetism in a magnetic material



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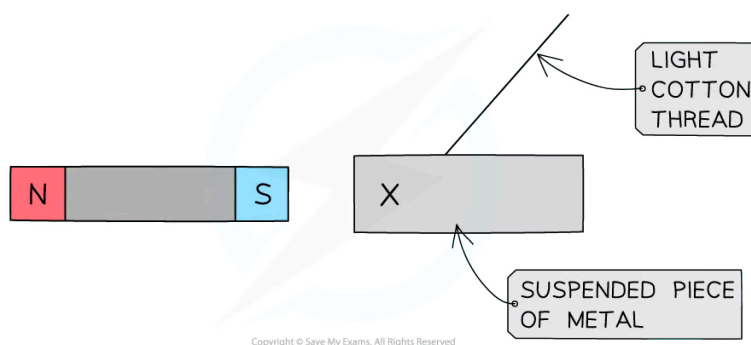


### Inducing magnetism in a magnetic material



#### Worked Example

The diagram below shows a magnet held close to a piece of metal suspended by a light cotton thread. The piece of metal is attracted towards the magnet.



Which of the following rows in the table gives the correct type of pole at X and the correct material of the suspended piece of metal?

	Type of pole at X	Material of suspended piece of metal
A	North	Nickel
B	South	Nickel
C	North	Aluminium

D	South	Aluminium
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**Answer: A**

- X must be a north pole
  - The piece of metal is being attracted towards the magnet
  - The law of magnetism states that opposite poles attract
- The material of the suspended piece of metal is nickel
  - Nickel is a magnetic material (It will experience a force when it is placed in a magnetic field, in this case it is attracted towards the magnet)
- **B** is incorrect because X cannot also be a south pole (and hence is a north pole)
  - If the pole at X was a south pole then the piece of metal would be repelled from the magnet because the law of magnetism states that like poles repel
- **C** and **D** are incorrect because aluminium is not a magnetic material
  - A non-magnetic material would be unaffected by the magnetic field produced by the magnet



# Magnetic fields

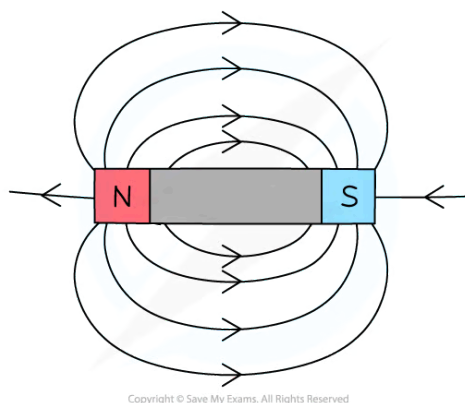
- A magnetic field is defined as:

**A region in which a magnetic pole experiences a force**

## Magnetic field around a bar magnet

- The magnetic field is **strongest at the poles**
  - Therefore, the magnetic field lines are **closer** together at the ends of the magnets
- The magnetic field becomes **weaker as the distance from the magnet increases**
  - Therefore, the magnetic field lines get **further apart**

## Magnetic field around a bar magnet



*The magnetic field around a bar magnet*

## Magnetic field lines

- Field lines always have an **arrow** indicating the **direction** of the field line
  - The direction of the field line shows the **direction** that the magnetic **force** would act
  - The field lines always go **from a north pole to a south pole**

