THE REPUBLIC OF UGANDA

Ministry of Education
and Sports

HOME-STUDY LEARNING

SENIOR 4

PHYSICS

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NCDC
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This material has been developed as a home-study intervention for schools during the lockdown caused by the COVID-19 pandemic to support continuity of learning.

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FOREWORD

Following the outbreak of the COVID-19 pandemic, government of Uganda closed all schools and other educational institutions to minimize the spread of the coronavirus. This has affected more than 36,314 primary schools, 3129 secondary schools, 430,778 teachers and 12,777,390 learners.

The COVID-19 outbreak and subsequent closure of all has had drastically impacted on learning especially curriculum coverage, loss of interest in education and learner readiness in case schools open. This could result in massive rates of learner dropouts due to unwanted pregnancies and lack of school fees among others.

To mitigate the impact of the pandemic on the education system in Uganda, the Ministry of Education and Sports (MoES) constituted a Sector Response Taskforce (SRT) to strengthen the sector's preparedness and response measures. The SRT and National Curriculum Development Centre developed print home-study materials, radio and television scripts for some selected subjects for all learners from Pre-Primary to Advanced Level. The materials will enhance continued learning and learning for progression during this period of the lockdown, and will still be relevant when schools resume.

The materials focused on critical competences in all subjects in the curricula to enable the learners to achieve without the teachers' guidance. Therefore effort should be made for all learners to access and use these materials during the lockdown. Similarly, teachers are advised to get these materials in order to plan appropriately for further learning when schools resume, while parents/guardians need to ensure that their children access copies of these materials and use them appropriately.
I recognise the effort of National Curriculum Development Centre in responding to this emergency through appropriate guidance and the timely development of these home study materials. I recommend them for use by all learners during the lockdown.

Alex Kakooza
Permanent Secretary
Ministry of Education and Sports

ACKNOWLEDGEMENTS

National Curriculum Development Centre (NCDC) would like to express its appreciation to all those who worked tirelessly towards the production of home–study materials for Pre-Primary, Primary and Secondary Levels of Education during the COVID-19 lockdown in Uganda.

The Centre appreciates the contribution from all those who guided the development of these materials to make sure they are of quality; Development partners - SESIL, Save the Children and UNICEF; all the Panel members of the various subjects; sister institutions - UNEB and DES for their valuable contributions.

NCDC takes the responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for improvement. The comments and suggestions may be communicated to NCDC through P.O. Box 7002 Kampala or email admin@ncdc.go.ug or by visiting our website at http://ncdc.go.ug/node/13.

Grace K. Baguma
Director,
National Curriculum Development Centre

ABOUT THIS BOOKLET

Dear learner, you are welcome to this home-study package. This content focuses on critical competences in the syllabus.

The content is organised into lesson units. Each unit has lesson activities, summary notes and assessment activities. Some lessons have projects that you need to carry out at home during this period. You are free to use other reference materials to get more information for specific topics.

Seek guidance from people at home who are knowledgeable to clarify in case of a challenge. The knowledge you can acquire from this content can be supplemented with other learning options that may be offered on radio, television, newspaper learning programmes. More learning materials can also be accessed by visiting our website at www.ncdc.go.ug or ncdc-go-ug.digital/. You can access the website using an internet enabled computer or mobile phone.

We encourage you to present your work to your class teacher when schools resume so that your teacher is able to know what you learned during the time you have been away from school. This will form part of your assessment. Your teacher will also assess the assignments you will have done and do corrections where you might not have done it right.

The content has been developed with full awareness of the home learning environment without direct supervision of the teacher. The methods, examples and activities used in the materials have been carefully selected to facilitate continuity of learning.

You are therefore in charge of your own learning. You need to give yourself favourable time for learning. This material can as well be used beyond the home-study situation. Keep it for reference anytime.

Develop your learning timetable to ca ter for continuity of learning and other responsibilities given to you at home.

Enjoy learning

CHAPTER: GAS LAWS

By the end of this chapter, you should be able to;

- State Boyle's law, Charles law and pressure law
- Carry out simple experiments to demonstrate Boyle's law, Charles' law and Pressure law
- Draw graphs of volume, V against pressure, P, and P against 1/V at constant temperature
- Draw graphs of volume against temperature in both degree Celsius and kelvin at constant pressure
- Draw graphs of pressure against temperature at constant volume
- Solve numerical problems using the three gas laws

LESSON 1: BOYLE'S LAW

Competences:

In this lesson, you will:

- State Boyle's law
- Carry out simple experiment to demonstrate the law
- Draw graphs of volume V, against pressure P, and V against 1/P at constant temperature
- Solve numerical problems related to Boyle's law

Materials you need:

- 50 ml syringe
- 2 small balloon
- Thread

Introduction

In S1, you learnt that gases, liquids and solids usually expand when heated. So when the temperature, T, of a gas is raised, either the pressure, P, or the volume, V, or both increase. In this lesson you will find out how pressure and volume are related at constant temperature.

Activity

Part (I)

a) Inflate the balloon with air and tie it with a knot
b) Place the balloon inside the syringe and insert the plunger inside the syringe
c) Push the balloon up to the tip of the syringe using the plunger

Part (II)

d) Pull the plunger backwards
e) Close the tip of the syringe with your finger
f) Push the plunger into the syringe again until it touches the balloon

What do you noticed when pushing the plunger into the syringe in part 1&II?

For your knowledge:

- The air can escape through the opening at the tip of the syringe in part I. In part II the air can't escape anymore. If you press on the plunger, you increase the pressure of the air and as a result it contracts leading to the decrease in volume.
- Similarly in this experiment, the balloon doesn't compress when the piston is pushed as the air escapes hence keeping the atmospheric pressure the same
- The amount of atmospheric pressure increases when the piston is being pushed and the opening of the syringe is blocked (Fig 1 below).
- The balloon remains the same size when the pressure decreases and the volume increase; this is however, not the same when the pressure increases and volume decreases.
- The experiment explains inverse proportional relationship between the pressure and volume hence demonstrating Boyle's law.

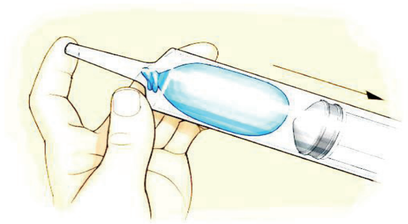


Fig 1

Project

Replace the air-filled balloon with water filled inside the syringe and repeat the experiment.

Observe what happens and explain your observations

Laboratory method to verify Boyle's law

Materials you need

- Volume scale

- Bicycle pump
- Thick glass walled tube closed at one end
- Pressure gauge
- Oil

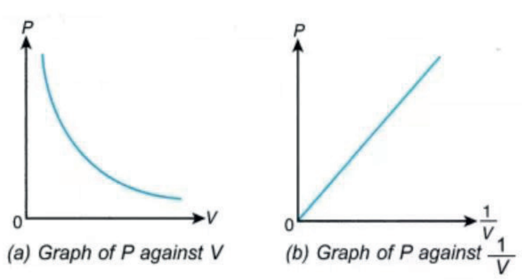
Procedures

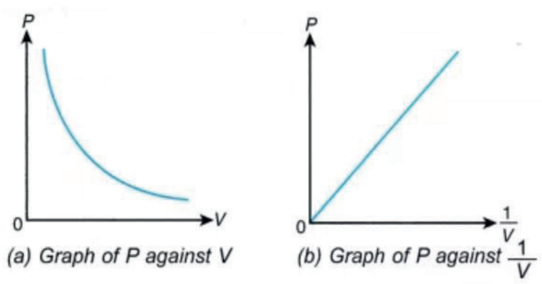
a) Increase the pressure on the air in the tube using a bicycle pump
b) Close the valve and wait for a short time for the temperature of the enclosed air to reach equilibrium
c) Record the volume V of the air column and the corresponding value of the pressure P
d) Reduce the pressure by opening the valve slightly and allow the temperature of the enclosed air to reach equilibrium.
e) Record the pressure P and the corresponding value of the volume V
f) Repeat procedure (d) and (e) and enter your results in a suitable table including the values of 1/v
g) Plot a graph of V against 1/P

Volume (V)	Pressure (P)	

For your knowledge

When a graph of P is plotted against 1/V, straight line through the origin is obtained.





A graph of P against V

Fig (a) **fig (b)**

Figure (b) verifies Boyle's law which states that:

"*the volume of a fixed mass of gas is inversely proportional to the pressure at constant temperature*"

Do you know that from this law when volume increases, pressure decreases such that:

Pressure × volume = constant

P × V = constant

$P_1V_1 = P_2V_2$--------------------------Boyle's law equation

Using the above equation work out the following exercises

Exercise 1

1) The volume of a fixed mass of gas at constant temperature is $150cm^3$when the pressure is 76Pa. Calculate the volume when pressure is 38Pa
2) The volume of a fixed mass of gas at constant temperature is $8cm^3$ when the pressure is 6 cmHg. Find the pressure when the volume is $4cm^3$
3) The volume of a fixed mass of gas at constant temperature is $250cm^3$ when the pressure is 720mmHg. Find the pressure when the volume is increased to $600cm^3$.

LESSON 2: CHARLES' LAW

Competences:

In this lesson, you will:

- Describe simple experiments to illustrate Charles law
- Draw graph of volume against temperature in both degree Celsius and kelvin at constant pressure
- State Charles law
- Solve numerical problems related to Charles law

Introduction

In lesson 1 you learnt how pressure and volume of a fixed mass of gas are related at constant temperature. In lesson 2 you will learn how volume and temperature are related at constant pressure.

Materials you need

- Empty mineral water bottle
- Saucepan /beaker
- Source of heat

- water

Activity

a) put water in a saucepan and heat it until it boils
b) squeeze the empty bottle to remove air out of it and close it tightly
c) place the bottle in the boiling water

What happens to the bottle when it's in hot water?

For your knowledge:

Charles' law describes the expansion of gases when they are heated. As the temperature of any particular gas increases, the molecule in that gas will increase movement and as a result there is increase in collisions. The more frequent collusions will result in increased pressure.

If a balloon is taken out in a chilly day the balloon crumbles. If you take it back to a warm room it regains its shape. This is because on a cold day the temperature is low so the volume decreases. From Charles law when you enter a warm room the temperature increases hence increase in volume so, the balloon regains its original shape

In our experiment, air inside the bottle starts to expand when boiling water.

Application of Charles' law in real life situation

A bottle of deodorant should be kept away from the sunlight and high temperature because under high temperature, inside the bottle will expand leading to the bursting of the bottle.

Laboratory method of verifying Charles' law in the laboratory

Material you need

- thermometer
- scale
- water bath
- uniform tube
- concentrated sulphuric acid bead

- heat source

Procedure

a) heat the air trapped in a capillary tube by concentrated sulphuric acid
b) stop heating and stir the water before taking the readings
c) read and record the values of temperature and the volume
d) repeat procedure (a) to (c)
e) record your results in a suitable table as shown below

st is always used ii

Volume of air (V)	Temperature (T)	$\frac{V}{T}$

NOTE: Draw an appropriate diagram for the above experiment

For your knowledge

- the volume of the air column and temperature are varied by heating the water can
- the pressure of the air column is constant as it is equal to atmospheric pressure plus the pressure of the acid index.

A graph of volume against temperature

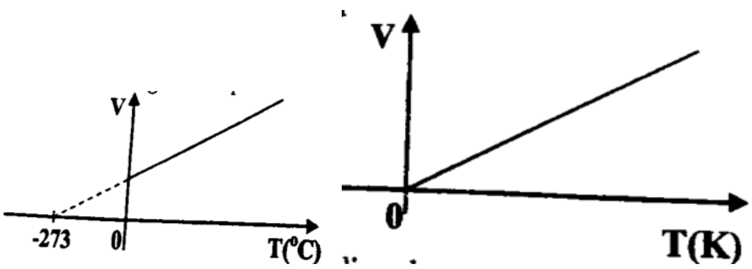


Fig (a)

Do you know that from the graph we can deduce Charles' law? The law states that "*the volume of a fixed mass of gas is directly proportional to its absolute temperature at constant pressure*"

Volume α Temperature

= Constant

= -- Charles' law equation

For your knowledge:

- In S1 lesson, you studied how to convert degree Celsius to kelvin scale. Therefore when carrying out calculation in gas laws, all temperatures must be changed to kelvin
- The temperature at -273°C (0K) is the **absolute zero temperature**. What is the meaning of this?
- Any unit of pressure and volume can be used so long as they are the same on both sides of the equation.

