ELECTRICITY NOTES
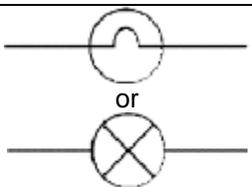
Week5
Unit 6.1: ELECTRICAL COMPONENTS
At the end of this lesson, students should be able to:

□   Draw and name the symbol for each component

□   Identify components to know symbols of an electric component.

□   State the function of each component.

Component	Symbol	Function
1. Cell		• Supplies electrical energy • The larger terminal indicates the positive (+) • A single cell is often interpreted and called a battery, but a battery is two or more cell joined together.
2. Battery		• Supplies electrical energy • A battery is more than one cell. • The larger terminal is the positive (+) and the small terminal is called the negative (-)
3. DC Supply		• Supplies electrical energy. • DC = Direct Current, always flowing in one direction.
4. AC Supply		• Supplies electrical energy. • AC = Alternating Current, continually changing direction of its currents. It is negative and then positive which alternates again.
5. Fuse		• A safety device, which will 'blow' or melt if the current flowing through it exceeds specified value. • Used as a protection for electrical circuits.
6. Lamp	 or	• A component that converts electrical energy to light energy.
7. Switch		• A switch controls the flow of current. • It allows current to flow only in the closed position.
8. Resistor	 or	• A resistor restricts the flow of current • For example: to limit the current passing through an LED
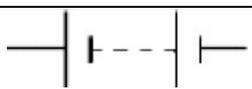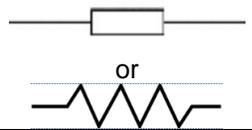
Component	Symbol	Function
9. Variable Resistor (Rheostat)	Or	• Controls the current that flows through a component.
10. Diode		• The device that allows current to flow in only one direction.
11. Light Emitting Diode (LED)		• A component that has the ability to convert electrical energy into light energy.
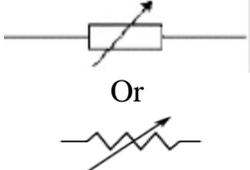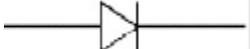
Component	Symbol	Function
12. Voltmeter	V	• A voltmeter is used to measure voltage. • The proper name for voltage is "potential difference", but most people prefer to say voltage!
13. Ammeter	A	• An instrument that is used to measure the current flowing through a circuit. Current is measured in amps.
14. Galvanometer		• An galvanometer is a very sensitive meter which is used to measure very small currents, usually 1mA or less.
15. Capacitor		• Stores electrical energy

Unit 6.2: ELECTRICAL CIRCUITS

At the end of this lesson, students should be able to:
- □ Define and describe electric circuit.
- □ Compare and contrast series and parallel circuits.
- □ Know and use Ohm's Law to calculate voltage, current and resistance.
- □ Connect simple circuits.
- □ Draw series and parallel circuit diagrams.

Introduction

Current: is the movement of charged particles.
In electrical circuits, the moving particles are usually electrons.

- A circuit is made up from various components which are connected together so that electrons can move through the components.

- A power supply is the component which supplies electrical energy to the moving electrons.
- The power supply is usually the mains supply (240V), a dry cell, a battery (several cells together, usually in series) or a power pack.
- Power packs are connected to the mains and allow the voltage of the electrical energy supplied to be varied.
- A circuit will have one or more components in which the moving electrons will *lose* electrical energy.
- In electrical circuits, electrical energy from the power supply is changed into other forms of energy as the electrons move around the circuit.

Possible Energy Transformations are:

1. Heating

- Many components in a circuit change electrical energy into heat energy and often get warm.
- Heating elements, like those found in a kettle or a hair dryer, are designed to get hot when a current passes through them.
- In other components the changing of electrical energy into heat energy is wasteful and often expensive.

2. Lighting
- In components such as lamps, electrical energy is changed into light energy.
- Large amounts of heat energy are also produced.

3. Magnetic Fields
- An electrical current can produce a magnetic field.
- This occurs in transformers and some types of motors and generators.

4. Chemical Energy
- Electrical currents can make chemical reactions occur.
- This happens in the process called *electrolysis*.
- *Re-chargable* 'Nicad' cells use electrical energy when being charged and change this energy into chemical energy.
- When the cell is being used as a power supply, it *discharges* and the chemical energy is changed into electrical energy.
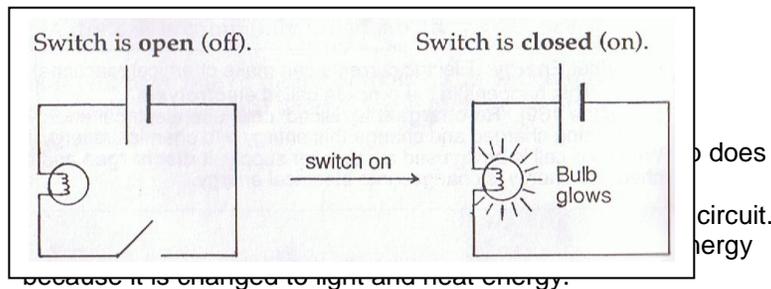
NOTE:
- There must be a path in electric circuits to allow electrons to move through the power supply and other components.
- Copper wires, strips of metal or solder are commonly used to make a pathway between components.
- The direction of the **convectional current**, (symbol I) is from the *positive terminal* of the power supply to the *negative terminal*.
- In the circuits illustrated below, the conventional current is shown moving from the positive terminal to the negative terminal.

This circuit is represented by:
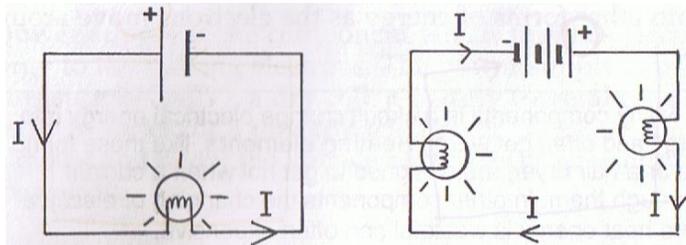
- A circuit is **complete** if there is a path which allows electrons to move all the way around the circuit continuously from one terminal of the power supply and back to the other terminal.
- A **switch** is a compent used to complete or break a circuit.
- Breaking a circuit means stopping the electrons from moving.
- No energy is supplied to electrons by the power supply and no energy is lost in the components when the circuit is broken.

  Example: In the following circuit, the switch is used to complete the circuit.

Switch is **open** (off).   Switch is **closed** (on).

