LEARNER'S BOOK

ELECTRICAL TECHNOLOGY

GRADE 8

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

KAGISO TRUST
Overcoming poverty

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Electrical Technology Grade 8 Learner's Book

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INTRODUCTION, CONTENT OVERVIEW

Civil Technology focuses on the concepts and principles in the built environment and on the technological process. It includes the practical skills and application of scientific ideas. The subject aims at the improvement of skills in the building environment.

Civil technology has the following specialisations namely:

- Plumbing (Civil Services)
- Bricklaying and Plastering (Construction)
- Woodworking and Timber (Woodworking)

Plumbing (Civil services) deals with supply of cold and hot water to buildings. Installation of sewerage systems and control of storm (rain) water. Plumbing also focuses on materials and the way they are used to provide water and sanitation on a site.

Bricklaying and Plastering (Construction) deals with concrete and brick structures in the building environment. E.g. Building of houses, malls and shopping complexes. It focuses on materials and the way they are used to provide infrastructures in the development of sites.

Woodworking and Timber deals with wood structures such as roof trusses, doors, windows and any part of a building that is made of timber. Woodworking works hand in hand with construction. It also focuses on providing temporary supporting to construct permanent structures such as suspended floors, stairs, arches and roofs.

Civil Technology prepares a person for the following career paths/choices:

- Plumber
- Drainlayer
- Carpenter and joiner
- Builder
- Teacher
- Building inspector
- Quantity surveyor
- Architect
- Draftsperson
- Building surveyor
- Engineering technician
- Engineering technologist
- Civil Engineer
- Handyman

Occupational Health and Safety

CHAPTER

1

Learning objectives

By the end of this chapter, learners should be able to use the electrical workshop safely and follow all measures identified in the Occupational Health and Safety Act (OHSA), Act No. 85 of 1993. The following will be covered in this chapter:

- learning about a safe workshop layout
- defining occupational health and safety
- learning about demarcated areas, emergency stops, exits and first aid stations
- defining what an accident is and learning about the different causes of accidents
- identifying unsafe acts and unsafe conditions
- learning about good housekeeping
- learning about different personal protective equipment (PPE)
  - Eye and ear protection
  - Head protection
  - Footwear
  - Protective clothing
- identifying and learning about different safety signs
  - Information signs
  - Prohibition sign
- emergency evacuation procedure
- exploring basic first aid

1.1 Introduction to occupational health and safety

Figure 1.1 First aid station sign

What is Occupational Health and Safety?

Occupational health and safety is a planned way of working to prevent illness and injury in the workplace by identifying **hazards and risks.**

Workshop safety

Workshops should:

- be well lit.
- be adequately ventilated.
- have a good standard of housekeeping.
- be provided with fire-fighting equipment.
- have clearly identified pedestrian routes.
- have pits that are covered when not in use or have guard rails in place.
- have an inspection scheme for all tools and equipment so that they are safe to use.
- have access to workstations restricted to maintenance personnel.

Occupational Health and Safety Act

All safety rules and procedures are regulated by the Occupational Health and Safety Act (OHSA) (No. 85 of 1993). Section 8 is outlined below.

General duties of employers to their employees

8. (1) Every employer shall provide and maintain, as far as is reasonably practicable, a working environment that is safe and without risk to the health of his employees.

(2) Without **derogating** from the generality of an employer's duties under subsection (1), the matters to which those duties refer include in particular-

(a) the provision and maintenance of systems of work, plant and machinery that, as far as is reasonably practicable; are safe and without risks to health;

(b) taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment;

(c) making arrangements for ensuring, as far as is reasonably practicable, the safety and absence of risks to health in connection with the production, processing, use, handling, storage or transport of articles or substances; ·

New words

hazards DUMMY TEXT DUMMY TEXT
risks DUMMY TEXT DUMMY TEXT.

Take note
It is the responsibility of everyone to observe the health and safety procedures in the Electrical Technology workshop.

New words

derogating DUMMY TEXT DUMMY TEXT
mitigate DUMMY TEXT DUMMY TEXT.

New words

precautionary DUMMY TEXT DUMMY TEXT

(d) establishing, as far as is reasonably practicable, what hazards to the health or safety of persons are attached to any work which is performed, any article or substance which is produced, processed, used, handled, stored or transported and any plant or machinery which is used in his business, and he shall, as far as is reasonably practicable, further establish what **precautionary** measures should be taken with respect to such work, article, substance, plant or machinery in order to protect the health and safety of persons, and he shall provide the necessary means to apply such precautionary measures;

(e) providing such information, instructions, training and supervision as may be necessary to ensure, as far as is reasonably practicable, the health and safety at work of his employees;

(f) as far as is reasonably practicable, not permitting any employee to do any work or to produce, process, use, handle, store or transport any article or substance or to operate any plant or machinery, unless the precautionary measures contemplated in paragraphs (b) and (d), or any other precautionary measures which may be prescribed, have been taken;

(g) taking all necessary measures to ensure that the requirements of this Act are complied with by every person in his employment or on premises under his control where plant or machinery is used;

(h) enforcing such measures as may be necessary in the interest of health and safety; · · · ·

(I) ensuring that work is performed and that plant or machinery is used under the general supervision of a person trained to understand the hazards associated with it and who have the authority to ensure that precautionary measures taken by the employer are implemented.

The OHSA can be summarised as follows:

- All employers must ensure that the workplace is safe, and that employees are not at risk of becoming infected with HIV at work.
- All employees are responsible for conducting safe working practices in order to avoid accidents and injuries.
- It is the duty of employers to make sure that rubber gloves and surgical masks are available in all first-aid kits.

Take note

The code of good practice on HIV/AIDS and employment contains common guidelines on how employers, employees and trade unions should respond to HIV/AIDS in the workshop.
In Grade 9, you will learn more about the rights and responsibilities of workers who are infected with HIV/AIDS.

1.2 Workshop layout

Workshop layout is the art of planning and positioning the machine tools, equipment, operator workbenches, assembly areas, storage areas, supervisor areas, shipping areas, employee amenities, and related items in a manner which result in optimal efficiency in the use of labour, machinery, and space.

Each workshop must satisfy safety requirements by adhering to the following factors:

Demarcated areas

To prevent accidents, workshop floors must be levelled and free from dirt, water, oil, grease, or objects lying around. Openings on the floors and other dangerous places should be protected or securely fenced. Demarcated areas must differentiate between walkways that are safe for walking and working areas. In the working areas it is prohibited for unauthorised people to walk as it is generally where you would find dangerous machines and equipment.

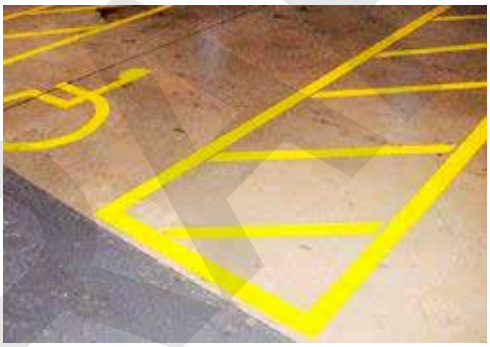


Figure 1.2 (a) and (b) Examples of demarcated floors

Emergency stops

All power machines in the workshop must be installed with emergency stop devices. The workshop must also have an emergency stop switch on electrical main panel. The purpose of an emergency stop device is to stop the machine in an emergency.

Figure 1.3 Emergency stop switch

Figure 1.4 Emergency stop sign

Emergency exit

An emergency exit in a structure is a special exit for emergencies such as a fire: the combined use of regular and special exits allows for faster evacuation, while it also provides an alternative if the route to the regular exit is blocked.

Figure 1.5 Examples of evacuation signs indicating escape route

Figure 1.6 First Aid kit location sign

1.3 General workshop rules and procedures

The basic regulations for safety rules are included in the OHSA (No. 85 of 1993).

General workshop safety rules

Figure 1.7

Take note
We will learn more about Personal Protective Equipment (PPE) later in this chapter.

The following are some general workshop safety rules that should be followed in the electrical technology workshop.

- Do not enter or leave the workshop without a teacher's permission.
- No playing and running around is allowed in the workshop.
- Know where the emergency stop buttons are positioned in the workshop.
- Wear personal protective equipment (PPE) all the time when in the workshop.

- Do not use a machine if you have not been shown how to operate it safely.
- Do not use machinery without permission.
- Always use a guard when working on a machine.
- Keep your hands away from moving or rotating machinery.
- Use hand tools carefully, keeping both hands behind the cutting edge.
- Report any damage to machines or equipment as this could cause an accident.
- No food or drink in the workshop.
- Tie up long hair.
- Turn the machine off before cleaning it.
- Keep the workshop clean.
- No-one under the influence of any illegal substance is permitted in a workshop.
- No unauthorised person is allowed in the workshop.
- Never put sharp tools or instruments in your pocket.
- Return tools to their places after use.
- Smoking is not allowed in the workshop.

New words

Personal Protective Equipment (PPE) DUMMY TEXT DUMMY TEXT
guard DUMMY TEXT DUMMY TEXT
illegal substance DUMMY TEXT DUMMY TEXT.

ACCIDENTS

What is an accident?

An accident is an unplanned and uncontrolled incident caused by unsafe acts and/or unsafe conditions which may result in an injury and or damage to property.

Figure 1.8 A man falling

Main causes of accidents

Accidents are caused by unsafe acts and/or unsafe conditions.

Unsafe Acts

Every workplace has rules and guidelines to ensure that work is done safely, without injuries or damage to tools and equipment. Unsafe acts are therefore things done without adhering to these rules and guidelines. These acts can range from incorrect use of tools and equipment to behaviour that has potential to cause injuries or damage to tools or equipment.

Figure 1.9

Examples of unsafe acts:

- Fooling around or teasing your fellow workers.
- Failing to secure machinery.
- Placing objects in unsafe places.
- Making safety devices inoperative.
- Working at unsafe speeds.
- Careless and improper use of tools and machinery.
- Lack of/or improper use of Personal Protective Equipment (PPE).
- Bypass or removal of safety devices.
- Unsafe position or posture.
- Wearing loose clothing near machines.
- Failure to put warning signs where they are needed.
- Entering or working in the workshop without permission.
- Improper adjusting of machines while it is in operation.

Unsafe Conditions

A work environment should be free from hazards that can cause injury. The hazards posed by a work environment constitute unsafe conditions. These have a potential to cause injury or damage to tools or equipment.

Examples of unsafe conditions

- Overcrowding in the workshop.
- Unsafe and poor workshop ventilation.
- Poor (dull) lighting and unsafe workshop lighting (e.g., flashing or flicker).

- Poor housekeeping.
- Unsafe constructed buildings.
- Working without personal protective equipment.
- No machine guards on equipment.
- Slippery floors.
- Defective hand tools, equipment, or machines.
- Poor workshop layout or workflow.

Figure 1.10

Good housekeeping

"A clean, orderly workshop is a safe workshop." Good housekeeping means a place for everything and everything in its place all the time. This practice ensures that the workshop is kept clean and tidy at all times making it a better and safe place to work. Housekeeping is a crucial aspect of workplace safety as good housekeeping helps prevent accidents and reduces the severity or consequences of accidents.

The OHSA regulations require that each working surface be cleared of debris – including solid and liquid waste – at the end of each work shift or job, whichever occurs last, to fully realise the benefit of a clean workplace. It is recommended that good housekeeping be maintained throughout the job and workday. To continually improve the safety culture, housekeeping is the responsibility of everyone.

Why is good housekeeping desirable?

Good housekeeping:

- saves time,
- cuts costs,
- ensures that the workplace is safe,
- eliminates clutter which is a common cause of accidents, such as slips, trips, falls, fires, and explosions,
- reduces the chances of harmful materials entering the body (e.g., dusts, vapours),

- improves productivity (the right tools and materials for the job will be easy to find), and
- helps to keep the workshop inventory to a minimum (good housekeeping makes it easier to keep an accurate count of inventory).

Effects of poor housekeeping

- Falling or slipping on greasy or wet floors.
- Learners tripping over loose objects on the floor.
- Injury caused by poorly stacked objects and falling materials.
- Poor housekeeping could conceal hazards which would normally be visible.
- Exposure to hazardous substances or chemicals from poor storage and ineffective labelling.

Activity 1

Have you learnt something? Test your Knowledge …

- List any six workshop rules.
- Define an accident.
- List two main causes of accidents.
- Provide five examples of unsafe acts.
- Provide five examples of unsafe conditions.
- Define good housekeeping.
- Why is good housekeeping desirable?

1.4 Personal protective equipment (PPE)

PPE is a collective name for all items worn or used to prevent or minimize injury or hazards, when performing a task. The hazards addressed by protective equipment include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. There is a variety of PPE, designed to offer specific protection. These should always be worn or used when working. Firefighters' gear for example, is suited for an environment of extreme heat with open flames and smoke. Likewise, in the workshop, the appropriate PPE is to be used.

PPE refers to protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards addressed by protective equipment include **electrical hazards, physical hazards, and exposure to heat, chemicals, biohazards, and airborne particulate matter.**

New words

electrical DUMMY TEXT DUMMY TEXT
biohazards DUMMY TEXT DUMMY TEXT
airborne particulate matter DUMMY TEXT DUMMY TEXT.

Examples of PPE:

Safety gloves

Safety gloves protect the hands from several types of hazards, infection, and contamination. It can give protection to a range of injuries, from minor cuts and bruises to deep wounds and severe hand burns. Safety gloves can also protect the wearer from electrical shock.

Figure 1.11 Safety gloves

Earmuffs

Covers the ears to block out background noise and sound impulses.

Figure 1.12 Earmuffs

Ear plugs

Ear plugs are inserted in the ear canal to protect ears from loud noises, intrusion of water, foreign bodies, dust, and excessive wind. They are used to prevent hearing loss.

Figure 1.13 Ear plugs

Dust mask

A dust mask is worn over the nose to protect against inhaling **dust particles** etc.

Figure 1.14 Dust mask

Safety goggles

Protective eyewear that usually enclose or protect the area surrounding the eye to prevent particles, water or chemicals striking the eyes to prevent injury.

Figure 1.15 Safety goggles

Welding helmet

Commonly known as a hood. It protects the eyes and skin from severe sparks and potentially vision damaging ultraviolet and infrared rays emitted by the **arc** during welding.

Figure 1.16 Welding helmet

New words

arc DUMMY TEXT DUMMY TEXT DUMMY TEXT.

Safety glasses

Safety glasses protect the eyes. They have lenses that are scratch resistant. Safety glasses allow air in and around the eye.

Figure 1.17 Safety glasses

Helmet

Helmets are worn to protect the user's head from injury due to falling objects.

Figure 1.18 Helmet

Safety boots

Safety boots protects the feet from falling objects or compression, and against punctures from below.

Figure 1.19 Safety boots

Overall

Protects the body and clothing worn under the overall from work hazards and limits the exposure of the body/skin against heat, chemicals and the others risks.

Figure 1.20 Overall

Figure 1.21 Apron

Apron

Protects clothing worn underneath from staining, splashes and hazards, etc.

1.5 Safety signs

Safety signs indicate **safety regulations** that must be adhered to. Signs are used to convey a message without words (written or verbal). This **non-verbal** way of communication is effective and has no limitations like the spoken language has. The message conveyed by a "no entry" sign will be understood correctly by people who do not even speak the same language or someone who is illiterate for example. Different signs are used in the workshop. It is important to know the meanings of these signs.

Safety signs must be used in the workshop to indicate safety regulations that must be adhered to. It is important to know the meanings of these signs. Safety signs are classified into different groups, namely:

- Informative signage (colour code green/white/red/black)
- Fire prevention signage (colour code red/white)
- Danger signage (colour code yellow/black)
- Mandatory or compulsory signage (colour code blue/white)
- **Prohibition** signage (colour code red/white/black)

What are mandatory safety signs? *(Not for examination purposes)*

Mandatory safety signs are used to show actions or behaviours that are to be implemented within a workplace or area of public access to comply with relevant health and safety regulations.

New words

safety
regulations DUMMY TEXT DUMMY TEXT
non-verbal DUMMY TEXT DUMMY TEXT.

New words

prohibition DUMMY TEXT DUMMY TEXT DUMMY TEXT.

Figure 1.22 Different mandatory safety signs

Prohibition signs

Prohibition signs send a clear message to all who see them that some actions are either not safe or are outright not permitted.

Figure 1.23 Different prohibition signs

Information signs

Information signs are used to give indication of a certain activity or area set aside for certain activities.

Figure 1.24 Different information signs

Danger signs (Not for examination purposes)

Danger signs are used to warn against potential danger.

Figure 1.25 Different danger warning signs

Fire prevention signs (Not for examination purposes)

Fire prevention signs gives guidance on fire-related issues.

Figure 1.26 Different safety signs

Activity 2

Have you learnt something? Test your Knowledge …

- Explain why workshop floors need to be demarcated.
- What is the purpose of emergency stops on machines?
- Provide the reason for first-aid stations in the workshop.
- By referring to safety signs, classify each sign below with its related group.

	Sign	Group
A		• First aid is the assistance. • Given to a sick » injured person to save life

	Sign	Group
B		
C		
D		
E		

- Discuss why good ventilation is needed in workshops.
- Why should flashing lights be replaced in workshops?
- When do you report damaged electrical cords?

1.6 Emergency Evacuation

Emergency evacuation is the urgent immediate escape of people away from an area that contains an imminent threat, an ongoing threat or a hazard to lives or property. The purpose of evacuation is to leave the premises as quickly and safely as possible. It is conducted when there is a serious threat in the workshop, for example, a gas leak or electrical fire. Evacuation drills should be practiced at least once a month to keep learners trained so that they know what to do when an emergency happens.

Figure 1.27 Emergency assembly sign to indicate assembly point

Evacuation-, clear EXIT-, as well as Assembly point signs, should be clearly visible. Maps indicating exit routes should also be displayed at various points in the workshop.

When people escape from an area that contain an imminent threat, they assemble at an emergency assembly point provided.

Emergency Procedure

An emergency procedure is a plan of actions to be conducted in a certain order or manner, in response to a specific class of foreseeable emergency, a situation that poses an immediate risk to health, life, property, or the environment. Where a range of emergencies are foreseeable, an emergency plan may be drawn up to manage each threat. Most emergencies require urgent intervention to prevent a worsening of the situation, although in some situations, mitigation may not be possible. The emergency plan should allow for these possibilities.

How to safely evacuate your building or area in an emergency.