Using the above equation work out the following exercises

Exercise 1.1

1) The volume of a fixed mass of gas at constant pressure is 300cm^3 at a temperature of 127°C. Calculate the volume when the temperature is reduced to 27°C
2) The volume of a fixed mass of gas at constant pressure is 400cm^3 at a temperature of -73°C Calculate the volume when the temperature is raised to 27°C
3) The volume of a fixed mass of gas at 17°C is 5.0×10^{-4} m^3. Calculate its temperature if the volume reduces to 4.0×10^{-4} m^3 at constant pressure.

LESSON 3: PRESSURE LAW

Competences:

In this lesson, you will:

- State Pressure law
- Solve numerical problems related to Pressure law

Introduction

For the pressure law we shall look at the relationship between pressure and temperature and you should note that in this case increase in pressure leads to increase in temperature.

The results from experiment can enable you to understand the concept of Pressure law. Do you know how the law is stated? *This law states that; the pressure of a fixed mass of a gas is directly proportional to its absolute temperature at constant volume*

Pressure α Temperature

= Constant

= constant

= -------------------------------Pressure law equation

Using the above equation work out the following exercises

Exercise 1.2

1) The pressure of a fixed mass of a gas at 200K is 50Pa what would be the pressure if the temperature was increased to 300K at constant volume.
2) A fixed mass of gas at 19°C exerts a pressure of 2.0× Pa. What pressure would the gas exert when the temperature is raised to 317°C at constant volume?
3) The pressure of a fixed mass of gas at 127°C is 800mmHg. What is the pressure at constant volume if the temperature reduces to 27°C.?

The general gas laws

= Constant

= constant

The general equation is expressed as follows:

--------------------------------------**Universal gas equation**

Exercise 1.3

1) A mass of gas has a volume of $5m^3$, a pressure of 20cmHg and a temperature of 300K. What will be the new pressure if the volume is changed to $4m^3$ and the temperature to 400K.

Summary of the topic

- According to Boyle's law, the volume of a fixed mass of gas is inversely proportional to the pressure at constant pressure. In other words PV is a constant
- Charles' law states that "the volume of a fixed mass of gas is directly proportional to its absolute temperature at constant pressure. In other words is a constant
- Pressure law states that; the pressure of a fixed mass of a gas is directly proportional to its absolute temperature at constant volume. In other words is a constant

CHAPTER: AMMETERS, VOLTMETERS AND GALVANOMETERS

By the end of this chapter, you should be able to;

- Demonstrate the practical arrangement of converting galvanometers into an ammeter
- Calculate the suitable resistances for the above conversion.

LESSON 1: CONVERSION OF GALVANOMETER (MILLIAMMETER) TO AN AMMETER

Competences:

In this lesson, you will:

- Demonstrate the practical arrangement of converting galvanometers into voltmeters and ammeters respectively.
- Calculate the suitable resistances for the above conversion.

Introduction

A galvanometer is a device which is used for measuring a small electric current or voltage

In the previous lesson you learnt about the connection and uses of an ammeter and a voltmeter. In this lesson, you will look at how a galvanometer can be converted to measure a larger current and voltage.

Note: The galvanometer can be made to read larger current in amperes by connecting it in parallel to a low resistance called a **shunt.**

Activity:

Material you need

- Galvanometer
- Connecting wires
- A resistor of low resistance (Shunt)

Procedure

a) Connect one end of the wires on the terminals of the galvanometer

b) Connect the low resistor parallel to the galvanometer (fig 3.0)

Fig3.1 shows an ammeter formed by connecting a shunt across a galvanometer (milliammeter**)**

Note:

- A galvanometer that measures current in milliamperes (mA) is called a ***milliammeter***.
- The current needed to move the pointer to the end of the scale in a milliammeter (galvanometer) is called full scale deflection current (f.s.d)

Example:

A milliammeter (galvanometer) has a resistance of 5Ω and a f.s.d current of 10mA.the meter is to be adapted to measure currents up to 1A. Calculate the shunt resistance required.

Solution

For your knowledge

Since the connection of the galvanometer and the shunt is in parallel then:

- The p.d across them is the same
- The current flowing through them is different

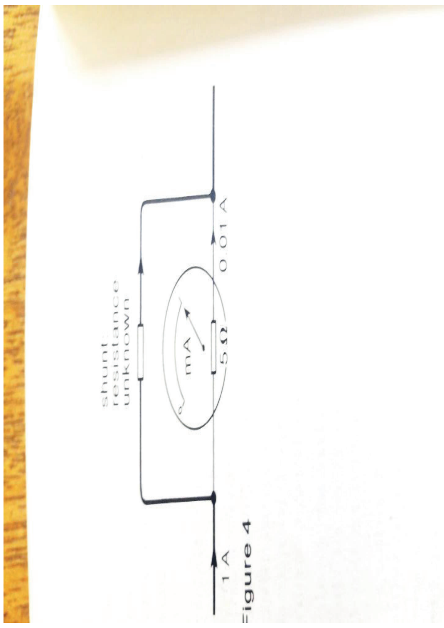


Fig 3.2

This problem is very easy when you solve it in these steps:

i. Current through shunt = total current thorough shunt and meter – current through meter

= 1A – ()   (10 mA=A)

= 1A – 0.01A

= **0.99A**

ii. The p.d across the meter and the shunt is the same since they are connected in parallel and is calculated as follows:

P.d across meter =current through meter × resistance of meter that is

V   = IR (from Ohm's law)

= 0.01× 5 Ω

= 0.05A

iii. Resistance of shunt =

R   =

Figure 1

=

= 0.051 Ω

Therefore a shunt of resistance 0.051 Ω is required

Exercises

1) A galvanometer of resistance 20 Ω reads 50 mA at f.s.d. What value of shunt must be connected across the galvanometer to convert it to an ammeter that will read 4A.
2) A moving coil galvanometer of resistance 10 Ω gives a f.s.d. of 20mA What resistance must be connected across the galvanometer to convert it to an ammeter that will read 1A
3) A galvanometer of resistance 100Ω gives a full scale deflection (f.s.d) of 1mA. What is the value of the resistor that must be connected across the galvanometer to enable it read a maximum current of 5A?

LESSON 2: CONVERSION OF GALVANOMETER (MILLIAMMTER) TO A VOLTMETER

Competences:

In this lesson, you will:

- Demonstrate the practical arrangement of converting galvanometers into voltmeters
- Be able to calculate the suitable resistances for the above conversion

Introduction

A galvanometer is design to measure very small voltages in milli- volts. However, it can be made to read larger voltages by connecting it in series to a resistor of high resistance called the **multiplier.**

Example

A milliameter (galvanometer) has a resistance of 5Ω and a f.s.d current of 10mA. The meter is to be adapted to measure voltage (P.d) up to 10 V. Calculate the multiplier resistance required.

Solution

For your knowledge

- The p.d across the meter and the multiplier is different
- The current flowing through the galvanometer and the multiplier is the same since they are in series

Therefore the multiplier value is calculated as follows:

i. The resistance of the meter and multiplier =

R =

$=$

$= 1000\ \Omega$

Therefore the resistance of multiplier = resistance of both the multiplier and meter – resistance of meter

$$= 1000\Omega - 5\ \Omega$$

$$= 995\ \Omega$$

Therefore a multiplier with resistance of **995 Ω** is required

Exercises

1) A galvanometer has a resistance of 5Ω and a f.s.d of current of 100mA calculate the multiplier resistance required to convert the meter into a voltmeter reading up 5V
2) A galvanometer of resistance 12 Ω reads 200 mA at f.s.d . What resistance must be connected in series with it in order to read up to 10V.?
3) A current of 0.2A passes through a milliammeter of resistance 20 Ω. What is the value of the resistance that must be connected in series with the meter to convert it to voltmeter that reads 12 V.

Summary of the chapter

- **A** galvanometer can be made to read larger current in amperes by connecting it in parallel to a low resistance called a **shunt.**
- A galvanometer that measures current in milliamperes (mA) is called a ***milliammeter***.
- The current needed to move the pointer to the end of the scale in a milliammeter (galvanometer) is called full scale deflection current(f.s.d)
- A galvanometer can be made to read larger voltages by connecting it in series to a resistor of high resistance called the **multiplier.**

CHAPTER: ELECTRIC ENERGY

By the end of this chapter, you should be able to;

- Explain the heating effect of an electric current
- Derive the equation of electric energy and power
- Solve numerical energy related to electrical energy and power

LESSON 1: HEATING EFFECT OF ELECTRIC CURRENT

Competences:

In this lesson, you will:

- Explain the heating effect of an electric current
- Examine the effect of resistance on heating as a factor affecting electrical heating

Materials you need

- A 2cm nichrome wire
- Batteries (Lemons)
- Connecting wires
- Switch

Introduction

You learnt about the flow of current in an electrical circuit. You should be able to remember that in an electrical circuit, the flow of current is maintained by energy supplied by the battery or cell which is referred to as electromotive force.

When current flows through a conductor, heat energy is generated in the conductor.

Activity 1

a) connect the nichrome wire coil to a battery and a key as in the image below.
b) Switch on the circuit for about 30 seconds.
c) Touch the nichrome wire coil

How do you feel?

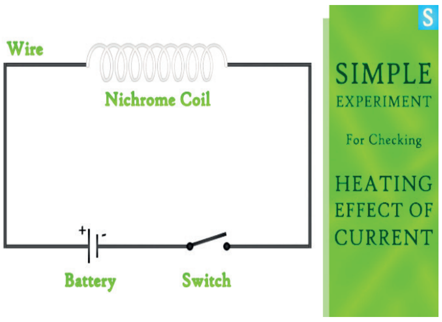


Fig 1

Activity 2

a) Take a small beaker half filled with water and cover it with a cardboard lid

b) Insert a 2 cm length nichrome wire coil into the water as well as a stirrer

c) Connect the ends of the nichrome coil to a circuit with a battery and a switch on

d) Place a thermometer into the water

e) Close the switch and stir the water

f) Keep it on for about 5 minutes and then measure the temperature of water

g) Repeat the experiment using two batteries and then three batteries.

What do you notice?

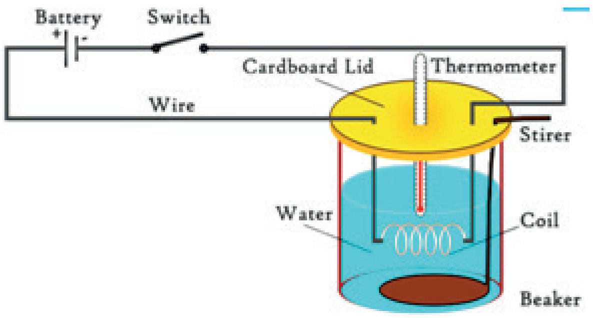


Fig 2

When you add more batteries the electric current increases, temperature increases hence the heating effect also increases, meanwhile a decrease in electric current also decreases the heating effect.

The heating effect of an electric current depends on three factors:

- The resistance, R of the conductor. A higher resistance produces more heat.
- The time, t for which current flows. The longer the time the larger the amount of heat produced
- The amount of current, I. The higher the current the larger the amount of heat generated.

Look at some appliances below which use heating effect of current.

Appliances Using Heating Effect of Current

LESSON 2: ELECTRIC ENERGY AND POWER

Competences:

In this lesson, you will:

- Derive the equation of electric energy and power
- Solve numerical problem related to electric energy and power

Introduction

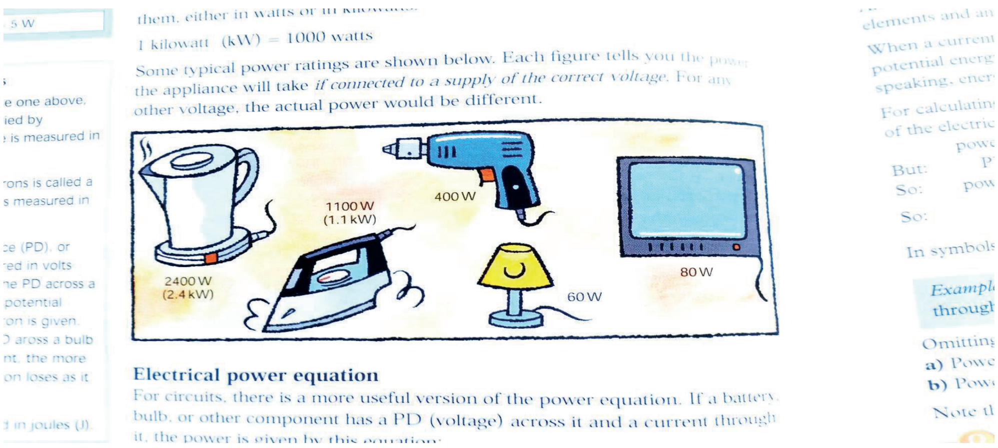
In your earlier Physics lessons about work, energy and power you learnt the definition of the three terms and how to manipulate numerical problems related to them. In this lesson, you will look at electrical energy and power.