-                           does
-                           circuit.
                            ergy

  switch on   Bulb glows

CIRCUIT DIAGRAMS

- A circuit diagram uses symbols to represent components and shows how they are connected together.
- Circuit diagrams must be drawn neatly, using a ruler and without any gaps in the connecting wires.
- Usually a rectangular shape is used for the layout.
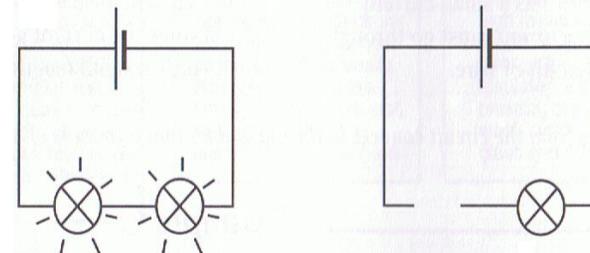
  Example:
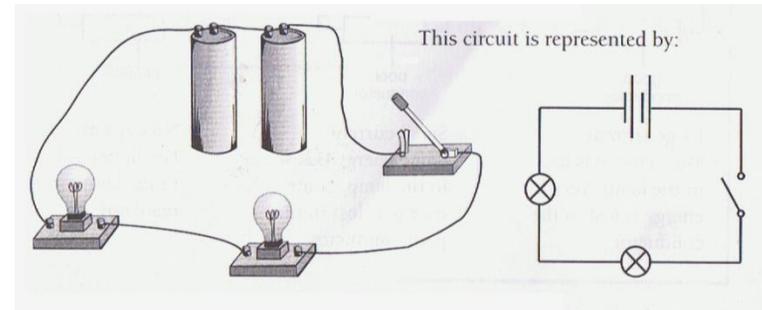
TYPES OF ELECTRICAL CIRCUITS

1. SERIES CIRCUITS

- In a series circuit, the electrons all move along the same path, through one component, then another and so on.
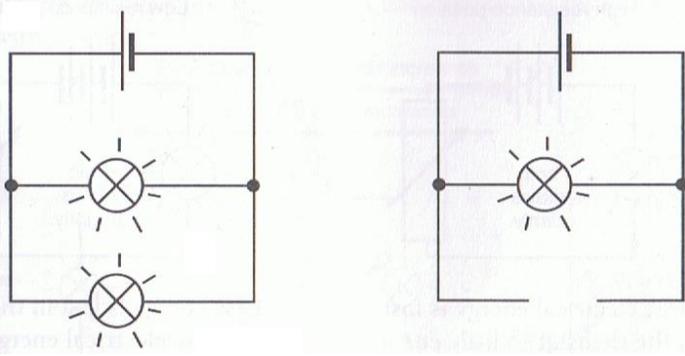
  For Example:

- The circuit shows a series circuit because the components (lamps) are connected in the same path.
- If one lamp is removed, the other lamp goes out because the current cannot flow in the broken circuit.

2. PARALLEL CIRCUITS

- In parallel circuits, the current has a 'choice' of pathways.
- Most electrons go along the path which is easiest to move through. It is the path with the smallest resistance.

For Example:

- The above circuit shows a parallel circuit because the components are connected in different pathways.
- The current has a choice of which pathway it will travel.
- If one lamp is removed the other lamp continues to glow because the current can still flow around a complete circuit.

CURRENT (*I*)
- The current flowing in a circuit refers to the movement of charged particles (i.e electrons) in a circut.
- Current is measured by a unit called the **ampere** (symbol A). Ampere is often abbreviated to **'amp'** or **'amps'**.
- A current of 1 ampere means that 6×10^{18} (six million million million) electrons pass a point in the circuit every second.
- The symbol *I*, is used to represent current.
- The **ammeter** is the component which measures current in a circuit.
- Ammeters are *always connected in series* with other components in a circuit.

To measure the current at X, put the ammeter in the circuit at X.
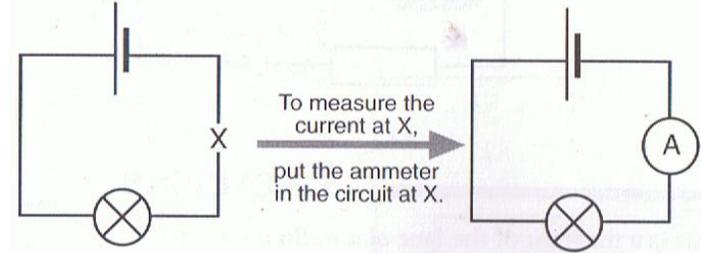
- To avoid damaging an ammeter, it must be connected so that the positive terminal of the ammeter leads back to the positive terminal of the power supply.
- The negative terminal of the ammeter is connected so that it leads back to the negative terminal of the power supply.


Positive terminal on the ammeter leads to the *positive* terminal on the power supply.

Negative terminal on the ammeter leads to the *negative* terminal on the power supply.
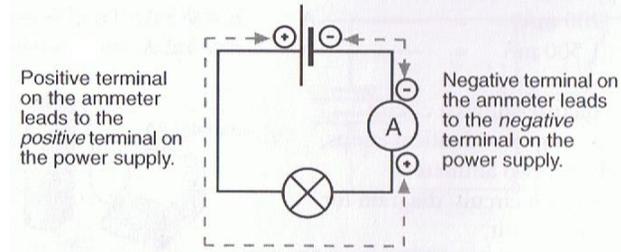
- An ammeter has a *very small resistance* so that it will not change the amount of current flowing in the circuit if it was absent.

Current in a series circuit
- In a series circuit the *current is the same* at any point in the circuit.

Example:
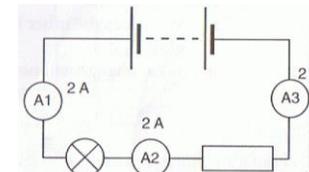
- As the current flows through the components in the circuit, the ammeters (A_1, A_2 and A_3) will read the same amount of current.

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Total current flowing through the circuit = $A_1 = A_2 = A_3$

Current in a parallel circuit

- However, if components are arranged in a parallel circuit, the currents have the tendency to choose which pathway it will travel.
- Currents in parallel parts of a circuit add up to equal the current from the power supply.
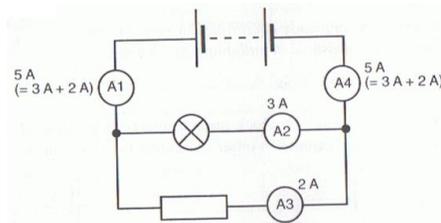
Total current flowing through the parallel circuit:
$A_1 = A_2 + A_3$
$A_1 = 3A + 2A$
∴ **A_1 = 5A**

Note: $A_1 = A_4$ since they are connected in series.

VOLTAGE (V)

- Voltage is also called potential difference.
- Voltage measures:
  (i)   the energy lost across a component or
  (ii) energy supplied by the power supply or battery.

- The unit of voltage, the **volt** (symbol V) represents the 'energy change each second for every amp of current'.
- Voltage is measured with a **voltmeter.**
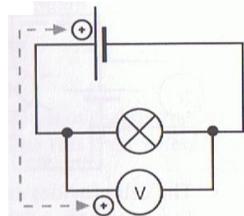
- A voltmeter is ***always connected in parallel*** to the component for which the voltage is being measured because it has a <u>very high resistance</u> so that it does not draw off any significant current from the circuit to make it work.
- Like an ammeter, a voltmeter must be connected so that the positive terminal of the meter leads back to the positive terminal of the power supply.
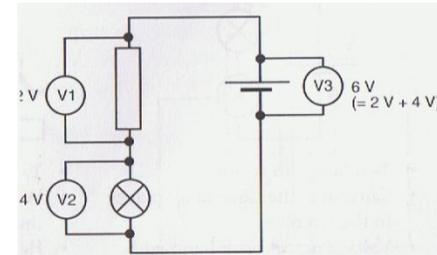
Voltage in a series circuit

- In a circuit containing a *single component*, the voltage across the power supply is **equal** to the voltage across the component.