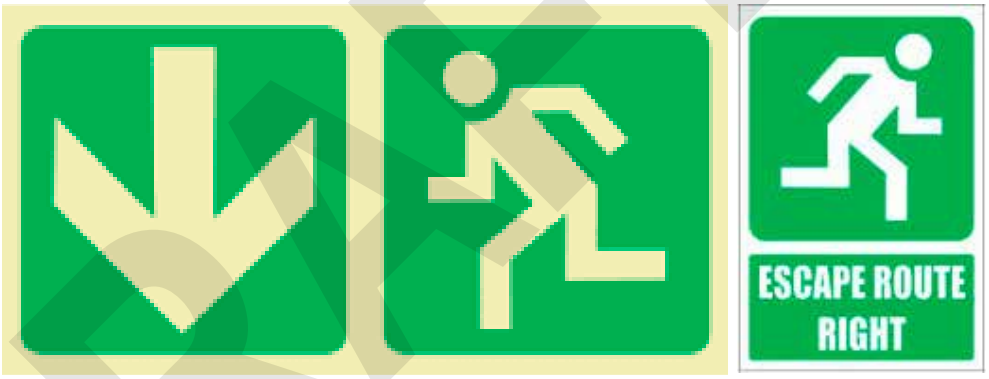


Figure 1.28 Examples of evacuation signs indicating escape routes

Building evacuation procedures in the event of an emergency:

1. Safely stop your work.
   - » Shut down equipment that could become unstable or present a hazard.
   - » Gather your personal belongings such as glasses, prescription medication, keys, purse.
2. Leave the building through the nearest door with an EXIT sign.
   - » Do not use elevators.
   - » Go to the nearest safe stairway.
   - » Help those who need special assistance, such as disabled persons and small children.
   - » Touch closed doors before opening. If the surface is hot, do not open — use another exit route.
   - » Close, but do not lock, all doors as you leave.

3. Report to your designated assembly area.
   - » Stay in your designated outdoor assembly area for a head count.
   - » Report any missing individuals and their last known locations to emergency responders.
   - » Notify emergency responders about sensitive research, operating equipment, animals left in buildings, etc.
4. Wait for instructions from educators or emergency responders.
   - » Remain outside at your designated assembly area.
   - » Do not re-enter the building until authorised to do so by an appropriate authority (police, fire department, etc.).

1.7 Basic first aid

Incident management

The seven critical steps of incident investigation are:

- Take immediate action.
- Report the incident to persons in charge (e.g., teacher or the principal).
- Report to the authorities.
- Investigate and develop corrective actions.
- Calculate the costs.
- Conduct a root cause analysis.
- Record the details.

Figure 1.29

What is first aid?

First aid is the assistance (help) given to a sick or injured person to save life and prevent the condition from worsening. The primary goal of first aid is to prevent death or a serious injury from worsening.

Notices giving the names, telephone numbers, and locations of persons qualified as first aid workers, and the location of the nearest first aid station must be prominently displayed in each electrical technology workshop.

First aid is conducted in three stages:

- Examination
- Diagnosis
- Treatment

1.8 First Aid kit contents

The following is a checklist of basic first aid kit content:

Figure 1.30 First-aid kit checklist

First aid supply	First aid kit components	Functions
	Adhesive Bandages.	Covering open wounds and controlling bleeding wounds.
	Adhesive Tape.	Holding bandages or dressings on wounds.
	Antibiotic Ointment.	Preventing infections in minor cuts, scrapes, or burns and cleansing wounds prior to applying a bandage.

First aid supply	First aid kit components	Functions
	Antiseptic.	Destroying micro-organism growth and cleansing wounds prior to applying a bandage.
	Burn Treatment.	Treating burns and helping with pain associated with burn.
	Cold Pack.	Reducing swelling and cooling burns to reduce damage done to soft tissue.
	Eye Covering (with attachment).	Bandaging an injured eye.
	Hand Sanitizer.	Killing germs and microorganisms on hands after caring for patient.
	Medical Exam Gloves.	Providing body substance isolation to protect rescuer from contacting blood borne pathogens from patient.

First aid supply	First aid kit components	Functions
	Scissors.	Cutting bandages to the proper size.
	Triangular Bandage.	Slinging and swathing limbs and wrapping around wounds to make a large pressure bandage.

Table 1.1 First-aid kit contents

Activity 3

Have you learnt something? Test your Knowledge …

- What is the purpose of first aid?
- Name the three stages when first aid is being conducted.
- List at least seven items that must be included in a first-aid box.
- List and briefly explain the four steps for safe evacuation.

Practical Activity: EMERGENCY EVACUATION DRILL

1. Perform an emergency evacuation drill.

Graphics Communication

CHAPTER 2

Learning objectives

By the end of this chapter the learner should be able to use graphics and symbols such as images and drawings to communicate. The following will be covered in this chapter:

- What is Graphics Communication
- The purpose of Graphics Communication
- Safety precaution to be taken when using drawing instruments
- Correct use and care of drawing instruments
- Types of lines
- Printing/lettering, dimensions, and border
- Freehand drawing
- Orthographic (2D) and pictorial drawings (3D)
- Scale drawing 1:1 and 1:2
- Lines (SANS110 guidelines)
- Dimensions, lettering and border

2.1 What is Graphics Communication

New words

cognitive DUMMY TEXT DUMMY TEXT DUMMY TEXT DUMMY TEXT

Graphics communication is a language which enables us to describe the exact size and shape of physical objects. Graphics communication is an international language used in the engineering field. The emphasis in Graphics communication is on teaching specific basic knowledge and various drawing techniques and skills so that the learners can interpret and produce drawings. Graphics communication integrates the **cognitive** and manipulative skills that are used to design and communicate graphically.

2.2 The purpose of Graphics Communication in the technological world

The aim of graphics communication is to explain and teach the learners the vocabulary and terminology used in drawing with emphasis on the following aspects:

- The technological drawings as a primary means of communication in the technological world
- The use of different line types
- Correct printing and dimensioning techniques
- Freehand drawing techniques and skills
- Instrument drawing techniques and skills
- Visualization and interpretation of drawings
- The accurate application of given dimensions
- Principles of basic 1st angle orthographic projection
- Principles of basic isometric drawings
- Graphically representing the objects

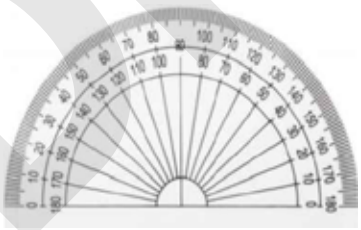
2.3 Safety precautions to be taken when using drawing instruments

Precautions to be taken in the Graphics Communication classroom when working with sharp objects such as dividers, compasses to prevent injury and bleeding. The Human Immunodeficiency Virus (HIV) is the virus that causes Acquired Immunodeficiency Syndrome (AIDS). HIV attacks the human immune system, making humans more vulnerable to diseases and infections. There is no cure for HIV infection.

HIV infection spreads through exchange of bodily fluids of an infected person. Bodily fluids that carry and allow transmission of HIV includes blood, semen, and vaginal fluids. An infected person, aware or unaware of their status, is a carrier of the virus and can infect other people.

2.4 Correct use and care of drawing instruments

Drawing instrument	Use	Care
 Drawing board	It is used for any kind of drawing, writing, or sketching on a piece of paper.	Clean your board by using a household degreaser or low odour white spirit.
 T- Square	It is used to draw horizontal lines and guide when drawing vertical lines.	Wipe with clean cloth preferably yellow duster.

Drawing instrument	Use	Care
 45º set square	It is used to draw parallel lines, perpendicular, standard measure angle (45º & 90º).	Wipe with clean cloth preferable yellow duster.
 30º/60º set square	It is used to draw parallel lines, perpendicular, standard measure angle (30º & 60º).	Wipe with clean cloth preferable yellow duster.
 Scale rule	It is used to measure length, width and height.	Wipe with clean cloth preferably yellow duster.
 Protractor	It is used to measure angles.	Wipe with clean cloth preferably yellow duster.
 Compass	It is used to draw circles and arcs.	The lead on the compass must be kept sharp.

Drawing instrument	Use	Care
 Pencil	It is used for lettering, drawing straight lines. Pencils comes in different grades (H, B, F and HB).	Keep always sharpened.
 Pair of dividers	It is used to transfer the measured distances on maps and drawings.	Always ensures that he points remains sharp for accuracy.
 Eraser	It is used to clean the dirt off the drawing. It is also used for making changes for correcting errors on drawing.	Use cotton cloth or soapy water to clean it. It must be dry before use.

2.5 Types of lines

The application of line work for graphic communication must be in accordance with the South African National Standards (SANS 0111). Graphic communication as language is composed of symbols, dimensions, notes, and different types of lines to convey the correct meaning.

The table below shows different line types which are used in graphic communication.

First aid supply		First aid kit components	Functions
A		Continuous line – dark	Visible outlines and edges
B		Continuous line – light	Dimension lie, Extension lines, Hatching lines, Leader lines
C		Continuous line – very light	Construction lines, Projection lines, Guidelines for printing
D		Dashed line – light	Hidden details line
E		Chain line – light	Centre lines, Pitch lines and circles, Lines indicating symmetry
F		Chain line with dark ends	Cutting planes
G		Short break line	Irregular boundaries
H		Long break line	Limits of views and sections if the line is not an axis

2.6 Printing

New words

freehand DUMMY TEXT DUMMY TEXT
printing DUMMY TEXT DUMMY TEXT DUMMY TEXT

Poor lettering and figuring can spoil a good drawing, therefore here are some useful suggestions and hints when lettering:

- all lettering should be done **freehand** and in **printing**.
- all lettering should be done between guidelines. Guidelines are very feint lines which are barely visible.
- use of capital letters is encouraged over lower-case lettering as it appears neat and less congested.

FREEHAND LETTERING

ABCDEFGHIJKLMNOPQRSTUVWXYZ&

1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ&

1234567890 $4\frac{5}{8}$ $3\frac{9}{16}$ $7\frac{1}{2}$

Activity: 2.1

Print the given alphabets in CAPS /capital letters and numbers between very feint 5mm guidelines.

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

1 2 3 4 5 6 7 8 9 0

Print the given alphabets in small caps / lower case letters and numbers between very feint 3mm guideline.

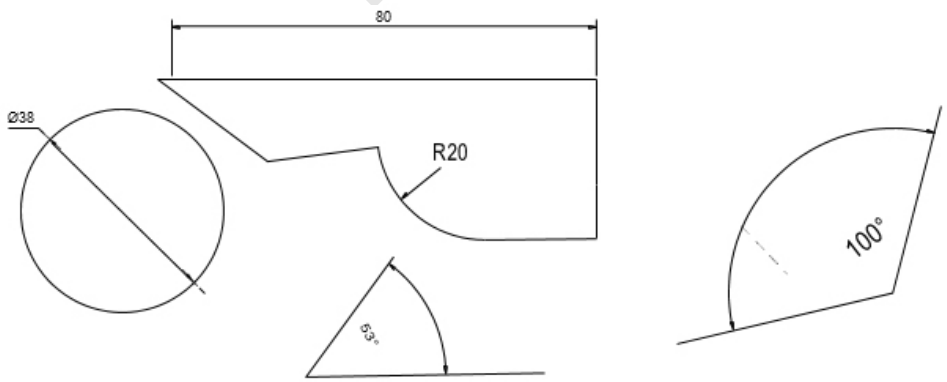
a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0

2.7 Dimensions

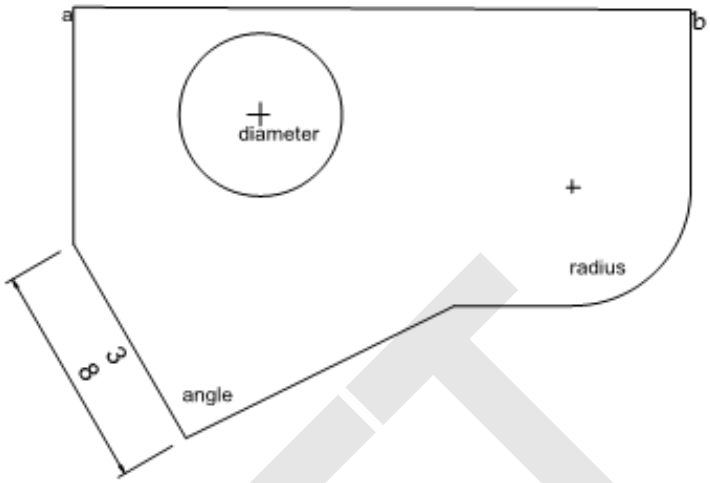
The application of line work for graphic communication must be in accordance with the South African National Standards (SANS 0111). Graphic communication as language is composed of symbols, dimensions, notes, and different types of lines to convey the correct meaning.

The table below shows different line types which are used in graphic communication.



Activity 1

Measure and insert the dimensions for line ab, diameter, radius, and angle.

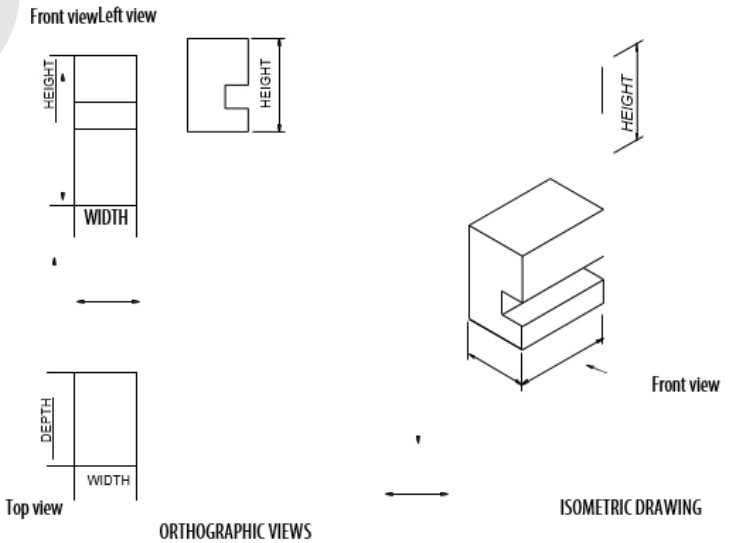


2.8 Orthographic (2D) drawing

Orthographic projection is also known as two-dimensional projection.

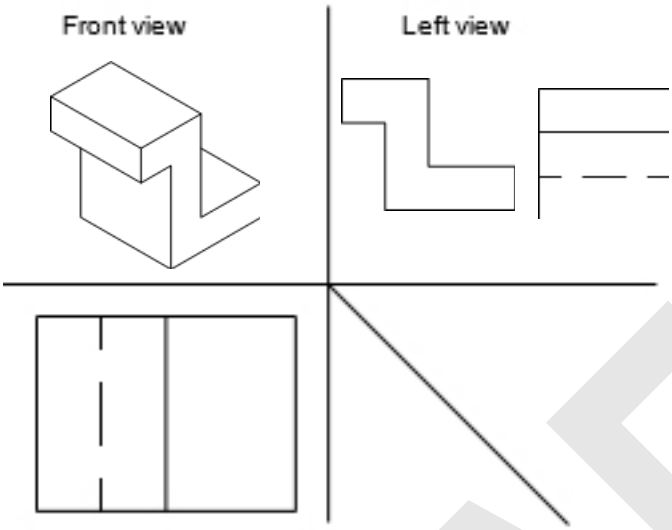
Orthographic projection gives the actual measurements of the object. The projection lines are parallel with each other and perpendicular to the projection planes. The different views are related to each other. Some of the views represent two dimensions (principal views) or three dimensions (pictorial views).

The principal view which describes the object best is chosen as the front view and describes the width and height of an object.



The left view describes depth and height whilst the top view describes the width and depth of the object.

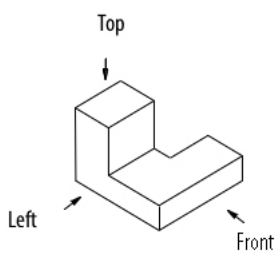
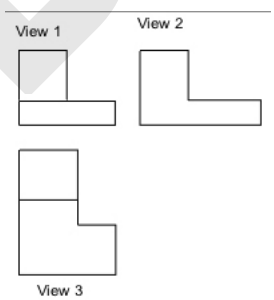
The principal views (front and top) and some cases the left or right view describe the true size and therefore also the true shape of the model.

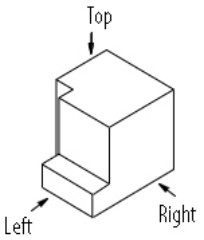
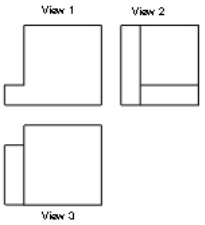
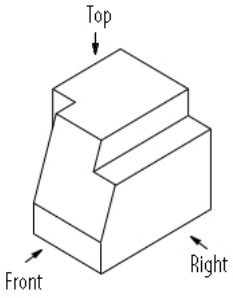
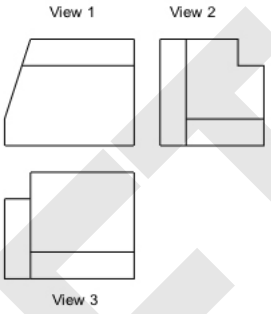


Activity 2

Study the drawings in the pictorial view column.
The column labelled ORTHOGRAPHIC VIEW shows three views of an object.
Each orthographic drawing represents either Front, Left, Right and Top view.

Identify the views and give the answer (Front, Left, Right or Top) in the provided table.

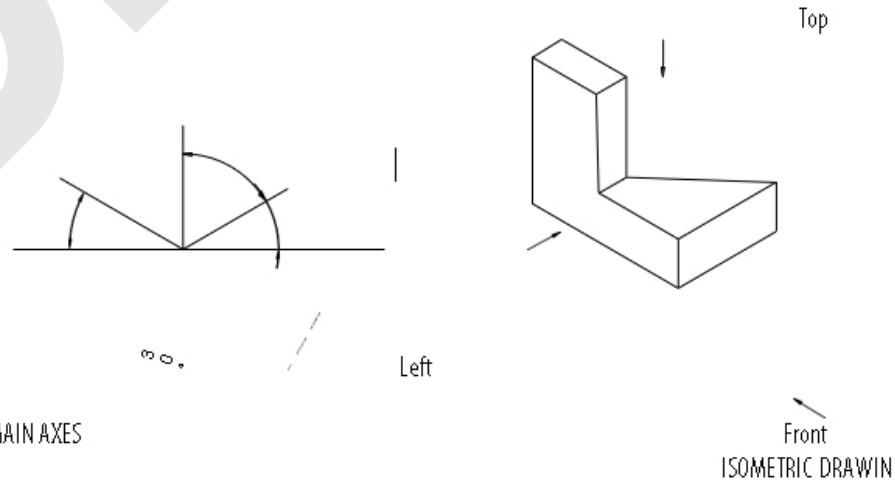
Pictorial view	Orthographic view	
		**Identify and name each view** View 1 ____ View 2 ____ View 3 ____

Pictorial view	Orthographic view	
		**Identify and name each view** View 1 View 2 View 3
		**Identify and name each view** View 1 View 2 View 3

2.9 Isometric drawing

Definition of Isometric drawing

Isometric drawing is a method of presenting drawings in three dimensions. A three-dimensional object is presented as an isometric drawing when the horizontal edges of the object are drawn (projected) at **30º angles** and all the vertical heights are drawn (projected) as vertical lines. All isometric lines are drawn to scale.