For your knowledge, power is the rate at which energy is transformed

i.e Power =

The SI unit of power is watt (W). A watt is equal to '**one joule per second**'(Js^{-1})**.** Therefore a power of 20 W for an electric device means that the device transfers 20 Joules of energy in one second.

The images below show the power rating of some electrical devices indicated on them.



Can you try to interpret the power ratings?

Derivation of electrical energy

For your knowledge

i) When a charge moves in a conductor, work is done by that charge and the work done is converted into heat.
ii) The potential difference between two points say A and B is one volt if the work done in moving a unit charge from B to A is one joule. therefore from the definition of potential difference, V ,

Work done (p.d is potential difference)

$W = V\ Q$ ---(1)

Where Q is the Quantity of electricity (charge)

But Charge, Q = current time i.e. ,

Therefore Q =

Substituting for Q in (1)

Work done **= V I t**-- (2)

Note that work done = Electrical heat and according to Ohm's law:

V = IR so substituting for V in (2),

Work done --(3)

Similarly, **I =** and substituting for I in (3),

Work done --(4)

In conclusion,

Electrical energy =

ELECTRICAL POWER

This is the rate at which heat is generated in the conductor when current flows through it.

Electrical power =

Using equations 1, 2, 3 and 4 above

Therefore Electrical Power P **= ,= VI, = I^2R ,** = **.**

For your knowledge, a watt is the rate of working of 1 joule per second so the other unit of electrical power is joules per second

Numerical examples related to electrical energy and power

Example

An electric water heater of power 4.8 kW is connected to a 240V mains supply, calculate:

a) the current in its element
b) the resistance of the element
c) the energy converted into heat in 1 minute

Solution

a) Electrical power = IV

Current I = =

I =

I = 20 A

b) From V = IR , R = =

= 12 Ω

c) Electrical energy = Power time

= 4800 60

288000 J

Exercises

1) An electrical bulb is labeled 100W, 240V. Calculate:

a) The current through the filament when the bulb works normally

b) the resistance of the filament used in the bulb.

2) A lamp is rated 120 W, 240 V
   a) what does that statement mean?
   b) calculate:
      i) current consumed by the lamp
      ii) resistance of the filament

Summary of the chapter:

- Various applications of the heating effects of current is used in light bulbs, electric heaters, stove electric kettle, toasters etc
- When a charge moves in a conductor, work is done by that charge and the work done is converted into heat
- Electrical power is the rate at which heat is generated in the conductor when current flows through it
- A watt is the rate of working of 1 joule per second so the other unit of electrical power is joules per second (Js^{-1}).

CHAPTER: DOMESTIC ELECTRIC ENERGY SUPPLY

By the end of this chapter, you should be able to;

- describe the advantages and disadvantages of series and parallel connections in domestic appliances
- correctly identify the 3- pins and wire them
- explain the necessity of earthing domestic electrical installation
- calculate the cost of electrical energy consumption using the kWh as the base unit
- explain how electrical energy is transmitted over long distances

LESSON 1: DOMESTIC APPLIANCE ARRANGEMENT AND COSTING OF ELECTRICITY

Competences:

In this lesson, you will:

- state the advantages and disadvantages of series and parallel connection in domestic electrical appliances
- be able to calculate of the cost of electricity

Introduction

So far you have learnt how to connect cells and resistors both in series and in parallel. You have also learnt how to obtain the effective resistance for both series and parallel connections. In this lesson you will apply the knowledge in connecting domestic appliances.

Note that domestic electrical connections are always done is series connection and in parallel.

Series connection

When electric components or appliances are connected in series, it will have the following advantages:

- Series circuits do not overheat easily.
- Series circuits are easy to learn and make; this means that it's simple to conduct repairs
- all of the components in a series connection carry the same current.
- each component or appliance will have its own potential difference across its terminals depending on its resistance.

Disadvantages of series connection

- the series connection would require a very large voltage to supply them.
- As the number of components in a circuit increases , there will be greater resistance in the circuit
- If one of the appliances is faulty or switched off, all the other appliances in the circuit will go off.

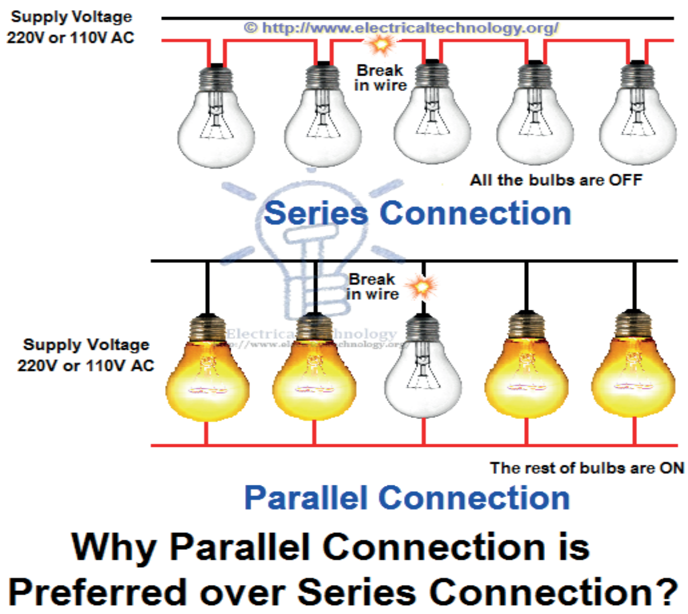
Parallel connection:

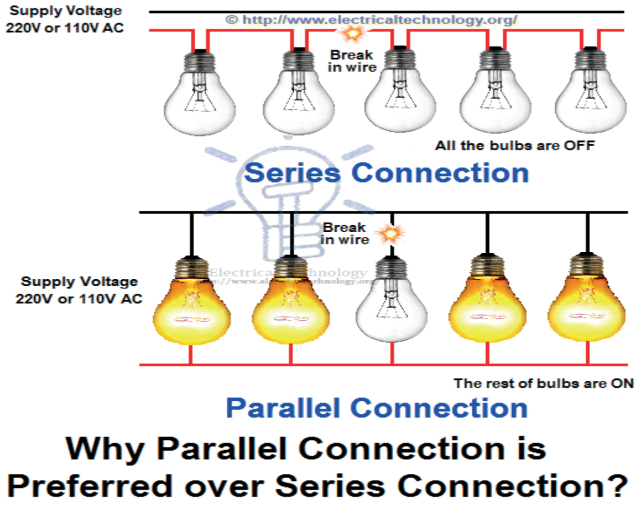
Advantages:

- all the appliances or components operate with the same potential difference
- If one of the appliances is faulty or switched off, the other appliances in the circuit remain unaffected
- It becomes easy to connect or disconnect a new element without affecting the working of other elements
- different currents flow through each of the components or appliances in the parallel connection

Disadvantages:

- It requires the use of lot of wires
- We cannot increase or multiply the voltage in a parallel circuit
- Parallel connection fails at the time when it is required to pass exactly same amount of current through the units



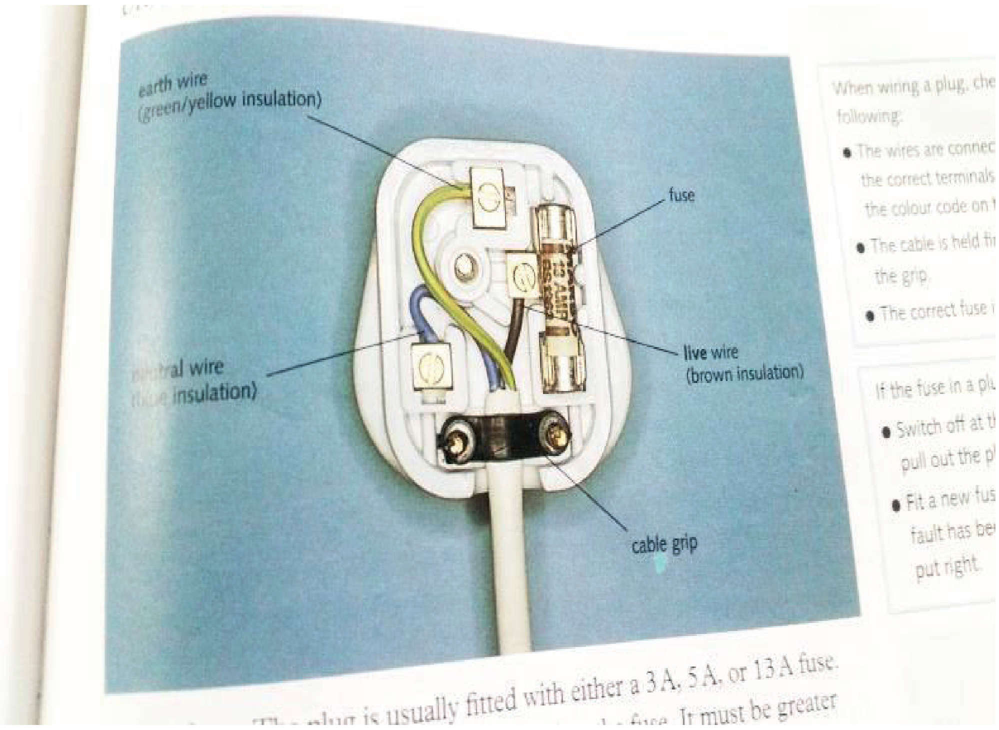


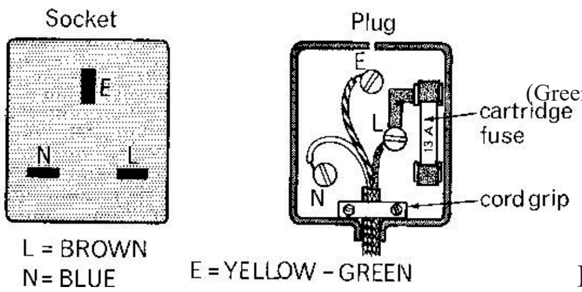
Identify the type of connection in fig 1 & 2

Three pin plugs

Introduction

Plugs are a safe and simple way of connecting appliances to the mains supply. In this case the three -pin plugs are commonly used in such connections.





Earth wire

(Green/yellow insulation)

Do you know how to identify a 3-pin plug?

Fig 5.3 **Fig 5.4**

The 3 – pin plug has three pins that are marked with letters L, N and E standing for *live*, *neutral* and *earth* respectively.

The plug is usually fitted with the fuse value of either a 3A, 5A or 13A fuse. This tells you the maximum current needed to blow the fuse. For example, a kettle is marked: 2300W, 230V find the value of the fuse to be used in the appliance.

From current = = = 10 A therefore a fuse of 13 A is needed.

Calculating the cost of electricity

The electricity board (**UMEME)** charges for electric energy they supply to the clients. The board of trade unit of electric energy is referred to as ***kilowatt hour (kWh)***.

For your knowledge

- *A kilowatt hour is the energy supplied by a rate of working of 1000 watts for 1 hour.*
- *Electrical cost = power consumed in kW number of hours cost per unit*

Example

Calculate the cost of running four 60W lamps and five 100W lamps for 5 hours if electrical energy costs shs 500 per unit.

Total power = 4 60 + 5 100

= 240 +500 =740W

Neutral wire (blue insulation)

Total power in kW = **= 0.74kW**

Therefore Electrical cost = 0.74 5 hours 500

= Shs 1,850

Exercises

1) An electric kettle is rated at 2500W, and uses a voltage of 240V. If the cost of electricity is shs. 400 per unit, what is the cost of running it for 6 hours.
2) A laundry worker uses a 750W electric iron to press her clothes for an average of 5 hours a week. What is the cost of electricity she uses in 4 weeks, if electrical energy costs shs 350

per kWh

3) A 4 kW electric heater is used for 10 hours each week, a 100 W bulb is used for 10 hours each day find the total cost for each week if a unit of electricity cost shs. 200.

