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GCSE Physics

AQA Topic – Magnetism and Electromagnetism

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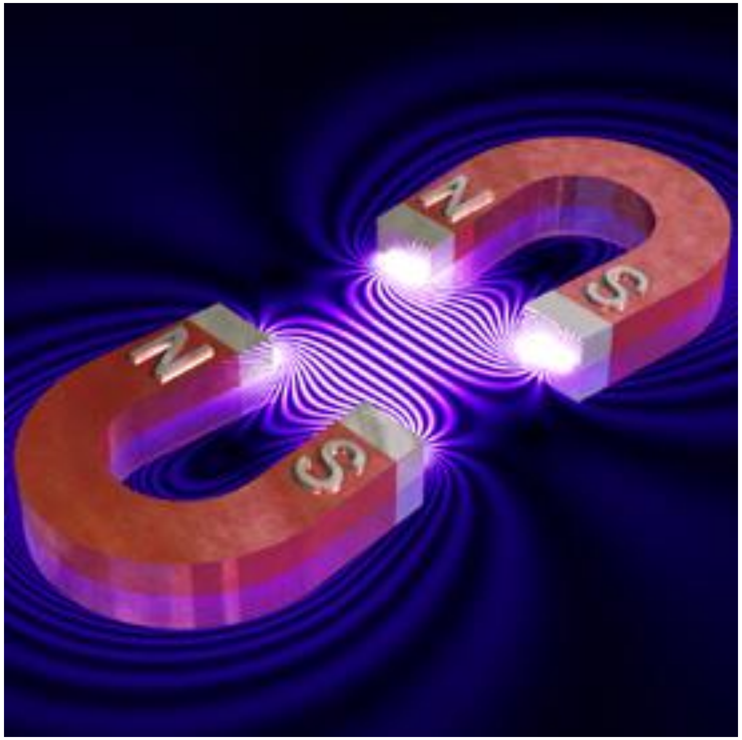
Overview
Magnetism and Electromagnetism

Permanent and Induced Magnetism, Magnetic Forces and Fields

- Poles of a Magnet
- Magnetic Fields



The Motor Effect

- Electromagnetism
- Fleming's Left-hand Rule (HT)
- Electric Motors (HT)
- Loudspeakers (HT)(Physics)

Induced Potential, Transformers and the National Grid (HT)(Physics)

- Induced Potential (HT)
- Uses of the Generator Effect (HT)
- Microphones (HT)
- Transformers (HT)

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Permanent and Induced Magnetism, Magnetic Forces and Fields

- Poles of a Magnet
- Magnetic Fields

Poles of a Magnet

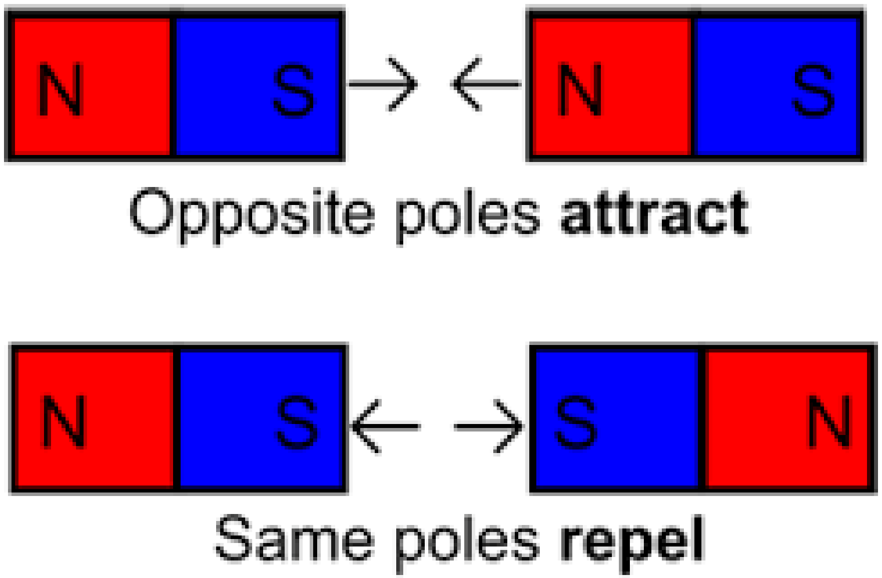
Object	Definition
Poles	Places where the magnetic forces are strongest.
Permanent Magnets	Produce their own magnetic fields. Permanent magnets can attract and repel.
Induced Magnets	Material that becomes magnetic when placed in a magnetic field. Induced magnets can only attract. When the magnetic field is removed an induced magnet will lose most/all of its magnetism quickly.

When two magnets are brought together they exert a force on each other. Two like poles repel each other, two unlike poles attract each other.

Attraction and repulsion are examples of non-contact force.

Magnetic Forces

When two poles of two magnets are placed near each other they can either attract or repel each other. The combination of north and south poles determines whether they attract or repel.

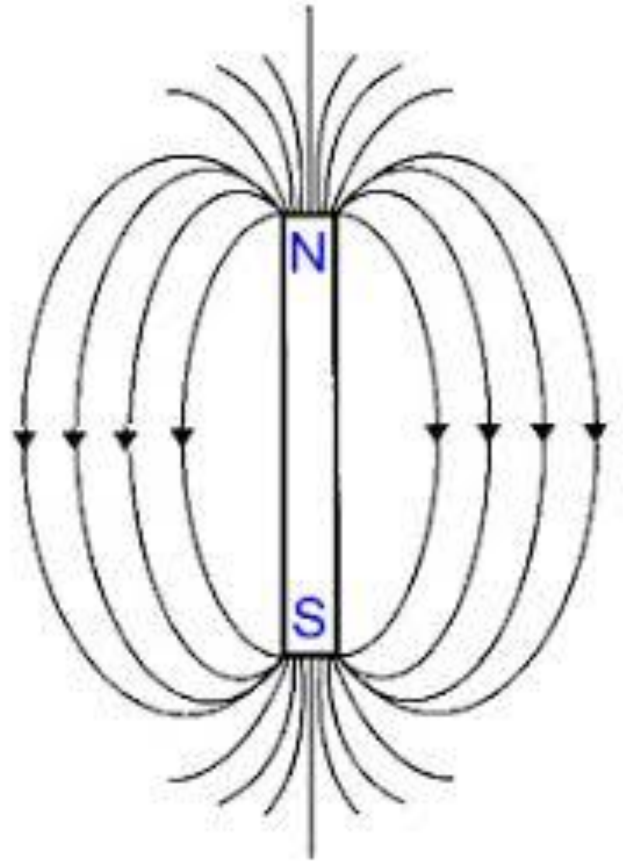


Magnetic Fields

There are four main magnetic materials that you need to know: **iron**, **steel** (because it is made from iron), **nickel** and **cobalt**. There is always a force of **attraction** between magnets and magnetic materials.

Magnetic field = The region around a magnet where a force acts on another magnet (or magnetic material).

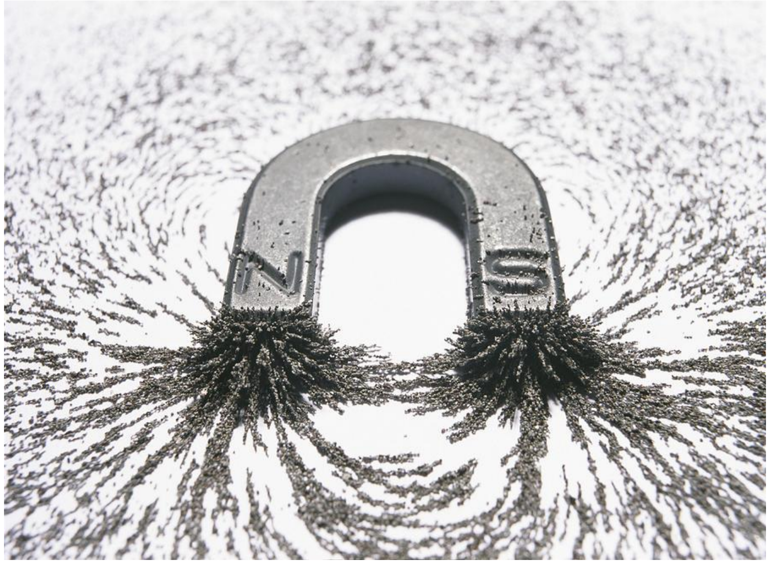
The **strength** of a magnetic field depends on the **distance from the magnet**.
The field is **strongest at the poles**.



Direction of a Magnetic Field

The direction of the magnetic field at any point is given by the direction of the force that would act on another north pole placed at that point.

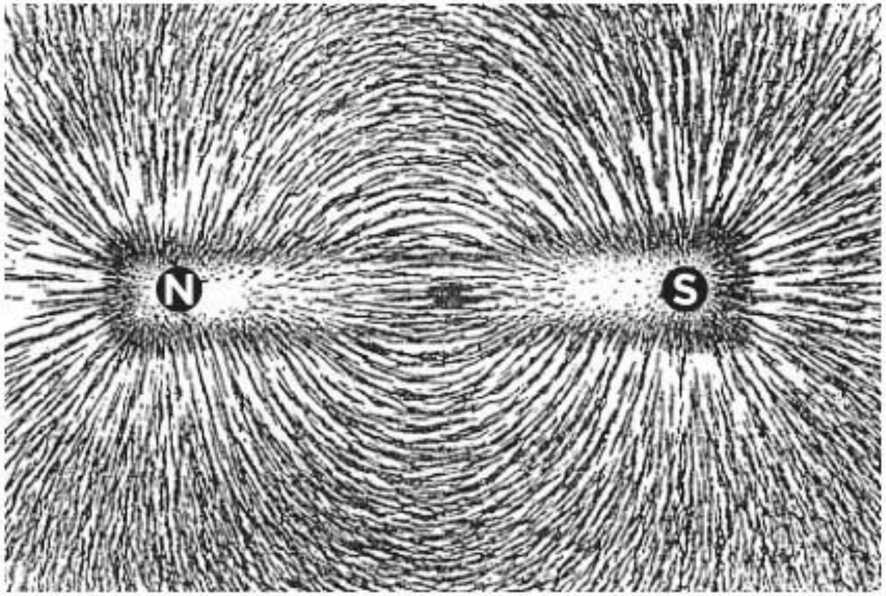
The direction of a magnetic field line is always from north (seeking) pole to south (seeking) pole.



