SCIENCE DEPARTMENT

Year 8

Physics Friend

Magnetism

This booklet contains information to support your work in science lessons. You **must** bring it with you to all science lessons on the Magnetism topic.

Replacement booklets must be paid for at a cost of £1.

Name:

Form:

Science Teacher:

CONTENT

Key Words

Magnetism	Electromagnet	Poles	Force	Solenoid
Compass	Iron Filings	Field	Induced	Permanent
Cobalt	Nickel	Iron	Steel	Neodymium
Attractive	Repulsive	Motor	Continuous	Current
Faraday	Tesla	Magnetises	Demagnetises	Magnetically

The word search below contains the key words above

Y	M	J	R	K	U	Q	R	W	S	A	O	T	M	Y	A	F	J	O	G
S	O	A	C	E	N	P	S	O	T	E	E	N	S	A	L	R	I	O	E
T	C	O	G	P	P	H	O	T	T	N	G	Z	I	D	S	W	B	I	U
J	D	X	Z	N	L	U	R	L	G	O	G	N	T	A	E	J	W	L	A
Z	X	S	B	K	E	A	L	A	E	G	M	H	E	R	T	X	L	Q	U
K	E	G	Z	F	C	T	M	S	B	S	W	K	N	A	I	J	N	S	O
D	N	D	J	T	V	O	I	N	I	Y	K	G	G	F	R	V	T	D	B
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G	U	V	G	T	C	L	S	H	A	E	E	W	M	W	N	N	O	N	G
S	E	E	C	L	E	E	T	S	H	L	S	Y	M	K	F	J	L	T	M
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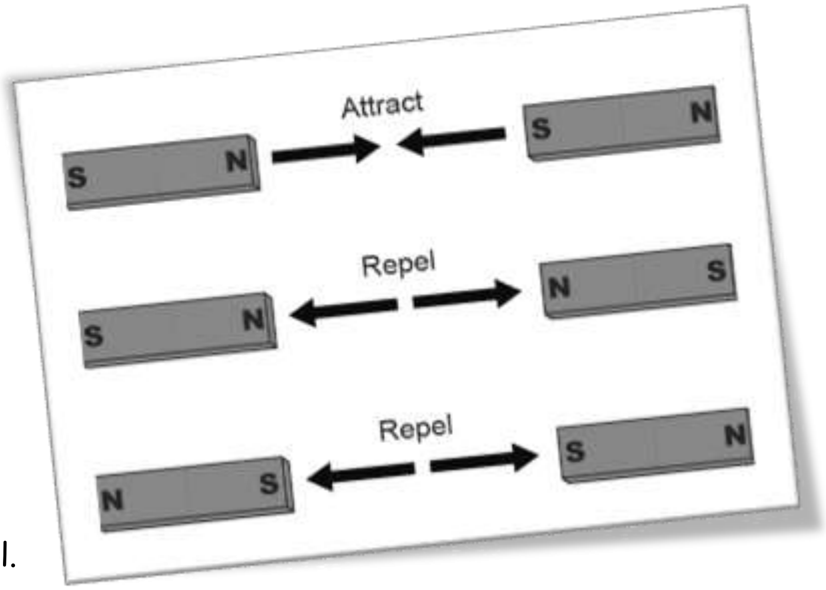
R	L	S	U	O	U	N	I	T	N	O	C	Y	T	C	L	A	N	G	B
E	D	E	M	A	G	N	E	T	I	S	E	S	O	E	I	E	O	T	Y
D	E	C	U	D	N	I	L	J	N	H	N	M	L	F	N	Q	I	K	O
N	L	K	T	X	U	A	H	R	J	E	P	Q	I	A	G	G	D	C	E
D	S	X	Z	O	B	F	G	A	T	A	R	E	M	D	S	D	A	T	L
P	L	E	S	O	M	O	V	C	S	U	L	R	U	R	Q	J	X	M	B
M	Y	W	C	F	A	R	J	S	T	D	E	G	U	F	O	L	U	Y	L
N	I	C	K	E	L	C	O	J	T	P	K	O	T	C	N	R	L	M	O
C	D	Y	X	D	R	E	H	C	H	K	Z	T	J	G	K	U	L	P	T

Magnetism Basics

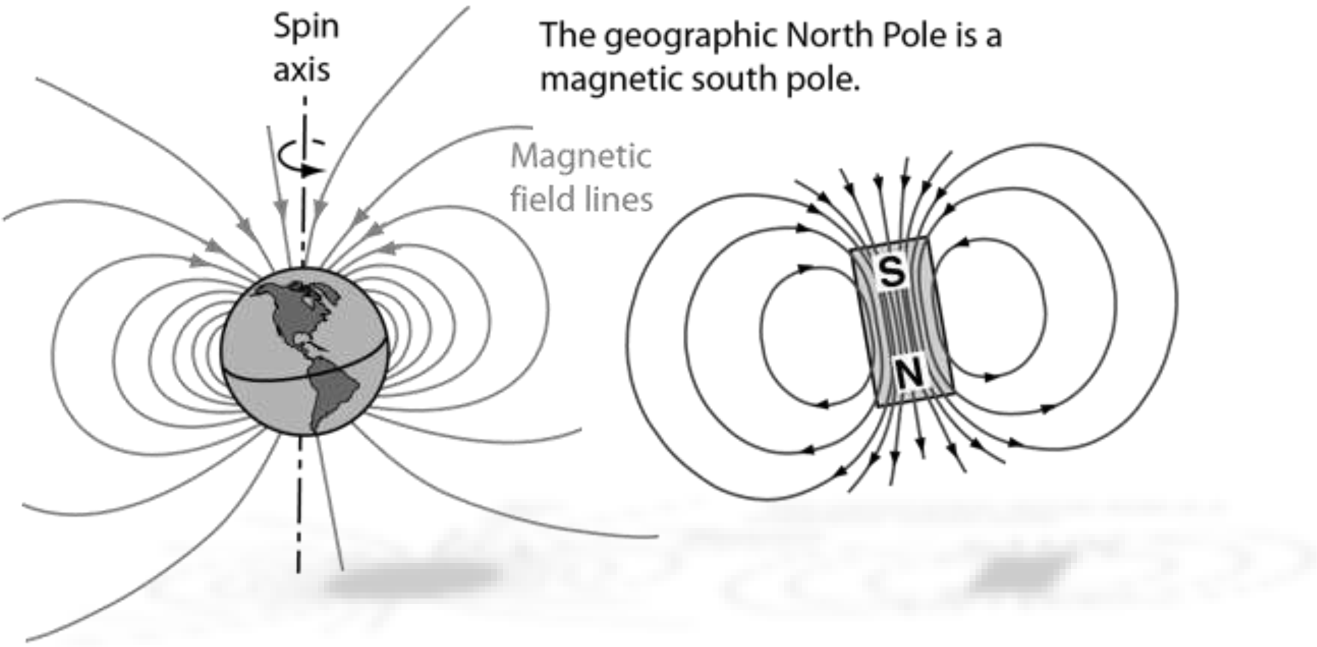
The arrangement of particles in some materials makes them magnetic. This means that they can be affected by a **magnetic field**.