LESSON 3: HOUSE WIRING

Competences:

In this lesson, you will:

- explain the concept of the domestic house wiring
- explain how electrical energy is transmitted over long distances

Material you need

- Diagram of a domestic house wiring

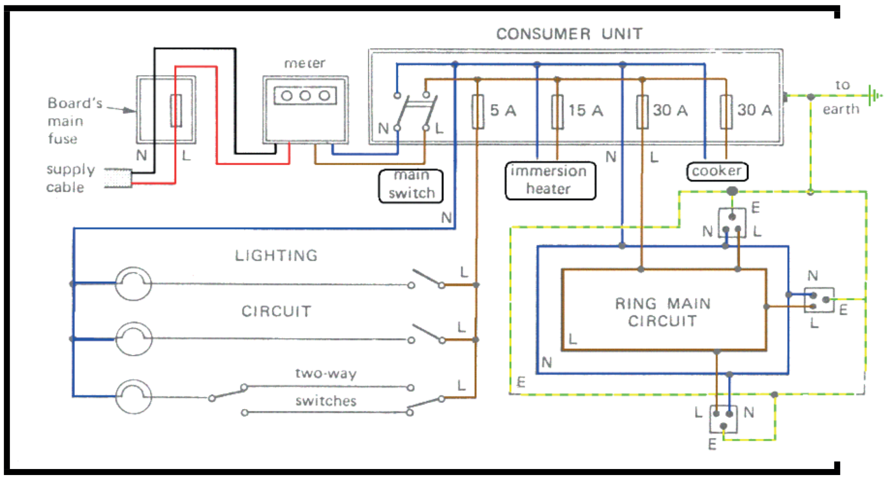


Fig 1: Domestic house wiring image

Introduction

In domestic electricity, it's important to note the following points:

a) Electricity enters the house through the ***supply cable*** from the pole.
b) The supply cable consists of two insulated wires, the **live** and the **neutral** wire.
c) The neutral is earthed at the local substation and is therefore at zero potential while the live wire is at a potential of 240 V.
d) The *live wire* (**L**) is either **red** or **brown** while the *neutral (***N***)* is **black** or **blue.**
e) The live wire delivers current from the local sub-station or power supply to the respective appliances while the neutral carries it back to the power supply, thus completing the circuit.

For your knowledge

a) all **switches** and **fuses** are connected to the *live wire*
b) each of the two wires (live and neutral) is connected to the **meter** through the **main fuse box**
c) a thick copper wire is connected from the meter to the earth and it is therefore at zero potential. It protects the meter and the house against damage in case of overloading or short circuit.
d) from the meter the cables are passed to the consumer unit which contains the main switch to switch off all current in the house
e) the main switch is a double pole(D.P) switch which breaks both the live and the neutral
f) the consumer unit also contains single pole fuses for each of the following circuits
i) lighting circuit connected to 5A fuse
ii) immersion heater circuit controlled by 15A fuse
iii) the ring main circuit is controlled by 30 A fuse
iv) cooker controlled by a 30 A fuse

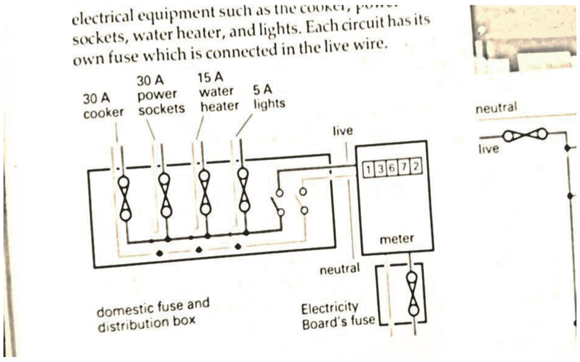


Fig 2: Main switch

Note: Every circuit is connected in parallel with the power supply, i.e. across the live and the neutral wires. There is no connection between the live and the neutral wires except through an electrical appliance.

In any domestic wiring the following devices are very important

- **The fuse**
  It melts and breaks the circuit in case of overloading or short circuit.
  Note: in a modern wiring, fuses are no longer in use in the main switch instead circuit breakers are used because of their sensitivity.
- **Circuit breaker**
  Is an automatically operated **electrical** switch designed to protect an **electrical circuit** from damage caused by excess current from an overload or short **circuit**
- **The earth wire.**
  The earth wire prevents electric shocks in case short circuits occur.
- **Switches:**
  Switches are connected to the live wire to break and complete the circuit.

Discuss with your neighbors the safety precautions one should take when wiring a house

LESSON 4: POWER TRANSMISSION

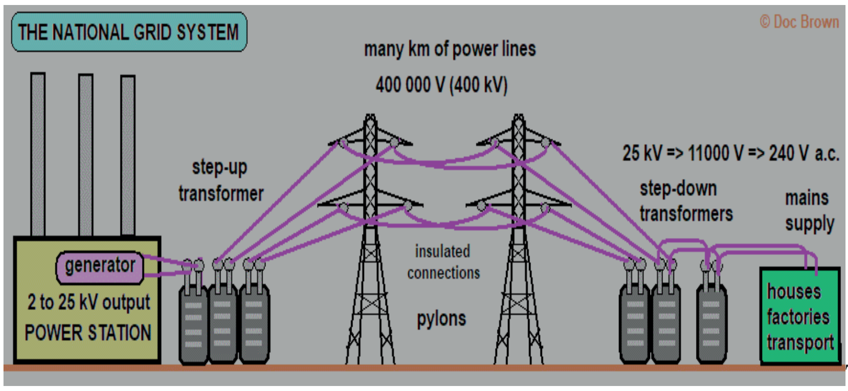
Material you need

- Diagrams showing how power is transmitted by the national grid system

Introduction

Electricity generated at a power station is transmitted to various users by overhead or underground cables. The entire system that connects power station and users is called a grid.

From the substation, power is brought to the house through a two wire cable. One of which is earthed at the transformer, called the neutrals wires and the other wire is live.



The mains cable goes through the fuse box.

Fig 1: Distribution of electricity

Electric power transmission is the bulk movement of electrical energy from a generating site,

such as a power plant, to an electrical substation. The interconnected lines which facilitate this movement are known as a *transmission network*. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution.

Heat losses during power transmission can be minimized by using a transformer to step up the voltage at the transmitting station. Electricity is transmitted in form of alternating current (a.c).

Fig 2: High voltage transmission lines

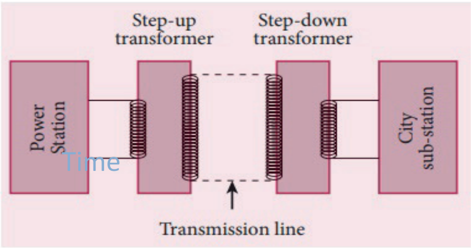


Figure 4.38 Long distance power transmissions

Fig 3

For your knowledge, a.c has the following advantages over d.c in power transmission

- a.c can be easily stepped up for transmission over long distances with less loss of power than d.c
- a.c can easily be converted into d.c but it's difficult to convert dc to a.c.

Please look for more advantages at your free time.

Summary of the topic:

- The electricity generated at a power station is transmitted to various users by overhead or underground cables.
- The entire cable system that connects power stations and users is called the grid.

CHAPTER: THE PRINCIPLE OF ELECTRIC MOTOR

By the end of this chapter, you should be able to;

- demonstrate the existence of a force on a current carrying conductor in a magnetic field
- use Fleming's left hand rule to predict the direction of force
- explain the operation of moving coil instruments

LESSON 1: FORCE ON A CURRENT CARRYING CONDUCTOR

Competences:

In this lesson, you will:

- demonstrate the existence of a force on a current carrying conductor in a magnetic field
- use Fleming's left hand rule to predict the direction of force
- state the factors affecting the magnitude of a force on a current carrying conductor

Introduction

When a conductor carrying current is placed in a magnetic field, it experiences a mechanical force. This force comes as a result of the interaction between the magnetic field around a conductor and magnetic field in which it's situated. The direction of the force on the conductor is predicted using Fleming's Left hand rule,

For your knowledge, Fleming's Left hand rule states that: If the first finger, the second finger and the thumb of the left hand are placed at right angles to each other, with the **F**irst finger pointing in the direction of the **F**ield, the second finger in the direction of the **C**urrent, then the thumb points in the direction of the Motion or Force.

Activity

Place your left hand as shown in fig 6.0 and identify the direction of the field, current and motion.

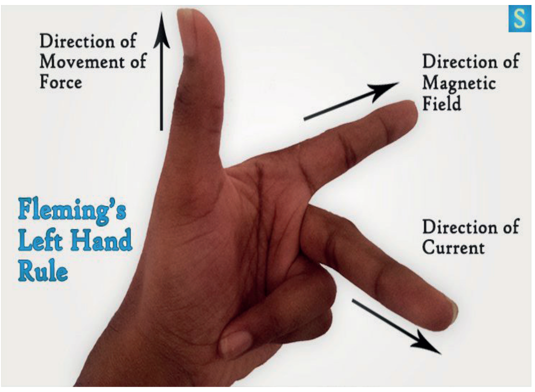


Fig 1

To investigate force on a current carrying conductor

Material you need:

- U-shaped magnet
- Copper Wire
- Battery & Switch

Activity

(a) connect the copper wire between the poles of the magnet
(b) Close the switch

Briefly explain what happens when:

- The switch is closed? The direction of the current or field is reversed.

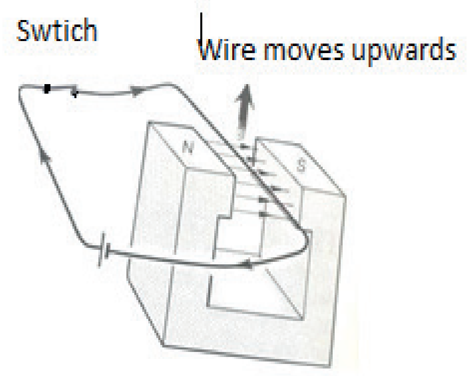


Fig 2

For your knowledge: When the switch is closed, current flows through the wire. The wire moves upwards, indicating that there is upward force acting on it. If the direction of either the current or the field is reversed, the wire moves downwards.

Note: the current in a straight wire produces a circular magnetic field pattern. When the wire is between the poles of a magnet, the combined field appears as shown in **fig 3**. There are more field lines below the wire since both fields act in the same direction, but fewer above it because they are in opposition.

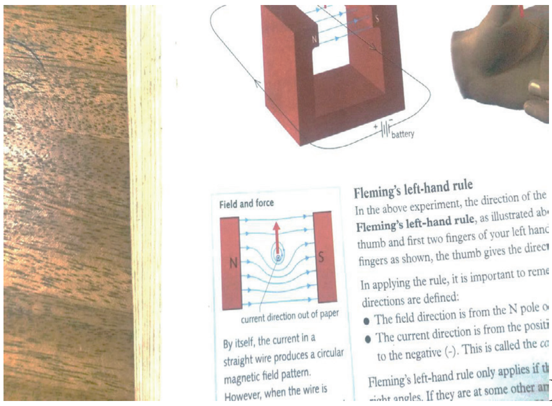


Fig 3

For your knowledge, When the current is flowing out of the paper we represent its direction using a dot (**.**) and current flowing into the paper we use a cross (×)

Factors that affect the magnitude of force on a current carrying conductor

Magnitude of force on a current carrying conductor in a magnetic field depends on:

- The magnitude of current flowing through the conductor.
- The strength of the magnet field.
- The length of the conductor in the magnetic field.