# Magnetic field strength

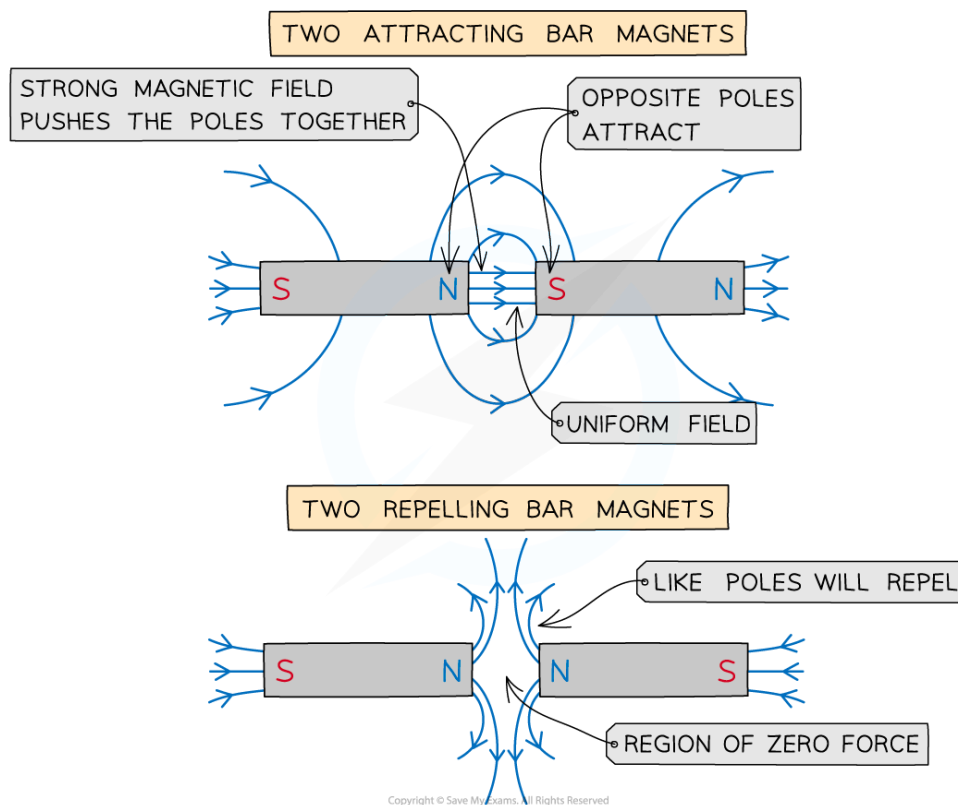
### Extended tier only

- Magnetic forces are due to interactions between magnetic fields
  - Two bar magnets can repel or attract
- This is shown by the magnetic field lines between the two magnets:

## Attractive and repulsive magnetic fields



Your notes



### Magnetic field lines for attracting and repelling bar magnets

- The **strength** of the magnetic field is shown by the **spacing** of the magnetic field lines
  - If the magnetic field lines are **close together** then the magnetic field will be **strong**
  - If the magnetic field lines are **far apart** then the magnetic field will be **weak**



### Examiner Tips and Tricks

If you are asked to draw the magnetic field around a bar magnet remember to indicate both the **direction** of the magnetic field and the **strength** of the magnetic field. You can do this by:

- Adding arrows pointing away from the north pole and towards the south pole
- Making sure the magnetic field lines are further apart as the distance from the magnet increases