It is All About the Angle

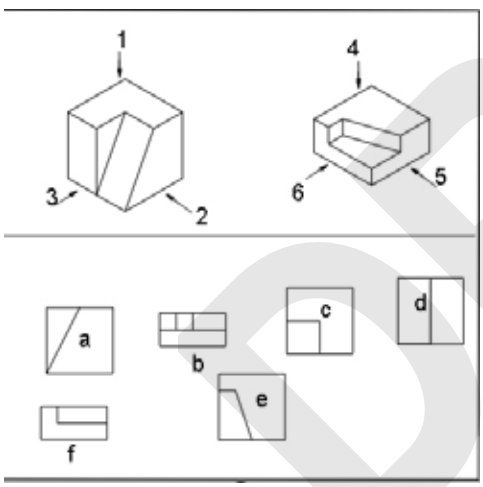
So, what makes an isometric drawing different from other 3-dimensional drawings? The axes are drawn so that the two horizontal axes are at 30o degrees angles. It is as if the vertical axis is in its true position, but the horizontal axes are bent 30o degrees from their true position.

Although the isometric lines are drawn to scale, none of the isometric planes of the isometric drawing will be a true shape. The isometric drawing will appear distorted because all the vertical heights are drawn (projected) as vertical lines.

Activity 3

The lower block shows alphabetic labels on orthographic views which can be linked to the numbers on isometric drawings. Fill in the provided table by matching the alphabetic label with the corresponding numbered isometric drawing.

Study the isometric drawings in the upper block.



	Match the numbers with the alphabetic labels.	Front, Left, Right or Top
1		
2		
3		
4		
5		
6		

Tools and Measuring Instruments

CHAPTER

3

Learning objectives

By the end of this chapter the learner should be able to identify the parts and functions of tools and measuring instruments. The care and safe use of the following will be covered in this chapter:

- Hand tools
  - Phillips/Star screwdrivers
  - Flat nose, longnose and round nose pliers
  - Combination pliers
- Cutting tools
  - Side cutter
  - Hacksaw
  - Files
- Stripping tools
  - Wire Stripper
  - Utility knife
- Measuring tools
  - Steel ruler
  - Measuring tape
  - Engineering square
- Marking tools
  - Scriber
  - Centre punch

3.1 Introduction

*Actual **tools** date back at least 2.6 million years in Ethiopia. One of the earliest distinguishable stone **tool** forms is the hand axe. Up until recently, weapons found in digs were the only **tools** of "early man" that were studied and given importance.*

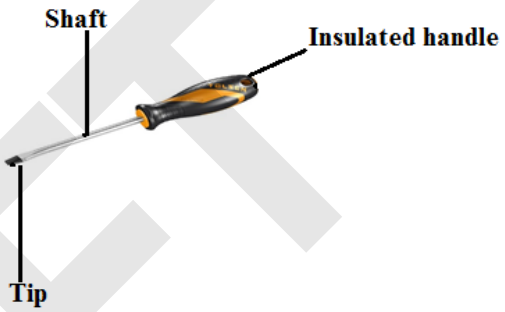
A tool is any instrument or simple piece of equipment that you hold in your hands and use to do a particular kind of work.

3.2 Parts and functions including care and safe use of tools and measuring instruments

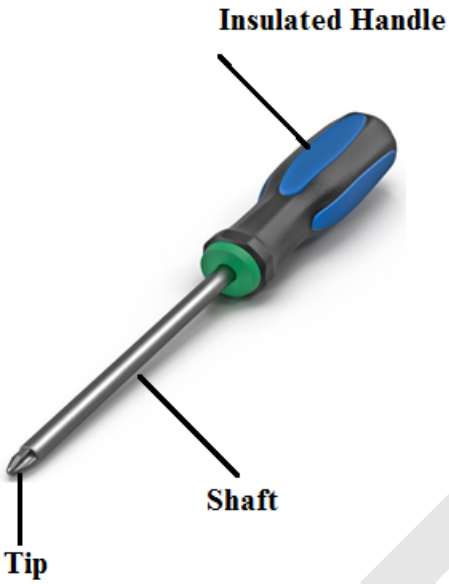
Hand tools:

Screw drivers:

FLAT SCREWDRIVER

PICTURE:	
FUNCTION:	A screwdriver is a hand tool used to *loosen* or *tighten* screws.
CARE and SAFE USE:	• Do not use a screwdriver for a job it is not intended to do, for example, using it as a chisel or lever. • Do not use a screwdriver that has a damaged or broken handle or tip. • Use the correct size and type of the screwdriver to loosen or tighten screws. Make sure that the tip of the screwdriver 'fits well' into the screw slot. • Clean the screwdriver tips with a brush or sponge regularly. • Isolate or switch off the power of any appliance or panel where the screwdriver is to be used. • It is good housekeeping practice to return or safely store away the screwdriver after use.

STAR (PHILLIPS) SCREWDRIVER

PICTURE:	
FUNCTION:	A screwdriver is a hand tool used to *loosen* or *tighten* screws.
CARE and SAFE USE:	• Do not use the screwdriver for the job it is not intended to do, for example using it as a chisel or lever. • Do not use a screwdriver that has a damaged or broken hand and tip. • Use the correct size and type of the screwdriver to loosen or tighten screws. Make sure that the tip of the screwdriver 'fits well' into the screw slot. • Clean the screwdriver tips with a brush or sponge regularly. • Isolate or switch off the power of any appliance or panel where the screwdriver is to be used. • Return or safely store away the screwdriver after use.

COMBINATION PLIERS

PICTURE:	 *Courtesy of e bay.com*
FUNCTION:	This is a multipurpose tool used for cutting and gripping objects.
CARE and SAFE USE:	• Never use the combination pliers to tighten bolts. • Always keep your pliers clean.

LONG NOSE PLIERS

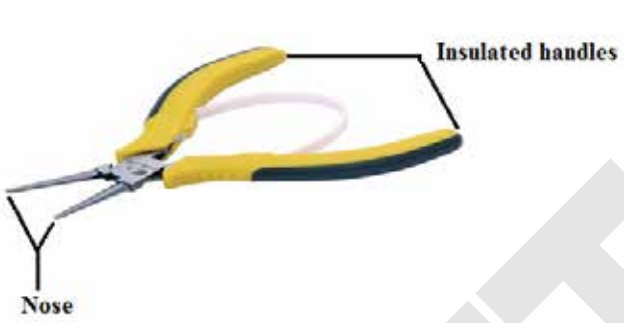
PICTURE:	 *Courtesy of hyperclaw.com*
FUNCTION:	Long nose pliers is used to hold, grip, twist, and bend wires as well as to reach places that are difficult to reach with one's fingers.
CARE and SAFE USE:	• Never use the long nose pliers to tighten bolts. • Always keep your pliers clean.

FLAT NOSE PLIERS

PICTURE:	
FUNCTION:	Flat nose pliers is used to grip flat object in narrow places.

CARE and SAFE USE:	• Never use the flat nose pliers to tighten bolts. • Always keep your pliers clean.

ROUND NOSE PLIERS

PICTURE:	
FUNCTION:	Marking loops and bends at the end of the conductor which must be fixed to terminal screws.
CARE and SAFE USE:	• Never use the round nose pliers to tighten bolts • Always keep your pliers clean.

Activity 1

1.1 State the function of a screwdriver.
1.2 Name two types of screwdrivers.
1.3 Explain the importance of a rubber handle on a screwdriver.

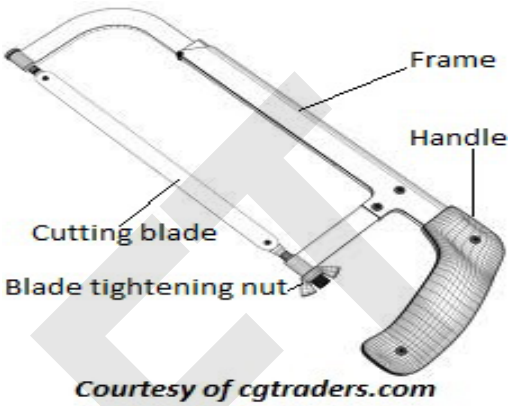
Cutting tools:

SIDE CUTTER

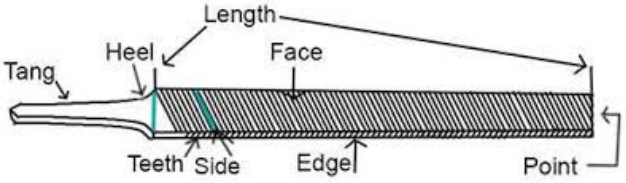
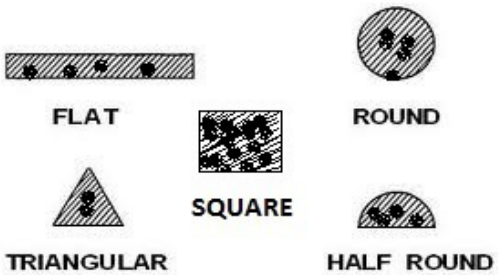
PICTURE:	
FUNCTION:	Use to grip, splice, or cut wires, and strip insulation.

CARE and SAFE USE:	• Cut at right angles. • Never rock the cutting tool from side to side or bend wire back and forth against the cutting edges. • Always keep your side cutter clean.

THE HACKSAW

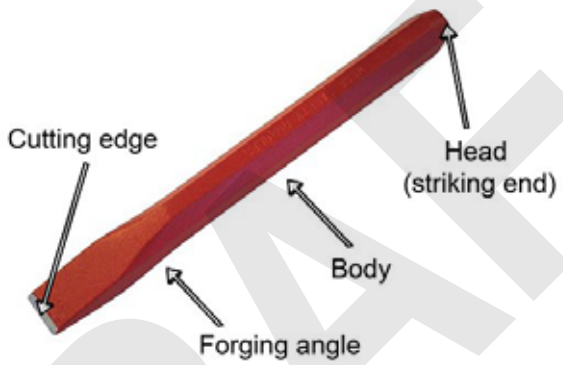
PICTURE:	 *Courtesy of cgtraders.com*
FUNCTION:	A hacksaw is used to cut materials like metals, thick cables and at times plastics.
CARE and SAFE USE:	• Do not excessively press and shake the hacksaw when working because the blade can warp or break. • Check the teeth of the blade for wear and tear and then replace if required.

FILES

PICTURE:	 **DIFFERENT TYPES OF FILES:** 

FUNCTION:	A file is used to cut, shape or smooth rough surfaces of metal, wood, or plastic.
CARE and SAFE USE:	• Do not use broken files because their sharp edges might cut your hands or fingers. • Always use a file with a proper handle. • Return the files to their original storage places after use. • Clean the file with a file card or brush to remove the filings.

CHISEL

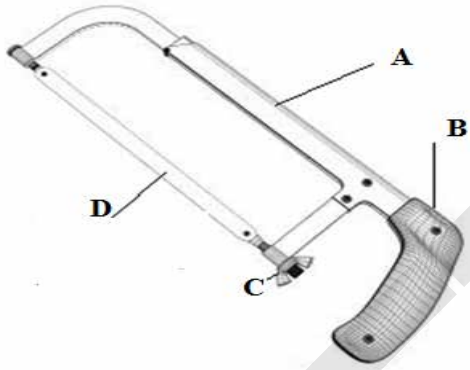
PICTURE:	
FUNCTION:	• Chisels are used for cutting or carving hard materials such as metal, stone or wood. An example is to carve channels or **chasing** into walls. • Used to remove waste and excessive wood.
CARE and SAFE USE:	• Use the right size of chisel for the job. • Return the files to their original storage places after use.

New words

chasing DUMMY TEXT DUMMY TEXT DUMMY TEXT.

Activity 2

1. State the function of the following tools:
   a. Combination plier
   b. Hacksaw
2. List the different types of files.
3. Label the hacksaw below:



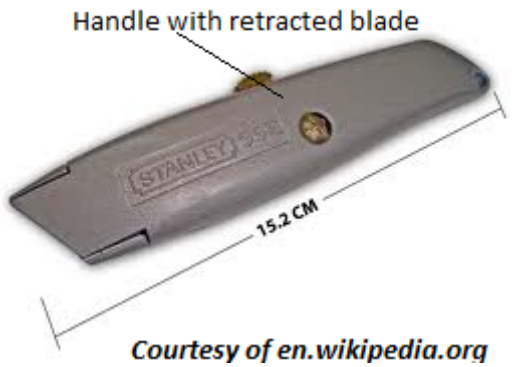
4. State two functions of a chisel.
5. Explain the major difference between combination pliers and long nose pliers.

Stripping tools:

WIRE STRIPPER

PICTURE:	 *courtesy of robotshop.com*
FUNCTION:	It is used to remove (or strip) the insulation from electric wires.
CARE and SAFE USE:	• Only strip wire that is not live! • Oil or grease the moving parts regularly. • Regularly clean the tool before and after use. • Return or safely store away the tool after use *(Good housekeeping practice)*.

UTILITY KNIFE

PICTURE:	 *Courtesy of en.wikipedia.org*
FUNCTION:	It is used for cutting plastic or wooden materials and stripping insulation of cables or wire.
CARE and SAFE USE:	• Clean the utility knife after use. • Return the utility knife to its storage place after use. • The blade is razor sharp. It is extremely dangerous if it is not handled with care.

Measuring tools:

STEEL RULER

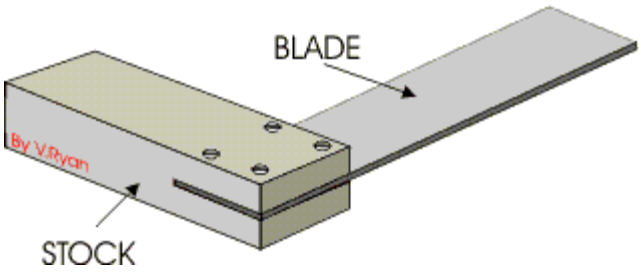
PICTURE:	

FUNCTION:	Steel rulers are used to measure the length and the width of work pieces in centimetres and millimetres.
CARE and SAFE USE:	• Ensure the ruler is clean and dry before storing. • They should be stored flat in a drawer or toolbox. • The blade is razor sharp. It is very dangerous if it is not handled with care.

MEASURING TAPE

PICTURE:	
FUNCTION:	Measuring tapes are used to measure length in metres, centimetres and millimetres.
CARE and SAFE USE:	• Do not drop the measuring tape. • Return the measuring tape to its storage place after use. • Do not make any marks or scratches on the measuring tape.

ENGINEERING SQUARE

PICTURE:	
FUNCTION:	To mark out material for cutting or shaping.
CARE and SAFE USE:	• Return the engineering square to its storage place after use. • Keep the engineering square dry to prevent it from rusting.

Activity 3

1 State how one would take care of a wire stripper in a workshop environment.
2 Identify the tool used in Figure 4.1.

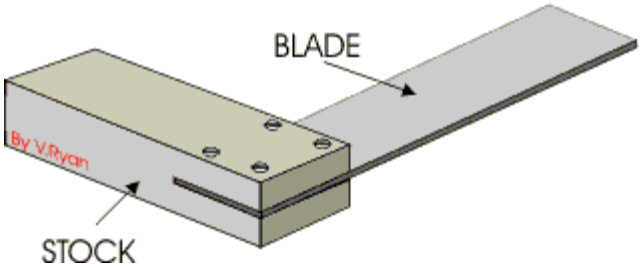
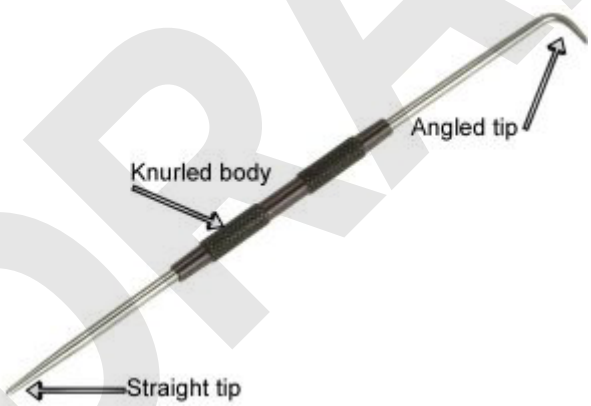


Figure 4.1

3 State the function of the tool in Figure 4.1.

MARKING TOOLS:

SCRIBER

PICTURE:	
FUNCTION:	Scribers are used to make markings on work pieces.
CARE and SAFE USE:	• Return the scriber to its storage place after use. • The tips of the scriber are pointed and sharp. It is very dangerous if it is not handled with care.

CENTRE PUNCH

PICTURE:	
FUNCTION:	The centre punch is used to make a shallow indention in a workpiece for the purpose of drilling.
CARE and SAFE USE:	• Use extreme care to retain the original shape of the centre punch • Return the centre punch to its storage place after use.

Activity 4

1 State the function of the following tools:
   a) Scriber.
   b) Centre punch.
2 State how a scriber can be used safely.

Practical Activity 1: Use of Hand Tools

Aim: To demonstrate the effective use of different tools used in a workshop.

Pick out one to three tools from the following types of tools to practice on how they are used:

- Hand tools
- Marking tools
- Measuring tools
- Cutting tools
- Stripping tools

Practical Activity 2: Use of Hand Tools

Aim: To practice the use of different tools used in a workshop on a specific project.

Cut the 5 mm Flat Bar as shown in Figure 3.1 below.
Accurately use the measurements as indicated.
Relevant tools should be used.

Use the following tools:

- Hand- and power tools
- Marking off tools
- Engineering vice

N.B. All the dimensions should be in millimetres.

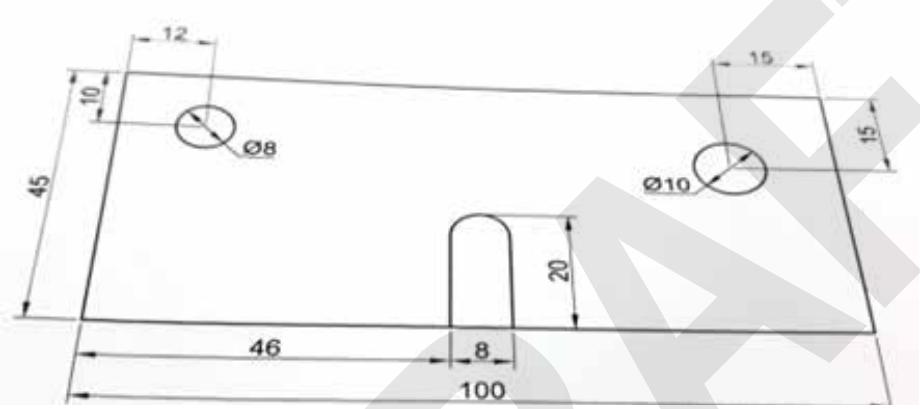


Figure 3.1

3.3 Measuring instruments

Multimeter

PICTURE:

FUNCTION:	An multimeter is used as a voltmeter, ammeter, and ohmmeter to measure voltage, current and resistance respectively in both DC and AC circuits.
CARE and SAFE USE:	• Ensure that you set the multimeter dial and the probes to the correct function before using it. • Do not immerse in water or use it in wet conditions. • Always start with the highest scale if you are not sure of the range of the values to be read.

Activity 5

1 Identify the different electrical quantities that can be measured using a multimeter:

2 List three safety precaution when using a multimeter.

Practical Activity 3: Using a Multimeter in the workshop

Aim: To practice the measuring of different electrical components using the different functions of the multimeter in the workshop.