Magnetic Field Shapes

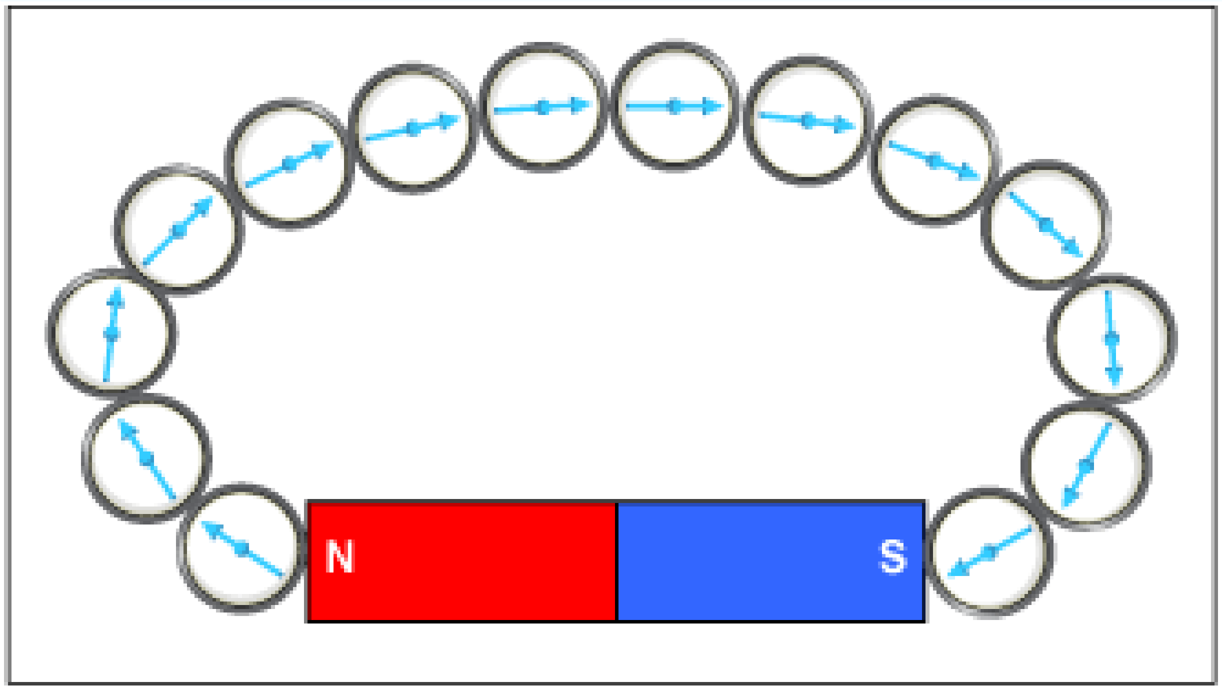
To find the direction of the magnetic field of a bar magnet there are two main techniques.

1. Place the bar magnet under a piece of paper and sprinkle **iron filings** over the paper. Tapping the paper will produce the magnetic field pattern of the bar magnet.



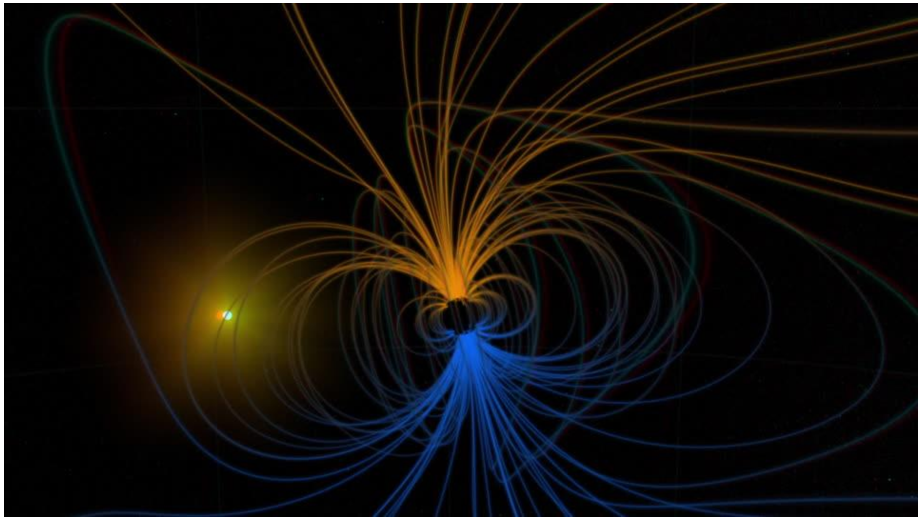
Magnetic Field Shapes…continued

2. Placing a **magnetic compass** (which contains a small bar magnet) in the magnetic field of a bar magnet causes the compass needle to point in the direction of the magnetic field.



Earth's Magnetic Field

A **magnetic compass** contains a small **bar magnet**. The Earth has a magnetic field. The compass points in the **direction of the Earth's magnetic field**.



The magnetic field pattern produced by compass needles leads us to conclude that the **Earth's core is magnetic**. The origin of the Earth's magnetic field is thought to be the movement of **molten iron** in the core.

QuestionIT!

Permanent and induced magnetism, magnetic forces and fields

- Poles of a Magnet
- Magnetic Fields

1. What are the poles of a magnet?
2. When two magnets are brought together what do they do?
3. When a magnet and a magnetic material are brought together what do they do?
4. What is a permanent magnet?
5. What is an induced magnet?

6. Describe the difference between permanent and induced magnets.

7. Which part of a magnet has the strongest magnetic field?

8. Two magnets are placed close together, north seeking pole to north seeking pole. Describe the forces acting on the two magnets.

9. Name three magnetic elements.

10. Describe two methods for finding the magnetic field pattern of a bar magnet.

11. Draw the magnetic field pattern of a bar magnet.

12. How would you describe the direction of a magnetic field line?

13. What does a magnetic compass contain?

14. Which way does the compass needle point?

15. What do scientists think is the cause of the Earth's magnetic field?

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AnswerIT!

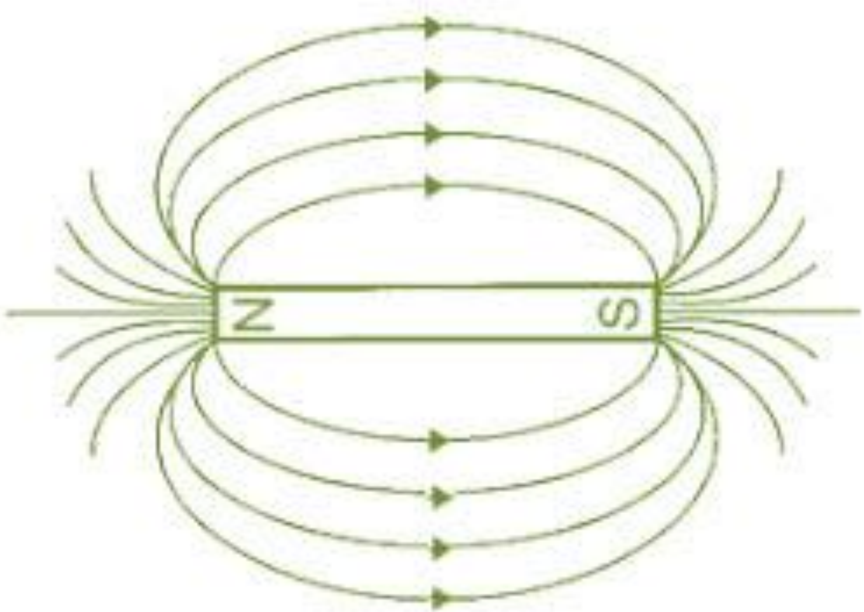
Permanent and induced magnetism, magnetic forces and fields

- **Poles of a Magnet**
- **Magnetic Fields**

1. What are the poles of a magnet?
   Places where the magnetic forces are strongest.
2. When two magnets are brought together what do they do?
   Exert a force on each other; attraction or repulsion.
3. When a magnet and a magnetic material are brought together what do they do?
   Attract.
4. What is a permanent magnet?
   Material that produces its own magnetic field.
5. What is an induced magnet?
   Material that becomes a magnet when it is placed in a magnetic field.

6. Describe the difference between permanent and induced magnets.
   Permanent produces its own field/ induced becomes magnetic when placed in a field.
   Permanent can attract or repel/ induced always attracts.
   Induced magnet loses most/all of its magnetism quickly when removed from magnetic field.
7. Which part of a magnet has the strongest magnetic field?
   Poles.
8. Two magnets are placed close together, north seeking pole to north seeking pole. Describe the forces acting on the two magnets.
   Repulsion.
9. Name three magnetic elements.
   Iron, steel, cobalt, nickel.

10. Describe two methods for finding the magnetic field pattern of a bar magnet.
    Sprinkle iron filings onto paper, tap paper. Use small compasses to follow field from poles; mark paper at the compass needle end.
11. Draw the magnetic field pattern of a bar magnet.



12. How would you describe the direction of a magnetic field line?
    Given by the direction of the force that would act on another north pole placed at that point/ from the north (seeking) pole to the south (seeking) pole.
13. What does a magnetic compass contain?
    Small bar magnet.
14. Which way does the compass needle point?
    In the direction of the Earth's magnetic field.
15. What do scientists think is the cause of the Earth's magnetic field?
    Molten iron core.

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The Motor Effect

- Electromagnetism
- Fleming's Left-hand Rule (HT)
- Electric Motors (HT)
- Loudspeakers (HT)(Physics)

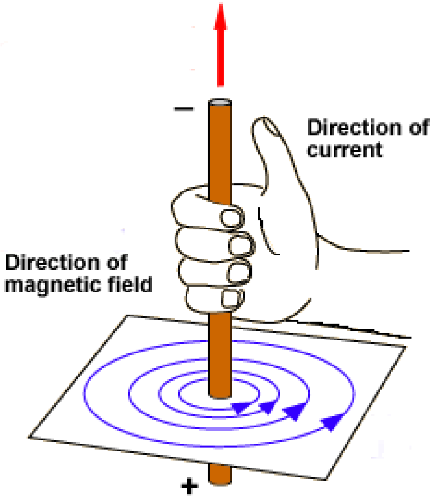
Electromagnetism

When a current flows through a conducting wire a magnetic field is produced around the wire.

The strength of the magnetic field depends on the current through the wire and the distance from the wire.

Increasing the current through the wire increases the strength of the magnetic field.

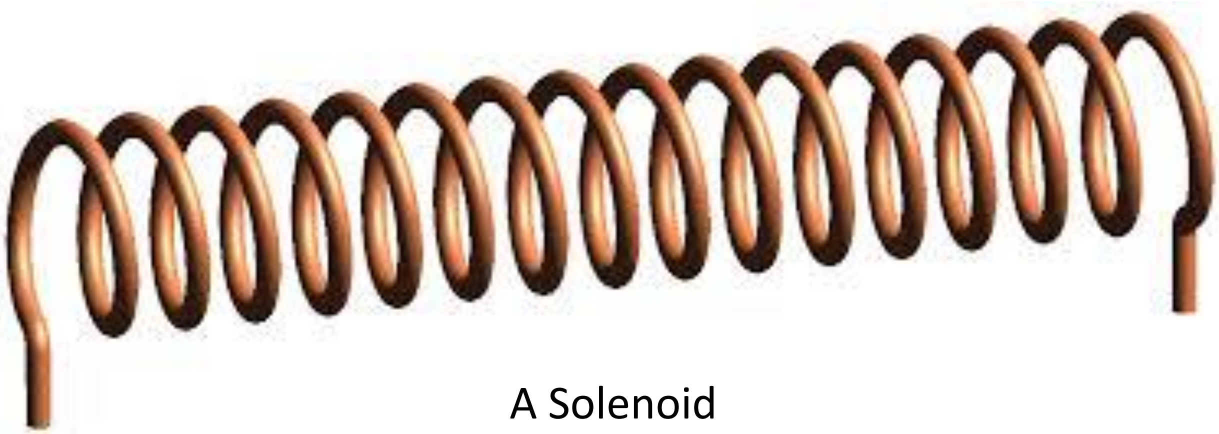
Increasing the distance from the wire decreases the strength of the magnetic field.