A **magnetic field** is an area in space where a magnet, or magnetic material, experiences a non-contact force (a force that doesn't require objects to be touching to have an effect on each other).



Some materials can produce their own magnetic field and these are class as **permanent magnets**.

The four magnetic materials we need to be aware of are; Iron, Cobalt, Nickel, and Steel.



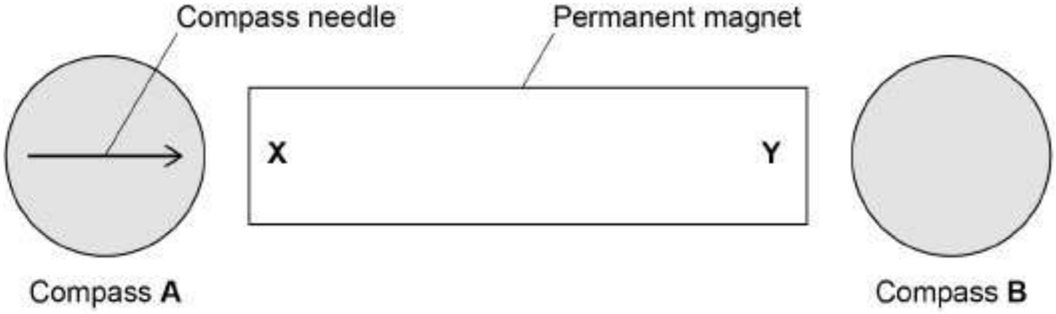
Most magnets have magnetic poles, called **North** and **South**. If two **unlike poles** are near each other they experience an **attractive force**, and two **like poles** near each other experience a **repulsive** force.

The Earth has a magnetic field all around it too, generated by the moving liquid iron in the Earth's core. This field has protected us for 4 billion years, shielding our atmosphere from harmful rays from the Sun!

Without this field, Earth would have ended up lifeless and desolate, like Mars or Anfield.

Questions:

The poles of the magnet are labelled **X** and **Y**.



1. The direction of the compass needle in compass **A** is shown.

Give the names of the poles labelled **X** and **Y**.

X ______________________

Y ______________________

2. Draw an arrow on compass **B** to show the direction of the magnetic field at that position.

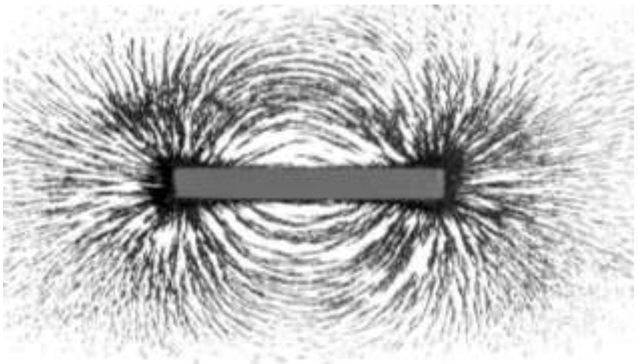
3. Which of the following are magnetic materials?

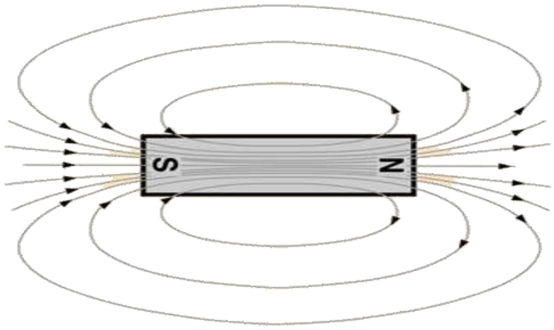
Tick (✓) **two** boxes.

Aluminium	☐
Copper	☐
Iron	☐
Lead	☐
Nickel	☐
Tin	☐

Challenge: How are the 'northern lights', or 'Aurora Borealis' linked to Earth's magnetic field?