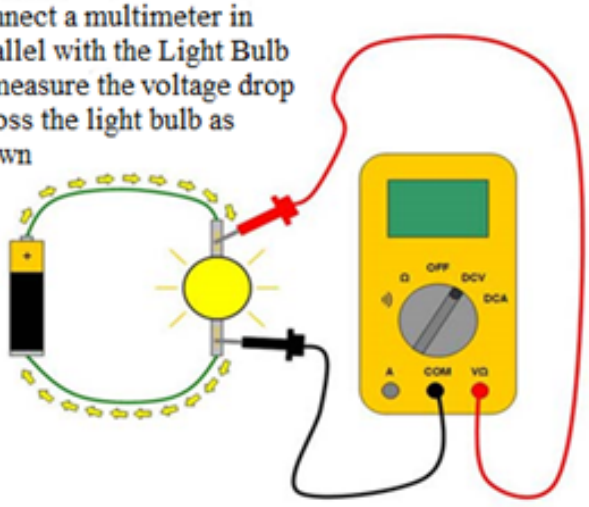
(a). Using the multimeter as a voltmeter:

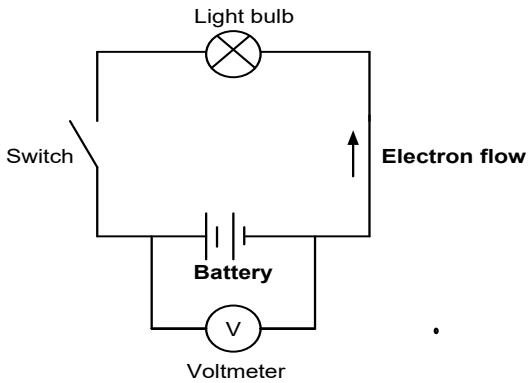
A voltmeter is used to measure the voltage across the load or the circuit and is denoted by the symbol V and its unit Volts (V).

Required items

Light bulb
Multimeter
Switch
Battery
Electrical wires

Connect a multimeter in parallel with the Light Bulb to measure the voltage drop across the light bulb as shown





Close the switch and choose the highest voltage range using the selector switch, then move the selector switch to lower range positions until the strongest indication is obtained on the meter display. Measure the voltage across the battery as shown on the diagram and continue measuring across the lamp, and across each jumper wire and observe. Write down your findings.

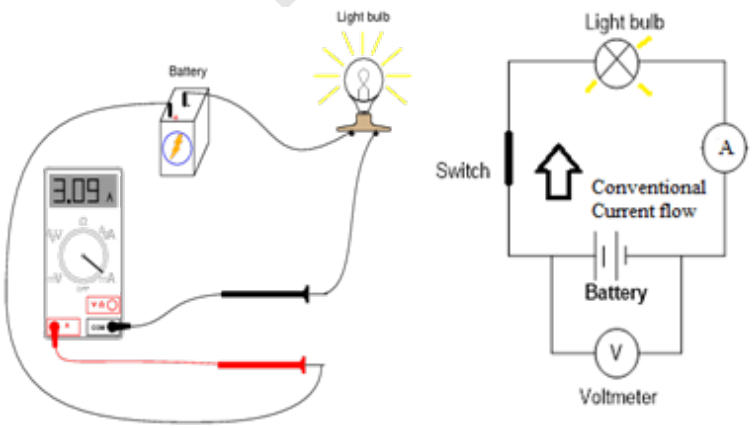
(b). Using the multimeter as an ammeter:

An ammeter is used to measure the current flowing in the circuit and is denoted by the symbol I and its unit is the Ampere (A).

Required items

Light bulb
Multimeter
Switch
Battery
Jumping wires

Close the switch and choose the current scale on the meter using the selector switch, then take the readings. Move the selector switch to lower range positions until the strongest indication is obtained on the meter display. Measure the current in the circuit as shown on the diagram and continue measuring across the lamp, and across each jumper wire and observe. Write down your findings.



(c). Using the multimeter as an ohmmeter:

An ohmmeter is used to measure the resistance of the resistor and denoted by the symbol R and its unit is ohms (Ω).

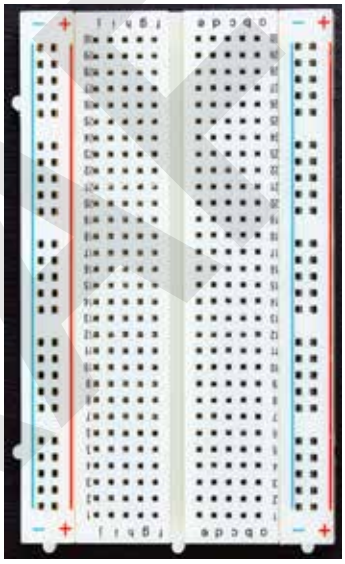
Required items

Resistor

Multimeter

NB. Do not to touch the probe tips with your fingers. If you do, you will be measuring the parallel combination of the resistor and your own body, which will tend to make the meter indication lower than it should be.

Breadboard

PICTURE:	
FUNCTION:	A horizontal row on a breadboard has 5 holes on the surface. These holes have a conducting material that connects these holes below the surface. The entire vertical row also has holes which are connected below the surface. The positive rail of the breadboard is used to connect to the positive terminal of the supply and the negative rail is used to connect to the negative terminal of the supply. The breadboard is used to construct circuits.
CARE and SAFE USE:	• Do not leave loose or open-ended wires when working with mains voltage (220 volts). You will get electrocuted! • Do not use it in wet places or with wet hands when working with high voltages.

Practical Activity 4: Testing continuity on a breadboard using a multimeter

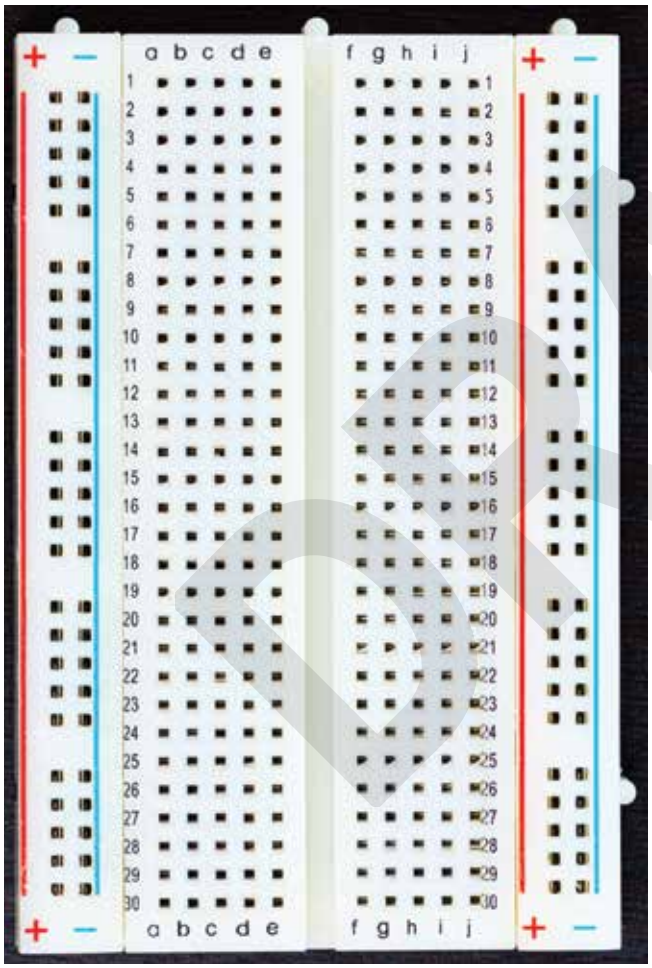
Aim: Testing continuity on a breadboard using a multimeter.

List of components required:

- Breadboard
- Multimeter
- Breadboard connecting wires

Procedure: Wind the connecting wires around the terminals of each probe.

- Set the multimeter to continuity scale.
- Randomly test for continuity between any five adjacent holes of the breadboard.
- Write down your findings.



Activity 6

Compile a list of tools that can be used to wire a three-pin plug.

Entrepreneurship

CHAPTER

4

Learning objectives

By the end of this chapter the learner should be able to understand what entrepreneurship is. The following will be covered in this chapter:

- Who is an entrepreneur
- Types of entrepreneurship
- Marketing and branding products
- Advertising on media platforms

4.1 What is Entrepreneurship?

Entrepreneurship is the act of creating a business or businesses while building and scaling it to generate a profit.

4.2 Who is an entrepreneur?

A person who starts a business and is willing to risk loss to make money.

The meaning of entrepreneurship involves an entrepreneur who takes action to make a change in the world. Whether start-up entrepreneurs solve a problem that many struggle with each day, bring people together in a way no one has before, or build something revolutionary that advances society, they all have one thing in common: **action**.

Importance of Entrepreneurship

What is entrepreneurship about? And why is it so important?

An entrepreneur is the person who sees a problem in the world and immediately focuses on creating the solution. They are the leaders that strike out on their own to improve society. Whether they are creating jobs or a new product, they constantly take action to ensure world progress. In the process of understanding what entrepreneurship is, let us look at why entrepreneurs are important in society.

- **Entrepreneurs create jobs:** Without entrepreneurs, jobs would not exist. Entrepreneurs take on the risk to employ themselves. Their ambition to continue their business' growth eventually leads to the creation of new jobs. As their business continues to grow, even more jobs are created. Thus, lowering unemployment rates while helping people feed their families.
- **Entrepreneurs create change:** Entrepreneurs dream big so naturally some of their ideas will make worldwide change. They might create a new product that solves a burning problem or take on the challenge to explore something never explored before. Many believe in improving the world with their products, ideas, or businesses.
  - **Entrepreneurship is the incubator of innovation.** (https://www.iedunote.com/entrepreneurship-definition)
  - Innovation creates disequilibria in the present state of order. It goes beyond discovery and does implementation and commercialization, of innovations. "Leapfrog" innovation, research, and development are being contributed by entrepreneurship.
  - Entrepreneurship nourishes innovation that provides new ventures, products, technology, markets, quality of goods, etc. to the economy that increases the Gross Domestic Product and standard of living of people.
- Entrepreneurs give to society: While some have this notion of the rich being evil and greedy, they often do more for the greater good than the average person. They make more money (and thus pay more in taxes which helps fund social services. Entrepreneurs are some of the biggest donors to charities and non-profit organisations for various causes.

Activity 1

1 Who is an *entrepreneur*?

2 Why are entrepreneurs important for society?

Why Do People Become Entrepreneurs?

Every entrepreneur has their own 'why' that drove them to dive into being their own boss. Whether entrepreneurs need more freedom or to make the world a better place, they all take control of their life by living life on their own terms. Here are a few of the reasons why people become entrepreneurs:

- **To change the world:** Many entrepreneurs strive to make the world better. Whether entrepreneurs believe in space exploration, eliminating poverty or creating a practical but game-changing product, they build a brand in service of others. Some entrepreneurs use their business to raise capital to funnel into their noble causes. To social entrepreneurs, building an empire is about creating a better world for everyone.
- **They do not want a boss:** Entrepreneurs often struggle with having a boss. They often feel suffocated, restricted and held back. Some entrepreneurs may feel that they have a more effective way of doing things. Others may dislike the lack of creative freedom. They become attracted to entrepreneurship to succeed on their own terms. Being the boss can be more fulfilling than having one.
- **They want flexible hours:** Entrepreneurship is often popular around those who need flexible hours. Many people with disabilities often enjoy entrepreneurship as it allows them to work when they can. Parents with young children might also prefer entrepreneurship as it allows them to raise young children at home or pick them up from school without having to feel guilty about it.

- **They are risk-takers:** Calculated risk-taking and entrepreneurship go hand in hand. Entrepreneurs do not apply to jobs, they create them. With that comes risk. Whether it is the financial risk of starting your first brand or the risk from not knowing what to expect, business is risky. Entrepreneurs are often taking risks by trying things the average person will not, to do things the average person cannot.
- **They cannot get a job:** Many people stumble into entrepreneurship when they cannot get a job. Getting fired, a lack of experience or a criminal record can prevent the average person from getting a job when they are desperate. Instead of being defeated by their situation, they create new opportunities for themselves.
- **They do not fit into the corporate environment:** Entrepreneurs often do not thrive in corporate environments. It is often very restricting for their growth. They may dislike the lack of control they have in their role or the office politics. In general, you can spot an entrepreneur in a corporate environment as they are usually trying to gain more control in their role and learning their co-workers' responsibilities to better understand how everything fits together.
- **They are curious:** Entrepreneurs love finding out the answer to the question, 'what will happen if...' They are experimental. Entrepreneurs love learning. They regularly read business books to advance their knowledge.
- **They are ambitious:** Those who love reaching difficult goals and milestones are made to be entrepreneurs. There is no limit to how much an entrepreneur can make and so they can always work to achieve higher levels of greatness. Since there is no limit to what they can achieve, entrepreneurs constantly find themselves growing and achieving more than they ever imagined.

4.3 Types of entrepreneurship

There is a difference between types of entrepreneurship and the types of entrepreneurs.

There are four major types of entrepreneurship:

- **Small business entrepreneurship.** Small business entrepreneurship makes up a big portion of all companies. It employs more than half of the non-government workforce. Examples are plumbers, carpenters, grocers, pharmacy owners, etc. They are usually barely profitable.
- **Scalable start up entrepreneurship.** Their mission from day one is to find a business model that is **scalable**. Not all of them are successful in that regard which is why investors have to bet big and often to make up for the losers. A traditional, growth-minded business adds to both sides of the scale proportionately, although the obvious goal is for profits to exceed

New words

scalable driving forces refer to situations that occur outside

revenues, even slightly. With a scalable business model, the result is not even close. Revenues in a scalable business rapidly outpace expenses. In fact, revenues are so accelerated that you could say that scaling is about adding revenue at an exponential rate while adding resources at an incremental rate. As Forbes puts it, scaling "means that your business has the potential to multiply revenue with minimal incremental cost."

- **Large company entrepreneurship.** This entrepreneurship from within huge conglomerates that already have established customer bases and market share. Why would they need entrepreneurship? Over time, consumer tastes change, and products are no longer in vogue. If the large company does not innovate, then they die a slow death.

- **Social entrepreneurship.** This is relatively new. Though they are still out for profit and sustainable business, they create products and services that solve social problems. Social entrepreneurship is an approach by individuals, groups, start-up companies or entrepreneurs, in which they develop, fund, and implement solutions to social, cultural, or environmental issues. This concept may be applied to a wide range of organisations, which vary in size, aims, and beliefs. Social entrepreneurs, however, are either non-profits, or they blend for-profit goals with generating a positive "return to society". Therefore, they use different metrics. Social entrepreneurship typically attempts to further broad social, cultural, and environmental goals often associated with the voluntary sector in areas such as poverty alleviation, health care and community development.

Activity 2

1 Why do people become entrepreneurs?

2 Discuss the major types of entrepreneurs.

4.4 Marketing and branding products

Product marketing is the process of **bringing a product to market**, promoting it, and selling it to a customer. Product marketing involves understanding the product's target audience, using strategic positioning, and messaging to boost revenue and demand for the product. **Product branding is a symbol or design that gives your products a proven identity in the marketplace**.

4.5 Advertising on media platforms

SOCIAL MEDIA ADVERTISING.

Social media advertising are advertisements served to users on social media platforms.

Examples of media platforms:

- Facebook
- Instagram
- Twitter
- TikTok
- Pinterest
- LinkedIn.

Materials

CHAPTER

5

Learning objectives

By the end of this chapter the learner should be able to understand and identify the properties of materials as conductors or insulators. The following will be covered in this chapter:

- Examples of conductors
- Properties of conductors
- Examples of insulators
- Properties of insulators

5.1 Introduction

Different materials have different properties. Think of the difference between the engine of a car and its wheels, or the metal in a wire and its insulator. All these objects can only be made from of materials that have properties suited to their application.

Based on the ability of various materials to conduct current, the materials are classified as conductors, insulators, and semiconductors.

5.2 What is a conductor?

Materials with high electron mobility (many free electrons) are called conductors. *Conductors can be defined as materials that can easily allow current to flow.*

Examples of conductors:

- Copper
- Aluminium
- Gold
- Silver

Properties of conductors:

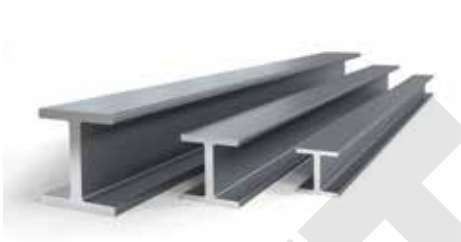
COPPER:

- Very high conductivity
- Non-corrosive
- Ductility
- Good machineability

ALUMINIUM:

- Light in weight.
- Electrical and thermal conductive.
- Ductile
- Good conductor at low temperatures.
- Non-magnetic.

STEEL:



- Made up of multiple elements (iron, carbon, manganese, chromium, nickel, molybdenum, phosphorous, and several others.)
- Is a ferromagnetic material.
- Is subject to rust.
- Lower conductivity when compared to aluminium and other conductors.

SEA WATER:

- Salt water is a good conductor of electricity.
- It is about a million times more conductive than fresh water.
- When it encounters other conductors, it can pose a problem of corrosion.
- Temperature changes will affect the conductivity of sea water. The temperature of sea water is directly proportional to conductivity.

5.3 Insulator

An insulator is a material which does not conduct electrical current very easily because of a lack of free electrons.

Examples of insulators:

- Rubber
- Glass
- Oil
- Wood
- Paper
- Porcelain
- Diamond
- Mica

New words

dielectric DUMMY TEXT DUMMY TEXT DUMMY TEXT

Properties of insulators:

- The electrical resistance and **dielectric** strength of an insulator is very high.
- Insulators have high mechanical strength so to withstand the tension and weight not affected by nature.

Activity 1

1. Define the term conductor.
2. State 2 properties of each of the following materials:
   a) Aluminium
   b) Copper
3. Define the term insulator.
4. List three examples of insulators.

Rubber:

- Good insulator
- It has a long lifespan
- It is flexible

Glass:

- It has a very high dielectric strength compared to porcelain.
- Its electrical resistance is also very high.
- It has low coefficient of thermal expansion.
- It has higher tensile strength compared to porcelain.

OIL:

- High Flash Point: To minimize risk of the formation of a flammable mixture of oil vapour and air at high operating temperatures.
- Low Pour Point: To reduce risk of inefficient cooling.
- Low Viscosity: To ensure good impregnation of cellulose insulation and free flowing circulation and heat transfer.
- Special mineral oil is used for insulation in transformers.

WOOD:

- Is a natural insulator due to air pockets within its cellular structure.
- Is light weight.
- Wood can also absorb moisture.

PAPER:

- Light
- Absorbs moisture easily (**hygroscopic**)

PORCELAIN:

- It is non-hygroscopic
- A very good insulator

DIAMOND:

- Extremely efficient thermal conductors
- Diamond is the hardest naturally occurring material known
- The diamond is an excellent electrical insulator.

MICA:

- It has a high dielectric strength
- It can withstand high temperatures
- It has poor mechanical strength

New words

hygroscopic DUMMY TEXT DUMMY TEXT DUMMY TEXT

Activity 2

Define the following terms:

1.1 Ductile

1.2 Malleable

1.3 Non-hygroscopic

Practical Activity 1: To distinguish between materials as conductors or insulators

Aim: To distinguish between materials as conductors or insulators.
The materials that are non-conductive need to be regarded as insulators, and the materials that are conductive need to be regarded as conductors.