Solenoids

A solenoid is a **coil of wire** used to produce a **magnetic field**.

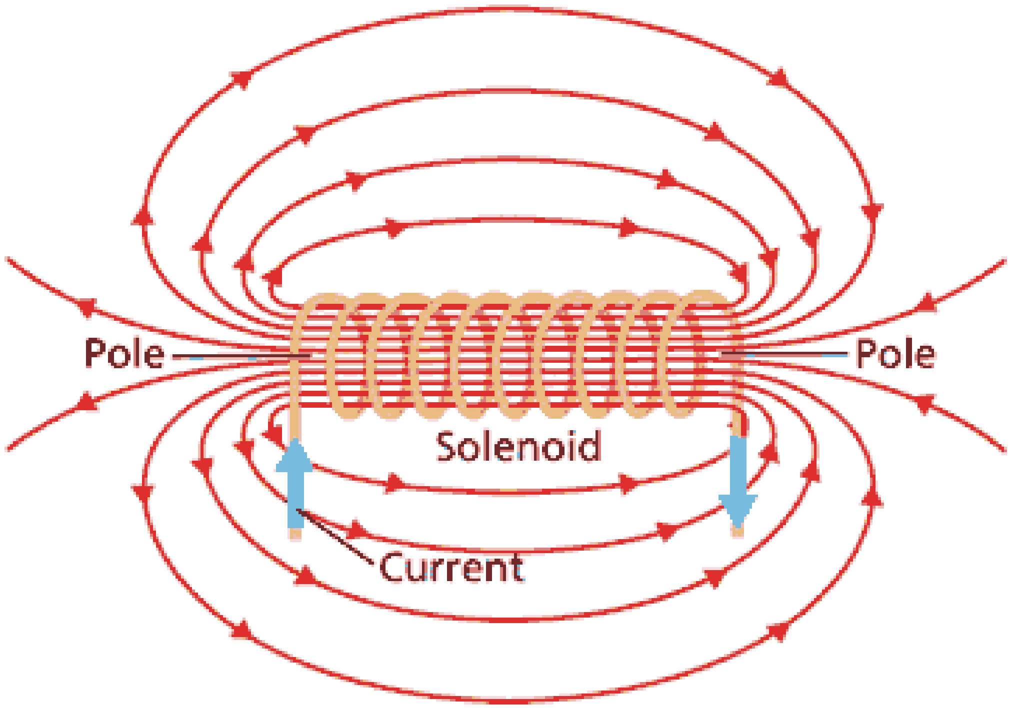
Shaping a wire to make a solenoid **increases the strength** of the magnetic field created by the current through the wire.



A Solenoid

Solenoids… continued

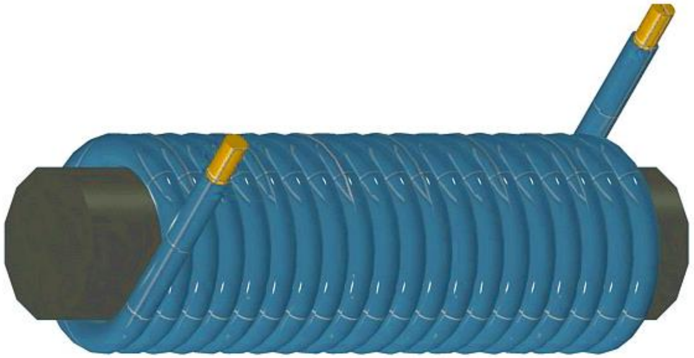
The magnetic field of a solenoid has a **similar shape to that of a bar magnet** – though the magnetic field extends inside the solenoid and is **strong and uniform**.



Making the Magnetic Field of a Solenoid Stronger

It is possible to increase the strength of a solenoid's magnetic field by…

1. Adding **an iron core** to a solenoid.
2. **Increasing the current** though the solenoid.
3. **Increasing the number of turns of wire** on the solenoid.

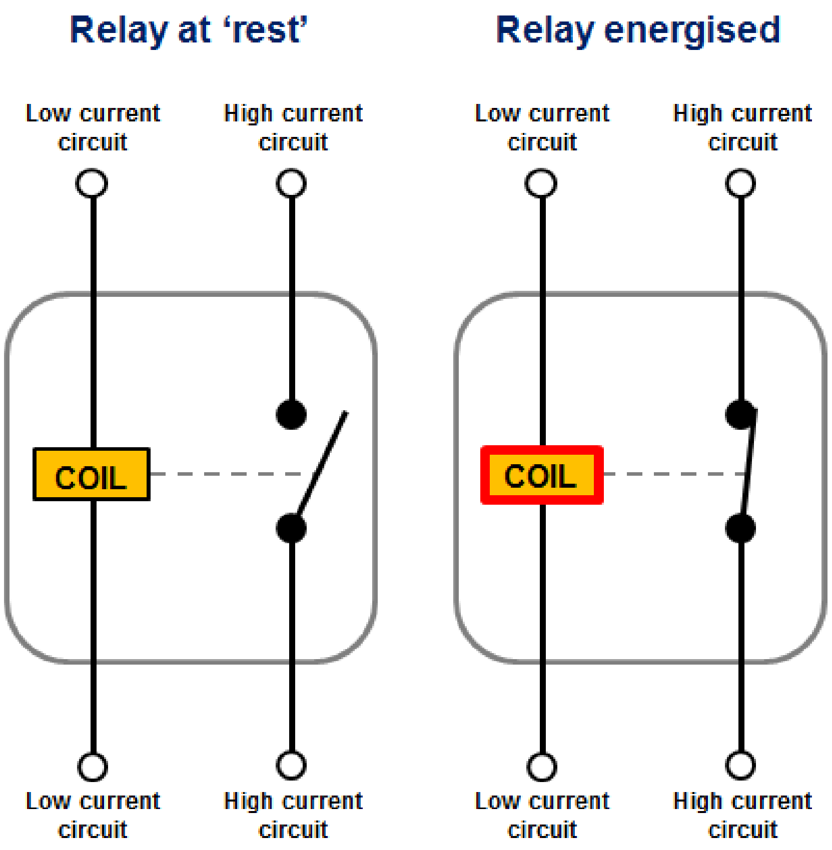


A **solenoid** with an **iron core** is an **electromagnet.**

(Physics only) Electromagnetic Device: Relay

A **relay is a switch**. It uses a **solenoid** (shown as a coil in the diagram opposite) to attract an iron armature.

Relays are used so that a **small current can turn on a larger current in an isolated circuit.** This reduces the amount of thicker, more expensive, wires needed.

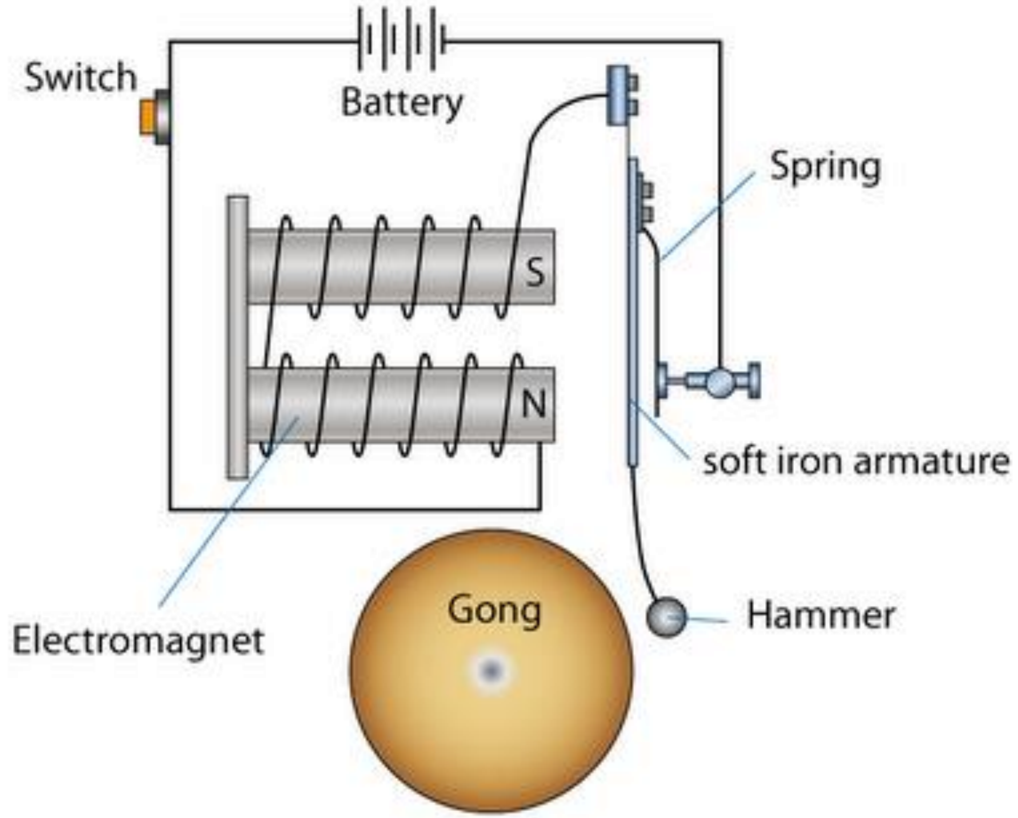


(Physics only) Electromagnetic Device: Electric Bell

An electric bell uses a **solenoid** to **attract a soft iron armature**.

This makes the hammer hit the bell making a single ring. The movement of the soft iron armature breaks the circuit demagnetising the soft iron armature which returns to its original position.

The whole process then repeats - as long at the switch is pressed.



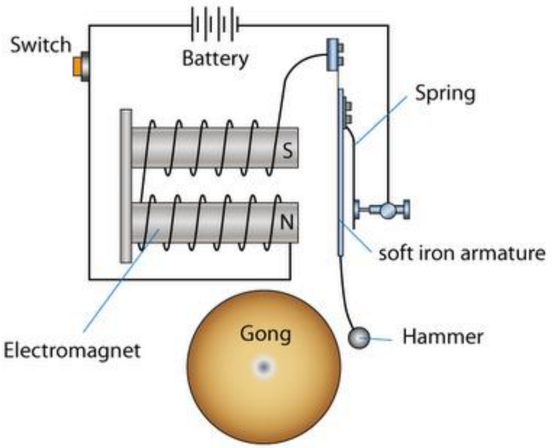
1. What is produced when a current flows through a conducting wire?
2. Name two factors which will impact on your answer to question 1.
3. What is a solenoid?
4. Describe the magnetic field inside a solenoid.
5. State three ways of increasing the strength of the magnetic field produced by a solenoid.

6. Draw the magnetic field pattern produced by a solenoid.

7. What is an electromagnet?

8. (Physics only) Describe how a relay works.

9. (Physics only) An electric bell uses a solenoid. Use the diagram below, and your own knowledge, to explain how an electric bell works.