Magnetic Fields - Introduction



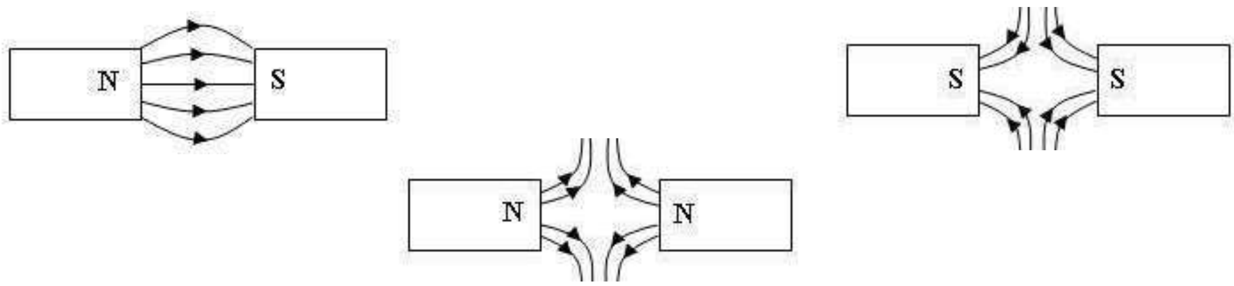


You'll hear and read a lot about **iron filings** in this topic– these are small shavings of iron. As you can see from the picture here on the top left the filings move to show shape of the field, which is quite useful. However, all fields also have a strength and a direction too. For this reason, we have rules to follow that let us draw the magnetic field around an object.

The rules;

- Field lines show where the magnetic field is
- Arrows on the lines show the direction of the force a North pole would experience if placed at that point in the field (so, from North to South)
- The spacing of the lines represents the strength of the field (closer together = stronger, further apart = weaker)

You can see how much more useful the image of a field becomes when we apply these rules! (Top right).



Field lines can also show how the fields of multiple magnets interact and combine – and help us explain some of the forces we experience between magnets.

Questions:

1. Write a method for determining the shape of the field around a wire using a plotting compass.

Challenge: Adapt your method to describe how this could be done with small pieces of magnetic material such as iron filings instead of a compass.

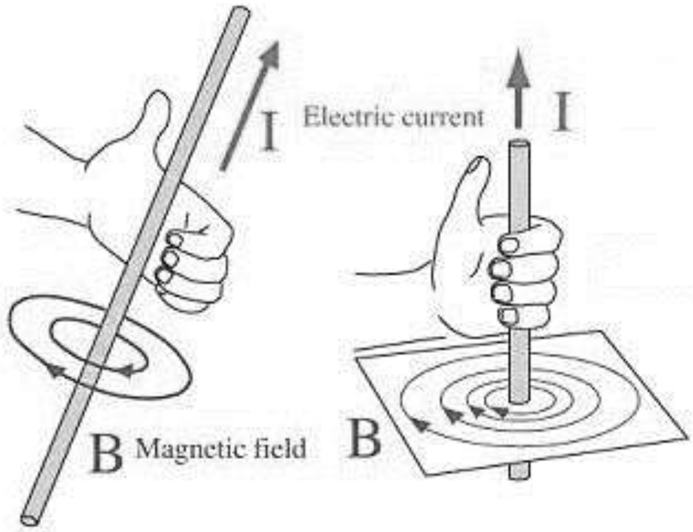
Field around a wire

Scientists noticed in the early 1800s that an electric current flowing through a wire seemed to affect a compass needle when it was placed nearby. Thanks to the work of great scientists and mathematicians such as Michael Faraday and James Clerk Maxwell, we came to understand the intrinsic link between electricity and magnetism.

An electric current is a flow of charged particles – these moving charged particles have their own tiny magnetic fields, and the combination of particles moving together in a specific direction leads to a larger more detectable external magnetic field.

The field around a wire has a circular cross section, and no poles, unlike that of a bar magnet. We can use the Right Hand Thumb Rule to determine the direction of that magnetic field.

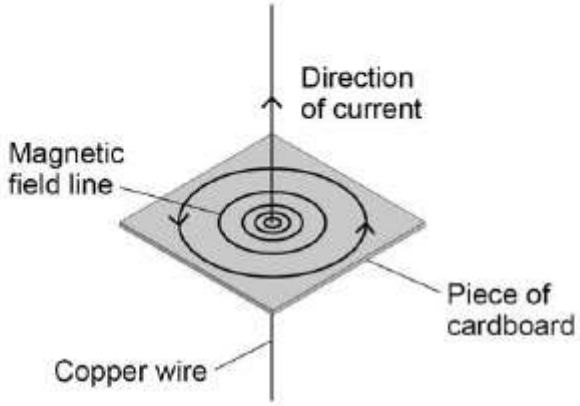
To use the rule, as shown on the right here, we must make a 'thumbs up' shape with our **right hand**. If we point our thumb in the direction of the current in the wire, the curl of our fingers tells us the direction of the magnetic field.



We could also use plotting compasses placed around the wire to show the direction of the field, too.

Questions:

The diagram shows the magnetic field around a copper wire carrying a current.



1. What do the arrows on the magnetic field line represent?

2. Complete the sentence.

Choose the answer from the box.

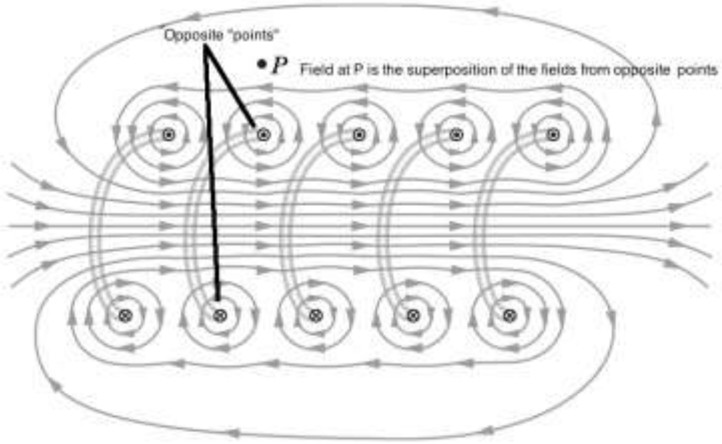
Decreases	**increases**	**stays the same**

As the distance from the copper wire increases, the magnetic field strength ______________________ .