What will you need:

- Multimeter
- Steel nail
- Eraser
- Plastic Ruler
- Coin
- Electrical wire
- Pencil lead
- Wood

What to do?

- Step 1: Put the multimeter into continuity mode (Diode Test mode).
- Step 2: Place the multimeter probes across the material to be tested.
- Step 3: What do you observe?
- Step 4: Fill in your observations in the table below.

MATERIAL	CONDUCTIVE (CONDUCTOR)	NON-CONDUCTIVE (INSULATOR)
Steel nail		
Eraser		
Plastic ruler		
Coin		
Electrical wires		
Pencil lead		
Wood		

Teacher Signature: …….. Date: ……..

Basic Principles of Electricity

CHAPTER

6

Learning objectives

By the end of this chapter the learner should be able to identify the basic principles of electricity. The following will be covered in this chapter:

- Identify the component, wiring symbol and function of electrical components
- Explain the function and safe use of a multimeter
- Use the multimeter as:
  - Voltmeter
  - Ammeter
  - Ohmmeter
- Quantity, SI units, symbol and description of:
  - Voltage
  - Current
  - Resistance
  - Energy
  - Power
- Basic components and functions of a basic electric circuit
- Ohm's law
- Electrical units/quantity symbols

Alessandro Volta
Italian physicist Alessandro Volta discovered that particular chemical reactions could produce electricity, and in 1800 he constructed the voltaic pile (an early electric battery) that produced a steady electric current, and so he was the first person to create a steady flow of electrical charge.

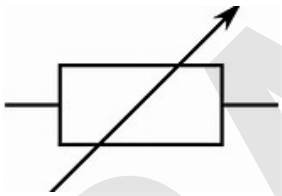
6.1 Introduction

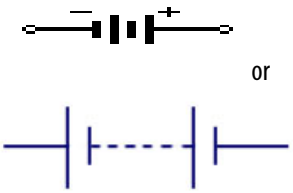
Electricity is the flow of electric current along a conductor. This electric current takes the form of free electrons that transfer from one atom to the next. The more free electrons a material has, the better it conducts. There are three primary electrical parameters:

- Volt,
- Ampere, and
- Ohm.

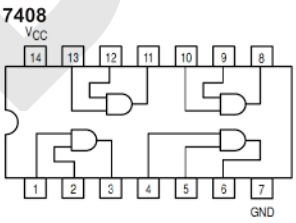
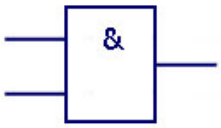
6.2 Name of component, wiring symbol and function

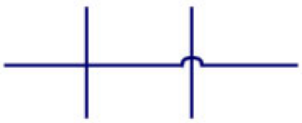
The following is a list of common wiring symbols which are required for understanding simple circuit diagrams:

Component name	Symbol	Function
 Resistor		Limit the flow of current
 Variable resistor		Adjust circuit resistance to control voltage or current of that circuit or part of that circuit.
 Light Dependent Resistor	 LDR Circuit Symbol	It is used to convert light into its corresponding resistance.
 Cell	 or 	Supply dc voltage

Component name	Symbol	Function
 Battery		Supply dc voltage
 Fuse		Protects circuits from high currents
Earth connections		Protection against Electrical Shock
 Light bulb	 Lamp Circuit Symbol	Produce light when current flow through it.
Bell		Used to produce a sound as the output, according to the electrical energy produced as the input.
 Buzzer		It is used to produce an output sound corresponding to the electrical energy in the input.

Component name	Symbol	Function
 Push button switch	 Push Switch Circuit Symbol	Momentary switch which is (Normally Open) to control the flow of current in the circuit once pressed.
 Single pole single throw switch		Also known as the ON/OFF switch. This switch allows the flow of current only when it is kept ON.
 Single Pole Double Throw Switch		Also known as the 2-way switch. It can be also called as an ON/OFF/ON switch as it has an OFF position in the centre. The switch causes the flow of current in two directions, depending on its position.
 Capacitor		Capacitor is a device that is used to store electrical energy.
 Light Emitting Diode (LED)		LED is used to emit light when a current is passed through the device.

Component name	Symbol	Function
	 Voltmeter Circuit Symbol	Voltmeter is used to measure the voltage at a certain point in the circuit.
	 Ohmmeter Circuit Symbol	Resistance of the circuit is measured using an Ohmmeter.
	 Ammeter Circuit Symbol	An Ammeter is used to measure the current that passes through the circuit at a particular point.
AND Gate 	American Symbol  IEC Symbol 	To allow the output to be High only when all inputs are HIGH and to be LOW when any of the inputs is LOW.

Component name	Symbol	Function
Wires Joined 		One device may be connected to another through wires. This is represented by drawing "blobs" on the point where they are shorted.
Unjointed Wires 		When circuits are drawn some wires may not touch others. This can only be shown by bridging them or by drawing them without blobs. Bridging is commonly practised as this is clearer and reduces confusion.

Activity 1

Complete the table below:

Symbol	Component name	Function
1.1	Resistor	1.2
	1.3	1.4
1.5	1.6	Supply dc voltage
1.7	1.8	It is used to convert light into its corresponding Resistance
	1.9	1.10

Symbol	Component name	Function
1.11	1.12	Also known as the ON/ OFF switch. This switch allows the flow of current only when it is kept ON
1.13	LED	1.14
1.15	1.16	Used to measure voltage in the circuit.

6.3 Multimeter

What is a Multimeter?

New words

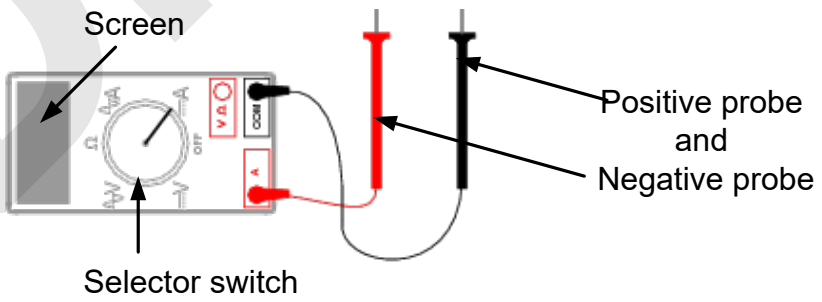
digital DUMMY TEXT DUMMY TEXT DUMMY TEXT.

analogue DUMMY TEXT DUMMY TEXT DUMMY TEXT.

A multimeter is a measuring instrument used to measure voltage, current and resistance. It is available in both **digital** and **analogue** form.

A Digital Multimeter has a numerical display for indicating the quantity of voltage, current and resistance while an Analogue Multimeter indicate these quantities by means of a moving pointer over a printed scale. There is a small adjustment knob or dial on the analogue multimeter to calibrate it for 0 ohms of resistance.

NB. You are encouraged to use both types of meters to gain familiarity with the operation of each in these experiments.

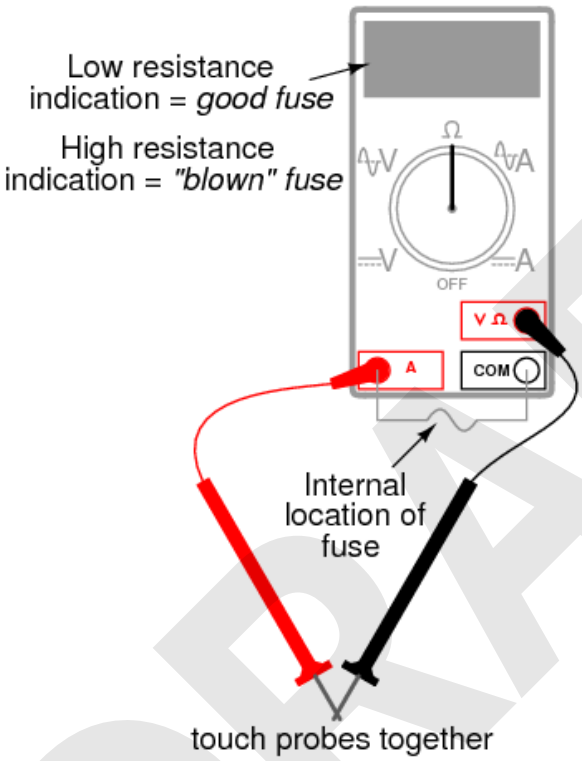


Digital Multimeter

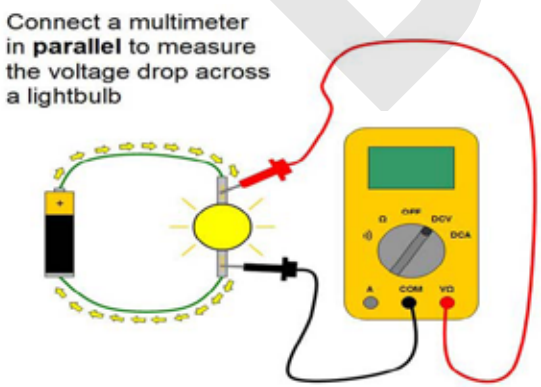
A multimeter is protected from excessive current by means of a fuse inside. If the ammeter is accidentally connected across a voltage source, the resultant surge in current will blow the fuse and the meter will be incapable of measuring current until the fuse is replaced.

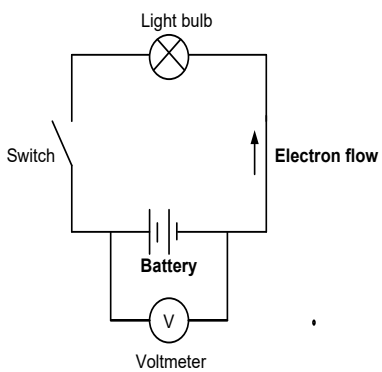
Testing the operation of the multimeter

Before using the multimeter, ensure that it is functional by connecting the red probe to the positive marked terminal and the black probe to the negative marked terminal. Touch the two probes, the digital multimeter will indicate zeros on the screen and the needle of the analogue multimeter will deflect to the right-hand side, and this is an indication that the multimeter is functional.



Use of multimeter as voltmeter: A voltmeter is used to measure the voltage across the circuit and is denoted by the symbol is "V" and its unit is Volts (V)

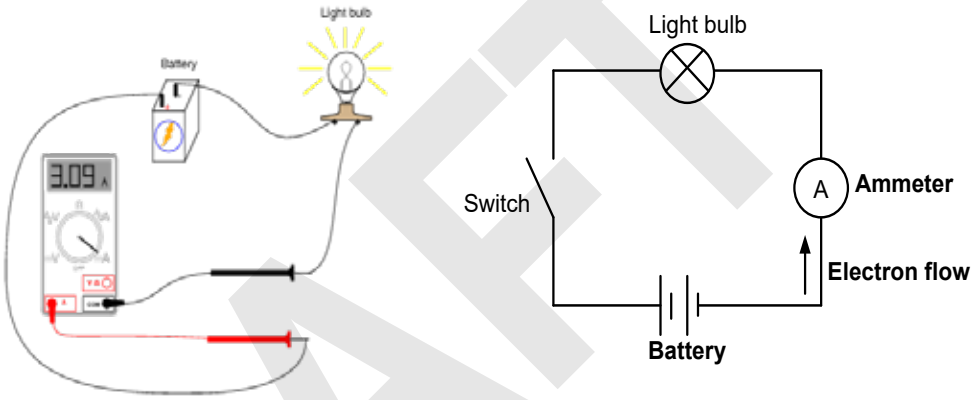




Procedure

Select the highest voltage range using the selector switch, then move the selector switch to lower range positions until the strongest indication is obtained on the meter display. Measure the voltage across the battery as shown on the diagram and continue measuring across the lamp, and across each jumper wire and observe. Write down your findings. Now, "break" the circuit at one point and re-measure voltage between the same sets of points.

Use of Multimeter as Ammeter: An ammeter is used to measure the current following in the circuit and is denoted by the symbol is "I" and its unit is the Ampere (A)



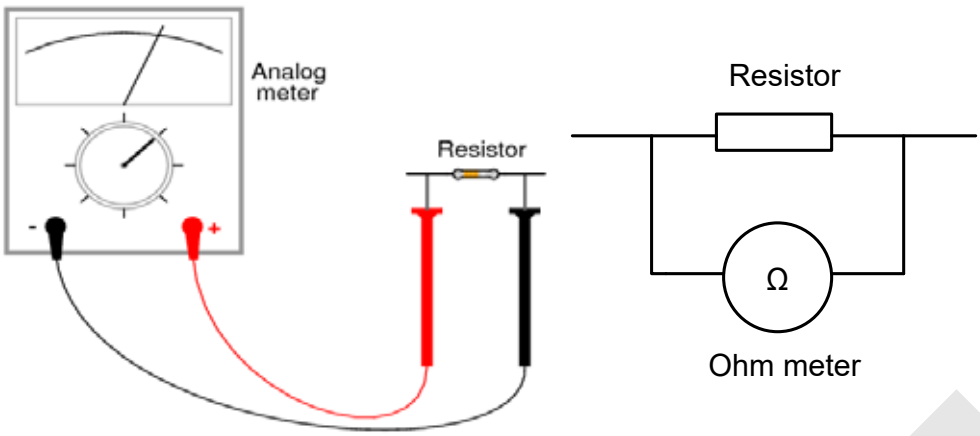
Procedure

An ammeter must be inserted in series (in-line) with the circuit to measure current. Turn the selector switch on the meter to the highest current range, then move the selector switch to lower range positions until the strongest indication is obtained on the meter display and observe.

If the meter indication is "backwards," (left motion on analogue needle, or negative reading on a digital display), then swop the test probe connections around and try again.

When the ammeter indicates a normal reading (not "backwards"), electrons are entering the black test lead and exiting the red. This is how you determine direction of current using a meter.

Use of multimeter as an ohmmeter: An ohmmeter is used to measure the resistance of the resistor and denoted by the symbol is "R" and its unit is ohms (Ω)



Procedure

- Use the selector switch to calibrate it for "zero" ohms of resistance.
- Touch the test probes together and move the selector switch until the needle exactly points to zero at the right-hand end of the scale.
- Set your multimeter to the highest resistance.
- Touch the meter probes to the resistor terminals.
- Do not to touch the probe tips to your fingers. If you do, you will be measuring the parallel combination of the resistor and your own body, which will tend to make the meter indication lower than it should be.

6.4 Quantity, SI units and symbols

Quantity	Symbol	SI units
Voltage	V	Volts (V)
Current	I	Amperes (A)
Resistance	R	Ohms (Ω)
Energy	E	Joules (J)
Power	P	Watts (W)

Activity 2

Explain what a multimeter is:

Briefly explain the steps followed to test whether the multimeter is operational.

State three quantities that can be measured with a multimeter.

Redraw the table below and fill in the correct symbols and SI units

Quantity	Symbol	SI Units
Current		
Resistance		
Power		

6.5 Atomic theory

One of the simplest working models of the atom is the Bohr model, which was developed by Niels Bohr. At the centre of the atom is a nucleus that consists of protons and neutrons. Revolving around the nucleus are electrons. Electrons move in orbits or shells around the nucleus. The number of electrons in any atom equals the number of protons and that makes the atom to be electrically neutral. Atoms differ from one another only in the number of electrons and protons they contain.

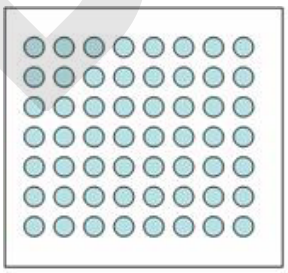
Phases of Matter

Matter can exist in the form of:

- gases,
- solids, and
- liquids (e.g., water).

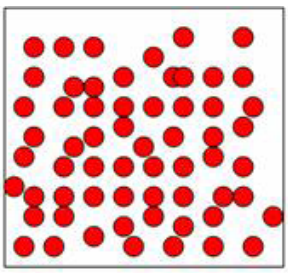
Water may be in three forms, namely:

- Solid (ice),
- Liquid (water) and
- Gas or steam (vapour)



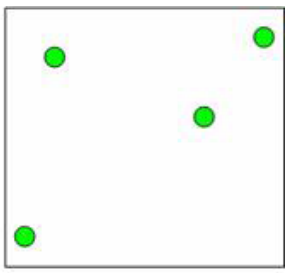
Solid

•Particles packed closely, often rigidly bonded to one another
•Definite shape
•Defiinite volume



Liquid

•Particles closely packed, but able to flow
•Indefinite shape
•Defiinite volume



Gas

•Particles far apart, able to shoot about freely
•Indefinite shape
•Indefiinite volume

Composition of Matter

Elements: Element is the basic material that makes up all matter i.e., silver, copper, oxygen etc.

Compounds: is a material made up of different elements combined i.e., water, sugar, salt etc.

Molecules: The smallest particle that a compound can be reduced to before it breaks down into its elements. For example, if we took water and have many small drops of water it will still be water.

Atom: The smallest particle that an element can be reduced to and still keep the properties of that element.

Examples of matter and non-matter

Matter	Non-matter
Conducting wire	Sunlight
Light bulb	Light
People	Thoughts
Animals	Heat

Basic Atomic structure

The atoms of all elements are composed of three types of particles namely: protons, neutrons, and electrons. Protons and neutrons are responsible for most of the atomic mass. The mass of an electron is very small ($9.10^{8} \times 10^{-28}$ grams).

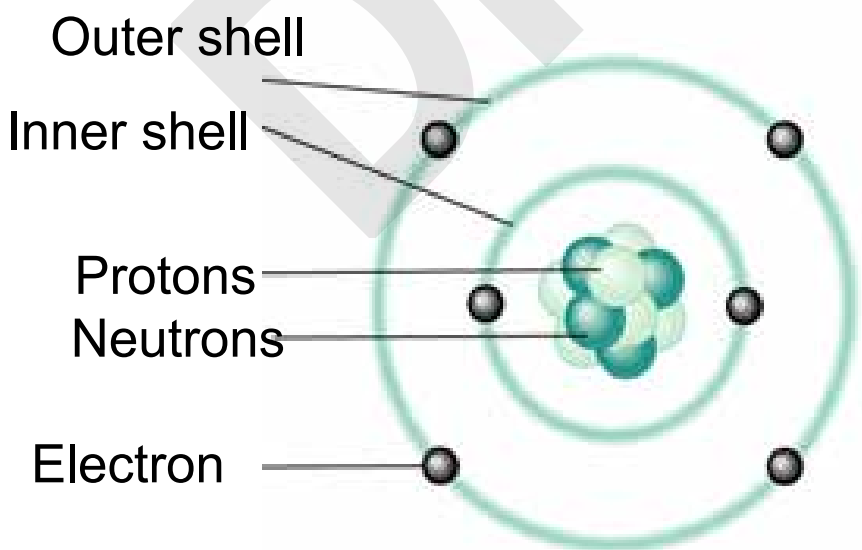


Figure 6.2.1 Atomic Structure

Electron shells

An electron shell is the outside part of an atom around the atomic nucleus. It is a group of atomic orbitals with the same value of the principal quantum number n. Electron shells have one or more electron sub shells, or sublevels.