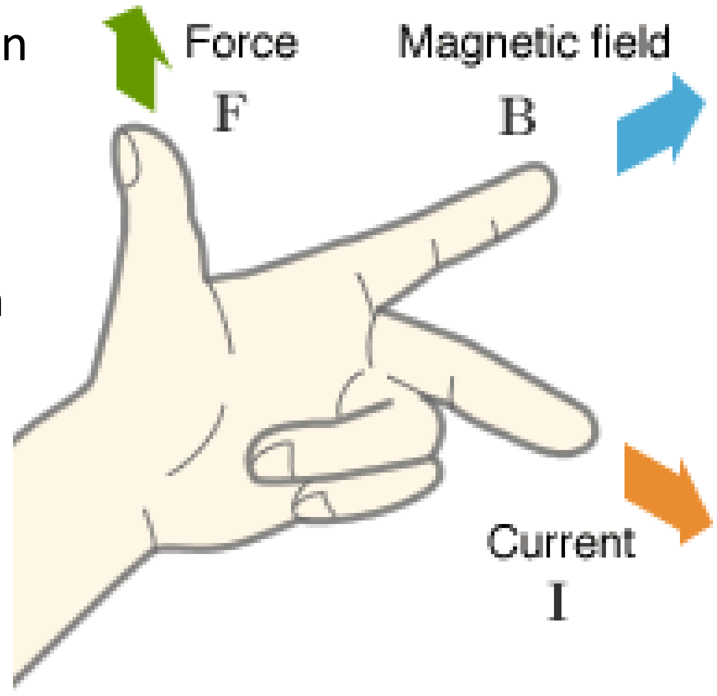
Fleming's Left-Hand Rule

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 other. This is called the **motor effect**.

The direction of the force can be found if the direction of the current flow and the direction of the magnetic field are known.

In the diagram the thumb, first finger and second finger are held at right angles to each other.

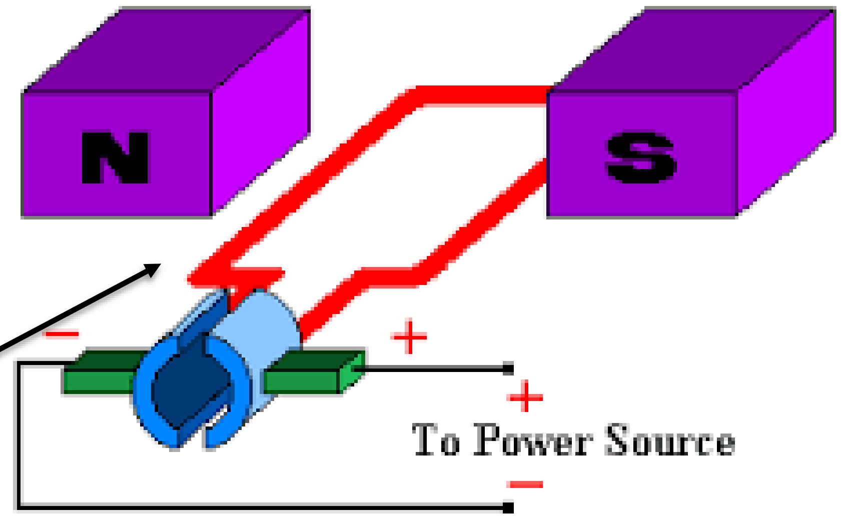
First Finger – Field (magnetic N to S)
Second Finger – Direction of current flow
Thumb – Direction of Force (motion)



Motors

Example:

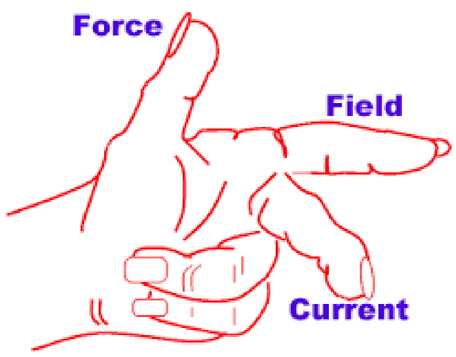
Determine the direction that the motor will spin using Fleming's Left-Hand Rule.



Solution:

Looking at the wire **next to the North seeking pole** of the magnet…

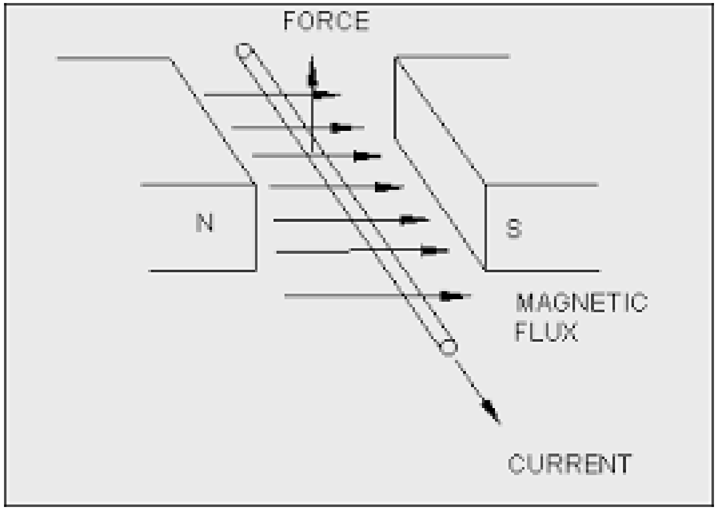
- **Magnetic field** (first finger) is pointing to the **right** (North to south).
- **Current flow** (second finger) is pointing **towards you**.
- (Remember, conventional flow is + to -)
- **Force/Motion** of the wire will be **upwards** (so the motor will spin clockwise.



Force on a Conductor

The factors that affect the force on a conductor are:

- **Magnetic Flux Density (B) in tesla**
- **Current (I) in amperes**
- **Length of Conductor (l) in metres**



These quantities are linked by the equation:

Force (N) = Magnetic flux density (T) x Current (A) x Length (m)

$$F = BIl$$

(a) (i) it moves or experiences a force horizontally to the right

for 1 mark

1

(ii) A – moves in opposite direction or force reversed e.c.f.
B – faster movement or larger force
(**not** move further)

for 1 mark each

2

(b) turns clockwise
oscillates/reverses
comes to rest facing field/at 90^{0} to field/vertically

for 1 mark each

3

(c) number of turns or linear number density of turns current core

for 1 mark each

3

[9]

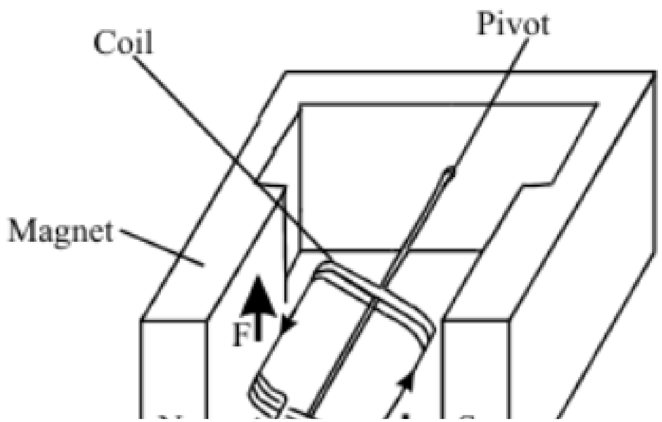
A The magnetic field is reversed.

____

____

B The current is increased.

(b) The diagram shows a coil placed between the poles of a magnet. The arrows on the sic
of the coil itself show the direction of the conventional current.



ɔ) turns clockwise
oscillates/reverses
comes to rest facing field/at 90° to field/vertically

for 1 mark each

3

The arrows labelled **F** show the direction of the forces acting on the sides of the coil.
Describe the motion of the coil until it comes to rest.

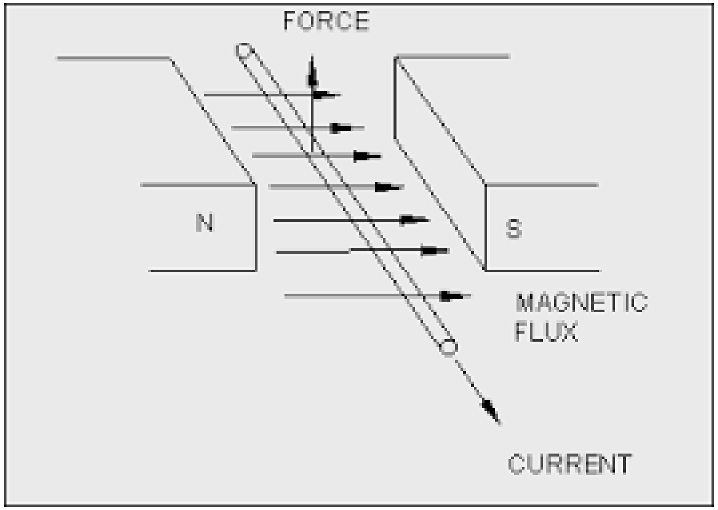
____

____

____

Force on a Conductor

The factors that affect the force on a conductor are:



- **Magnetic Flux Density (B) in tesla**
- **Current (I) in amperes**
- **Length of Conductor (ℓ) in metres**

These quantities are linked by the equation:

Force (N) = Magnetic flux density (T) x Current (A) x Length (m)

$$F = BI\ell$$

Force on a Conductor… continued

Example:

A 6 cm wire placed in a magnetic field carries a current of 50 mA.

Work out the force on the current carrying wire if the magnetic field strength of the magnetic field is 0.25 T.

Solution:

First step is convert the units: 6 cm = 0.06 m and 50 mA = 0.05 A

Then:

$$\boldsymbol{F = BI\ell}$$

$$F = 0.25 \times 0.05 \times 0.06$$

$$F = 7.5 \times 10^{-4}\ N$$

LO: Apply the equation F=BIl to an exam question

Example question

A 2m long wire is placed in a magnetic field strength 5T. If the current through the wire is 0.5A how much force will act on the wire?

$$F = B \times I \times l$$

$$F = 5T \times 0.5A \times 2m$$

$$F = 5N$$

LO: Apply the equation F=BIl to find the current flowing through a conductor and the length of a wire

Your turn!

4.4 A student builds a model motor. The magnetic field between the poles is 3×10^{-2} T. The length of one side of the coil in between the poles is 2 cm. The current is 0.5 A.

Calculate the force on the coil.

Give your answer in standard form.

[2 marks]

Force: ________________ N

LO: Apply the equation F=BIl to an exam question

Your turn!

4.4 A student builds a model motor. The magnetic field between the poles is 3×10^{-2} T. The length of one side of the coil in between the poles is 2 cm. The current is 0.5 A.

Calculate the force on the coil.

Give your answer in standard form.