3. Suggest how the field lines show the variation in field strength.

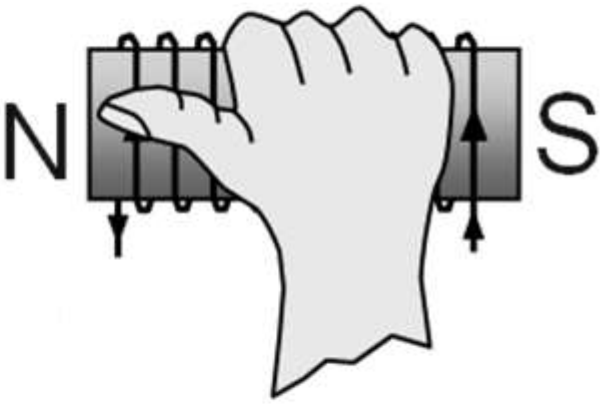
Challenge: What happens to the shape of the magnetic field if two parallel wires next to each other have currents in a) the same direction and b) opposite directions?

Electromagnets



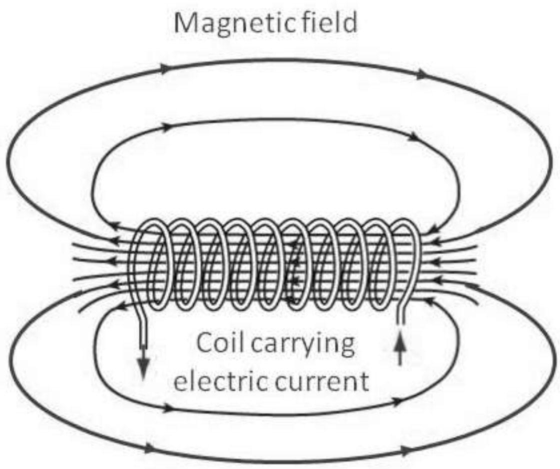
If we wrap a wire into a coil shape, called a **solenoid**, and pass a current through it the magnetic fields of each of the wires combine to form a much stronger one.

This all looks rather messy – but the end result is a magnetic field very similar in shape to that of a bar magnet. There is another convenient rule we can use to ensure we always know the correct direction of the magnetic field around a solenoid. This rule is called the **Right Hand GRIP Rule** and works as follows;



Curl your fingers on your right hand in the direction current is flowing around the loops in the solenoid. Stick out your thumb. The **north pole** of the field is at the end of the solenoid your thumb points to – so you can draw arrows on your field **coming out of the North pole** and looping back **in to the South pole**.

The tricky part is figuring out which way the current is flowing! Remember, in a circuit, the conventional current always flows from the **positive side of the power supply/battery to the negative side!**

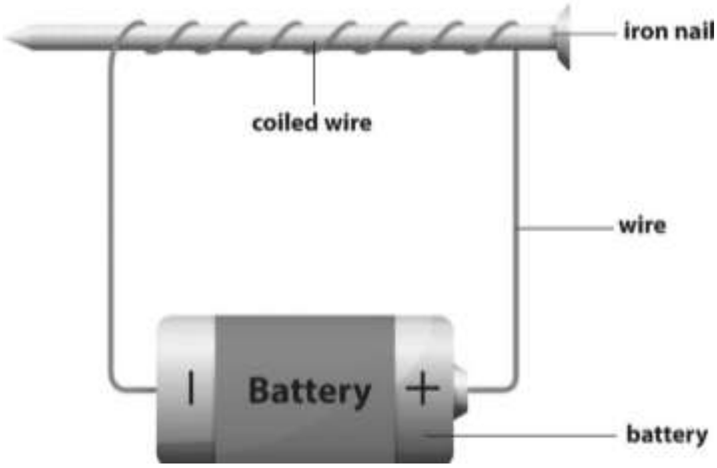


When a magnetic material, such is iron, is placed in a magnetic field the particles within the iron all align with this external field. The end result is that the iron itself becomes a magnet! We call a magnet produced this way an **induced magnet.**

The field of the solenoid combines with the induced field of the iron core, making the overall magnetic field strength increase.

The strength of an electromagnet can be increased further by;

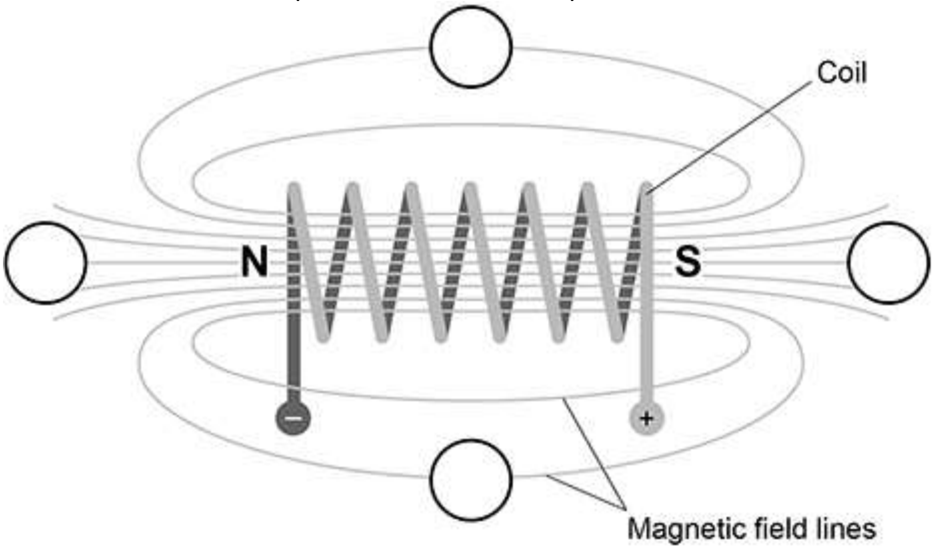
- Increasing the current through the solenoid
- Increasing the number of loops/turns of wire around the core
- Making the gaps between loops smaller,



We can make a simple electromagnet by wrapping wire around an iron nail, and connecting the ends of the wire to a battery!