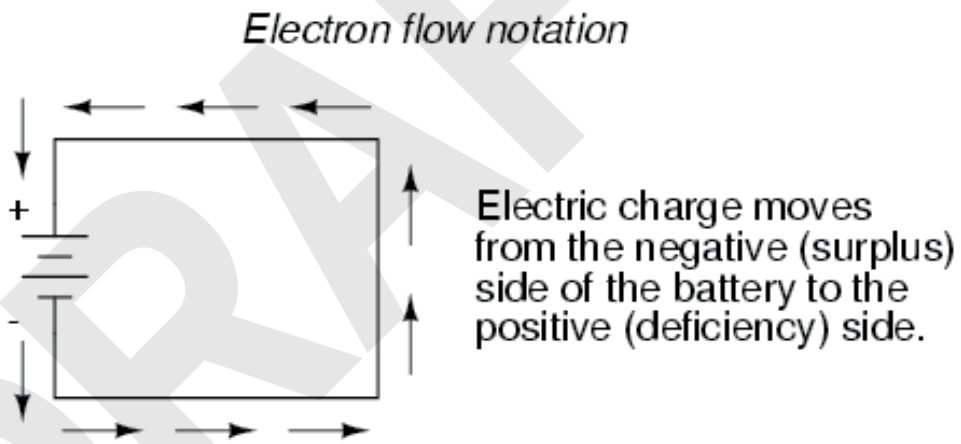
Nucleus

The nucleus is the centre of an atom. Almost all the mass in an atom is made up from the protons and neutrons in the nucleus with a very small contribution from the orbiting electrons.

- electrons (- charge)
- protons (+ charge)
- neutrons (no charge)

Electron current flow

Electron current flow: Electrons flow out of the negative terminal through the circuits and into the positive terminal of the source.



CIRCUIT DIAGRAM SHOWING ELECTRON CURRENT FLOW

6.6 The Three Effects of Current

When a current flows through a circuit it has various effects on different parts of a circuit. The effect may be one of the following:

- Magnetic effect
- Chemical effect
- Heating effect

Magnetic effects

When an electrical current flows through a conductor a magnetic field is established, which surrounds the full length of the conductor.

Uses of electromagnetic devices:

- Bells
- Relay switches
- Generators
- Lifting magnets

Chemical effects

When two different metals are connected to each other by means of a conductor, and then are placed in certain liquid known as electrolytes, a chemical reaction takes place which in turn will cause an electrical current to flow when a current is passed through.

Uses

- Car batteries
- Electroplating

Heating effect

When the flow of electric current is restricted, heat energy is generated. In some cases, the heat energy generated may be negligibly small, but in other cases it can cause problems such as the heating up of motors, generators, and transformers.

Uses

- Heating element of stoves plates or ovens
- Heating element of domestic heaters
- Heating elements of electric kettles
- Filaments of incandescent light bulbs

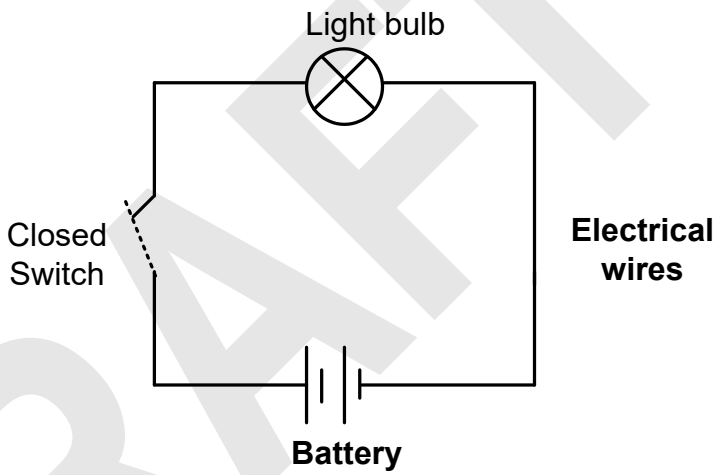
6.7 The Basic electric circuit:

Basic components and their functions

For an electric current to flow the electric circuit must exist.
A basic electric circuit requires the following:

- A load - i.e., bulb, bell, buzzer –Consumes power and give out the output.
- Switch - Opens and closes the electric circuit
- Conductors (electric wires) - Allow the electrons to flow through them
- Power source: i.e., cell, battery, or a generator - Produce and maintain a potential difference.

An electric current will not flow if we do not have a power source (cell or a battery).



SIMPLE CIRCUIT DIAGRAM

6.8 Introduction to Ohm's Law

In any electrical circuit there are always three terms present and in operation, the volt (representing the 'pressure' of the battery on the circuit), the amp (representing the circuit current) and the ohm (representing the resistance of the circuit).

A relationship between voltage, current and resistance exists and is known as Ohm's law, which can be expressed as follows:

Ohm's law:

The current flowing in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance of the circuit at constant temperature.

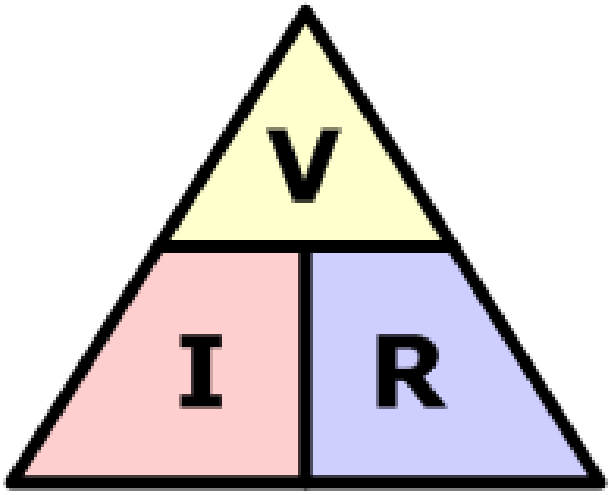


Figure 6.1 Ohm's Law Triangle

You can use the Ohm's law triangle to remember the three Ohm's Law equations. It can also serve as a quick reminder of which terms to use in the calculations.

Simple OHM's Law Calculations:

- To find voltage V, cover the V and what remains is I × R so V = I x R
- To find the current I, cover the I and what remains is so
- To find the resistance R, cover the R and what remains is

Transposing each of the quantities V, I and R in the triangle, the Ohms Law equation results in the following combinations of the same equation:

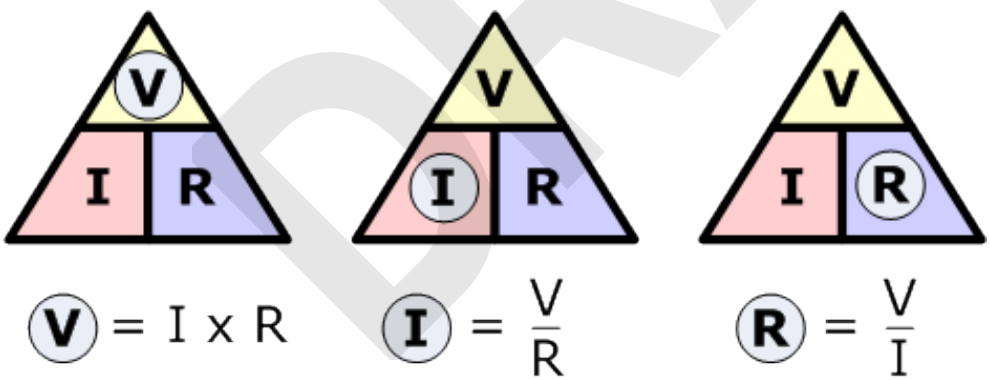


Figure 6.2 Using Ohm's triangle

Example 6.1

A heater element has a resistance of 50 ohms and is connected across a 200 volts supply. Determine the current drawn by this element.

Solution:

Given: R = 50 ohms

V = 200 V

I = ?

I = V/R

= 200/50

= 4 A

Example 6.2

The resistance of a heater is measured and found to be 20 ohms. On the heater the operating current is specified as 5.5 amps. What is the correct operating voltage for this appliance?

Solution:

Given: R = 20 ohms

I = 5.5 A

V =?

V = I x R

= 5.5 x 20

= 110 V

Example 6.3

When an electric toaster is plugged into a 220 volt supply it draws a current of 4.5 amps. What is the value of the resistance of the heating element?

Solution:

Given: V = 220V

I = 4.5 A

R =?

R = V/I

= 220/4.5

= 48.89 ohms (Ω)

6.9 Common Prefixes used with SI units

The International System of Units (abbreviated SI) is a modern form of metric system of units. It is the most widely accepted and used system for measurement in science, maths and technology. In conjunction with these units, certain prefixes are used to avoid writing very large or very small numeric values. Whenever these prefixes appear, unit conversions must be done first before substitutions to the formulae or equations are done. This is because all the SI system of units depends on the base units. If these conversions are not done, the answers to the calculations will not be correct.

Common Prefixes used with SI Units			
Prefix	Symbol	Meaning	Order of Magnitude
giga-	G	1 000 000 000	10^{9}
mega-	M	1 000 000	10^{6}
kilo-	k	1 000	10^{3}
hecto-	h	100	10^{2}
deka-	da	10	10^{1}
	base unit	1	10^{0}
deci-	d	0.1	10^{-1}
centi-	c	0.01	10^{-2}
milli-	m	0.001	10^{-3}
micro-	μ	0.000 001	10^{-6}
nano-	n	0.000 000 001	10^{-9}

Table SI prefixes

Example 6.5

Convert the following quantities:

(a) 10 000 Ω to kΩ

(b) 1 000000 KΩ to MΩ

(c) 0.001 A to mA

Solution:

$10\,000\ \Omega = (10\,000 \div 1000)\ k\Omega$

$= 10\ k\Omega$

OR

$10\,000 = 10 \times 10^{3} \times \Omega$

$= 10 \times k\Omega$

$= 10\ k\Omega$

$1\,000\ k = 1\,000 \times k \times \Omega$

$= 1\,000 \times 10^{3} \times \Omega$

$= (1\,000\,000 \div 10^{6})\ M\Omega$

$= 1\ M\Omega$

OR

$1\,000k = 1\,000 \times k \times \Omega$

$= 1\,000\ \Omega \times 10^{3} \times$

$= 1\,000\,000 \times \Omega$

$= 1 \times 10^{6} \times \Omega$

$= 1\ M\Omega$

$0.001\ A = 0.001 \times 1\,000\ mA$

$= 1\ mA$

OR

$0.001\ A = 1 \times 10^{-3} \times A$

$= 1 \times m \times A$

$= 1\ mA$

Activity 3

- List the three effects of current.
- State four examples of situations where electromagnetism is put to practical use.
- Explain what happens when a current is passed through an electrolyte.
- Convert the following quantities:
  - 10 000 µA to mA
  - 000 001F to nF
- An electric kettle with a 30 Ω resistance element is supplied with 3A of current. Calculate the supplied voltage.
- A toy car has a 6V battery and its motor has a resistance of 2Ω. Calculate the amount of current that will flow through the motor.

Practical Activity 1: Calibration of the multimeter

AIM: To set up the multimeter before use.

What you will need:

Multimeter

Procedure and observation:

Step 1: Check the multimeter probes for breaks or damages

Step 2: Insert the Red probe into the socket. (Depends on what is being measured)

Step 3: Insert the Black probe into the common socket.

Step 4: Switch On the multimeter and make sure that the display is functional

Step 5: Turn the multimeter selector to the correct quantity to be measured, make certain that the selector is on the highest range of the quantity to be measured.

Step 6: Before placing the probes into the circuit to measure resistance, make certain that the power to the circuit is switched off.

Step 7: Make certain that the proper polarity is observed (Positive to positive, negative to negative)

Step 8: When measuring voltage, the multimeter is connected across the component to be measured.

Step 9: When measuring current, the multimeter is connected in series with the component to be measured.

Step 10: Switch off the multimeter after use.

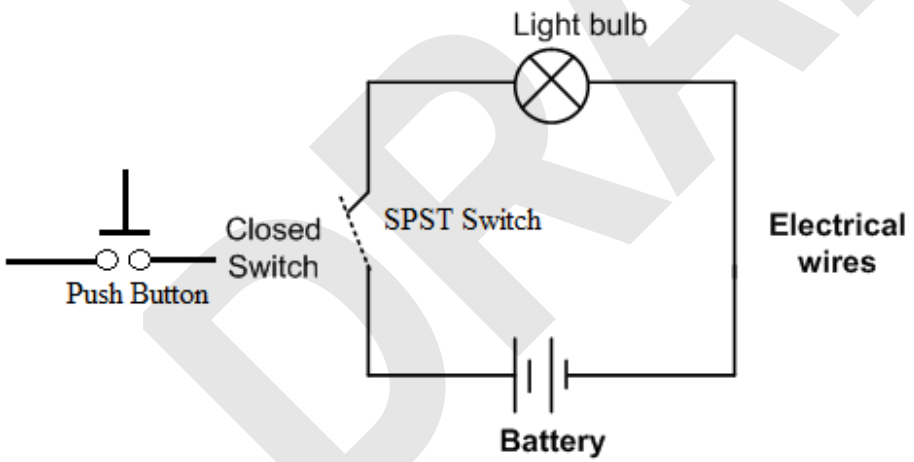
Teacher Signature: …….. Date: ……..

Practical Activity 2: Construction of a basic circuit

AIM: To build a basic circuit and to measure the voltage and current in the circuit.

What you will need:.

- Multimeter
- Light bulb
- 1.5 V Battery (Cell)
- Connecting wires
- SPST switch
- Push button switch
- Perform an emergency evacuation drill. (exercise)



Procedure and observation:

Step 1: The circuit is to be constructed and checked by the educator.

Step 2: Connect the SPST switch into the circuit and switch it ON

Step 3: Measure the voltage across the load (light bulb)

Step 4: Measure the current flowing through the circuit.

Step 5: Replace the switch with the push button in the circuit, press the button and observe the bulb. Depress the button and observe the bulb again.

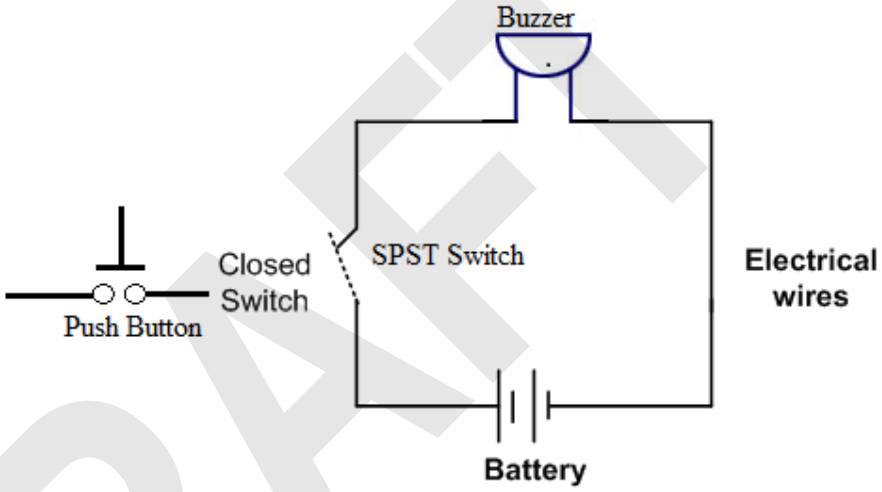
Teacher Signature: …….. Date: ……..

Practical Activity 3: Construction of a series circuit

AIM: To build a basic circuit and to measure the voltage, current and resistance in the circuit.

What you will need:.

- Multimeter
- Buzzer
- Battery 9 V
- Connecting wires
- SPST switch
- Push button switch



Procedure and Observation:

Step 1: The circuit is to be constructed and checked by the educator.

Step 2: Connect the SPST switch into the circuit and switch it ON

Step 3: Measure the voltage across the load

Step 4: Measure the current flowing through the circuit.

Step 5: Connect the push button into the circuit. Then push it down and release it. What do you observe?

Teacher Signature: …….. Date: ……..

Practical Activity 4: Investigate the difference between PD and EMF

AIM: Construct a simple circuit and measure the voltage when the switch is open (EMF) and when the switch is closed (PD).

What you will need:.

- Multimeter
- Bulb
- Battery 9V
- Connecting wires
- SPST switch

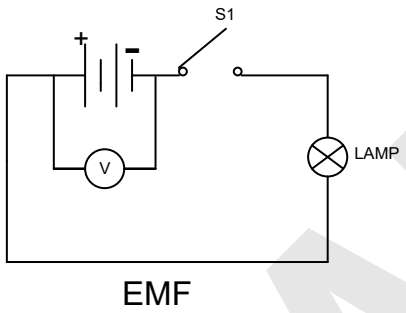


Figure 4.1

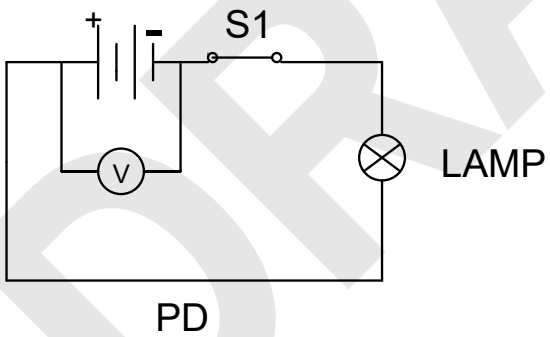


Figure 4.2

Procedure and observation:

Step 1: Circuit 4.1 is to be constructed and checked by the educator.

Step 2: Measure the voltage across the battery.

Step 3: Circuit 4.2 is to be constructed and checked by the educator.

Step 4: Measure the voltage across the battery.

Step 5: Write down the observation of the voltages in FIGURE 4.1 and FIGURE 4.2

Teacher Signature: …….. Date: ……..

Principles of Magnetism

CHAPTER

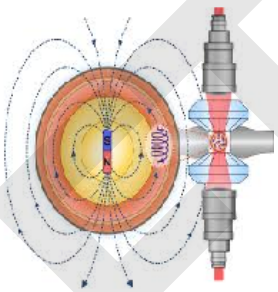
7

Learning objectives

By the end of this chapter the learner should be able to understand the basic principles of magnetism. The following will be covered in this chapter:

- Magnetic and non-magnetic material
- Types of magnets
  - Permanent magnets
  - Temporary magnets
- Laws of magnetism
- Application of electromagnets

The Englishman William Gilbert (1540-1603) was the first to investigate the phenomenon of magnetism systematically using scientific methods. He also discovered that Earth is itself a weak magnet.



7.1 Introduction into magnetism

The motion of electrically charged particles gives rise to magnetism. The force acting on electrically charged particle in magnetic field depends on the magnitude of the charge, the velocity of the particle and the strength of the magnetic field. All materials experience magnetism - some stronger than others.

7.2 Magnetic and non-magnetic material

Definition of magnetic material

Materials or substances which get attracted towards a magnet is known as magnetic materials. Magnetic material consists of a north and a south pole, produces magnetic fields which are invisible and responds to attract or repel other metal objects.