[2 marks]

Force: ________________ N

$F = B \times I \times l$

$2cm = 2 \times 10^{-2}m$

$F = 3 \times 10^{-3} \times 0.5A \times 2 \times 10^{-2}m$

$F = 3 \times 10^{-4}$ N

X go back

(c) $4.8 \times 10^{-4} = F \times 8 \times 10^{-2}$

$F = 6 \times 10^{-3}$ (N)

$6 \times 10^{-3} = B \times 1.5 \times 5 \times 10^{-2}$

$$B = \frac{6 \times 10^{-3}}{7.5 \times 10^{-2}}$$

$B = 8 \times 10^{-2}$ or 0.08

*allow 8×10^{-2} **or** 0.08 with no working shown for **5** marks*

*a correct method with correct calculation using an incorrect value of F gains **3** marks*

Tesla

accept T

do not accept t

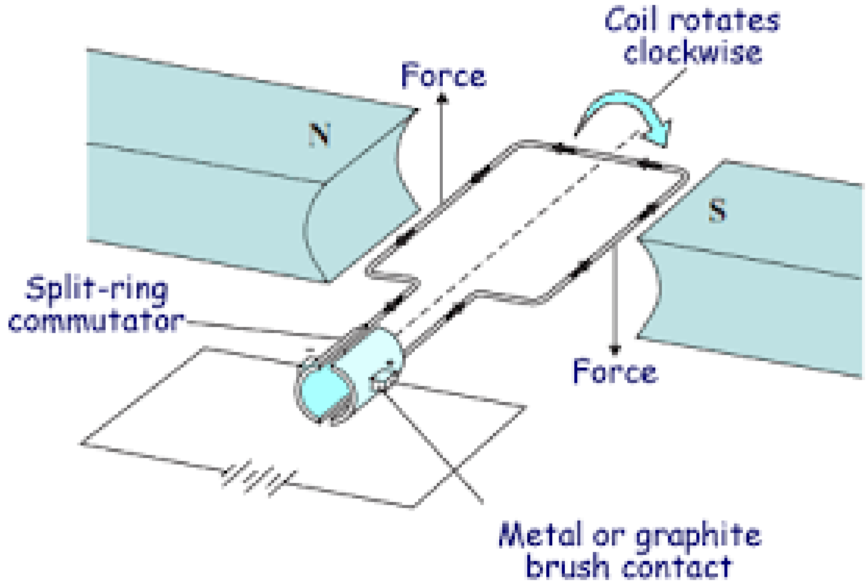
Electric Motors

A **coil of wire carrying a current in a magnetic field** tends to **rotate**. This is the basis of an **electric motor**.

As the coil of wire carrying a current is in a magnetic field, the coil will experience a **force** (the direction of which can be found from **Fleming's left-hand rule**).

The coil of wire shown will experience an **upwards force on the left-hand side** of the coil and a **downwards force on the right-hand side of the coil**.

As the coil will be **fixed** to an axle the coil of wire will **rotate in a clockwise direction**.

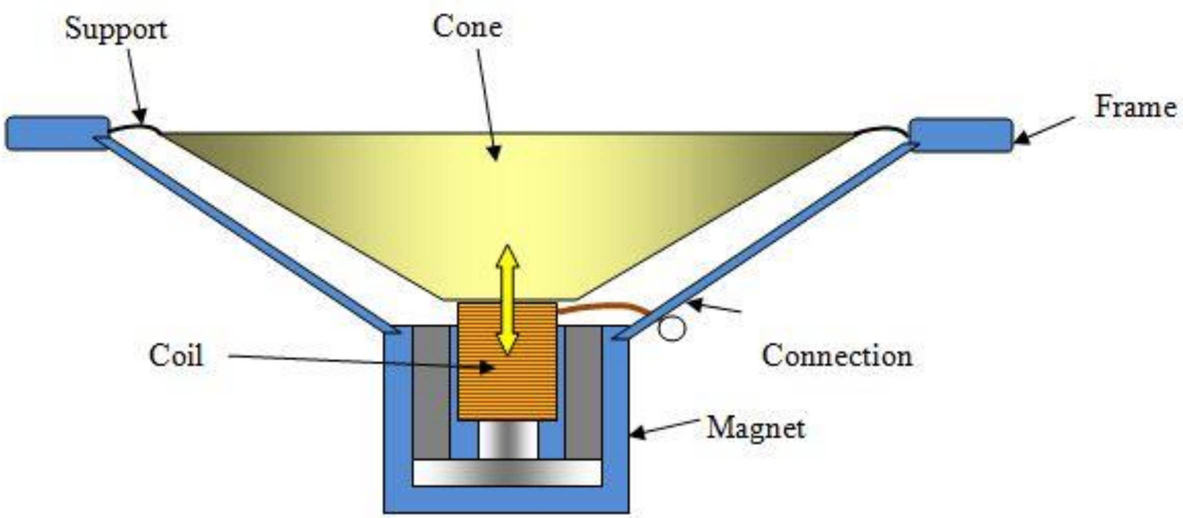


Loudspeakers

Loudspeakers and headphones use the **motor effect** to convert **variations in current** in electrical circuits to the **pressure variations in sound waves**.

Modern loudspeakers can be wired or wireless.

Loudspeakers… continued



- A **fluctuating electric current** flows through the **coil of wire**. The coil of wire then becomes an **electromagnet of variable strength**.
- The **electromagnet is then attracted or repelled** away from the **permanent magnet**.
- This **causes the cone to move** – producing a sound.

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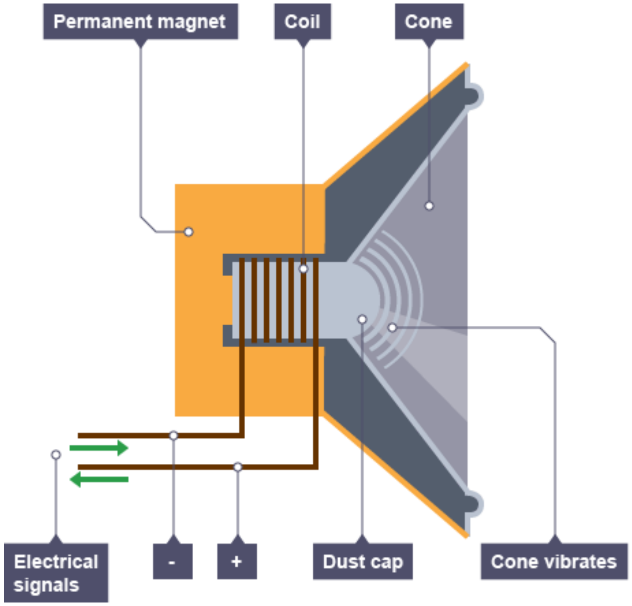
Using the motor effect

A high pitched noise is a sound that has a high frequency.

A loud sound is a sound with a large amplitude.

Using this information and your knowledge of the motor effect, explain how speakers make sounds of a range of different pitches and volumes.
6 marks



Hint: Permanent magnets and AC current!

Mark, Correct and Improve your answer in green pen!

- An AC passes through a coil of wire
- This wire passes through a permanent magnetic field
- The alternating magnetic field interacts with the permanent one
- This produces a force which also alternates
- This moves a coil back and forth, creating sound waves
- Higher frequency waves are made by a higher frequency AC
- Larger amplitudes are produced by a stronger current in the wires

Headphones

Headphones are **miniature loudspeakers**. As the headphones only have to move the air inside the ear canal they can be a lot smaller than typical loudspeakers.

QuestionIT!

The Motor Effect

- Electromagnetism
- Fleming's Left-hand Rule (HT)
- Electric Motors (HT)
- Loudspeakers (HT)(Physics)

10. (HT) Describe the motor effect.

11. (HT) What 3 factors does Fleming's left hand-rule represent?

12. (HT) Give three ways of making the electric motor spin faster.

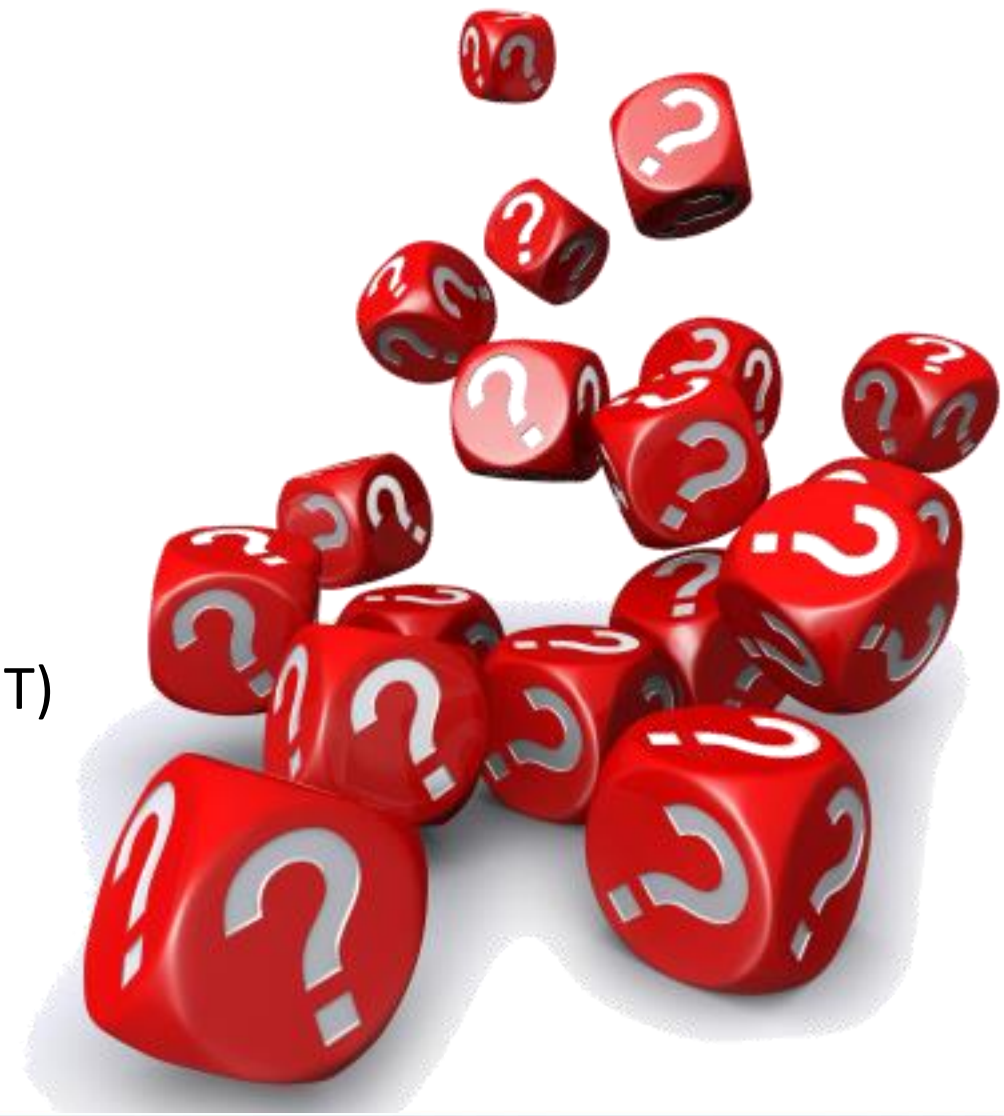
13. (HT) A 40 cm piece of wire is placed in a magnetic field of strength 0.4 T. The wire carries a current of 60 mA. Work out the force on the wire using the equation: Force = magnetic flux density x current x length.

14. (Physics HT only) Explain how a loudspeaker works.

AnswerIT!