  For example:
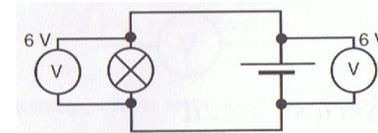
- If the series circuit contains *more than one* component, the voltage across the components **adds up** to equal the voltage across the power supply (total voltage).
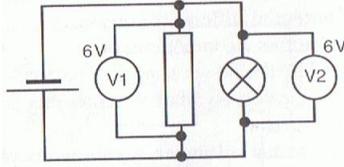
  For example:

$V_T = V_1 + V_2$
$V_T = 2V + 4V$
∴ **V_T = 6V**

Note: $V_T = V_3$ (the total voltage across power supply.

Voltage in a parallel circuit

- In a parallel circuit, the voltages across components that are connected in parallel are always the **equal**.

- The rheostat and the lamp in the circuit above are connected in parallel. The voltage across the rheostat (V_1) is 6 volts.
- Since voltages across components connected in parallel are equal – the voltage therefore across the lamp (V_2) is also equal to 6 volts.

RESISTANCE
- Resistance refers to "*how difficult it is for electrons to move through a component in a circuit*".
- If electrons move easily through a component that component has *low* resistance.
- **Good conductors** have low resistance. Electrons move easily through good conductors and usually little electrical energy is lost.
  Silver and gold are good conductors but are too expensive for most uses.
  Copper is widely used and aluminium is now used widely in power cables.
  Carbon, a non-metal, is also a fairly good conductor
- **Poor conductors** have high resistance. Electrons will move through a poor conductor but not easily.
  When electrons move through a poor conductor, they can lose a lot of electrical energy.
- **Insulators** have *very* high resistance. Electrons do not travel through insulators.
  Insulators include plastics, dry paper, wool, cotton, wood, glass and rubber.
  When insulators are placed in a series circuit, there is no current.

The following circuits show the effects of conductors and insulators in a circuit with a lamp.
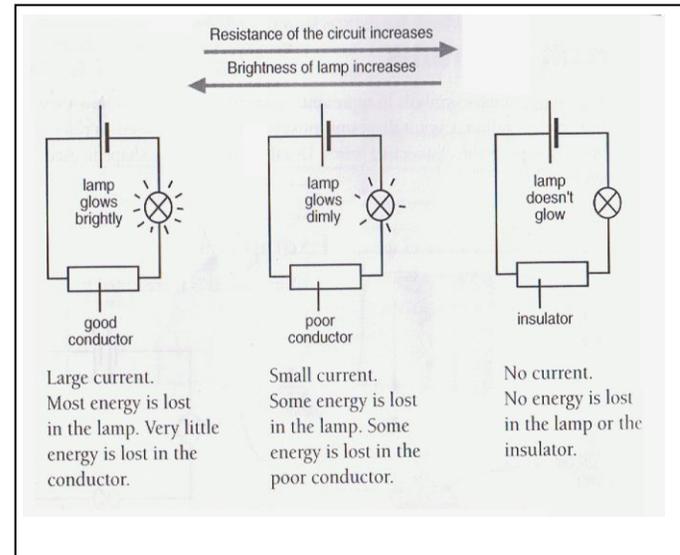
- The resistance of a component is measured in **ohms** (Ω)

Factors affecting the resistance of a wire:

1. The temperature of the wire; the higher the temperature the greater the resistance.

2. The thickness or **cross-sectional area** of the wire; the thicker the wire the smaller the resistance.

3. The type of metal the wire is made of; for example, the resistance of a piece of iron wire is about 7 times the resistance of a piece of copper wire of the same length and thickness.

4. The <u>length</u> of the wire; the longer the wire the greater the resistance. e.g a wire 10 metres long would have twice the resistance of a 5 metre length of the same wire.
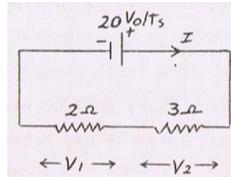
Resistors in a Series Circuit
- When the resistors are connected in series, the same current flows through each resistor.
- The total resistance in a series circuit is equivalent to
-
- the sum of the resistors in the circuit.
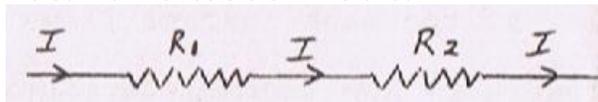
$$R_T = R_1 + R_2$$

For example:
What is the **total resistance** of the circuit shown?

$$R_T = R_1 + R_2$$
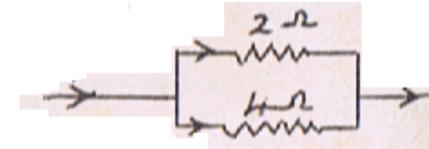$$R_T = 2\Omega + 3\Omega$$
$$\mathbf{R_T = 5\Omega}$$

Resistance in a Parallel Circuit
- When resistors are connected in parallel, the total resistance is equivalent to:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots\ldots$$

- The total resistance is *always* less than the smallest resistor.

Example: Calculate the total resistance of a 2Ω resistor and a 4Ω connected in parallel with each other.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_T} = \frac{1}{2} + \frac{1}{4}$$

$$\frac{1}{R_T} = \frac{6}{8} \ or \ \frac{3}{4}$$

$$4 = 3R_T$$

$$R_T = \frac{4}{3}$$

$$\therefore R_T = 1.3\Omega$$

Note: The total resistance is smaller than the smallest resistor. The smallest resistor is 2Ω.
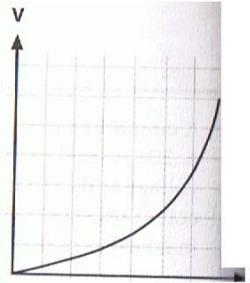
OHM'S LAW

"Provided that physical conditions, such as temperature, do not change, the current flowing through a conductor is directly proportional to the voltage across the ends of the conductor"

- Ohm's Law gives us the relationship between voltage, current and the resistance of a circuit.
- If the voltage across a component in a circuit is changed, the current through the component will also change.
- A component is believed to obey Ohm's Law if the component have constant resistance and are called ohmic conductors.

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Current (amps)
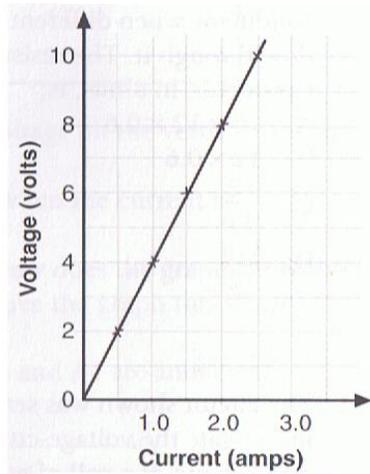
- Non-ohmic resistors does not have constant resistance.