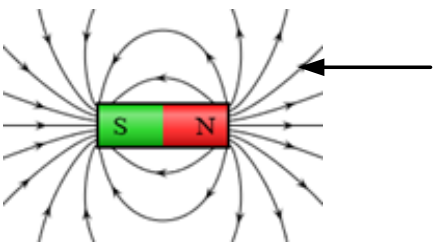


Figure 7.1 Magnet

Definition of non-magnetic material

Material that does not attract other metals is non-magnetic material.

7.3 Types of Magnets

Permanent magnet

Material which does not lose its properties of magnetism (creates its own magnetic field).

Temporary magnet

Soft iron material that remains magnetised only for a brief period.

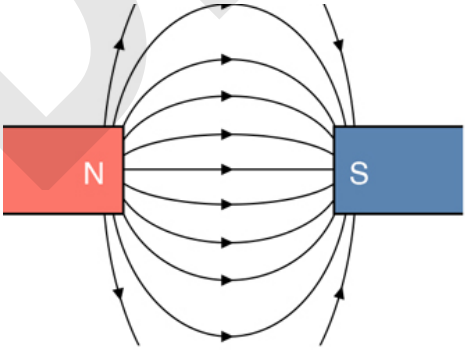
Activity 1

Define the following terms:

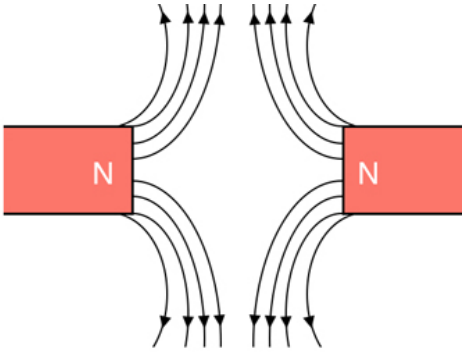
1. Magnetic material
2. Non-magnetic material
3. Permanent magnet

7.4 Laws of magnetism

- A magnet has two poles (north and south pole).
- Opposite or unlike poles (north and south) attract each other.
- Similar or like poles (north and north, or south and south) repel each other.



(a) Attraction between opposite poles



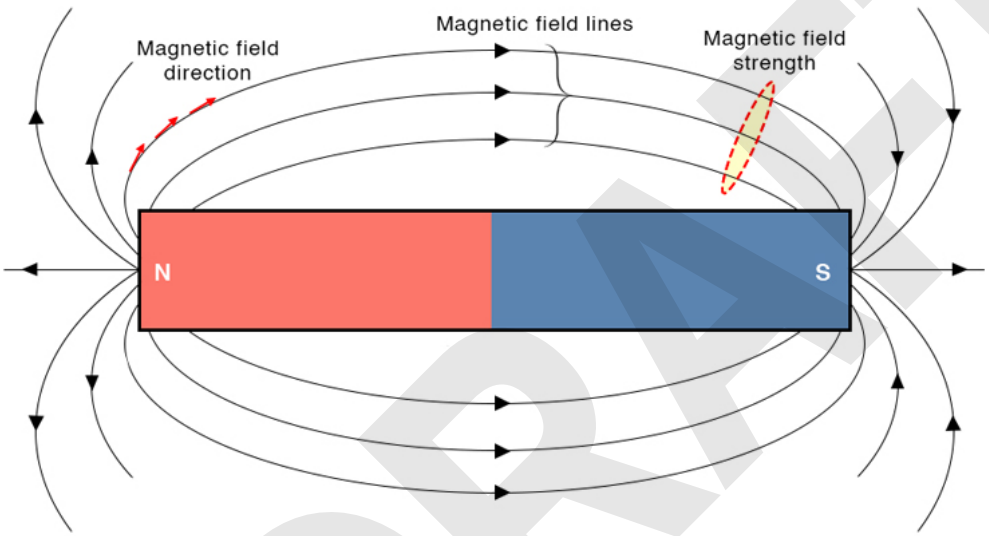
(b) Repulsion between similar poles

Properties of magnetic lines of force (or flux) states that:

- The field lines form closed paths at all times and are in a closed and continuous curve.
- The magnetic field lines always move from North to South outside the magnet and from South to North inside the magnet.
- The field lines will never cross or touch each other.
- Field lines have both direction and magnitude at any point on the field. Magnetic fields are the strongest at the edges or at the ends of the poles.

Magnetic fields

Magnetic fields can be visually represented as in the diagram below:



Definition of electromagnets

Magnetism formed by the flow of electrical current.

7.5 Application of electromagnets

- Microwave ovens
- Bank cards
- Cell phones

Activity 2

1 List the two types of magnets.
2 State three properties of magnetic lines of flux.
3 Differentiate between a permanent magnet and a non-magnetic material.

Practical Activity 1: The properties of a bar magnet using different materials

Aim: To demonstrate the properties of a bar magnet using different materials. During this practical experiment, the learner will be able to determine which materials are magnetic and which are non-magnetic.

What you will need:

- Iron filings
- nails
- glass
- paper

Instruction: The learners must take the materials and place them near the magnet.

Observe which of the materials are attracted or not attracted to the bar magnet.

Fill in the table below:

Table 8.1

MATERIALS	ATTRACTED (MAGNETIC)	NOT ATTRACTED (NON-MAGNETIC)
Iron filings		
Nails		
Glass		
Paper		

Teacher Signature: …….. Date: ……..

Practical Activity 2: The effect of magnetism

Aim: To show the effect of repulsion between two like poles using two bar magnets and iron filings.

What you will need:

- Iron filings
- 2 × Bar magnets
- A sheet of A4 paper

Procedure:

Sprinkle iron filings on a sheet of paper

Place the two magnets with two like poles facing one another under the paper.

Watch how the iron filings align themselves around the magnets.

Write down your observation in relation to the alignment of the iron filings.

Observation:

Teacher Signature: …… Date: ……

Practical Activity 3: The presence and pattern of magnetic field lines around the bar magnet

Aim: To demonstrate the presence and pattern of magnetic field lines around a bar magnet.

What you will need:

- Iron filings
- Bar magnets
- A4 paper

Write down what you observe:

Teacher Signature: …… Date: ……

Electrical Circuits and Electronic Components

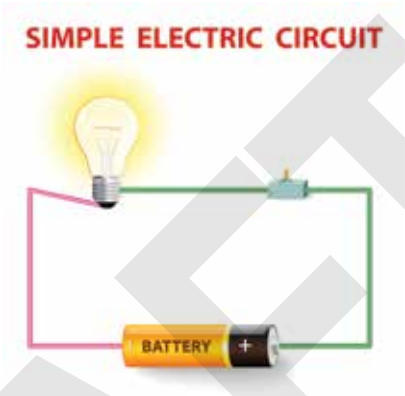
CHAPTER

8

Learning objectives

By the end of this chapter the learner should be able to identify symbols and components of electrical circuits. The following will be covered in this chapter:

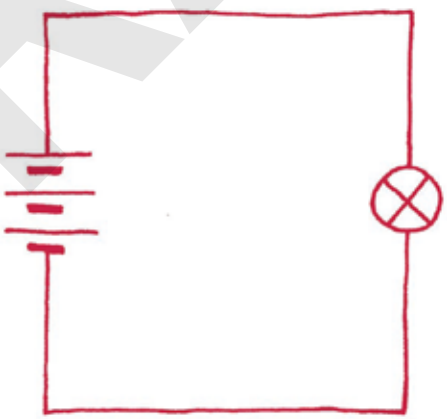
- Types of electronic components
- Purpose of electronic components
- Test components and measure components with a multimeter
- Identify the value of the components
- Series circuits consisting of two resistors



The first electric circuit was invented by Alessandro Volta in 1800. He discovered he could produce a steady flow of electricity using bowls of salt solution connected by metal strips.

8.1 Introduction

An electrical circuit is a closed path for transmitting electric current through the medium of electrical and magnetic fields. The flow of electrons across the loop constitutes the electric current.



An electrical circuit contains components like batteries, switches, bulbs, resistors, and capacitors, connected in a continuous loop. This allows electricity to flow and power the components. Many different components can be in a circuit.

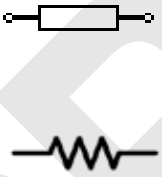
8.2 Electronic components and symbols

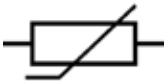
Electronic components are the basic building blocks of an electronic circuit or electronic device. They control the flow of electrons in an electronic circuit or electronic system.

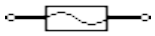
Electronic components are usually very small. Electronic components normally consist of two or more terminals. When electronic components are connected together in a system or an electronic board, for example a printed circuit board (PCB), a useful electronic circuit is formed. Each electronic component in a circuit performs a particular task or function.

Some of the most commonly used electronic components are resistors, capacitors, inductors, thermistors, LED's, diodes, transistors and oscillators.

Electronic components:

1. Resistor			
Symbol	**Unit**	**Component name**	**Function**
	Ω	Resistor 	Resists the flow of current. The main function of resistors in a circuit is to control the flow of current to other components.

2. Thermistors			
Symbol	**Unit**	**Component name**	**Function**
	Ω	Thermistors 	Thermistors are thermally sensitive resistors whose prime function is to exhibit a large, predictable, and precise change in electrical resistance when subjected to a corresponding change in body temperature.

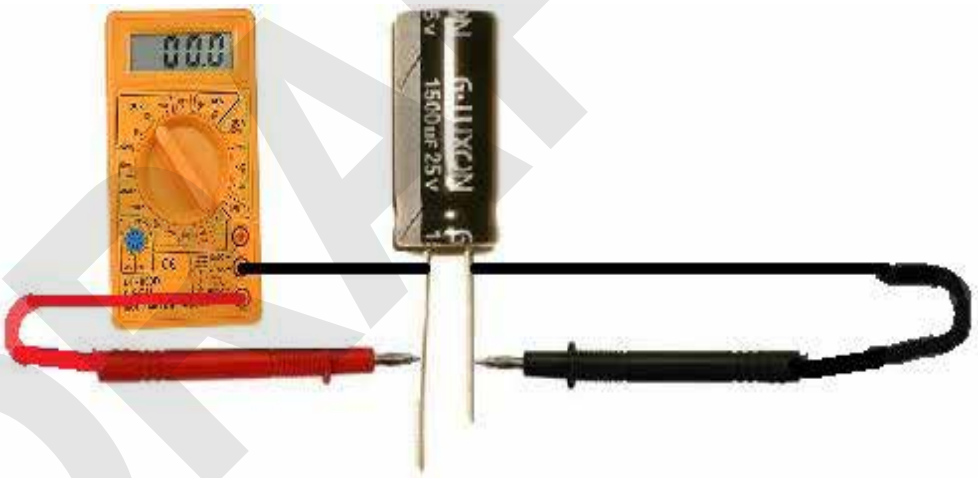
3. Capacitor			
Symbol	**Unit**	**Component name**	**Function**
	F	Capacitor 	A capacitor is used to store an electrical charge similar to a battery. Capacitors can also be used as filters, for bypassing or passing low frequency signals.
4. Fuse			
Symbol	**Unit**	**Component name**	**Function**
		Fuse 	Protects circuits from high currents a safety device consisting of a strip of wire that melts and breaks an electric circuit if the current exceeds a safe level.
5. LED			
Symbol	**Unit**	**Component name**	**Function**
		Light emitting diode (LED) 	LED is used to emit light when a current is passed through the device. It is abbreviated as LED.

Activity 1

1 Define the term electrical circuit.
2 Draw the symbols of the following:
  2.1 Resistor
  2.2 LED
  2.3 Fuse
3 State the function of the following components:
  3.1 Capacitor
  3.2 Thermistor

8.3 Test components and measure components with a multimeter

How to test a capacitor:



An electrolytic capacitor has two legs, one is longer and the other is shorter. The longer one is the positive terminal and the shorter one is the negative.

Step 1

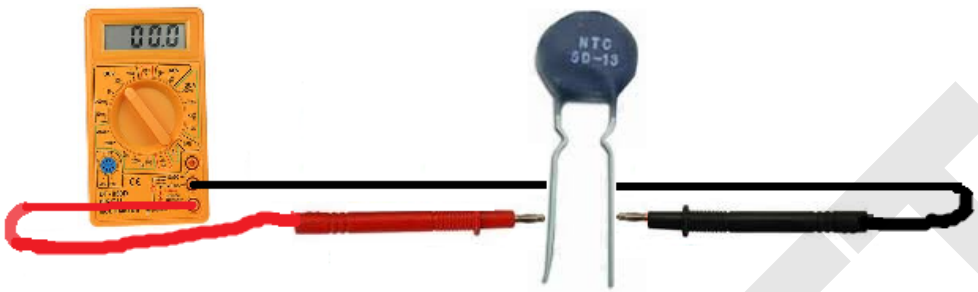
- Charge up the capacitor by connecting to a 9V battery.
- The longer leg must be connected to the positive terminal of the battery and negative leg connected to the negative terminal of the battery.
- Keep it connected for 10 seconds that will charge up the capacitor.

Step 2

- Disconnect the battery terminals from the capacitor.
- Turn on the multimeter and set the range to 20V DC.
- Touch the probes to the cap legs. Positive probe with positive leg and negative probe with negative leg.

Step 3

- Look at the measurement panel to take the voltage reading.
- The voltage should be decaying with time continuously.
- If the voltage decreases with time, then the capacitor is in good condition and if not then then the capacitor may not work properly in a circuit. An NTC thermistor, is a thermistor whose resistance decreases when the temperature it is exposed to increases.



Step 1

- First, set the digital multimeter (DMM) in **resistance** or **ohmmeter** mode using the selector dial.

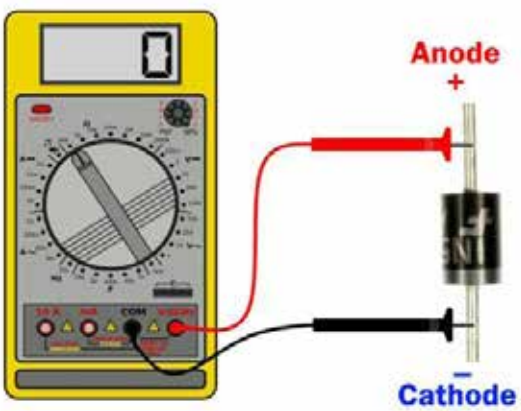
Step 2

- Thermistor has no polarity. Therefore, just place the DMM probes on the legs of a thermistor as in the above picture.

Step 3

- Take the reading of the thermistor.
- Thermistor may be 100Ω, 1KΩ, 10KΩ, 100KΩ, etc.
- If you are testing a 10KΩ thermistor, before we apply any heat, its resistance value should be very close to 10KΩ.
- If you are in a relatively warm room, it may be about 9.3KΩ.
- If you are in a colder area, it will be at a higher value.
- If it is near its rated resistance value, then so far, it is good.

Diode Testing using resistance



Step 1

- First, set the digital multimeter (DMM) in **resistance** or **ohmmeter** mode using the selector dial.

Step 2

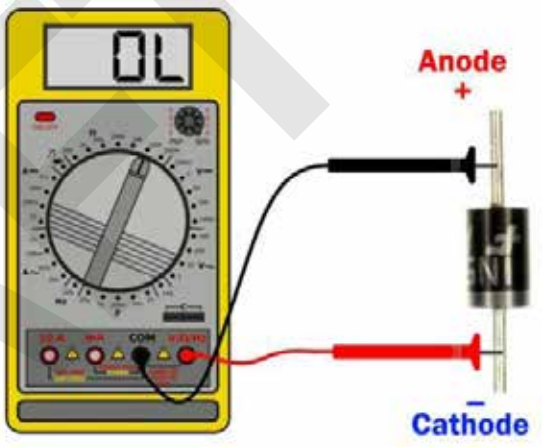
- Identify the terminals (**Anode** & **Cathode**) using the picture given above.
- Place the common probe (Black probe) of DMM on the cathode and red probe on the Anode of the diode.
- This configuration is **forward bias**.

Step 3

- Now record the reading.
- If the DMM reading has a very low resistance (ideally zero), then the diode is in good condition.

Step 4

- Now swap the probes such that the red probe is on Cathode and black probe (common probe) is on the Anode of the diode.
- Such configuration becomes **reversed bias**.

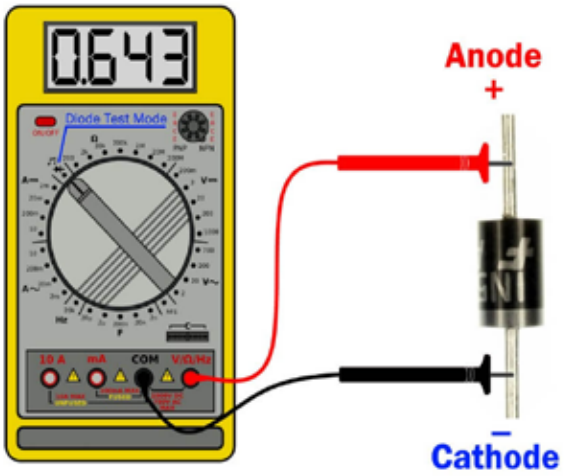


Step 5

- Now, record the reading as well.
- If the DMM reading is over limit (OL) a high resistance (Ideally infinity). Then diode is in good condition.

Diode Testing using diode mode

- **Diode Test Mode** in DMM is specifically designed for diode testing.
- It may share other function in different meters like continuity test mode etc.



Step 1

- Set the DMM in diode test mode.

Step 2

- Identify the terminals using the instructions in the above picture.

Step 3

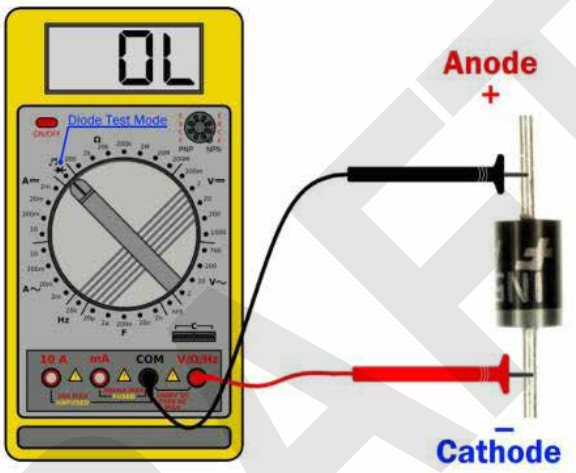
- Place the common probe (black probe) on cathode & the red probe on the anode of the diode.
- This makes it forward bias.

Step 4

- Record the reading.
- If the reading is 0,6. Then diode is in good condition.

Step 5

- Now swap the probe's position on diode such that the black probe connects with the anode & the red probe connects with the cathode according to the above picture.
- Now it is in **reversed bias**.



Step 6

- Record the reading.
- If the DMM reading is infinite (1) or over limit (OL)then the diode is in healthy & good condition.

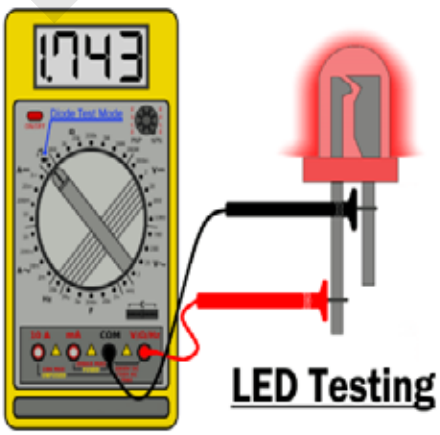
LED Testing using the diode mode

Step 1

- Put the DMM in diode test mode using the knob.