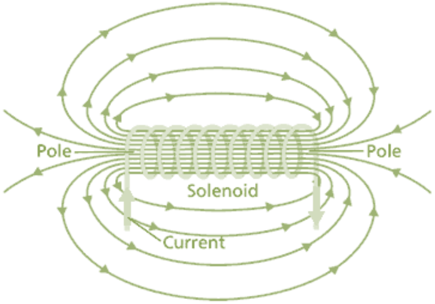
The Motor Effect

- Electromagnetism
- Fleming's Left-hand Rule (HT)
- Electric Motors (HT)
- Loudspeakers (HT)(Physics)

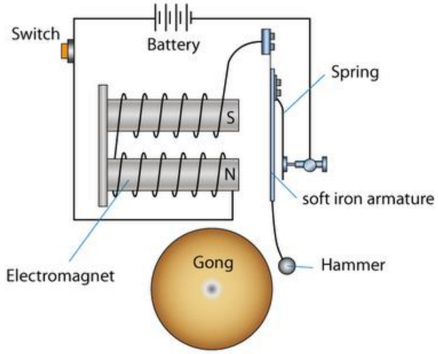


1. What is produced when a current flows through a conducting wire?
   Magnetic field.
2. Name two factors which will impact on your answer to question 1.
   Current flowing through the wire, distance from the wire.
3. What is a solenoid?
   Coil of wire in which a magnetic field is created by passing a current though it.
4. Describe the magnetic field inside a solenoid.
   Strong and uniform.
5. State three ways of increasing the strength of the magnetic field produced by a solenoid.
   Increase the current

6. Draw the magnetic field pattern produced by a solenoid.



7. What is an electromagnet?
   Solenoid with an iron core.
8. (Physics only) Describe how a relay works.
   A switch; uses a solenoid to attract an iron armature; small current turns on a larger current.
9. (Physics only) An electric bell uses a solenoid. Use the diagram below, and your own knowledge, to explain how an electric bell works.
   Solenoid attracts an iron armature, breaking the circuit.
   Demagnetises, armature springs back.
   Circuit reformed. Repeat.



9. (HT) Describe the motor effect.
   Conductor carrying current placed in magnetic field; magnet and conductor exert a force on each other; this force = motor effect.
10. (HT) What 3 factors does Fleming's left hand-rule represent?
    The force, the current in the conductor, the magnetic field.
11. (HT) Give three ways of making the electric motor spin faster.
    Increase the current; increase the number of turns on the coil; increase the strength of the magnets.

12. (HT) A 40 cm piece of wire is placed in a magnetic field of strength 0.4 T. The wire carries a current of 60 mA. Work out the force on the wire using the equation: Force = magnetic flux density x current x length.

    0.0096 N

    40 cm = 0.4 m

    60 mA = 0.06 A

    $F = BIl$ $F = 0.4 \times 0.06 \times 0.4$ N

13. (Physics HT only) Explain how a loudspeaker works.

    A fluctuating electric current flows through the coil of wire.

    The coil of wire then becomes an electromagnet.

    The electromagnet is then attracted or repelled away from the magnet.

    This causes the cone to move – producing a sound.

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LearnIT!
KnowIT!

Induced Potential, Transformers and The National Grid (Physics HT only)

- Induced Potential
- Uses of the Generator Effect
- Microphones
- Transformers

The Generator Effect

If an electrical conductor moves relative to a magnetic field or if there is a change in the magnetic field around a conductor, a **potential difference** is **induced** across the ends of the conductor. If the conductor is part of a complete circuit, a current is **induced** in the conductor. This is called **the generator effect**.

Induced means to bring about, produce or cause. An induced current is one that is produced by moving a conductor relative to a magnetic field.

An **induced current generates a magnetic field** that **opposes the original change**, either the movement of the conductor or the change in magnetic field.

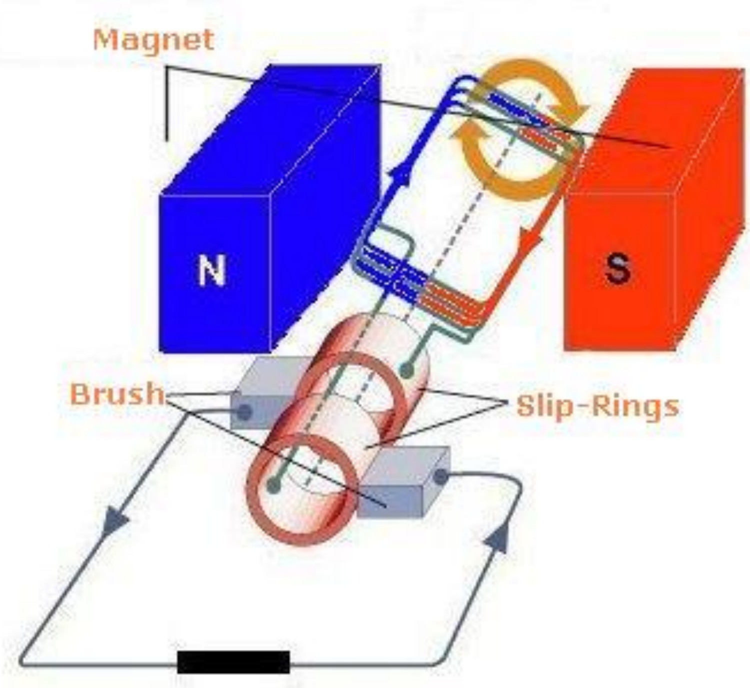
Generators

A simple generator will have a **coil of wire** that **moves** in a **magnetic field**.

A potential difference is induced across the ends of the conductor – and as there is a complete circuit a current is induced in the coil of wire.

To **increase** the **size** of the induced potential difference/current…

- The coil of wire should be **rotated faster**;
- The **magnetic field** should be made **stronger**;
- The **number of turns** of wire on the coil should be **increased**.



Direction of Induced Potential

The **direction** of the induced potential difference/induced current are **dependent on the direction of rotation** of the coil and the orientation of the magnetic field.

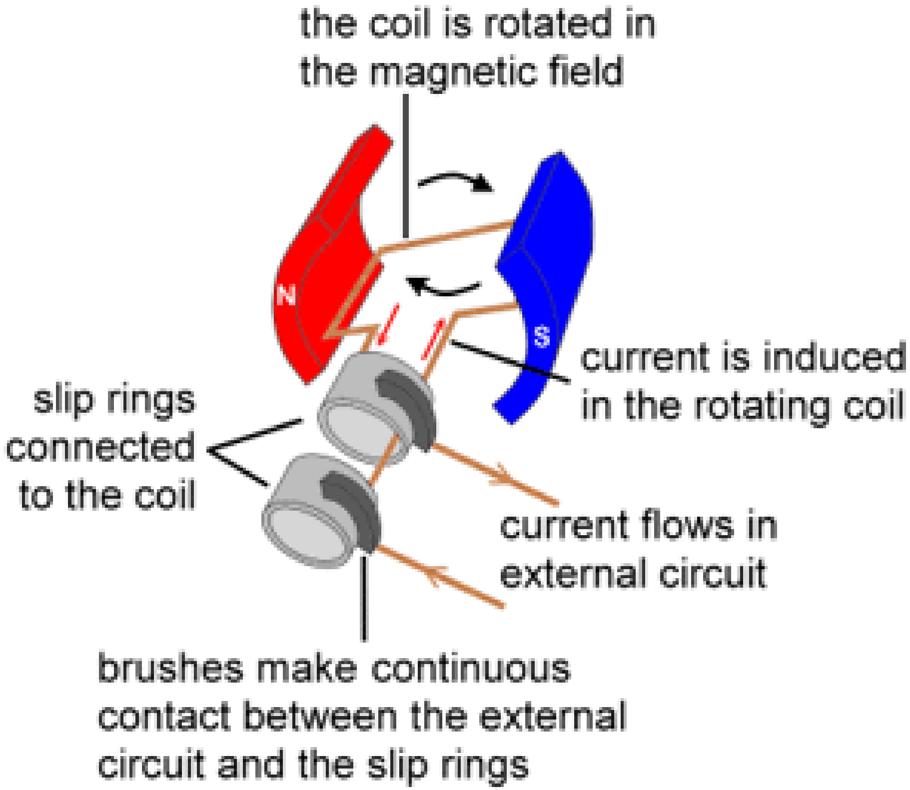
- **Reversing the direction** of rotation of the coil will reverse the direction of the induced potential difference/induced current.
- **Swapping the polarity** of both magnets will also reverse the direction of the induced potential difference/induced current.
- **Swapping the direction of rotation** of the coil **AND swapping the polarity** of each magnet will give **no change to the direction** of the induced potential difference/induced current (as it would have been reversed and reversed again).

Alternators

Alternators use the **generator effect** to generate an **alternating current** (ac).

As a coil of wire moves relative to a magnetic field there is an induced potential difference / induced current.

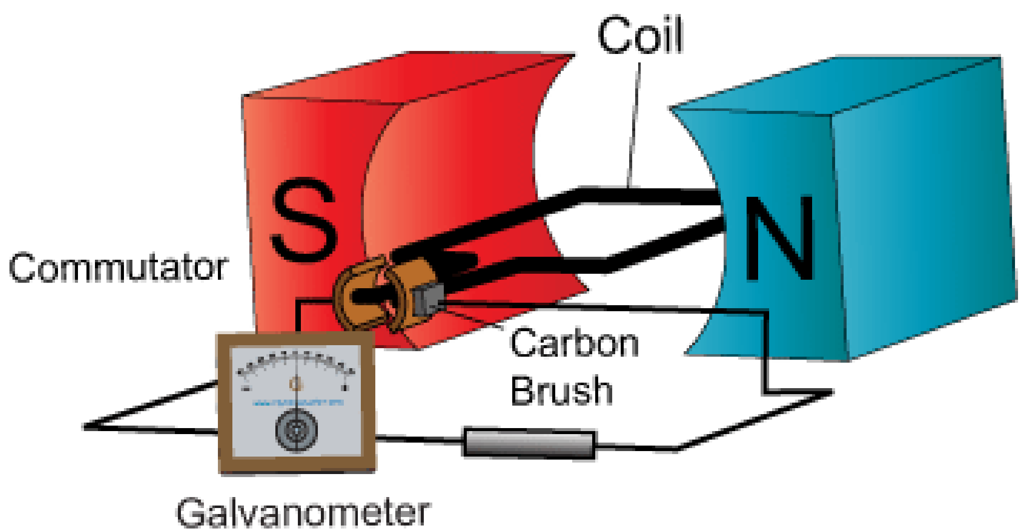
Since the direction of movement of one side of the coil of wire changes, so does the direction of the induced current – so giving ac.



Dynamos

Dynamos use the **generator effect** to generate a **direct current** (dc).

With a dynamo the coil of wire is connected to **split ring commutators** rather than **slip ring commutators**. This means that every half rotation one side of the coil of wire attaches to a different side of the circuit, but as the direction of motion of the coil on the left and right-hand side remain the same the current in the external circuit only moves one way – a dc output.