- The following equation can be derived from Ohm's Law:

$$V = IR$$

where:

V = Voltage
I = Current
R = Resistance

- The formula of Ohm's Law can be re-arranged to find any quantity you are trying to find.

Examples:

1. What is the resistance of a wire if it takes a current of 2 amps when a voltage of 10 volts is applied across its ends?

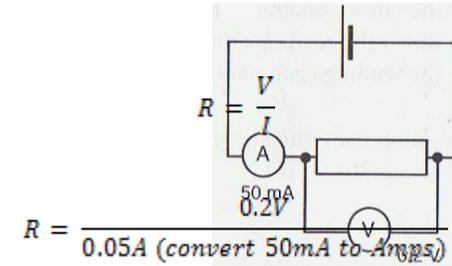$$I = 2A$$
$$V = 10V$$

$$V = IR$$

$$R = \frac{V}{I}$$

$$R = \frac{10V}{2A}$$

$$R = 5\Omega$$

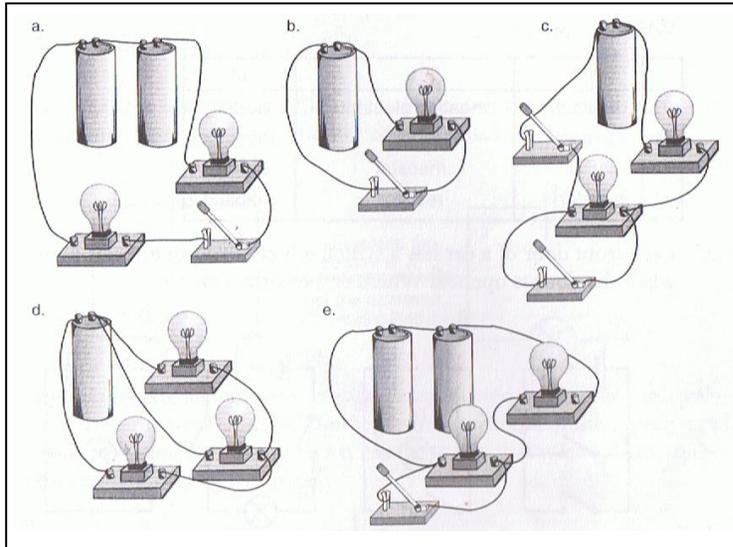2. Calculate the total resistance of the resistor in the circuit below.

$$V = IR$$

$$R = \frac{V}{I}$$

$$R = \frac{0.2V}{0.05A \ (convert \ 50mA \ to \ Amps)}$$

R = 4Ω

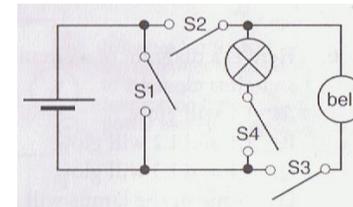## Self-check 6.1: Electrical Components

1. Draw a circuit diagram for each of the following circuits.

2. Complete the table below by filling them in.

| Electrical component	Symbol	Function
Switch		Controls the flow of current
	⌐WWW⌐	
		Allows the current to flow in only one direction
Rheostat		

3. Study the circuit diagram below carefully then answer the questions that follow.

Which switch(es) must be closed to:
a) Allow only the lamp to glow
b) Allow only the bell to ring
c) Allow both the lamp to glow and the bell to ring.

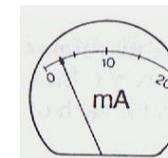4. Draw a circuit diagram to show a lamp in series with two cells, a switch and a rheostat.

5. Here are some circuit symbols.
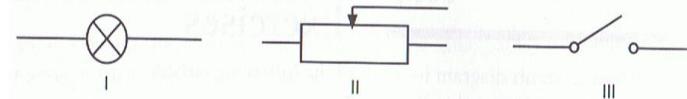
Which one is correct?

	I	II	III
A.	Rheostat	Diode	Switch
B.	Lamp	Resistor	Rheostat
C.	Lamp	Rheostat	Switch
D.	Resistor	Resistor	rheostat

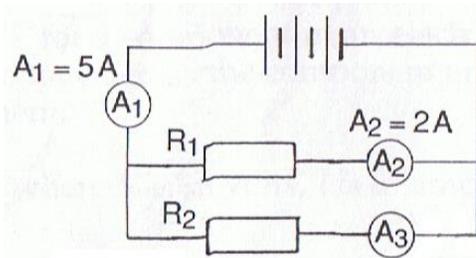6. This is a diagram of the face of a milliammeter. The reading on the meter is:

A. 2.5×10^{-6} amp   C. 2.5 amp
B. 2.5×10^{-3} amp   D. 2.5×10^{3}

7. In the electric circuit shown M_1 and M_2 are meters. What does the meter labelled M_2 measure?

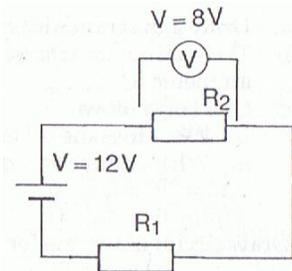A. Current
B. Voltage
C. Resistance
D. Power
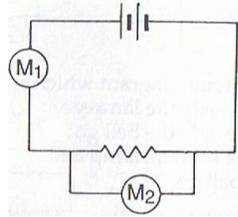
8. In the circuit diagram shown, A_1, A_2 and A_3 are ammeters. The reading on A_1 is 5A and on A_2 is 2A. What is the reading on A_3?
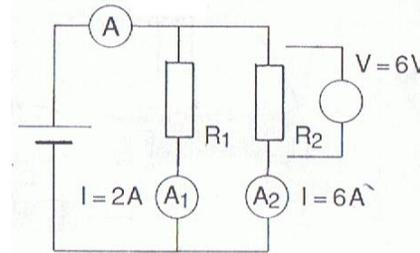

A. 2A
B. 3A
C. 5A
D. 7A

9. Look at the circuit diagram which shows two resistors in series and some measurements.

a) What is the voltage across R_1?
b) If $R_2 = 2\Omega$, what is the current in R_2?

10. In the circuit shown,

a) What is the current reading on ammeter **A**?
b) What is the voltage reading across resistor R_1?
c) What is the voltage across the power supply?
d) What is the resistance of R_2?

11. Use the formula **V = IR** to find the quantities labelled 'a' to 'i' in the following table. Take care with units.

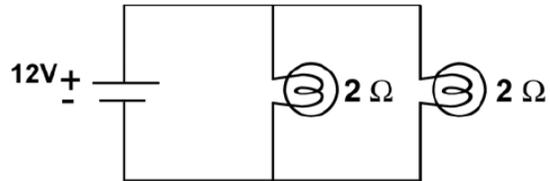| Resistance	Current	Voltage
a	2A	12V
b	4A	10V
c	1.2A	4.8V
d	70mA	2.8V
200Ω	e	4V
48Ω	f	0.6V
1000Ω	g	5V
75Ω	3A	h
1500Ω	12mA	i

12. Use the diagram below to answer the questions that follows.
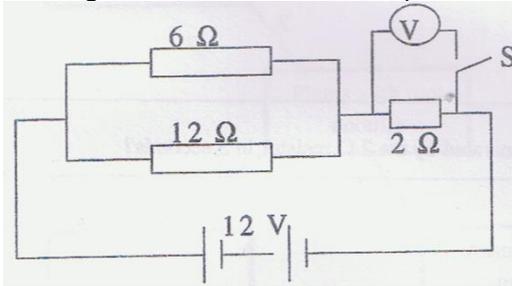
a) Calculate the **total resistance** of the circuit.
b) Determine the current flowing through the 2Ω resistor.
c) Determine the current flowing through the 6Ω resistor.
d) Calculate the reading of the voltmeter when the switch S is closed.
e) What is the total amount of heat generated by the 2Ω resistor in 5 seconds?