Questions:

The diagram shows a coil of wire.
There is a current in the coil.
The circles show the position of four compasses.



1. Which statement describes the magnetic field around the coil?
Tick (✓) **one** box.

The field has the same strength at all points.	☐
The field is stronger further away from the coil.	☐
The field is strongest at the ends of the coil.	☐

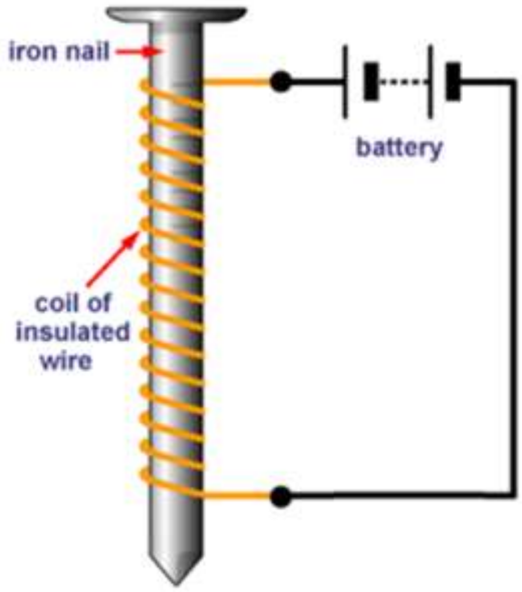
2. Draw **one** arrow in **each** circle to show the direction of the magnetic field at that

Challenge: Why might striking a permanent magnet many times with a hammer demagnetise it?

Making Electromagnets

You are going to carry out an experiment to investigate how the number of turns in an electromagnet affects its strength. You will follow the instructions below:

1. Set up the circuit below. Ensure your power supply is off and set to 4 V.
2. Count the number of turns of wire (i.e. 10, 20, 30) around the nail, and record this in a results table. (NOTE: Make the turns as close together as possible, and move them to the end of the nail).
3. Turn on the power supply and note down the longest chain of paperclips the magnet can hold. (NOTE: Do not leave the power on for long!
4. Repeat steps 1-3 for different numbers of turns of the coil.
5. Plot a suitable graph to analyse your data.



Questions:

1. What is the independent variable in this investigation?
2. What is the dependent variable?
3. Suggest one control variable (something that must be kept the same throughout).
4. Suggest one possible hazard involved in this experiment.
5. What type of graph would be suitable for recording the results?

Uses of Electromagnets

One of the most useful things about electromagnets is that they can be turned on and off! When a current is switched on, this causes the electromagnet to magnetise. Turn the current off and the electromagnet demagnetises. You now have a system which can exert magnetic forces at the flip of a switch!

Below is a great example of the use of an electromagnet – that to sound a school bell! Make sure you can understand each step, and how it can make the hammer hit the bell repeatedly.