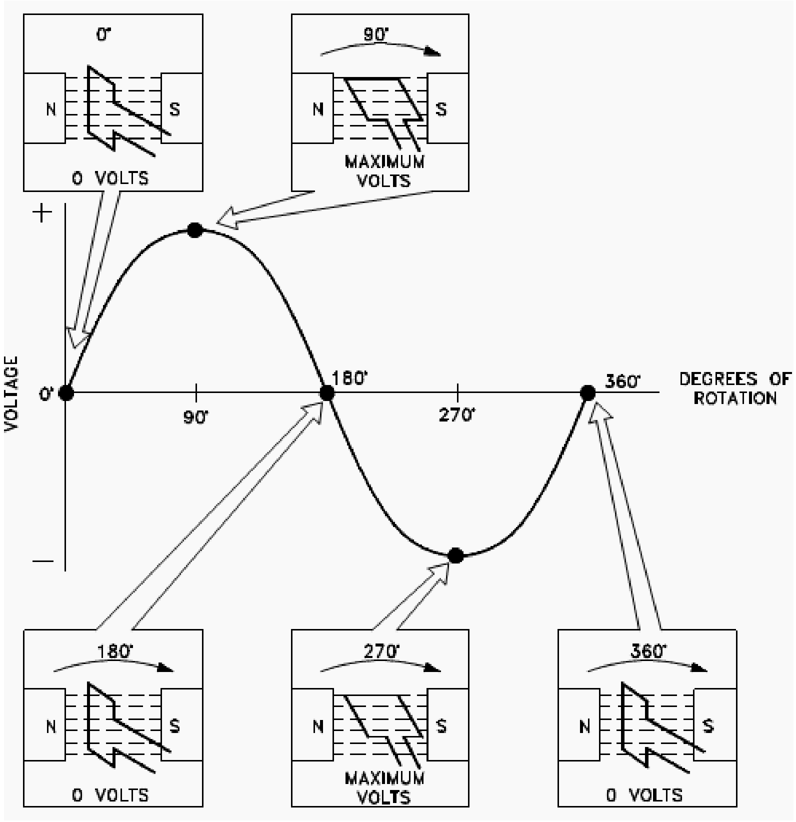
The Output of a Generator

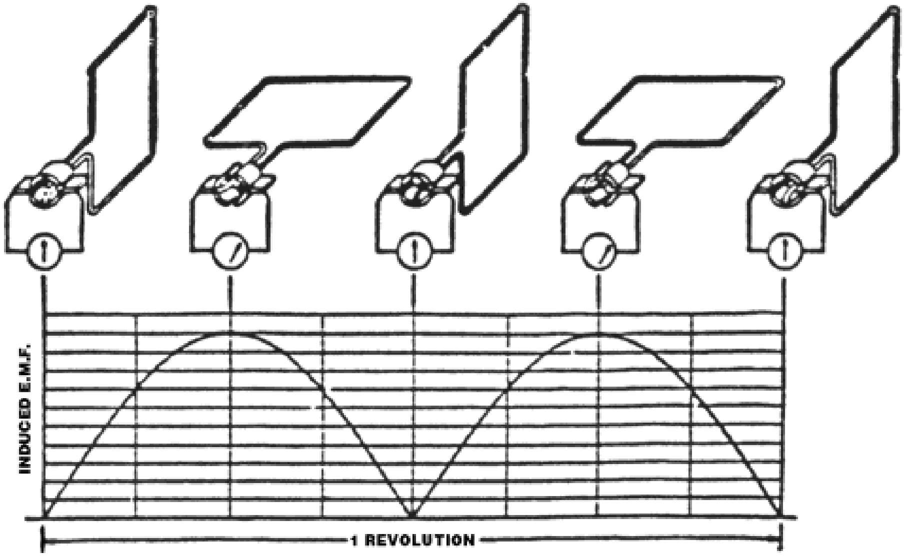
The output of a generator is greatest when the magnetic field lines of the magnets used are being broken at the fastest rate.

For a coil of wire rotating between two magnets the magnetic field lines are being broken fastest when the **coil is moving vertically upwards** – this occurs when the coil of wire and the magnetic field are horizontal.

No current is induced when the coil moves parallel to the magnetic field lines – as no field lines are being broken. The output is zero when the coil of wire is vertical.

The Output of a Generator… continued





Dynamo Output

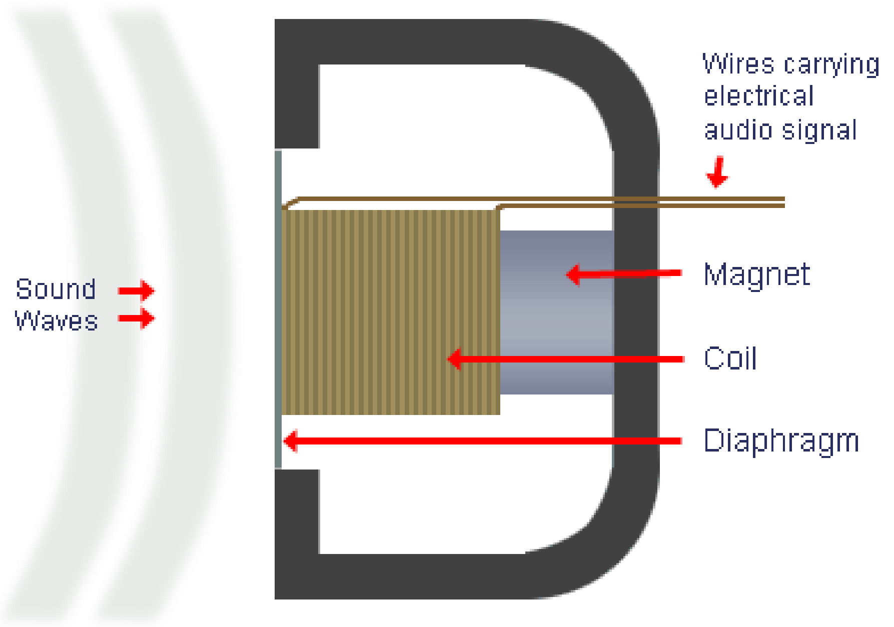
Alternator Output

Microphones

Microphones use the **generator effect** to covert the **pressure variations** in sound waves into **variations in current** in electrical circuits.

Microphones contain a diaphragm that moves when sound waves hit it. The movement of the **diaphragm** makes the **coil of wire** move relative to the **magnet**, which induces a current in the wires (the generator effect).

Cross-Section of Dynamic Microphone



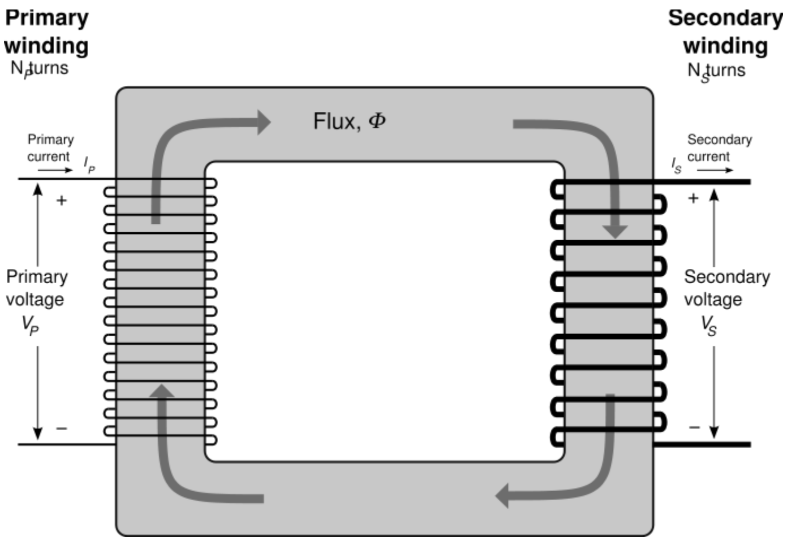
Transformers

A **basic transformer** consists of a **primary and a secondary coil** wound on an **iron core**.

Iron is used as it is **easily magnetised**.

You need to know about two types of transformer:

- **Step-up transformer**
- **Step-down transformer.**



Transformer Equations

The ratio of the **potential differences (in Volts, V)** across the primary and secondary coils of a transformer V_p and V_s depends on the ratio of the number of **turns on each coil**, **Np** and **Ns**.

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

If transformers were **100% efficient**, the **electrical power output (V_s x I_s)** would equal the **electrical power input (V_p x I_p)**.

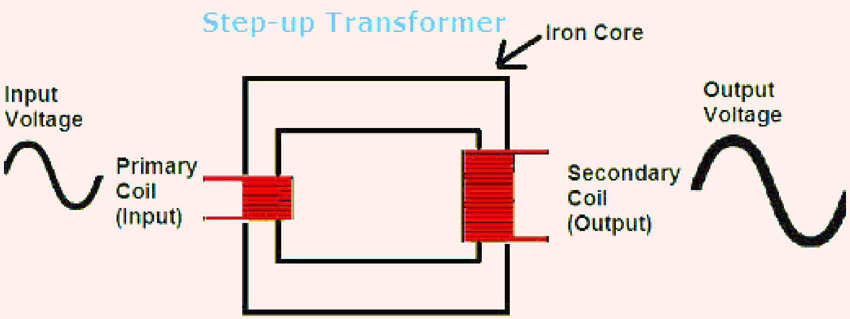
$$V_s \times I_s = V_p \times I_p$$

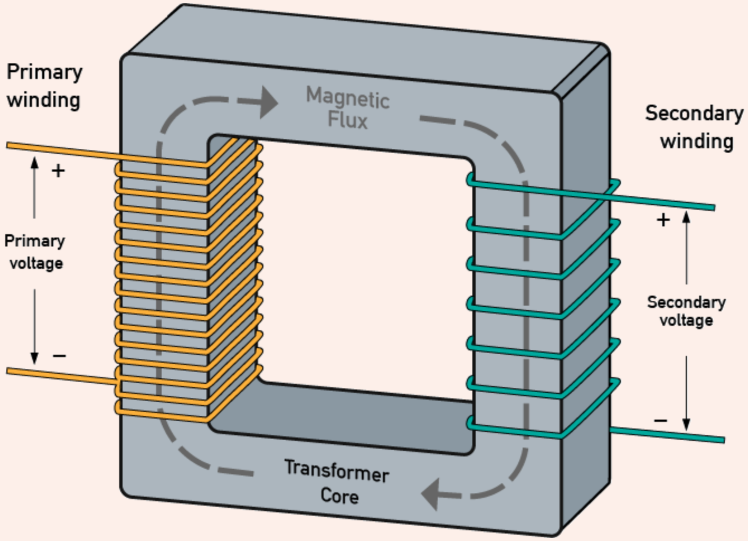
The output can also be calculated using ratios.

- If there are 3 times the number of turns of wire on the secondary coil then the output potential difference will be 3 times greater.
- If there are 10 times fewer turns of wire on the secondary coil the output potential difference will be 10 times less.

Induced Potential, Transformers and The National Grid
Part 4: Transformers

Step-up transformers	Step-down transformers
• Increase the potential difference so $V_s > V_p$ • More turns on the secondary coil	• Decrease the potential difference so $V_s < V_p$ • More turns on the primary coil





How Transformers Work.

- Transformers have a **primary coil of wire** with an **alternating current (ac)** flowing.
- This produces an **alternating magnetic field** in the **iron core**.
- On the **secondary side** of the transformer there is a **coil of wire** and an **alternating magnetic field**.
- So the **magnetic field is moving relative to the coil of wire**.
- This **induces** a potential difference (and **induces** a current if there is a complete circuit). This is the **generator effect**.

Advantages of power transmission at higher voltages

Transformers are used in **The National Grid** to make the transmission of electricity more **efficient**.