13. Use the parallel circuit below to answer the questions below.

a) What is the voltage across each bulb?
b) What is the current in each branch?
c) What is the total current provided by the battery?
d) Use the total current and the total voltage to calculate the resistance of the circuit.

14. Study the circuit below then answer the questions that follow.
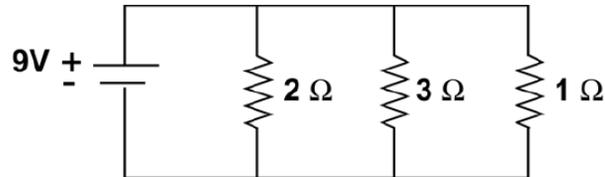
a) What is the voltage across each resistor?
b) Give a reason to explain your answer for (a) above.
c) What is the total resistance of the circuit?
d) What is the total current provided by the battery?
e) What is the current flowing through each branch?

15. Calculate the total resistance of a circuit containing each of the following combinations of resistors.

a) Two 8Ω resistors in parallel.
b) Two 12Ω resistors in parallel.
c) A 4Ω resistor and an 8Ω resistor in parallel.
d) A 12Ω resistor and an

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Week7
UNIT 6.3: ELECTRICAL POWER

> **At the end of this lesson, students should be able to:**
> □ Define and calculate power.
> □ Explain electricity conservation.
> □ Know the environmental and economic costs of producing electrical energy

Power

- In an electrical circuit, power (P) refers to the *"rate at which electrical energy is used up by a component in the circuit"*

- This means how quickly an electrical co.mponent uses energy.

- The unit for measuring power is **watt** (symbol **W**).

- A power of one watt means that one joule of electrical energy is used per second.

- A power of one watt is written "1W".

  1000W = 1 kW   [kW = kilowatts]

- To calculate the power, P of a component in an electrical circuit, the formula below is used:
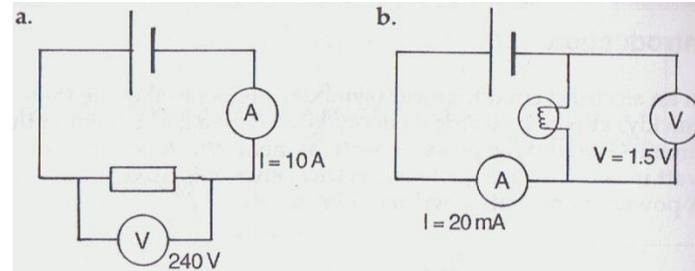
  $$\boxed{P = V \times I}$$

  Where **V** is in **volts**

  I is in **amps**.

  and   **P** is in **watts**

Example: Calculate the power supplied to the component in each of the following circuits is shown:

a.   I = 10 A   240 V

b.   V = 1.5 V   I = 20 mA

I = 20mA
= 0.02A

P = VI
= 240V x 10A
= 2400W
   (or 2.4kW)

P = VI
= 1.5V x 0.02A
= 0.03W

- The equation P = VI can be used to determine **V**, if *P* and *I* are known, or *I*, if *P* and *V* are known.

- The formula can be rearranged if required to give:

$$V = \frac{P}{I} \quad or \quad I = \frac{P}{V}$$

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Self-check 6.3: Power

Consider the circuit shown below:
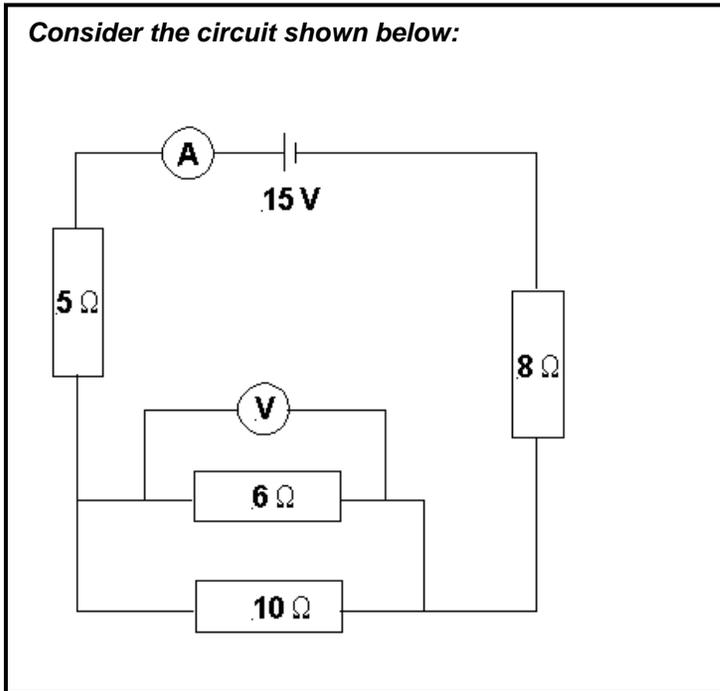
a)   Calculate the **total resistance** of this circuit.

b) What would be the reading on the ammeter, A?

c) What would be the reading on the voltmeter, V?

d) Determine the power dissipated by the:

(i)   Whole circuit

(ii) 5Ω resistor.

(iii) 10Ω resistor

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UNIT 6.4: ELECTROMAGNETISM

> **At the end of this lesson, students should be able to:**
> □ Define electromagnetism
> □ Construct simple electromagnets and describe its effects on coils
> □ Observe examples of electromagnetic induction
> □ State the relationship between current, magnetic field and force
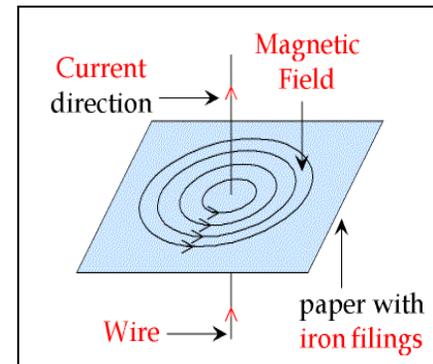> □ Draw magnetic field lines.