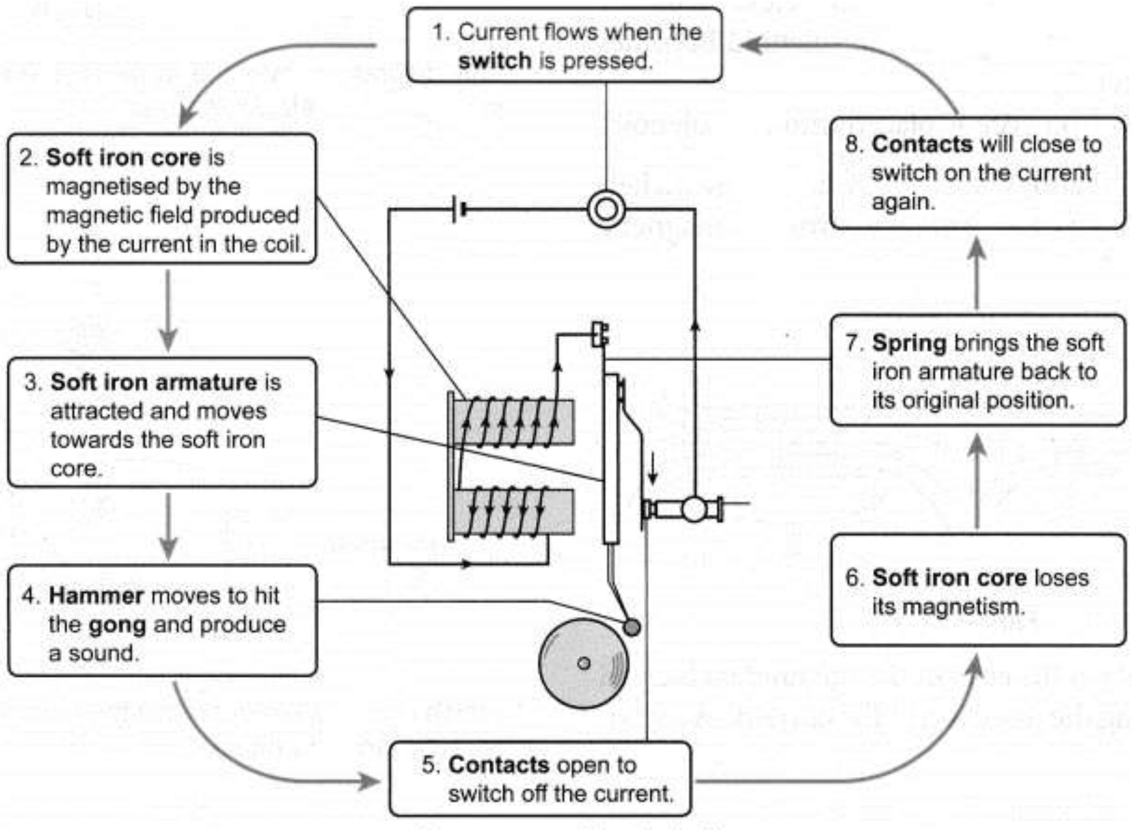


Figure *Electric bell*

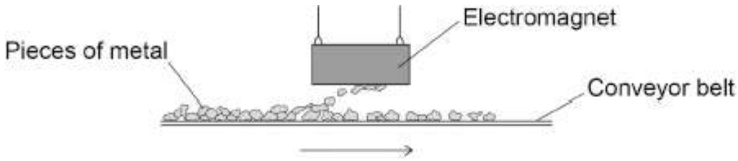
In order for a circuit like this to work correctly, we need to make sure that the instant current stops flowing the whole electromagnet demagnetises. To do this we use what we call a '**magnetically soft**' iron core. Materials which are magnetically soft magnetise and demagnetise **very quickly and easily.**

If we wish to make a permanent magnet we'd have to use a **magnetically hard** material – one that holds on to its magnetism for a long time!

Placing permanent magnets in a strong external magnetic field which opposes the field of the permanent magnet, for a long time, can demagnetise it.

Questions:

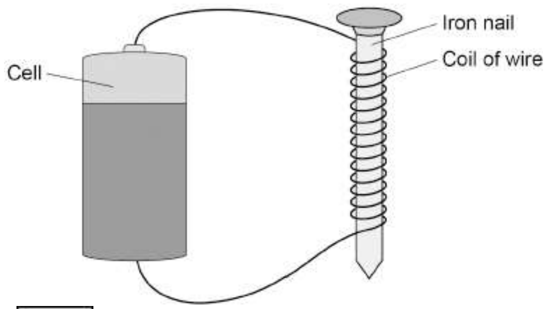
The diagram shows an electromagnet being used to separate pieces of different types of metal on a conveyor belt.



1. What is an advantage of using an electromagnet instead of a permanent magnet to separate the types of metal?
   Tick (✓) **one** box.

An electromagnet attracts more types of metal than a permanent magnet.	☐
An electromagnet can be switched on and off.	☐
An electromagnet transfers less energy than a permanent magnet.	☐

Now we see a simple electromagnet



2. What is the purpose of the iron nail inside the coil of wire?
   Tick (✓) **one** box.

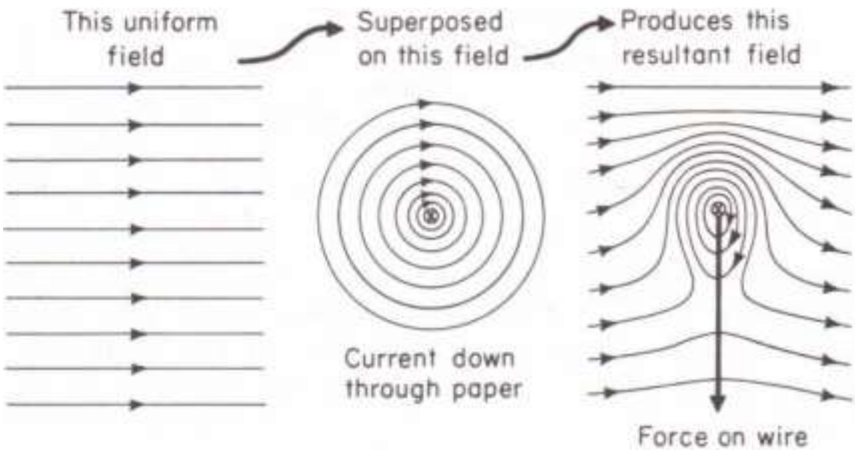
The iron nail makes the magnetic field stronger.	☐
The iron nail reduces the magnetic field to zero.	☐
The iron nail reverses the magnetic field.	☐

3. Which of the following would increase the strength of the electromagnet?
Tick (✓) **one** box.

Use a greater current.	☐
Use a shorter nail.	☐
Use a thinner wire.	☐

The Motor Effect

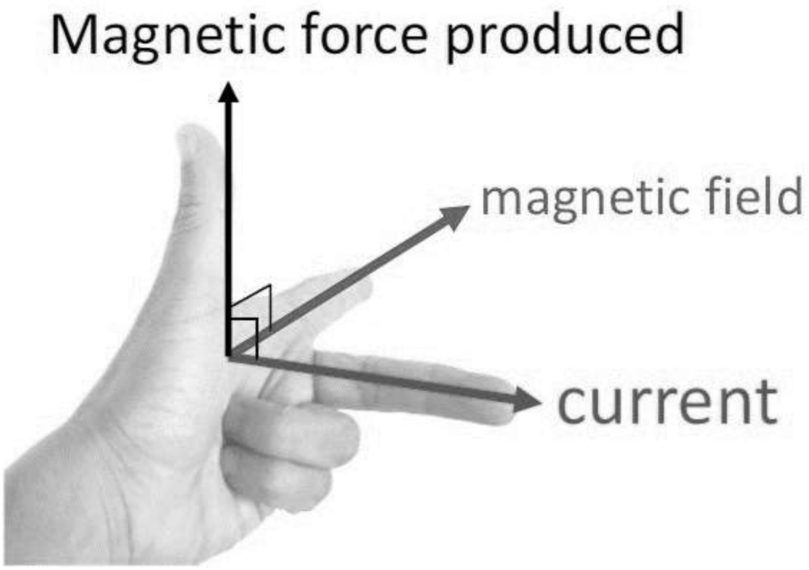
Michael Faraday was the genius that designed the first motor. We had realised that electricity and magnetism could be used to exert forces, but Faraday was the first to realise a way to put these forces to work. This revolutionised industry, and must be credited as one of the biggest discoveries of the past few centuries.