LESSON 2: OPERATION OF MOVING COIL INSTRUMENTS

Competences:

In this lesson, you will describe the structure and operation of the following instruments

a) Simple d.c motor
b) Moving coil loud speaker
c) Moving coil galvanometer

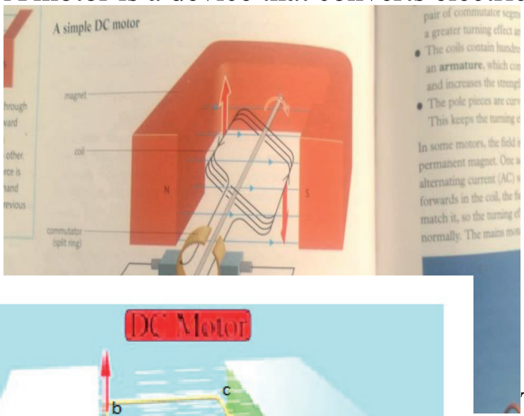
a) **A Simple Direct Current (D.C) motor**

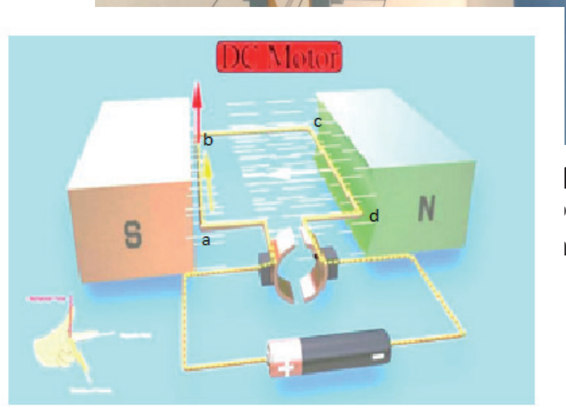
Materials you need

- Diagrams of a D.C motor

Introduction

- A motor is a device that converts electrical energy to mechanical energy





The Simple direct current motor consists of a rect-
pieces of a strong magnet, and its ends are connected
lit rings or commutators are each in contact with the
nected to a d.c supply. The coil is free to rotate in the

Fig 1 **Fig 2**

Fig 1 and 2 show the diagrams of a simple direct current motor

MODE OF OPERATION OF D.C MOTOR

- When current is passed through the coil, equal opposite forces are exerted on the wire sections ab and **cd (fig 2)** of the coil causing it to rotate.

- When the coil reaches the vertical position, the brushes lose contact with the commutators hence the current is cut off.

- The momentum of the coil however carries it beyond the vertical position and the commutator halves reverse contact and the coil continues to rotate in the same direction.

For your knowledge, the turning effect on the coil can be increased by:

- Increasing the current
- Using a stronger magnet
- Increasing the number of turns on the coil
- Increasing the area of the coil

The images in fig 3 show some of the home appliances that operate using motor

Can you identify them?

Fig 3

b) **MOVING COIL LOUD SPEAKER.**

Materials you need

- Diagram of a moving coil loud speaker

Introduction

A moving coil loudspeaker converts electrical energy into sound energy. It consists of a cylindrical voice coil placed inside a soft iron core which attached to a permanent magnet.

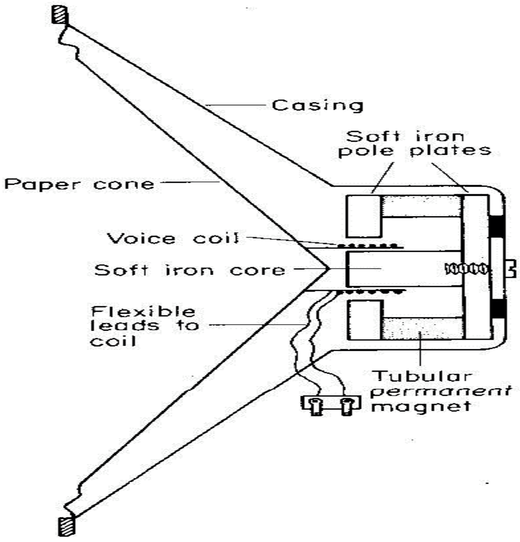
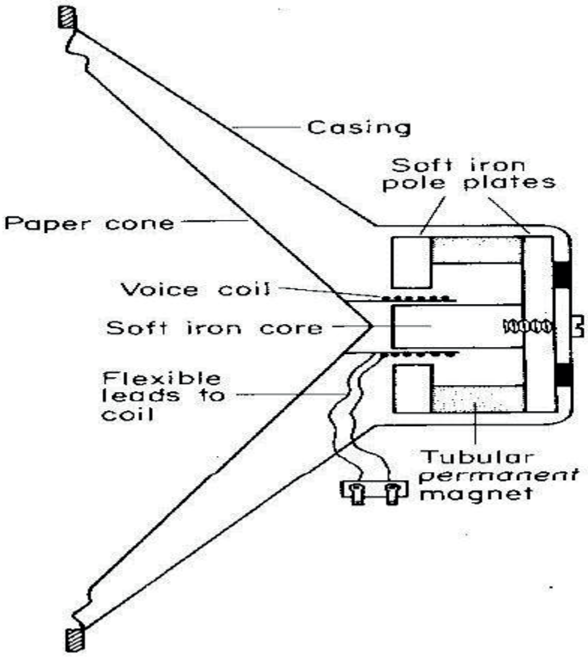


Fig 4



MODE OF OPERATION OF A MOVING COIL LOUD SPEAKER

- The loud speaker is connected to an amplifier which gives out alternating current
- Varying current flows through the terminal into the coil which is in a magnetic field.
- The coil experiences a varying force which causes it and the paper cone attached to it to move to and fro.
- This sets the air in contact with paper cone into vibrations, hence setting up a sound wave which follows the same pattern as the original electrical signal.
- The sound you hear depends on how the amplifier makes the current alternate.

c) **MOVING COIL GALVANOMETER**

Material you need

- **Diagram of a moving coil galvanometer**

Introduction

In the previous lesson you learnt the conversion of a moving galvanometer. In this lesson you will look at the structure and operation of a moving coil galvanometer and for your knowledge,

- The moving coil galvanometer consists of a fine insulated copper coil of several turns wound on a soft iron or light aluminum frame that rotates in a radial magnetic field provided by the semi – circular pole pieces of a permanent magnet.

- The frame is pivoted on jeweled bearings.
- The coil is connected to the pointer which moves over the scale when it turns.

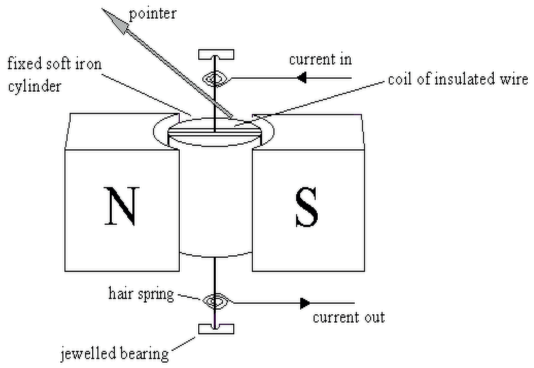


Fig 5

MODE OF OPERATION OF A MOVING COIL GALVANOMETER

- When current flows through the coil, a couple acts on the coil causing it to rotate until stopped by the springs. The coil comes to rest when the couple due to current flowing just balances with the couple due to the spring.
- The current to be measured is let in and out through the hair springs
- The greater the current, the greater the deflection which is shown by the pointer.
- The springs are placed in opposite directions so as to produce a couple which just balances with the couple due to the current.
- Current is measured from the position of the pointer

Summary of the topic:

- Flemings Left Hand rule is used to determine the direction of a current carrying conductor

Magnitude of force on a current carrying conductor in a magnetic field depends on:

- ✓ The magnitude of current flowing through the conductor.
- ✓ The strength of the magnet field.
- ✓ The length of the conductor in the magnetic field
- The magnetic effect of current can be used in making gadgets such as loudspeakers, magnetic relays and direct current motors

CHAPTER: ELECTROMAGNETIC INDUCTION

By the end of this chapter, you should be able to;

- practically demonstrate the generation of electricity from magnetism
- use Fleming's right hand rule to predict the direction of the induced current
- investigate the factors that affect the magnitude of the induced emf
- explain the working of simple a.c and d.c generators
- describe the structure and principle of operation of a transformer

LESSON 1: GENERATION OF ELECTRICITY FROM MAGNETISM

Competences:

In this lesson, you will:

- Demonstrate the generation of electricity from magnetism.
- State Faraday's and Lenz's laws and demonstrate the laws
- use Fleming's right hand rule to predict the direction of the induced current

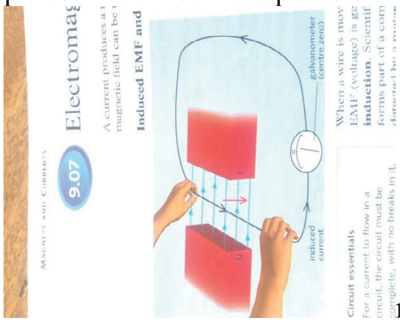
Introduction

Electromagnetic Induction is the production of electromotive force in a conductor when the magnetic flux linking the conductor changes.

Material you need

- bare wire
- connecting wires
- strong magnets
- image of centre zero galvanometer

Activity

(a) connect the bare wire to the galvanometer
(b) place it between the poles of magnets
(c)  move the wire to and fro as shown is the fig 7.0

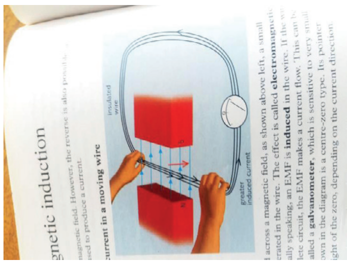


Fig 1 **Fig 2**

What do you notice on galvanometer?

For your knowledge

When a wire is moved across a magnetic field, as above a small emf (voltage) is generated in the wire; in other words an emf is **induced** in the wire. If the wire forms part of a complete circuit, the emf makes a current flow. This can be detected by a **galvanometer,** which is sensitive to very small currents.

The induced e.m.f (and current) can be increased by:

- moving the wire faster
- using a stronger magnet
- increasing the length of wire in the magnetic field – for example, by looping the wire through the field several times, as shown in **fig 2**

The results from the activity above are summed up by **Faraday's of electromagnetic induction.**

Friday's law of electromagnetic induction states that:

The emf induced in a conductor is proportional to the rate at which magnetic field lines are cut by the conductor.

Note: the direction of the induced emf and current can be reverse by:

- moving the wire in the opposite direction
- turning the magnet round so that the field direction is reserved

If the wire is not moving, or is moving parallel to the field lines, there is no induced emf or current.

Demonstration of the laws of electromagnetic induction

Activity

a) connect the wire to the galvanometer as shown in fig 3
b) push the bar magnet into the coil
c) explain briefly what happens

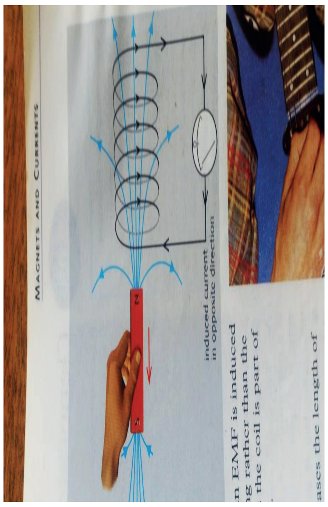


Fig 3

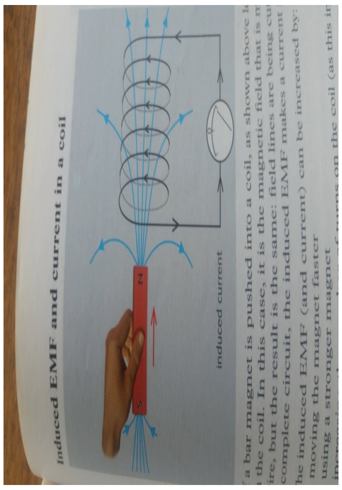


Fig 4

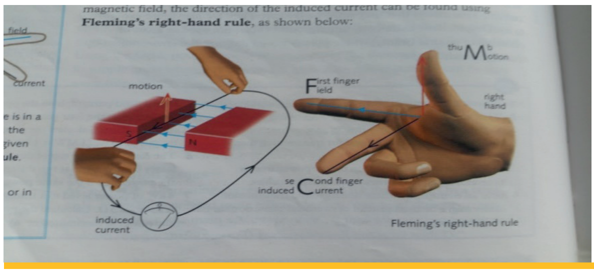
For your knowledge

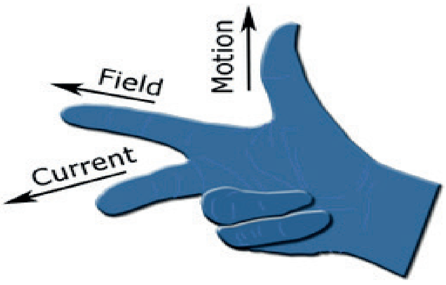
- If a bar magnet is pushed into a coil, an emf is induced in the coil
- In this case, it is the magnetic field that is moving rather than the wire
- The field lines are being cut. As the coil is part of a complete circuit, the induced emf makes a current flow
- If the magnet is pulled out of the coil, as shown in fig 4, the direction of the induced emf and current is reversed
- The direction of induced e.m.f depends on the direction of motion of the magnet.

- The magnitude of induced e.m.f depends on the speed of motion of the magnet and the number of turns of the coil.

What happened if the south pole of the magnet, rather than the north pole, is pushed into the coil?