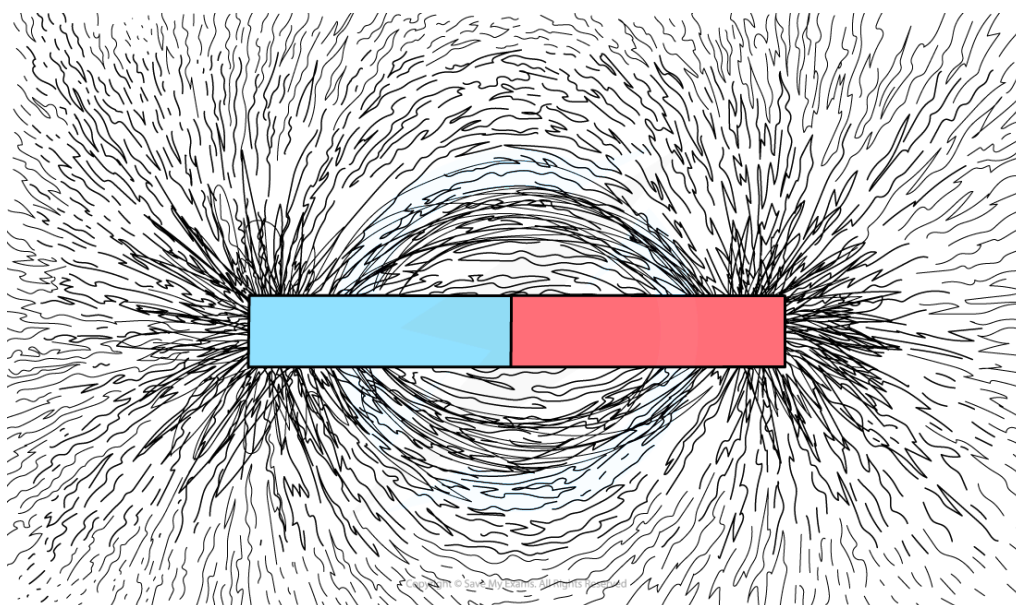
# Plotting magnetic field lines

- In your IGCSE examination, you might be asked to describe a method of plotting the magnetic field around a bar magnet
- There are two principal ways of doing this:
  - using iron filings
  - using plotting compasses

## Using iron filings

- Place a piece of paper on top of the magnet
- Gently sprinkle iron filings on top of the paper
- Now carefully tap the paper to allow the iron filings to settle on the field lines

## Magnetic field lines using iron filings



*Iron filings can be used to plot a magnetic field*

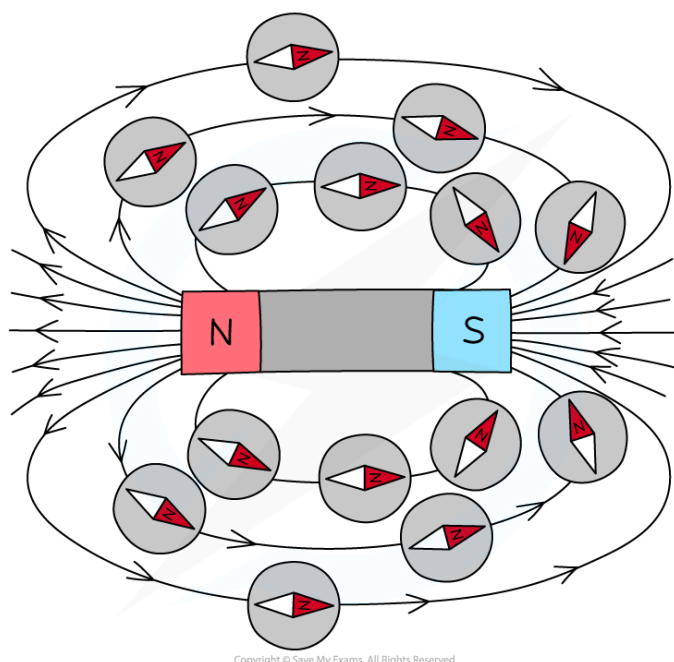
## Using plotting compasses

- Place the magnet on top of a piece of paper
- Draw a dot at one end of the magnet (near its corner)
- Place a plotting compass next to the dot, so that one end of the needle of the compass points towards the dot



- Use a pencil to draw a new dot on the other side of the compass needle
- Now move the compass so that it points towards the new dot, and repeat the above process
- Keep repeating until you have a chain of dots going from one end of the magnet to the other. Then remove the compass, and link the dots using a smooth curve. This is the magnetic field line
- The direction of the field lines go from the **north pole** to the **south pole** of the magnet.
  - This is the same as the direction of the north arrow on the plotting compass, which points towards the south pole
- Repeat the process to create other magnetic field lines around the bar magnet

## Using a compass to create magnetic field lines



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*Compasses can be used to plot the magnetic field around a bar magnet*