When a wire carries a current it has a magnetic field around it. When this current-carrying wire is placed in the field of another magnet, the two fields interact. The result of this interaction is a force exerted on both the wire and the external magnet (though we usually only see the wire move).

The diagram above shows the interaction of the two fields – don't worry, you don't have to learn this or know much of the physics behind the force – we just need to know that the **force is due to the two interacting fields**.

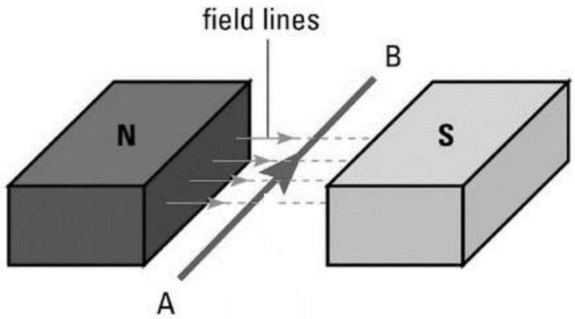
The Left Hand Rule



There is a rule, developed by an electrical engineer named John Ambrose Fleming, which allows us to identify the direction of the force produced by the motor effect provided we know the direction of the **external magnetic field** and **current in the wire**.

Tips for use;

- Look at any given diagram, and point the **index finger** of your left hand in the direction of the magnetic field **of the permanent magnet. (N to S)**
- Keeping your hand in the LHR shape, rotate your hand such that your **middle finger** points in the direction of the **current flow in the wire (positive to negative).**
- The direction your thumb is now pointing is the **direction of the force on the wire** in question.



See if you can use the LHR to show the direction of the force on the wire in this picture above. You should be able to verify that the force would push the wire **downwards**. If you can't, see a friend or your teacher for help!

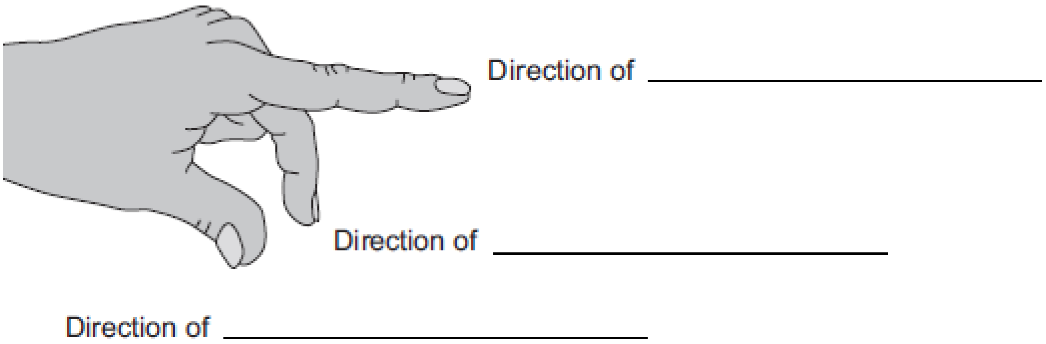
Questions:

The left-hand rule can be used to identify the direction of the force acting on a current-carrying conductor in a magnetic field.

1. Use words from the box to label **Figure 1**.

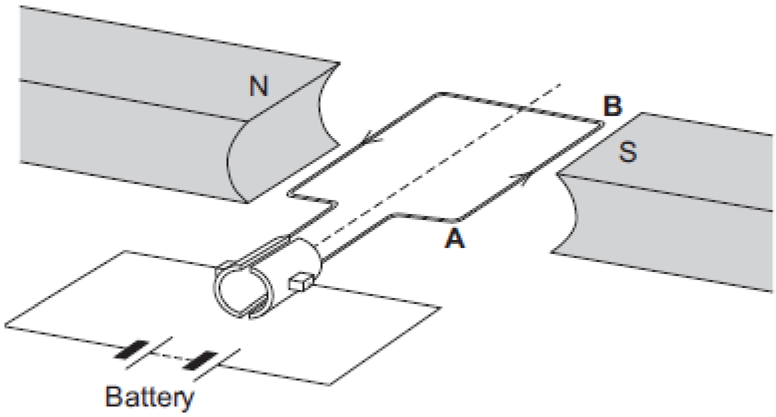
current	**field**	**force**	**potential difference**

Figure 1



The diagram shows an electric motor.

Figure 2



2. Draw an arrow to show the direction of the force acting on the wire **AB**.

Challenge: Suggest **two** changes that would increase the force acting on the wire **AB**.

1. ____

2. ____

Challenge: Suggest **two** changes that would reverse the direction of the force acting on the wire **AB**.

1. ____

2. ____

Revision Questions

Answer the following questions to check how well prepared you are for the end-of-topic test.

Diagram 1 shows a magnetic closure box when open and shut. It is a box that stays shut, when it is closed, due to the force between two small magnets.

These boxes are often used for jewellery.

Diagram 1

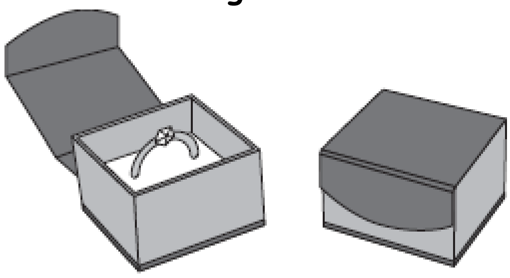
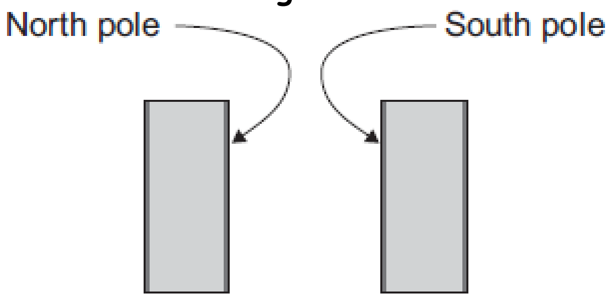


Diagram 2 shows the two magnets. The poles of the magnets are on the longer faces.