Note: The direction of induced e.m.f. is predicted by the use of Fleming's right hand rule.

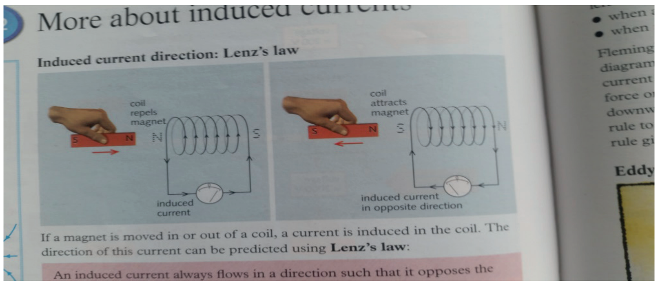




This rule states that if the first finger, the second finger and the thumb of the right hand are held at right angle to each other so that the first finger points in the direction of the field, the second finger points in the direction of the induced current, then the thumb points in the direction of the motion or force of the conductor

Activity

Place your Right hand and identify the direction of the Field, Current and Motion



Induced current direction

Fig 5

If a magnet is moved in or out of the coil, current is induced in the coil**(fig 5).** The direction of this current is predicted using **Lenz's law:**

Lenz's law of electromagnetic induction states that:

The direction of induced e.m.f is always such as to oppose the change producing it.

Factors affecting the magnitude of the induced current

(i) strength of the magnet
(ii) speed of the relative motion between the magnet and coil
(iii) area of the coil in the magnetic field
(iv) number of turns on the coil
(v) the resistance of the coil

LESSON 2: AC AND DC GENERATORS

Competences:

In this lesson, you will:

- Describe the structure and operation of simple a.c and d.c generators.

Material you need

- Diagrams of the alternating current (**a.c**) and direct current (**d.c**) generators

Note that a generator is a device that converts mechanical energy into electrical energy.

A simple A.C Generator

A simple a.c. generator consists of a rectangular coil mounted between pieces of a strong magnet that provide magnetic field and free to rotate with a uniform speed. The ends of the coil are connected to copper slip rings which press against the carbon brushes.

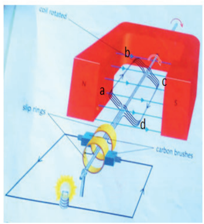


Fig 6

MODE OF OPERATION

- When the coil is rotated in the magnetic field, the field linking it changes and an induced current flows in the coil

- The induced current is led away by means of slip rings
- When side **ab** of the coil is moves upwards and side **cd** downwards, induced current flows from **a** to **b** and from **c** to**d** according to Flemings right hand rule

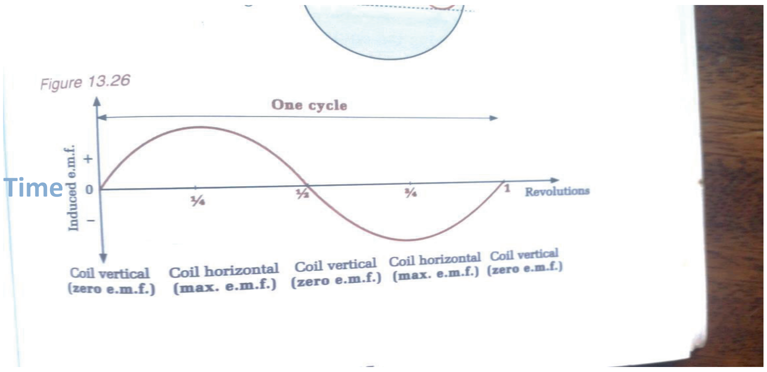
- When the coil reaches the vertical position, no current is induced but the momentum of the coil pushes it past this position

- As the coil moves past the vertical position the induced emf reverses direction

- This results into change in current in the circuit hence an alternating current flows in the external circuit

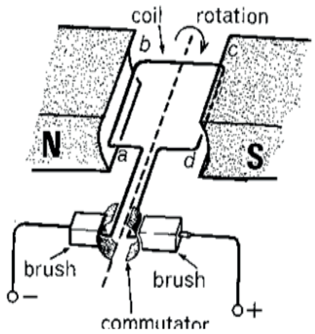
Note that: the polarity of the carbon brushes keeps changing every after half-cycle resulting into an alternating e.m.f. that causes an alternating current to flow in the external circuit.

Variation of induced emf against time



A simple D.C Generator

- This consists of a rectangular coil which is rotated between the pole pieces of a strong magnet.

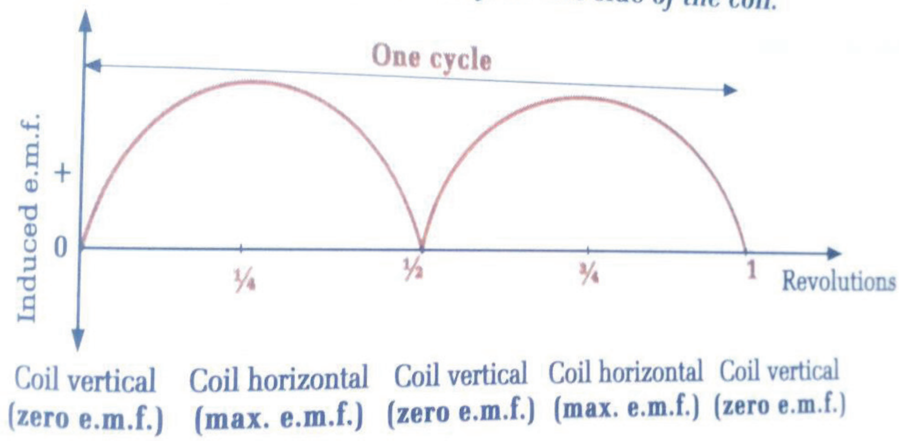


-
- The ends of the coil are connected to separate halves of a single split-ring or commutator. Each half of the split-ring makes contact with carbon brushes that connect them to an external circuit.

MODE OF OPERATION

- When the coil rotates about the axis, the magnetic field linking with it changes and an emf is induced n the coil.
- When the coil reaches the vertical position no current flows and there is no cutting of the field lines. Due to the momentum of the coil, it's pushed past the vertical position.
- The half-split rings change contact with the carbon brushes whenever the coil moves past the vertical position. This ensures that one brush is always positive and other negative, and a direct current flows through the external circuit.

Figure 13.29 ***Graph of induced e.m.f. on one side of the coil.***



Variation of induced emf against time

In summary, a.c, generator can be modified (converted) to a d.c. generator by replacing the slip rings with commutator (split rings).

LESSON 3: TRANSFORMERS

Competences:

In this lesson, you will:

- describe the structure and principle of operation of a transformer
- differentiate the types of transformer
- solve numerical problems related to transformer

Material you need

- Diagrams of transformer

Introduction

A transformer is a device which transfers electrical energy from one circuit to another by electromagnetic induction.

A transformer consist of a primary coil to which input alternating voltage is applied , a secondary coil to which output alternating voltage is induced and a laminated soft iron core.

The working of a transformer

An alternating voltage is applied to the primary coil and this sets up a varying magnetic field which links the secondary coil inducing an alternating voltage in the secondary coil hence an alternating emf is generated in the secondary coil.

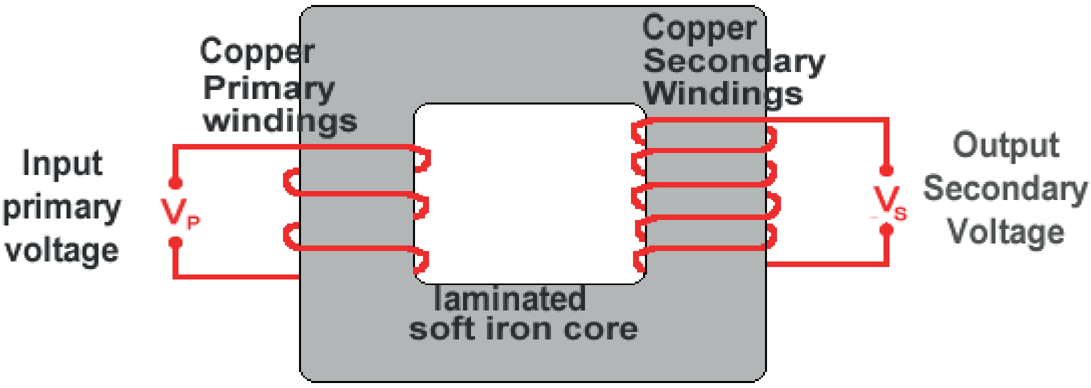


Fig 1

Types of transformer

There are two types of transformers namely:

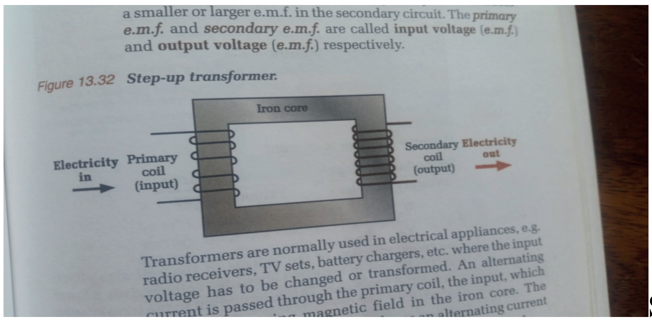
a. step-up transformer
b. step-down transformer

Step-up transformer

Fig 1

A step-up transformer is one which has more turns in the secondary coil than primary coil. So the voltage of the secondary coil is greater than the voltage of the primary coil. But current flowing in the Secondary coil is less than the current flowing in the primary coil.

Fig 2



a smaller or larger e.m.f. in the secondary circuit. The *primary e.m.f.* and *secondary e.m.f.* are called **input voltage** (*e.m.f.*) and **output voltage** (*e.m.f.*) respectively.

Figure 13.32 ***Step-up transformer.***

Transformers are normally used in electrical appliances, e.g. radio receivers, TV sets, battery chargers, etc. where the input voltage has to be changed or transformed. An alternating current is passed through the primary coil, the input, which ... magnetic field in the iron core. The ... alternating current

Step-down transformer

A step-down transformer is one which has less number of turns in the secondary coil than primary coil so the voltage of the secondary coil is less than the voltage of the primary coil.

But the current flowing in the secondary coil is greater than the current flowing in primary coil

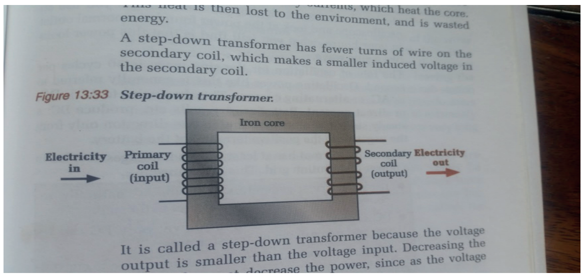


Fig 3

Transformer equation

This equation relates the number of turns of wire to the difference in voltage between primary and secondary coils

Power = voltage x current

= **OR** =

The condition for an ideal transformer (i.e. A transformer that is 100% efficient) is that:

Power input = power output

Power in the primary coil = power in the secondary coil

power input = VpIp,, power output= VsIs

Therefore $V_pI_p = V_sI_s$

Efficiency of a transformer:

The efficiency of a transformer is the ratio of the power output to power input expressed as a percentage.

Efficiency = %

= %

Numerical example

In a step up transformer, the secondary circuit has 600turns and a p.d of 1,200V. If the primary source is 240V, determine the number of turns in the primary circuit.

Solution

=

=

1200= 240 600

= 120 turns

Exercises

1) A transformer steps down a voltage from 240 V to12 V for a radio. if the primary windings are 300 turns, how many turns are in the secondary windings?
2) A transformer has 500turns in its primary coil and 3000 turns in the secondary. If it's connected to an alternate voltage of 240V, find the output voltage
3) A certain transformer has 600turns in the primary circuit. its connected to a 240V mains supply and produces an output of 12V. Determine the number of turns in the secondary circuit.