Introduction
- A *magnetic field* is a region where a magnetic force can be detected.
- There is a magnetic field around the earth which can be detected using a compass.
- There is a magnetic field around a bar magnet which can be detected using a compass, iron filings: both the needle of the compass and the filings line up in a magnetic field.
- The shape of the field around a bar magnet and the earth are shown below by lines:


Field Lines Around a Bar Magnet
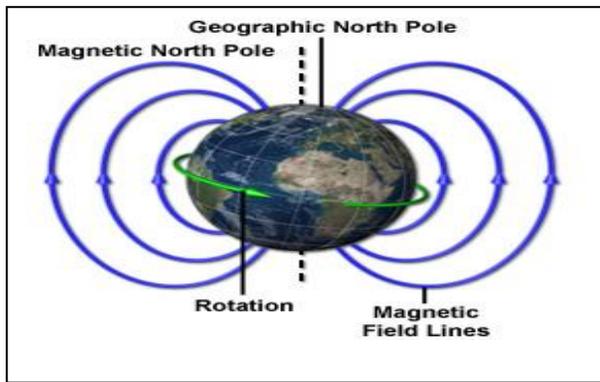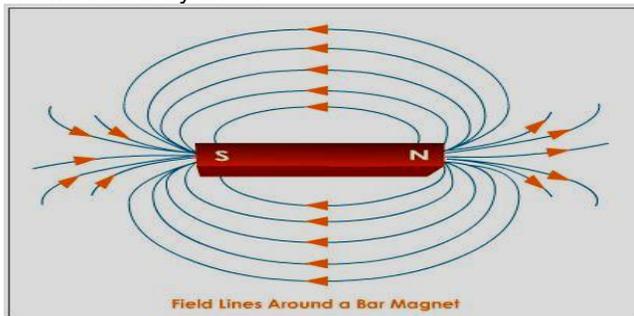
Magnetic Fields and Electric Current
- An electric current that moves along a wire have the capacity to generate a magnetic field around the wire.
- The shape of the field can be shown using iron filings.

 Example: In a piece of paper with iron filings

- The magnetic field lines formed around a wire which carries electric current form **concentric circles** around the wire.
- The direction of the magnetic field is *perpendicular* to the wire and is in the direction the fingers of your right hand would curl if you wrapped them around the wire with your thumb in the direction of the current.
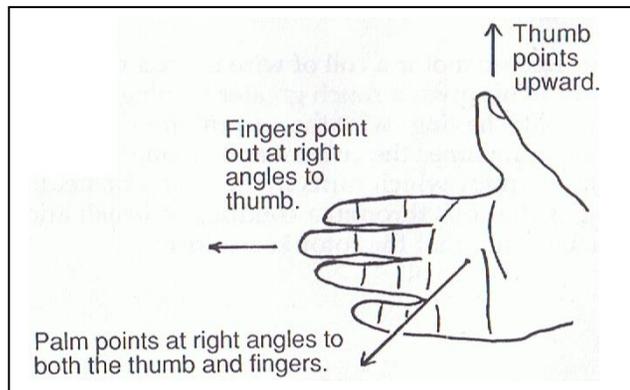

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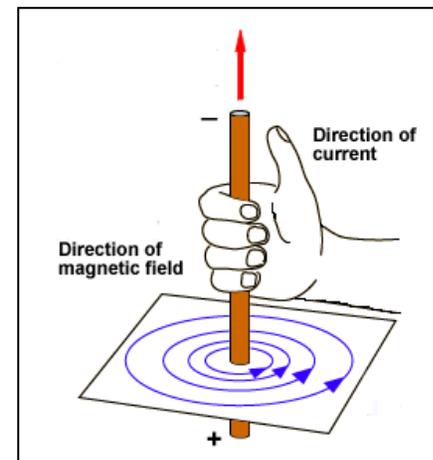
- A coil of wire carrying current will also produce magnetic field around the coil.
- The shape is like that of a bar magnet.
- The field around a coil may be strong enough to repel or to attract a bar magnet placed nearby.
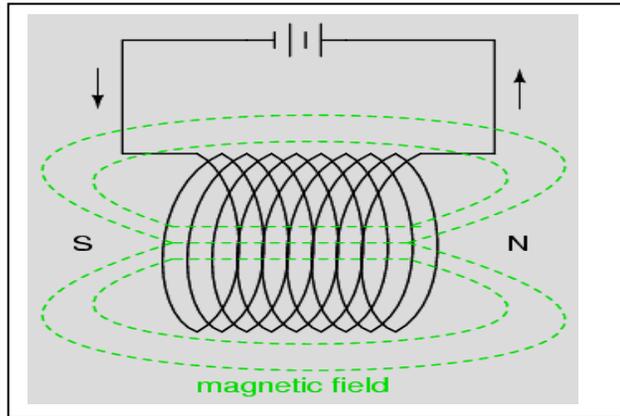
magnetic field

PRINCIPLE OF THE ELECTRIC MOTOR

- If a wire with an electric current is placed in a magnetic field, a **force** is produced on the wire.
- The wire will move if it is able to.
- The greatest magnetic force acting on the wire can only be produced if the wire carrying *current* is **perpendicular** to the direction of the magnetic field.
- The direction in which the wire will move can be determined using the **right hand rule**.

Thumb points upward.

Fingers point out at right angles to thumb.

Palm points at right angles to both the thumb and fingers.

Right Hand Slap Rule:
- The thumb points in the direction of the current.
- The fingers point in the direction of the magnetic field.
- The palm points in to the direction to which the wire will move.

The size of the magnetic force can be increased by:

(i) Increasing the size of the current
(ii) Increasing the strength of the magnetic field by using a stronger magnet.

- All electric motors work on the principle that a force is produced by a current carrying wire in a magnetic field.

- The force is greatest when the current is at right angles to the magnetic field.

- The force can be used to turn a rotor and to do work.

- Some of the details of a typical electric motor are shown in the following diagram.
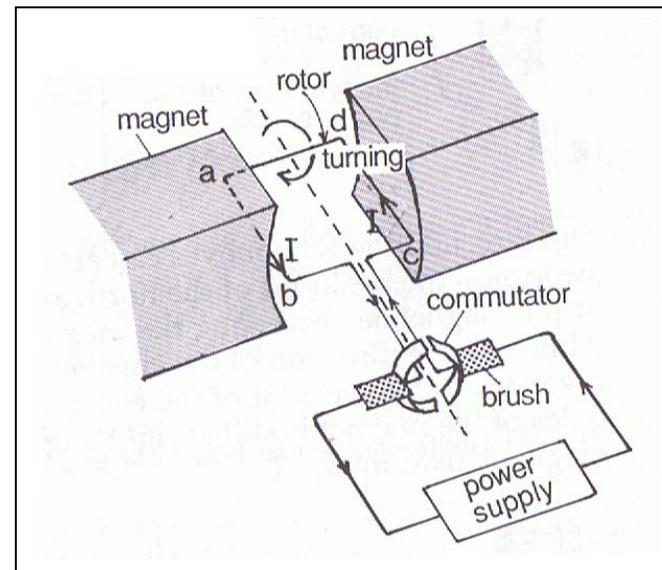
- Motors are designed so that when the side **ab** moves up, side **cd** moves down.
- This means that the current in each side is moving in opposite directions.
- In an electric motor, a coil of wire is used rather than one strand of wire. This gives a much greater turning force: two lengths of wire is like having twice the current, four lengths of wire is like having four times the current and so on.
- The wire is wrapped around a rotor which turns in the magnetic field.
- The current reaches the coils through a conducting **brush** and **commutator** which ensure that the rotor keeps turning.
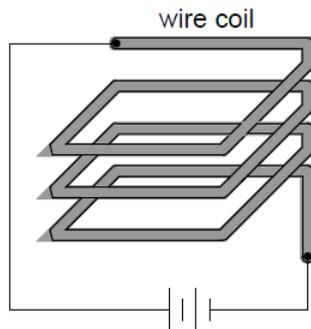
Self-check 6.4: Electromagnetism