Increasing the potential difference will **decrease** the current in the overhead powerlines. Assuming that the transformers are 100 % efficient, the power input and power output would be the same, so:

$$V_s \times I_s = V_p \times I_p$$

Where $V_s \times I_s$ is the power output (secondary coil) and $V_p \times I_p$ is the power input (primary coil).

Potential difference and **current** are **inversely proportional**. A lower current means that the powerlines will heat up less, less energy will be 'lost' as heat.

Using the Transformer Equations

Example 1

A step-up transformer has 100 turns of wire on the primary coil and 400 turns of wire on the secondary coil.

The input potential difference on the primary coil is 12 V. Work out the output potential difference of the transformer.

Using $V_p / V_s = N_p / N_s$

Substituting gives $12 / V_s = 100 / 400$

Rearranging gives $V_s = \frac{12 \times 400}{100}$

$V_s = 48\ V$

Alternatively, there are four times as many turns of wire on the secondary coil the output potential difference is four times greater.

Using the Transformer Equations…continued

Example 2

A step-down transformer has an input potential difference of 230 V. The output potential difference is 12 V and the current in the secondary coil is 30 mA.

Work out the current in the primary coil.

Assuming no power losses in the transformer…

$$V_s \times I_s = V_p \times I_p$$

Substituting gives $$12 \times 0.03 = 230 \times I_p$$

Rearranging gives $$\frac{12 \times 0.03}{230} = I_p$$

$$I_p = 0.0016 \text{ A} \quad \text{or } 1.6 \text{ mA}$$

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QuestionIT!

Induced Potential, Transformers and The National Grid

- Induced Potential
- Uses of the Generator Effect
- Microphones
- Transformers

Induced Potential, Transformers and The National Grid – QuestionIT

1. What does the term ‘induced current’ mean?
2. What is a simple generator made of?
3. How can the size of the induced potential difference/ current in a generator be increased?
4. What factors affect the direction of the induced potential difference/ current?
5. What type of current is induced by an alternator?
6. What type of current is produced by a dynamo?

7. Describe <u>two</u> ways of reversing the direction of current flow on a dynamo.

8. At which point of the rotation does a dynamo induce the greatest potential difference?

9. How do microphones use the generator effect?

10. What does a basic transformer contain?

11. Why are cores made of iron?

12. What can be said about the potential difference in the primary and secondary coils of a step-down transformer?

13. How do transformers work?

14. A step-up transformer is used in a power station to increase the potential difference output from 25,000 V to 400,000 V. The current through the overhead power lines is 25 A. Work out the current in the primary coil.

$$V_s \times I_s = V_p \times I_p$$

15. Why are transformers used when sending electricity through the National Grid?

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AnswerIT!

Induced Potential, Transformers and The National Grid

- Induced Potential
- Uses of the Generator Effect
- Microphones
- Transformers

1. What does the term ‘induced current’ mean?
   Current made by moving a conductor relative to a magnetic field.
2. What is a simple generator made of?
   Coil of wire; magnetic field, movement.
3. How can the size of the induced potential difference/ current in a generator be increased?
   More turns, stronger magnetic field, increase sped of movement.
4. What factors affect the direction of the induced potential difference/ current?
   Direction of movement/ rotation; reversing the polarity.
5. What type of current is induced by an alternator? ac
6. What type of current is produced by a dynamo? dc

7. Describe two ways of reversing the direction of current flow on a dynamo.
   Swap the polarity of both magnets.
   Spin the coil of wire in the opposite direction.
8. At which point of the rotation does a dynamo induce the greatest potential difference?
   When the coil of wire is perpendicular to the magnetic field; it is at this point that the magnetic field lines are being cut at the greatest rate.
9. How do microphones use the generator effect?
   Convert the pressure variations in sound waves into variations in current.
10. What does a basic transformer contain?
    Primary coil, secondary coil, iron core.
11. Why are cores made of iron? Easily magnetised.

12. What can be said about the potential difference in the primary and secondary coils of a step-down transformer?

    $V_s < V_p$

13. How do transformers work?
    - Transformers have a **primary coil of wire** with an **alternating current (ac)** flowing.
    - This produces an **alternating magnetic field** in the **iron core**.
    - On the **secondary side** of the transformer there is a **coil of wire** and an **alternating magnetic field**.
    - So the **magnetic field is moving relative to the coil of wire**.
    - This **induces** a potential difference (and **induces** a current if there is a complete circuit). This is the **generator effect**.

14. A step-up transformer is used in a power station to increase the potential difference output from 25,000 V to 400,000 V. The current through the overhead power lines is 25 A. Work out the current in the primary coil.

$$V_s \times I_s = V_p \times I_p$$

400 A

16 times more potential difference so 16 times less current.

$V_s \times I_s = V_p \times I_p$ or correct substitution.

15. Why are transformers used when sending electricity through the National Grid?

Increases potential difference; decreases current; decreases loss of energy through heat.

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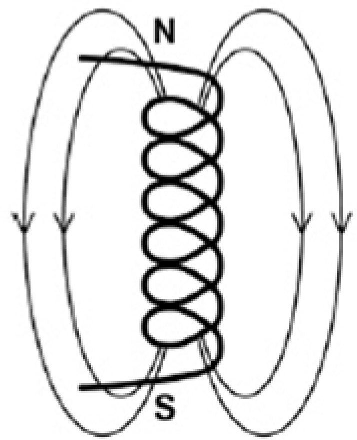
(g) **Figure 3** : (g) at least one field line on each side of the solenoid

an arrow to indicate the field going from North to South pole



Draw field lines to show the magnetic field around the solenoid.

(2)

(h) How can the solenoid be made into an electromagnet?

____

____

(1)

Q2.

A student placed a permanent magnet on a top-pan balance.

He clamped a straight piece of wire so that it was suspended in the magnetic field.

Figure 1 shows the apparatus.

Figure 1

(a) the current creates a magnetic field in the wire 1

which interacts with the magnetic field from the permanent magnet 1

Flemming's left hand rule says the force on the wire is upwards 1

so the force on the permanent magnets is downwards 1

(a) When a current passed through the wire from **A** to **B**, the reading on the balance increased.

c) The length of the wire in the magnetic field in **Figure 1** is 4.8×10^{-2} m

The current in the wire is 0.80 A

The reading on the balance is 1.2×10^{-3} kg

Gravitational field strength = 9.8 N/kg

Calculate the magnetic flux density of the permanent magnet.

(c) $W = mg = 1.2 \times 10^{-3} \times 9.8$ 1

$W = 0.01176$ 1

$0.01176 = B \times 0.80 \times 4.8 \times 10^{-2}$ 1

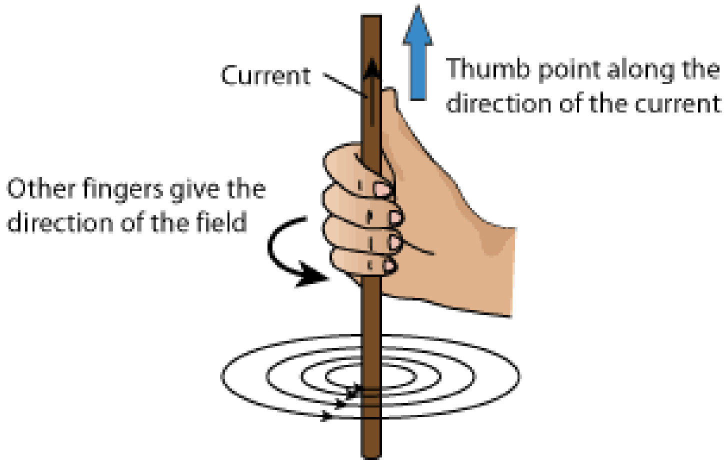
$$B = \frac{1.2 \times 10^{-3} \times 9.8}{0.8 \times 4.8 \times 10^{-2}}$$ 1

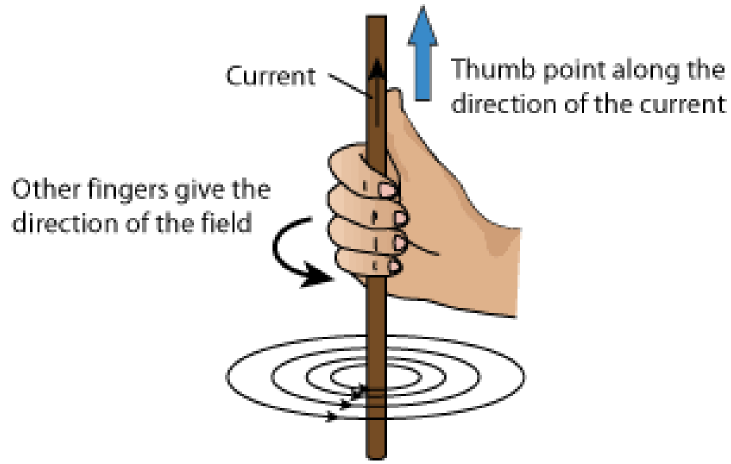
B = 0.31

*an answer of 0.031 scores **3** marks*

*an answer of 0.31 scores **5** marks* 1

[11]


Current
Thumb point along the direction of the current
Other fingers give the direction of the field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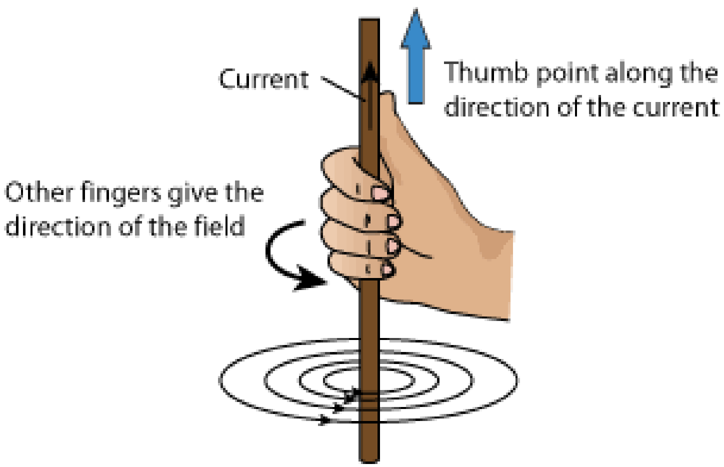
Current
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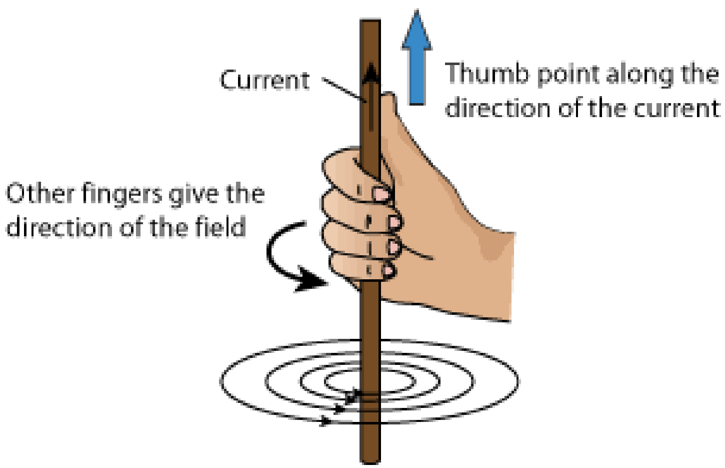
Current
Thumb point along the direction of the current
Other fingers give the direction of the field