Diagram 2



1.(a) Draw, on **Diagram 2**, the magnetic field pattern between the two facing poles.

1.(b) The magnets in the magnetic closure box must **not** have two North poles facing each other. Explain why.

2. **Diagram 3** shows two bar magnets.

Diagram 3

The magnets attract each other.

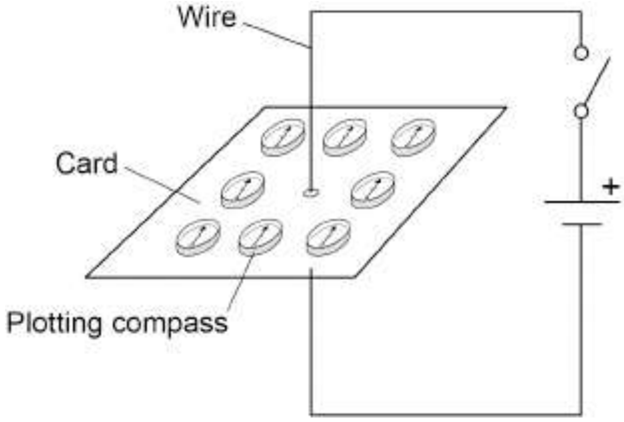
(a) What conclusion can be made about the two poles marked **X** and **Y**?

Tick (✓) **one** box.

They are both north poles.	☐
They are both south poles.	☐
They are opposite poles.	☐

3. **Diagram 4** shows some plotting compasses around a wire. There is no current in the wire.

Diagram 4



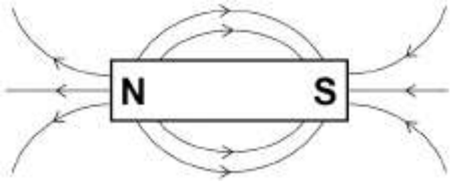
(a) Why do the plotting compasses all point in the same direction?

(b) When the switch is closed there is a current in the wire.

The current creates a magnetic field.
What shape are the magnetic field lines around the wire?
Tick (✓) **one** box.

Circular		Square	
Rectangular		Triangular	

4. Magnets attract some metals.
Which diagram shows the correct magnetic field pattern for a bar magnet?
Tick (✓) **one** box.



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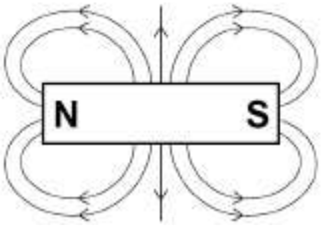

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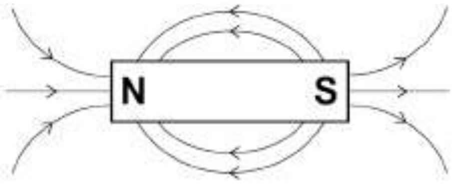

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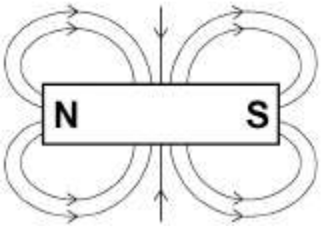


☐

5. **Diagram 5** shows an iron bar near a permanent magnet.

Diagram 5

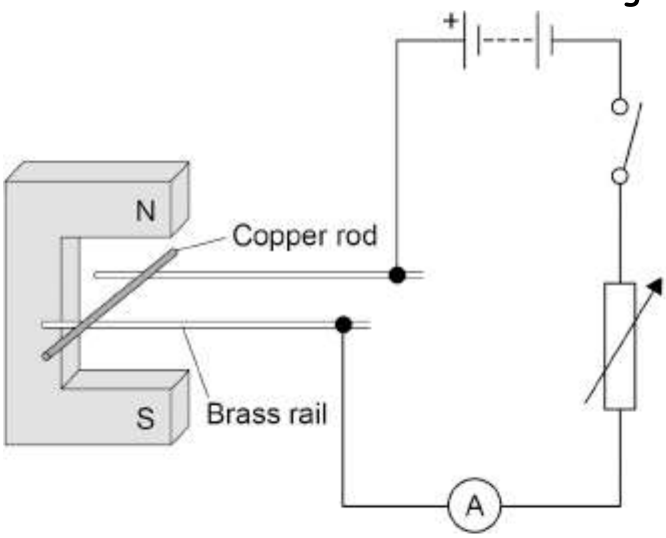
The iron bar becomes an induced magnet.
(a) Label the poles on the iron bar.
(b) The magnet is turned around so that the north pole is closest to the iron bar.
Which statement about the iron bar is true?
Tick (✓) **one** box.

The iron bar does not experience a magnetic force.	☐
The iron bar experiences a magnetic force of attraction.	☐
The iron bar experiences a magnetic force of repulsion.	☐

6. A teacher demonstrated the motor effect.

Diagram 6 shows the equipment used. The equipment includes a permanent magnet.

Diagram 6



When the switch is closed the copper rod accelerates.

(a) In which direction will the copper rod accelerate?

Tick (✓) one box.

 ☐

 ☐

 ☐

 ☐

(b) Explain one way the teacher could increase the acceleration of the copper rod without getting new equipment.

7. Diagram 7 shows a magnetic compass used by walkers.

Diagram 7

Explain how a magnetic compass provides evidence that the Earth has a magnetic field.

The Hand Rules

There have been three rules for you to learn and use in this topic – use the space below to summarise each of them!

Key Definitions

Use the space below to write definitions of important words in the topic!