1. Draw the pattern of the magnetic field produced by electric current through a straight wire and through a wire coil:
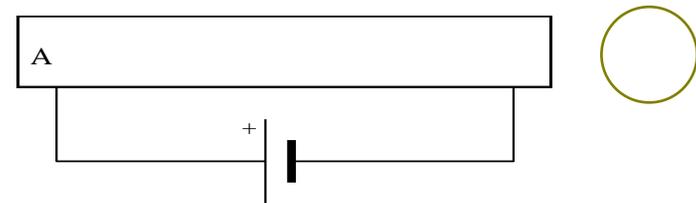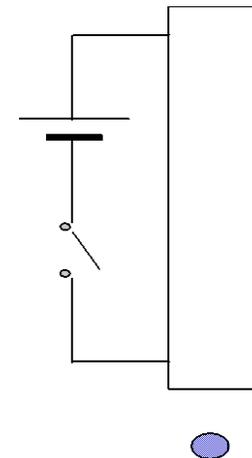
a)

b)

wire coil
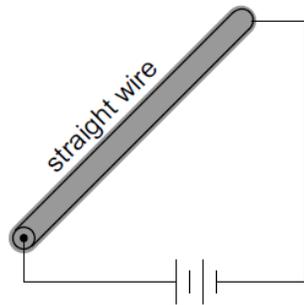
2. The figure below shows a solenoid wound round a core of soft iron.

a) If the current flows in the direction shown, what will be the polarity of end A? _____ .

b) In the space provided on the diagram, draw which way the compass will point.

3. A student constructed an electromagnet to be used for lifting and then releasing a small metal ball.

a) Explain why soft iron is a better material than steel to use for the core.

b) State *two* ways that will enable the student to lift a larger ball.

4. A piece of coper wire is connected to a battery and switch. It is placed in the magnetic field as shown in the diagram. When the switch is closed, a force moves the wire.
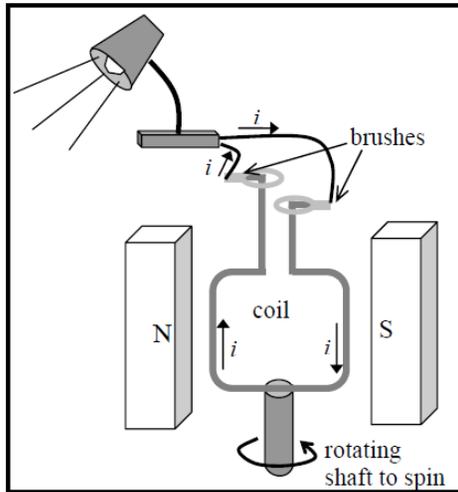
a) Give 2 ways of increasing the size of this force.

b) How could you reverse the direction of this force?

c) When the copper wire is replaced by a piece of plastic, no movement occurs. Explain why?

At the end of this lesson, students should be able to:
☐ Explain how current can be induced in a conductor without making contact.
☐ Describe the process of induction.

- We have now seen that if electrical current is flowing in a conductor, there is an associated magnetic field created around the wire.
- In a similar manner, if we move a wire inside a magnetic field there will be an electrical current that will be generated in the wire.

Before moving
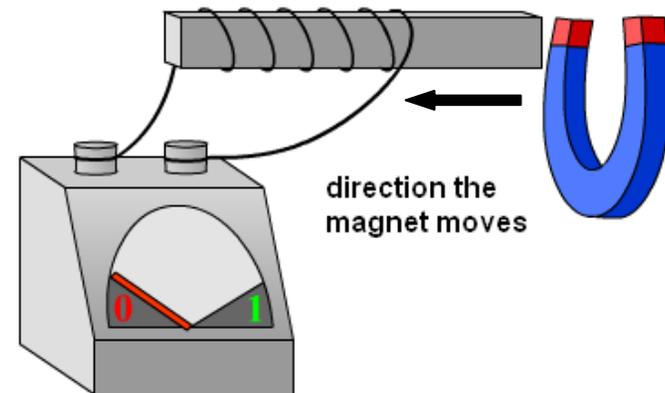
When coil and magnet is stationary, no current is detected.

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During movement of magnet

meter deflects from 0 to 1

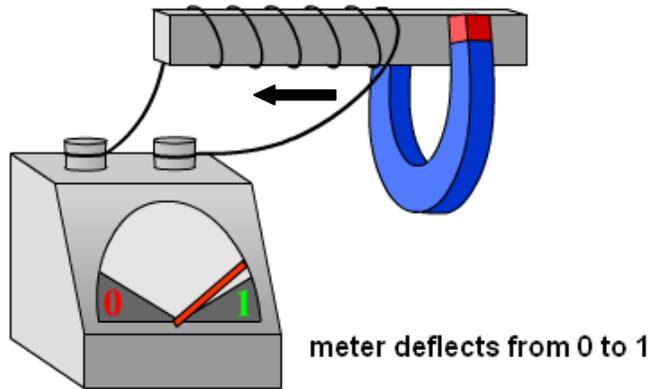*Once the magnet is moved towards the coil, current is detected.*

- When a coil is part of a complete circuit, and there is a changing magnetic field near the coil, a current is produced in the circuit.
- To produce a changing magnetic field a magnet can be moved near the coil.

INDUCTION
- Current is produced in a conductor when it is moved through a magnetic field because the magnetic lines of force are applying a force on the free electrons in the conductor and causing them to move.
- This process of generating current in a conductor by placing the conductor in a changing magnetic field is called **induction**.
- This is called induction because there is no physical connection between the conductor and the magnet.
- The current is said to be *induced* in the conductor by the magnetic field.
- One requirement for this electromagnetic induction to take place is that the conductor, which is often a piece of wire, must be perpendicular to the magnetic lines of force in order to produce the maximum force on the free electrons.

- The *direction that the induced current* flows is determined by the direction of the lines of force and by the direction the wire is moving in the field.
- In the animation above the ammeter (the instrument used to measure current) indicates when there is current in the conductor.
- The induced current is a very small current.
- A special type of devise that measures induced current is called **galvanometer** (symbol **G**). A galvanometer is a type of ammeter which is able to detect small currents in both directions.