Summary of the topic:

- Whenever the magnetic flux linked with a coil changes, an emf is induced. This is called Electromagnetic Induction
- The magnetic flux linked with the coil can be changed by changing magnetic field strength, the area of the coil, speed of the relative motion between the magnet and coil,the resistance of the coil and the number of turns in the coil.
- The magnitude of the induced e.m.f depends on the rate at which magnetic flux is changed in the circuit. This is Faraday's law of electromagnetic induction
- A transformer uses the application of electromagnetic induction

CHAPTER: ELECTRONS AND X-RAYS

By the end of this chapter, you should be able to;

- describe the experiment to produce cathode rays
- draw the CRO and explain how it works
- draw the structure of the X-ray tube and describe how X-rays are produced
- list properties and uses of X-rays
- state health hazards of X- rays and safety precautions

LESSON 1: CATHODE RAYS

Competences:

In this lesson, you will:

- describe the experiment to produce cathode rays
- investigate the properties of cathode rays

Material you need

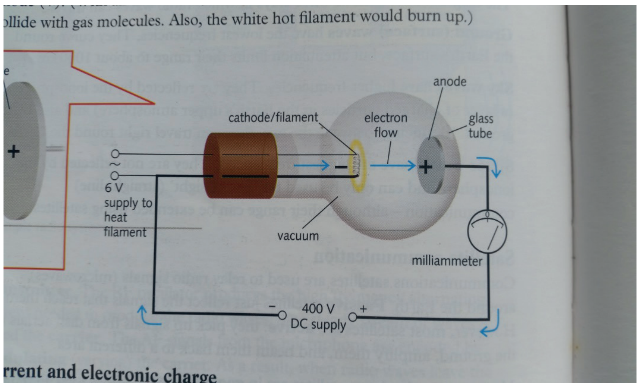
- Diagram showing the production of Cathode rays
- Diagrams showing deflection of electron in both electric and magnetic field

Introduction

Cathode rays are streams of fast moving electrons produced from the cathode by thermionic emission.

Production of cathode rays

- Cathode rays are produced when the cathode / filament is heated by low voltage
- The electrons are then emitted and accelerated by a large voltage towards the anode
- The fast moving electrons (cathode rays) pass through the anode and strike the fluorescent screen.
- Since the tube is evacuated the electrons move freely without collusion with air molecules



PROPERTIES OF CATHODE RAYS

a) They are deflected by both electric and magnetic field

b) They carry negative charge

c) They travel in a straight line

d) They ionize gasses

Deflection of cathode rays by an electric field

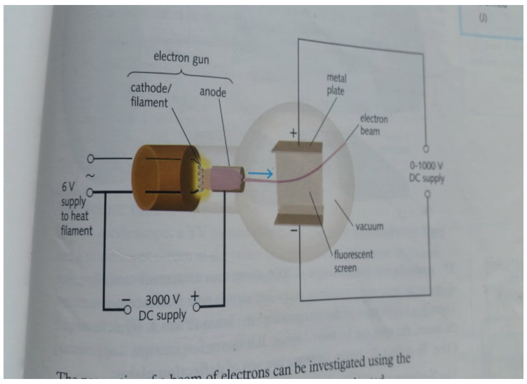


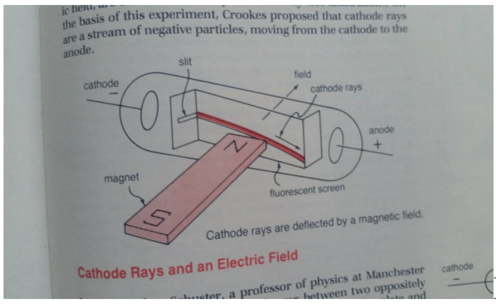
Fig 2

When the voltage is applied, the beam is deflected towards the positive plate, as shown in fig 2.

Deflection of cathode rays by a magnetic field

The beam can also be deflected by a magnetic field, produced by passing current through a pair of coils**(fig 3).**Similarly Cathode rays when passing through a magnetic field are deflected in the same way **(fig 4)**

For your knowledge, the direction of the force is given by Fleming's left hand rule.



Do you remember the rule from the previous lesson?

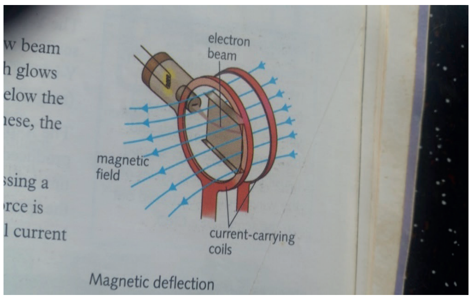


Fig 3 Fig 4

Note that: Cathode rays are applied in the following devices

- X-ray tube
- A diode
- Cathode Ray Oscilloscope
- Television set

LESSON 2: CATHODE RAY OSCILLOSCOPE (CRO)

Competences:

In this lesson, you will:

- draw the CRO and explain how it works
- uses of CRO

Material you need

- Diagram of the CRO

Introduction

The Cathode Ray Oscilloscope uses a narrow beam of electrons to trace out wave forms and other signals on a fluorescent screen. The CRO consist of three main parts namely; electron gun, deflecting system and fluorescent screen.

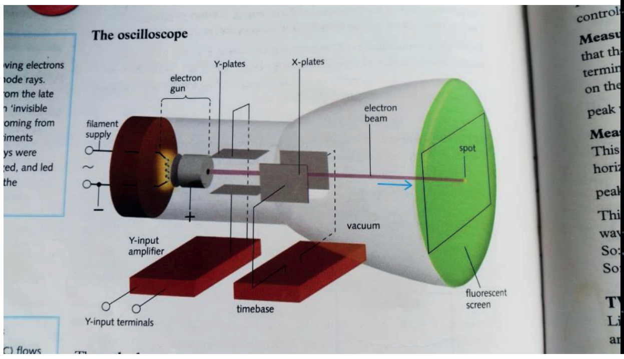


Fig 8.4

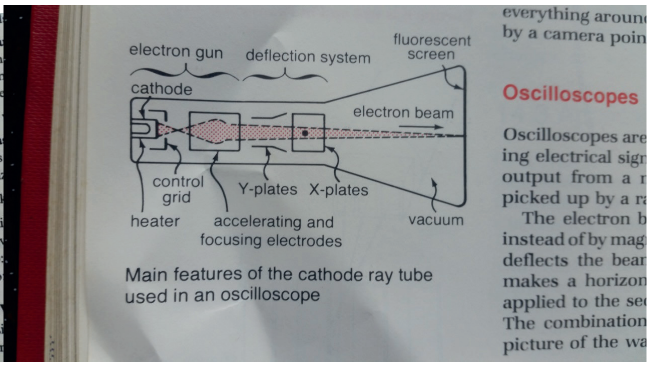


Fig 8.5

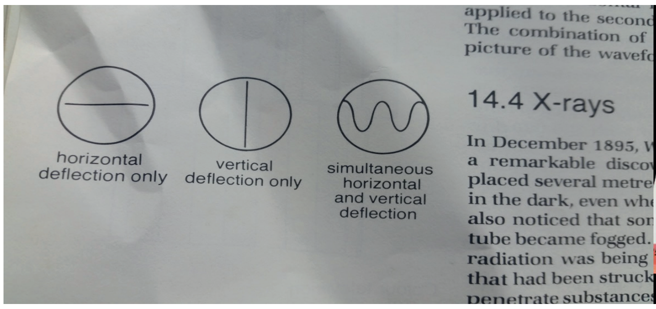
Do you know how a CRO works?

In the previous lesson, you looked at the production of cathode rays. This is how the CRO also works. In addition to that, note the following:

- The Grid controls the number of electrons reaching the anode and the brightness of the spot on the screen
- There are two plates in the deflecting system; the Y- plates which deflects the electron beam vertically and the X- plate deflects is horizontally.

- The movement is produced by a circuit called the **timebase** inside the oscilloscope. This automatically applies a changing voltage across the plates such that the spot moves.

Different wave forms in a CRO are as shown below:



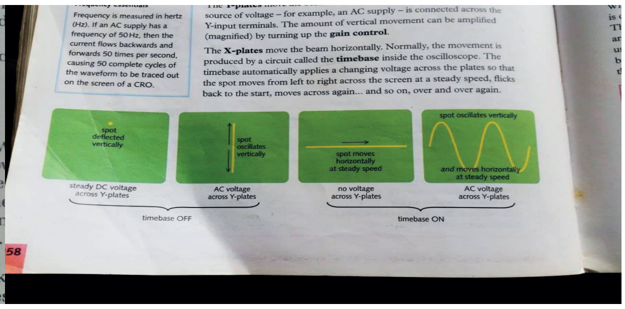


Fig 8.6 **Fig 8.7**

Discuss with your neighbors the uses of a CRO.

LESSON 3: X- RAYS

Competences:

In this lesson, you will:

- draw the structure of the X-ray tube and describe how X-rays are produced
- list properties and uses of X-rays
- state health hazards of X- rays and safety precautions

Introduction

In your previous lesson in waves you learnt that X-rays are electromagnetic radiations. When very fast electrons are stopped by metal target, most of their kinetic energy is changed into heat and the rest converted to X-rays.

Production of x-rays

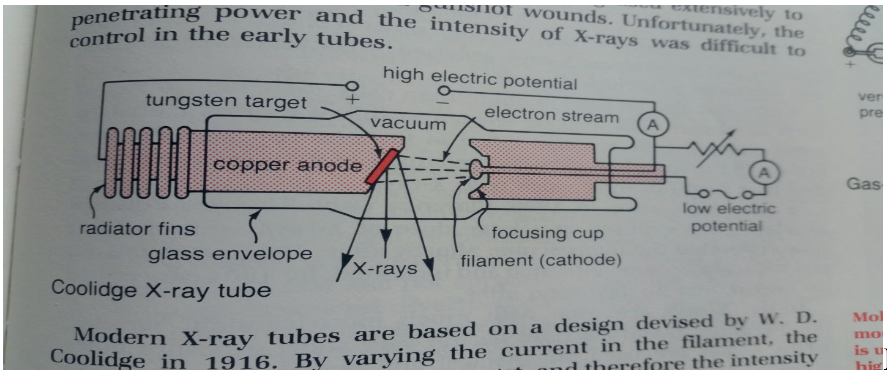


Fig 1

- In the production of X-rays, a low voltage is applied across the cathode and electrons are emitted by thermionic emission.
- A large voltage accelerates the electrons towards the anode and eventually they hit the metal target.
- Their kinetic energy is then converted into heat and X- rays.
- The cooling fins radiate the heat produced on the metal target away.

For your knowledge, there are two types of X-rays

- Soft X-rays are produced when a low voltage (a small potential difference) is used. Soft X-rays have long wave length and less penetrating power
- Hard X-rays are produced when high voltage (high potential difference) is used. Hard X-rays have short wave length and high penetrating power

PROPERTIES OF X- RAYS

- They are electromagnetic waves of very short wavelength
- They travel in straight lines at the speed of light
- They have no charge
- They cause ionization of gases
- They cause photographic material to blacken

Uses of X-rays

For your knowledge, X-rays are used mostly in medical and industry

- **Medicine**

In medicine, X – rays are used to**;** investigate born fractures, detect lung tuberculosis, treat cancer, locate foreign objects in the body etc.

- **Industrial use**

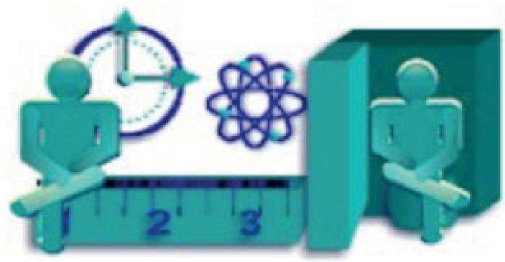
In industry, X-rays are used to; detect cracks in metals and car engines, locate internal faults in motor tyres, detect defects in paints etc. Workers dealing with X-rays should wear shielding jackets with a layer of lead

Health hazards of X- ray

- They cause genetic changes or mutation.
- They cause damage of eye sight and cause blood cells.
- They produce skin burns due to greater penetration

Safety precautions

- Avoid unnecessary exposure to X –rays
- Workers should wear protective gears with thick lead
- The X- ray beam should only be restricted to parts of the body being investigated.
- Soft X-rays should always be used on human tissues



- Use time, distance and shielding to protect yourself (fig above)

Summary of the topic

- When electromagnetic radiation of appropriate frequency falls on metals, the free electrons are emitted, this is photoelectric emission
- When a metal surface is heated directly, the electrons are emitted. This process is called thermionic emission.
- The main parts of the CRO are Electron gun, a deflection system and fluorescent screen
- The electron gun consists of the filament that heats the cathode. The heated cathode gives out a large number of electrons by thermionic emission
- In a CRO there are two sets of electrodes called the X and Y plates which constitute the deflection system.
- When high energy electrons are stopped by a heavy metal target X- rays are emitted
- X-rays carry no charge

CHAPTER: ATOMIC AND NUCLEAR STRUCTURE

By the end of this chapter, you should be able to;

- describe the atoms
- represent nuclides with their atomic numbers and atomic masses
- define nuclear fusion and fission
- explain the use of nuclear energy in the generation of electricity and bombs

LESSON 1: THE ATOM

Competences:

In this lesson, you will:

- describe the atoms
- represent nuclides with their atomic numbers and atomic masses

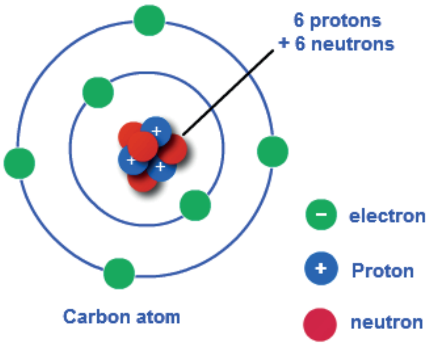
Material you need

- Beads of different colours
- Strings
- Mortar made of clay

Introduction:

Model of the atom

An atom consists of 3 particles namely -: **Proton, Neutrons** and **Electrons.**



d in the nucleus and are referred to as nuclei or nuclide particles.

while neutrons have no charge. Around the nucleus are electrons negatively charged and their number is equal to the number of rically neutral

Fig 1

Project Work:

Using the materials above build to the structure of carbon atom as shown in **fig 1.**

Isotopes are atoms of the same element having the same atomic number but different mass number. This means that an isotope of an element has the same number of protons and electrons but different number of neutron.