Some observations involved Induced Current
- The *direction* of the induced current in the circuit depends on whether a pole of the magnet is moved *towards* (field made stronger) or *away* (field made weaker) from the coil.
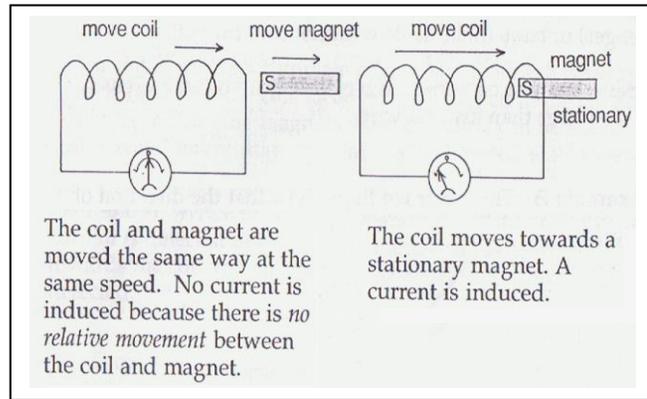
   Note: The induced current is bigger if a coil of wire is used rather than just one wire.

Example: The meter readings show that the direction of the induced current changes when the magnet is moved the other way.

Magnet moved towards the coil. A current is induced. | The magnet is moved the other way. A current is induced in the opposite direction.
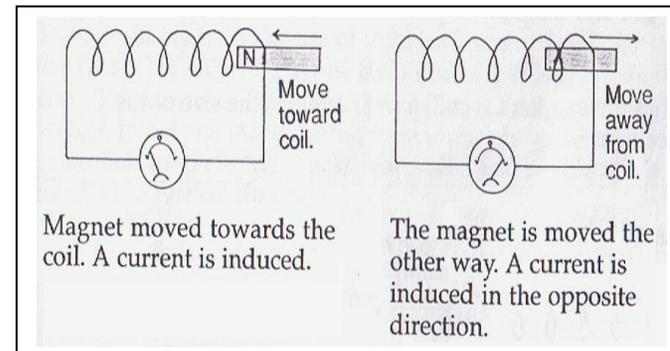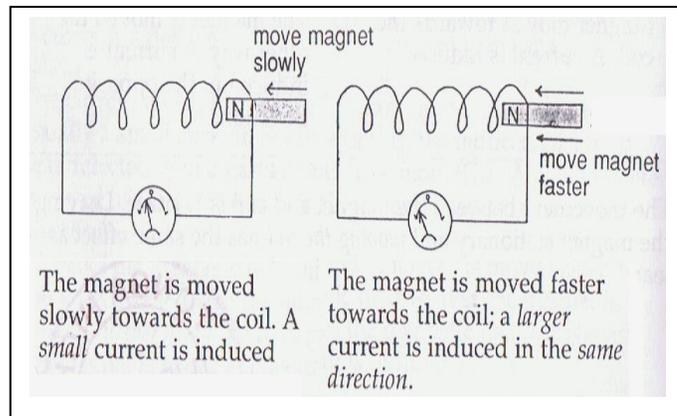
- The movement between the magnet and coil is **relative**. Leaving the magnet stationary and moving the coil has the same effect as leaving the coil stationary and moving the magnet.

Example:

move coil →   move magnet →   move coil →

magnet stationary

The coil and magnet are moved the same way at the same speed. No current is induced because there is *no relative movement* between the coil and magnet.

The coil moves towards a stationary magnet. A current is induced.

- Moving the magnet (or coil) *faster* increases the size of the induced current.

Example:

move magnet slowly

move magnet faster

The magnet is moved slowly towards the coil. A *small* current is induced

The magnet is moved faster towards the coil; a *larger* current is induced in the *same direction.*

USES OF INDUCED CURRENT

1. **Generators**
   In all generators, a current is induced in wires which are in region of a changing magnetic field in order to produce electrical power.

2. **Alternators**
   This is a type of generator which produces AC power.

3. **Transformers**
   Transformers uses two coils. A current in one coil induces a voltage in the other coil

Self-check 6.5: Electromagnetic Induction

1. When the white end of the magnet is pushed into the coil, the meter needle moves to +2 and then back to zero.

coil   magnet

meter
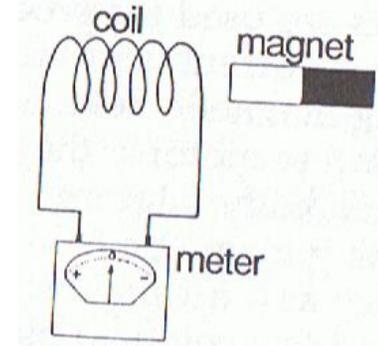
   a) Describe the motion of the needle when the magnet is held still inside the coil.
   b) Describe the motion of the needle when the white end of the magnet is pulled out of the coil at the same speed as it was pushed in.
   c) Describe the motion of the needle when the white end of the magnet is pushed in with double the original speed.

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d) What will happen to the meter needle when the magnet is pulled back out of the coil at the same speed as in c?

2. Conductor XY is connected by copper wire to a sensitive meter, G which measures current. The following experiments are performed with this conductor in a magnetic field as shown:
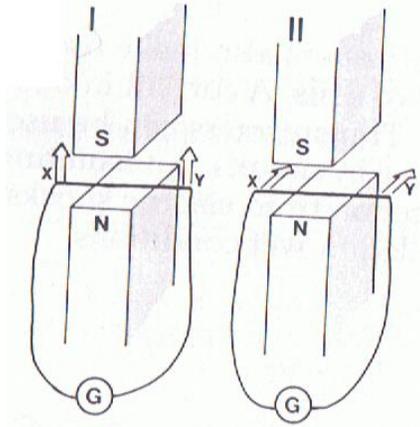
Which of the experiments resulted in a current reading on the meter?
A. Experiment I only
B. Experiment II only
C. Experiment I and II
D. Neither experiment.

3. When the conductor is moved up and down (vertically) between the magnets the sensitive meter shows a current flowing in the conductor.
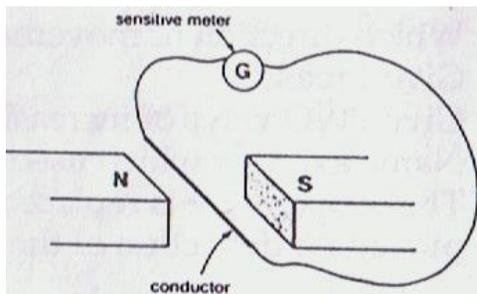

Which of the following would produce a larger current?

I. Moving the conductor back and forth (horizontally)
II. Moving the conductor faster
III. Using stronger magnets
IV. Moving the magnets further apart.

A. I and II
B. II and III
C. III and IV
D. I and IV

4. The diagram below shows a wire loop moving upwards at a constant speed through a magnetic field. A small current is induced in the loop.

Electromagnetic Induction
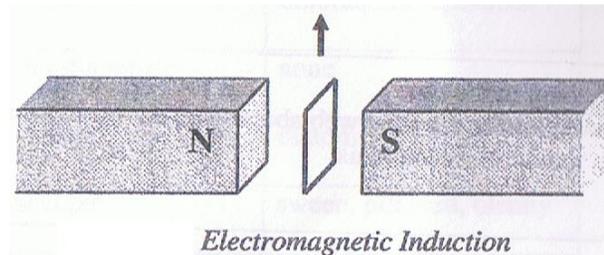
a) What would happen to the induced current if the loop is moved upwards at a higher speed?
b) What would happen to the current if the loop is moved downward?
c) What would happen if the loop is moved horizontally across the field?
d) Describe how to improve the design of the coil in order to increase the current.