Atomic number is the number of protons in the nucleus of an atom.

Mass number is the sum of protons and neutrons in a nucleus of an atom. Mass number is also referred to as the atomic mass.

You should note that; An atom Y is represented by: Where A = mass number and Z = atomic number

Note: Mass number = Atomic number + No. of Neutrons.

LESSON 2: NUCLEAR ENERGY

Competences:

In this lesson, you will:

- define nuclear fusion and fission
- explain the use of nuclear energy in the generation of electricity and bombs

Introduction

Do you know that Nuclear energy is referred to as the nuclear potential energy? This is because it's the energy stored up in the nucleus.

By definition, Nuclear energy is the type of energy made available from the disintegration of the nucleus of an atom.

Similarly, the process by which energy is produced is called nuclear reaction and there are two types of nuclear reaction i.e. **Nuclear Fission and Nuclear Fusion**

Nuclear Fission

This is the splitting of heavy unstable nucleus to form two or more lighter stable nuclei with the release of energy

.E.g. when Uranium is hit by high speed neutron it splits into two.

$+ \rightarrow + + 2$

Nuclear fission occurs in a nuclear reactor. it is the source of nuclear energy for generation of electricity in nuclear power stations.

Application of Nuclear Fission

- It's used in making atomic bombs.
- Used to generate electricity.

Condition for nuclear fission to occur

- There should be neutrons *moving at a high speed* when meeting heavy nuclei
- There should be a heavy unstable nucleus with isotopes which decay to produce isotopes and

high speed neutrons

Nuclear fusion

This is the union of two or more lighter unstable nuclei to form a heavy stable nucleus with the release of energy. Example:

+ + energy

Application of Nuclear Fusion

- In the production of the Hydrogen bomb.
- It's used to produce electricity

Condition for nuclear fusion to occur

- Nuclear fusion also requires that the particles approaching each other should be at very high speed
- Temperatures must be very higH

Summary of the topic

- Electrons, protons and neutrons form an atom
- The atom consist of the central nucleus i.e. protons and neutrons. The electrons move round in a fixed orbit
- A nuclide is characterized by the mass number and atomic number

CHAPTER: RADIOACTIVITY

By the end of this chapter, you should be able to;

- describe the nature of alpha and beta particles, and gamma rays.
- list the properties of the radiations from radioactivity.
- use knowledge of half-life to find the age and quantity remaining.
- state applications of radioactivity.
- list the safety precautions in the prevention of health hazards of radiations

Lesson 1: Types of radiations

Competences:

- nature of alpha and beta particles, and gamma rays
- properties of the radiations from radioactivity

In this lesson, you will:

- describe the nature of alpha and beta particles, and gamma rays
- list the properties of the radiations from radioactivity

Introduction

The study of radiations falls under the concept of radioactivity in this case; radioactivity is defined as the spontaneous disintegration of the unstable nuclei to a stable one by the emission of alpha particle, beta particles and gamma rays.

Nature of the three radiations

Alpha particles

Alpha particle is a helium atom which has lost two electrons; it consists of two protons and two neutrons. Alpha particles have a mass number 4 and an atomic number of 2. Alpha particles are therefore positively charged.

Beta particles

Beta particles are high energy electrons. Beta particles are negatively charged.

Gamma rays

Gamma rays are electromagnetic waves of very short wavelength and high frequency. Gamma rays are emitted by most radioactive sources along with alpha or beta particles. . Gamma rays have no electrical charge associated with them.

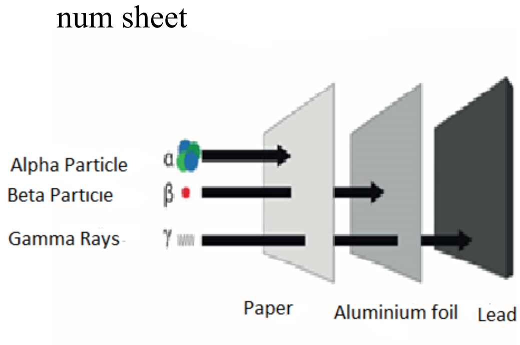
Properties of the radiations

Alpha particles

- Alpha particles highly ionize gases
- Alpha particles are deflected moderately by a magnetic field
- Alpha particles penetrate air but are stopped by thin sheets of paper or cardboard
- Alpha particles are positively charged because they are helium atoms

Beta particles

- Beta particles moderately ionize gases.
- Beta particles are deflected by a magnetic field more than alpha particle
- Beta particles can penetrate thin sheets of paper or cardboard but can be stopped by aluminum sheet



towards the positive plate.

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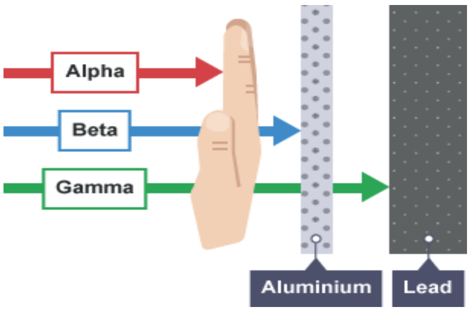
ɔwer.

Penetration power of radiations



Radioactive decay

Fig 2

For your knowledge

If isotopes are radioactive, then it will have an unstable arrangement of neutrons and protons in its nuclei. The emission of alpha **(α)** or beta **(β)** particle makes the nucleus more stable and this changes the number of protons and neutrons which becomes the nucleus of different element. The original nucleus is the parent and the one formed is the daughter nucleus.

Note that:

1) during alpha emission:
- The mass number reduces by 4

- The atomic number reduces by 2

Example:

When undergoes **alpha-decay**, it transforms into and the equation is written as;

$\rightarrow +$ (1)

In general;

$\rightarrow +$ ---(2)

2) Beta decay
- The mass number remains the same
- Atomic number increases by 1

Example

$\rightarrow +$ --(3)

In general;

$\rightarrow +$ ---(4)

3) Gamma emission
- Gamma emission causes no change in mass number or atomic number because it's pure energy.

Exercises

1) Radioactive source undergoes decay to nuclide " " by emitting a Beta particle. Write a balanced equation and state the mass number, number of protons and number of neutrons
2) Given $\rightarrow +$ find the value of x and y
3) Given that $\rightarrow + w$; name particle w emitted

LESSON 2: HALF LIFE

Competences:

- Use of half-life in numerical problems.
- Applications / uses of radioactivity.
- Safety precautions in the prevention of health hazards of radiations

In this lesson, you will:

- use knowledge of half-life to find the age and quantity remaining
- state applications of radioactivity
- list the safety precautions in the prevention of health hazards of radiations

Introduction

The half-life of a radioactive substance is a characteristic constant. It measures the time it takes for a given amount of the substance to become reduced by half as a consequence of decay, and therefore, the emission of radiation.

For your knowledge, the half – life of a radioactive substance, is defined as the time taken for the radioactive substance to decay to half of its original mass.

Calculation of half life

For your knowledge, half-life is calculated using three methods namely: table method, graphical method and formula method.

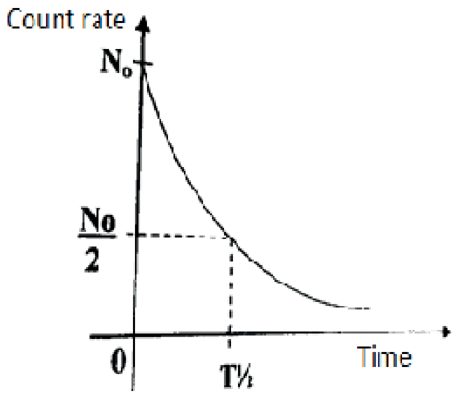
Note: The most simple and easy method of finding half-life is the table method and this can be done as shown in the example below

Example

A radioactive element of mass 32 g decays to2 g in 96 days. Find the half- life

Solution

No. of half - lives	Time	Amount present
		32g
		16g
		8g
		4g
		2g



= 96 days

Graphical method

The half-life is obtained from the graph using the following method

- plot a graph as shown above when the values are given to you
- draw a horizontal line from half of the highest value **(No)**on the graph to meet the line
- draw a vertical line from the point on the curve to meet the time axis
- the half-life is read from where the vertical line meets the time axis

1) The half-life of a sample of a radioactive material is 60 days. What fraction, of the sample will be left decayed after 120 days?
2) 9.6g of radioactive substance undergoes decay and after 24 hours 0. 15g remained Calculate the half-life of the radioactive substance

Application of Radioactivity

Medical uses of radioactivity

- It is used in the treatment of cancer.
- It is used in sterilization of medical equipment like syringes etc.
- It is used in investigation of the lung and heart conditions that is checking body organs**(fig below)**

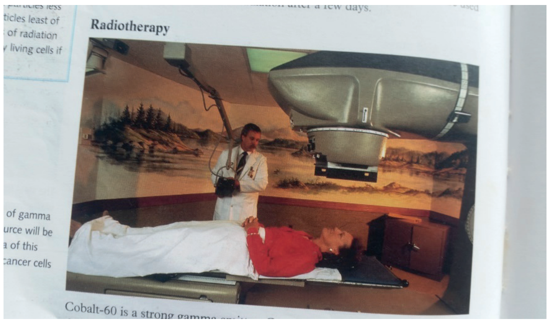


Fig 1

Industrial uses of radioactivity

- Radioisotope is used to measure and control the thickness or density of a metal and plastic sheets**(Fig below)**

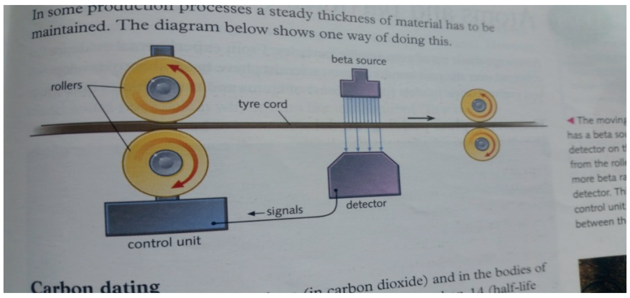


Fig. 2

- Induce mutation on plants in order to develop harder species
- Preserve certain types of food by killing microorganism

Carbon dating:

- In Archeology, it's used to determine the time that has elapsed since death of organisms occurred.
- In Geology they are used to determine the age of rocks.

Health hazards associated with the use of radioactive materials

- They cause skin burns
- They cause mutations in living organisms
- Nuclear weapons result into a lot of pollution and destructions

Safety precautions in the prevention of health hazards of radiations

- Workers should wear protective clothing
- Avoid unnecessary exposure to the radiations
- Transport them using thick lead containers
- Don't eat or drink near any kind of radioactive source

Summary of the topic:

- There are three types of radioactive radiations namely; alpha particles, beta particles and gamma rays
- during alpha emission, the mass number reduces by 4 and the atomic number reduces by 2
- For the case of Beta decay ;the mass number remains the same, atomic number increases by 1
- Gamma emission causes no change in mass number or atomic number because it's pure energy.

END

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