Step 2

- Place the common probe (black probe) on the cathode and the red probe on the Anode of LED according to the above picture.



Step 3

- Observe the LED.
- If the LED glow, then it is in good condition.
- If it does not glow, then the LED is probably burned or damaged.

8.4 Identify the value of the components

It is difficult to write the value of some components on the body of the component, because of the size of the components. Different codes are used on some components to show the value of the component. Some components that use codes are Resistors, Capacitors etc.

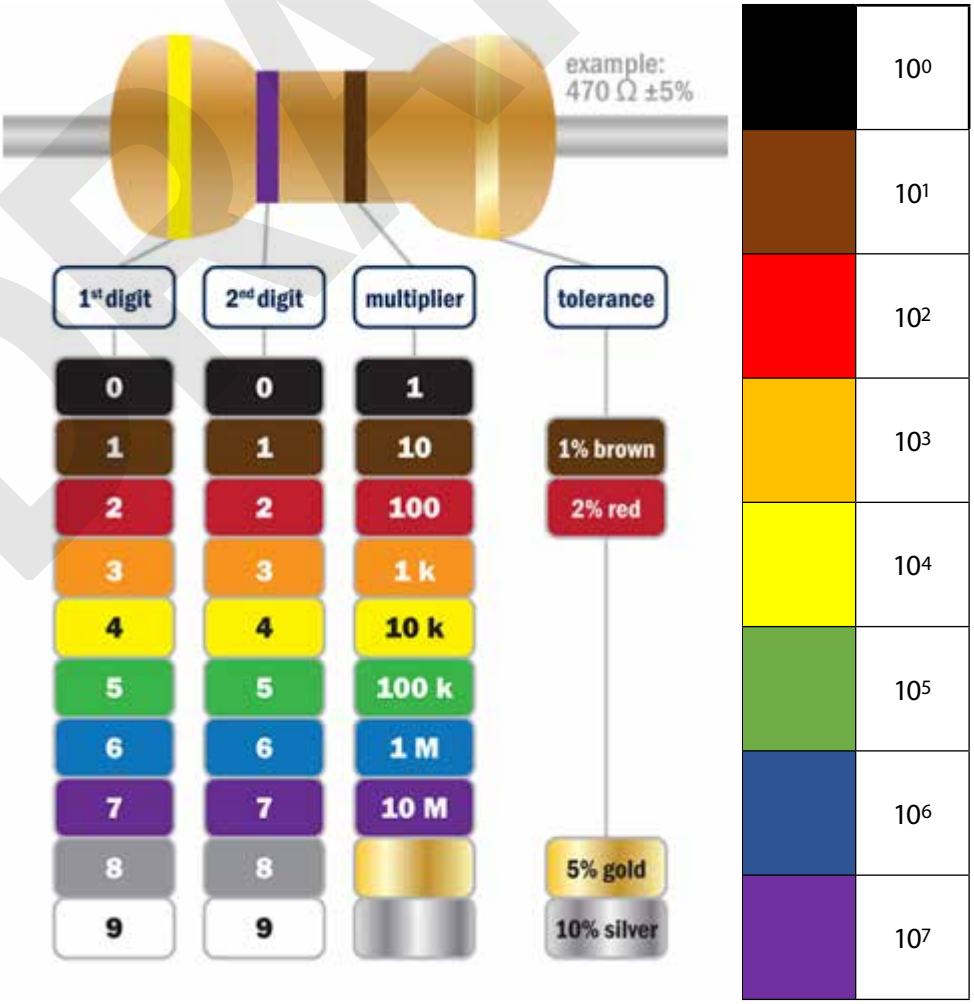
Resistor Colour Codes

Resistors resist the flow of electrical current. Each one has a value that tells how strongly it resists current flow. This value's unit is the ohm, often noted with the Greek letter omega: Ω.

The coloured bands on a resistor tells you everything you need to know about its value and tolerance.

Each value of resistor has its own unique colour bands

The first colour band represent the left most digit
The second colour band represent the second digit and the third colour band represent the number of zeroes after the first two numbers



Example:

Determine the value of the resistor with the following colour codes:
Orange, orange, black and gold

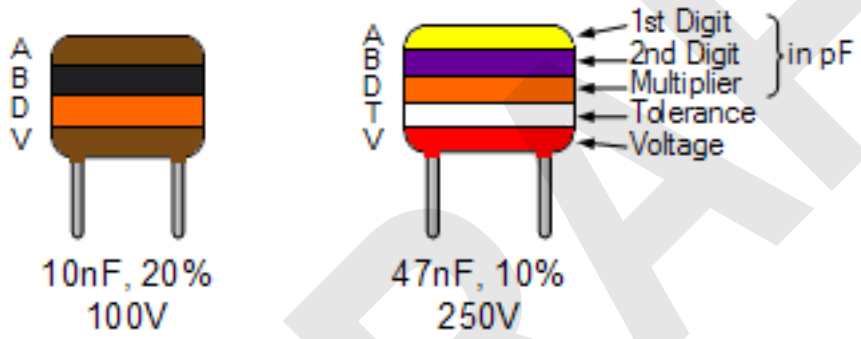
3 3 × 10^1 ± 5%

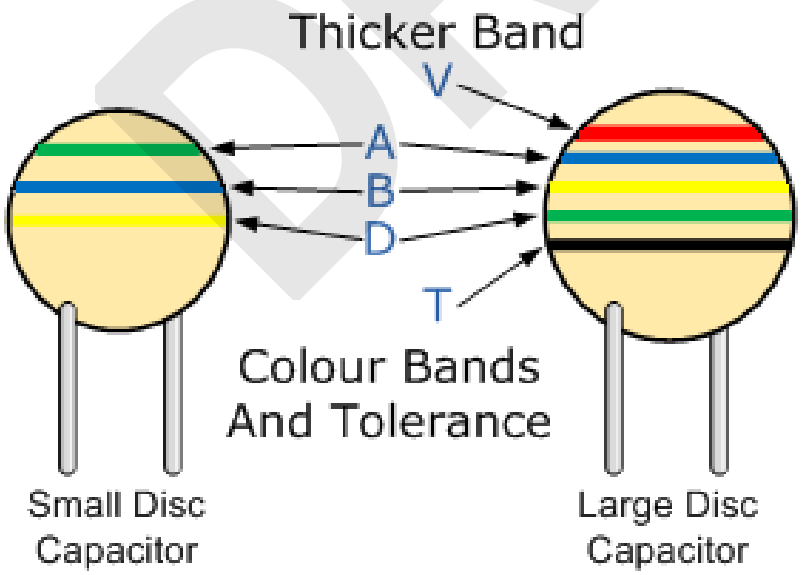
= 330 Ω ± 5%

Capacitor

Colour coded capacitor

The colour codes of capacitors are marked on their body so that they can be easily characterised and understood by electricians. These colour codes indicate the value of capacitance, voltage, and tolerance of the capacitor. Letters like p (pico) or n (nano), decimal points are used to identify the position and the weight of the number.

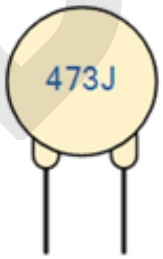




Band Colour	Digit A	Digit B	Multiplier D	Tolerance (T) > 10pf	Tolerance (T) < 10pf	Temperature Coefficient (TC)
Black	0	0	x1	± 20%	± 2.0pF	
Brown	1	1	x10	± 1%	± 0.1pF	-33×10^{-6}
Red	2	2	x100	± 2%	± 0.25pF	-75×10^{-6}
Orange	3	3	x1,000	± 3%		-150×10^{-6}
Yellow	4	4	x10,000	± 4%		-220×10^{-6}
Green	5	5	x100,000	± 5%	± 0.5pF	-330×10^{-6}
Blue	6	6	x1,000,000			-470×10^{-6}
Violet	7	7				-750×10^{-6}
Grey	8	8	x0.01	+80%,-20%		
White	9	9	x0.1	± 10%	± 1.0pF	
Gold			x0.1	± 5%		
Silver			x0.01	± 10%		

Number coded capacitor

The actual values of Capacitance, Voltage or Tolerance are marked onto the body of the capacitors in the form of alphanumeric characters.



A ceramic disc type capacitor above has a code 473J printed onto its body. Then the 4 = 1st digit, the 7 = 2nd digit, the 3 is the multiplier in pico-Farads, pF and the letter J is the tolerance, and this translates to: 47pF * 1,000 (3 zero's) = 47,000 pF, 47nF or 0.047uF the J indicates a tolerance of +/- 5%

Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code	Picofarad (pF)	Nanofarad (nF)	Microfarad (uF)	Code
10	0.01	0.00001	100	4700	4.7	0.0047	472
15	0.015	0.000015	150	5000	5.0	0.005	502
22	0.022	0.000022	220	5600	5.6	0.0056	562
33	0.033	0.000033	330	6800	6.8	0.0068	682
47	0.047	0.000047	470	10000	10	0.01	103
100	0.1	0.0001	101	15000	15	0.015	153
120	0.12	0.00012	121	22000	22	0.022	223
130	0.13	0.00013	131	33000	33	0.033	333
150	0.15	0.00015	151	47000	47	0.047	473
180	0.18	0.00018	181	68000	68	0.068	683
220	0.22	0.00022	221	100000	100	0.1	104
330	0.33	0.00033	331	150000	150	0.15	154
470	0.47	0.00047	471	200000	200	0.2	254
560	0.56	0.00056	561	220000	220	0.22	224
680	0.68	0.00068	681	330000	330	0.33	334
750	0.75	0.00075	751	470000	470	0.47	474
820	0.82	0.00082	821	680000	680	0.68	684
1000	1.0	0.001	102	1000000	1000	1.0	105
1500	1.5	0.0015	152	1500000	1500	1.5	155
2000	2.0	0.002	202	2000000	2000	2.0	205
2200	2.2	0.0022	222	2200000	2200	2.2	225
3300	3.3	0.0033	332	3300000	3300	3.3	335

Capacitors are components designed to store a charge. Capacitance is the ability of a capacitor to store a charge. Their unit of measurement is expressed in farad. However, the unit is too great, and as a result, the unit is expressed with a prefix to indicate a smaller scale.

8.5 Series circuit consisting of two resistors

Kirchhoff's Voltage Divider:

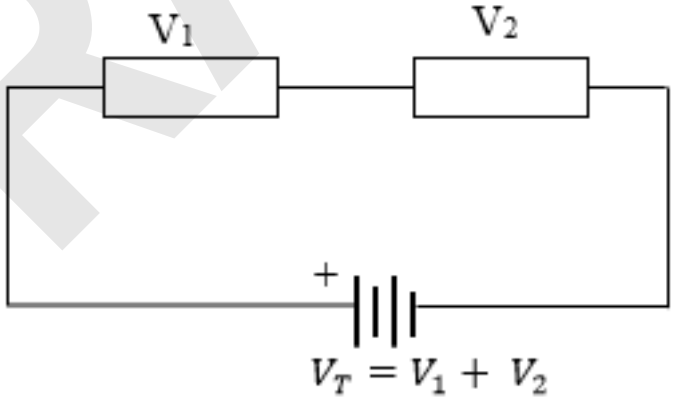
The voltage divider rule depends on Kirchhoff's Voltage Law which is also a consequence of the Law of conservation of energy.

Kirchhoff's Voltage Law

This law states that in any closed circuit, the sum of potential differences (PD's) around the circuit equals the supply voltage (EMF) of the circuit.

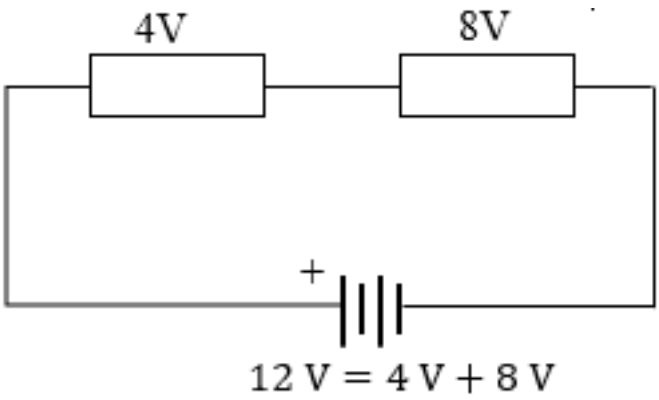
$$VT = V_1 + V_2 + V_3 \ldots \ldots Vn$$

For example, in the circuit below, two resistors are connected in series with a battery. The total voltage supplied by the battery (VT) is equal to the sum of the voltage drops across each of the resistors.



Example: 1

If two resistors are connected in series to a battery of 12 V and a voltmeter connected across each of them, the sum of the readings will be equal to the battery voltage.



8.6 What are Electronic Components

Electronic components can be divided into various categories. These include resistive components, reactive components, sensors, transducers, and semi-conductive components.

Purpose of electronic component

They are used to convert, alter or control electricity to serve a specific purpose. Each component serves a specific function, and all respond differently to a voltage and current supply but when combined they serve a different purpose. (Thomson N. G., 10_06 Electronic Components.pdf, 2013)

Types of components

- Resistive components are used primarily for their ability to resist an electric charge and develop a potential difference. Examples are resistors, variable resistors etc.
- Reactive components include capacitors and inductors. These components can change their "resistance" according to the applied frequency.
- Sensors and transducers are components that can alter their values according to external inputs or convert energy from one form to another. Examples of these are light dependent resistors (LDR), light bulbs, microphones, and speakers.

Activity 2

1 Define the term: electronic component.
2 List three different types of components and give an example of each.
3 Draw a circuit showing how two resistors can be connected in series.

Practical Activity 1: Test different electronic components using a multimeter

Aim: To demonstrate an understanding and an ability to correctly identify and test different electrical components using a multimeter.

Step 1 Measure the voltage across three batteries.

Step 2 Measure continuity across a switch.

Step 3 Measure the resistance of three resistors.

Practical Activity 2: Build a simple series circuit containing two resistors

Aim: To demonstrate an understanding and an ability to correctly build a simple series circuit containing two resistors.

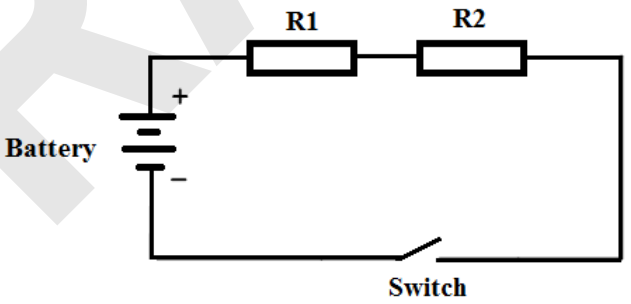
What you will need:

Connecting wires	Resistors x 2
Battery	
SPST switch	

What to do:

Connect the circuit as shown in the diagram below.

Measure the voltage across R1, R2 and the Battery to prove Kirchoff's law.



Write down your findings:
Measure the voltage drop across R1 =
Measure the voltage drop across R2 =
Measure the voltage across the battery =
Write down the relationship between the voltage drop between R1 and R2 and the voltage across the battery:
Teacher Signature: …… Date: ……

Power Sources

CHAPTER

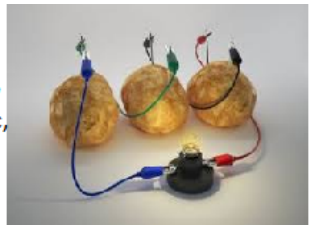
9

Learning objectives

By the end of this chapter the learner should be able to identify and define power sources. The following will be covered in this chapter:

- What is energy
- Classification of energy
- Kinetic energy
- Potential energy
- Renewable sources of energy:
  - Wind energy
  - Solar energy
  - Hydro/Water energy
  - Biomass energy
  - Geothermal energy
- Non-Renewable sources of energy:
  - Nuclear energy
  - Coal energy
  - Fossil fuel energy
- Storing energy
- Primary vs Secondary cells:
  - Difference
  - Advantages and disadvantages

The fundamental principles of **electricity generation** were **discovered** in the 1820s and early 1830s by British scientist Michael Faraday. His method, still used today, is for **electricity** to be generated by the movement of a loop of wire, or Faraday disc, between the poles of a magnet.



https://www.livescience.com/62570-potato-battery-conduct-electricity.html

9.1 Introduction

A power source is a source of electric energy, (e.g., a battery) which is used to supply the components of an electronic circuit with the proper electric voltage and current needed for their operation.

9.2 What is energy?

Energy is defined as the ability to do work.

9.3 Classification of energy

Energy can be classified as kinetic energy or potential energy.

Kinetic energy:

- The energy that an object possesses due to its motion.
- Examples of kinetic energy:
- Radiant, thermal, sound, electrical (light) and mechanical (motion)
- Electrical energy is a type of kinetic energy caused by moving electric charges.

Potential energy:

- The stored energy in an object.
- It is called potential because it has the potential to be converted into other forms of energy, such as kinetic energy.

Examples of potential energy:

- Nuclear energy, a book on a shelf, a battery.
- The heavy ball of a demolition machine is storing energy when it is held at an elevated position.

Activity 1

1 Define the term energy.
2 State the two classifications of energy.
3 Explain the classifications of energy mentioned in question 2.
4 List three examples of kinetic energy..

9.4 Sources of energy

Renewable energy

Is energy that is collected from renewable resources, which are naturally replenished on a human timescale.

Examples of renewable energy are wind, solar, hydro/water, **biomass**, and **geothermal** heat.

New words

biomass DUMMY TEXT DUMMY TEXT
geothermal DUMMY TEXT DUMMY TEXT

Wind energy

Wind energy is the kinetic energy of air in motion.

Advantages of wind energy	Disadvantages of wind energy
Low maintenance Wind fluctuates (not constant)	
Low running cost	Installation is expensive
Is cheap to generate	Threat to wildlife
Have relatively small land print	Noise pollution

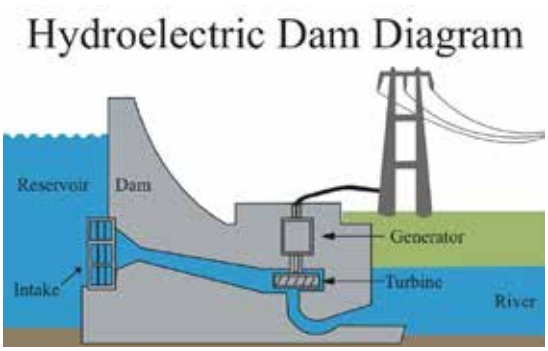
Solar energy

Solar energy is the conversion of energy from sunlight to electricity.

Advantages of solar energy	Disadvantages of solar energy
Renewable energy source	Cost of purchasing solar system is very high
Reduces electricity bills	Weather dependent
Low maintenance cost	Must be used right away or storage is expensive (in batteries)
Diverse application	Uses more space
Technology development	Associated with pollution

Hydro/water energy

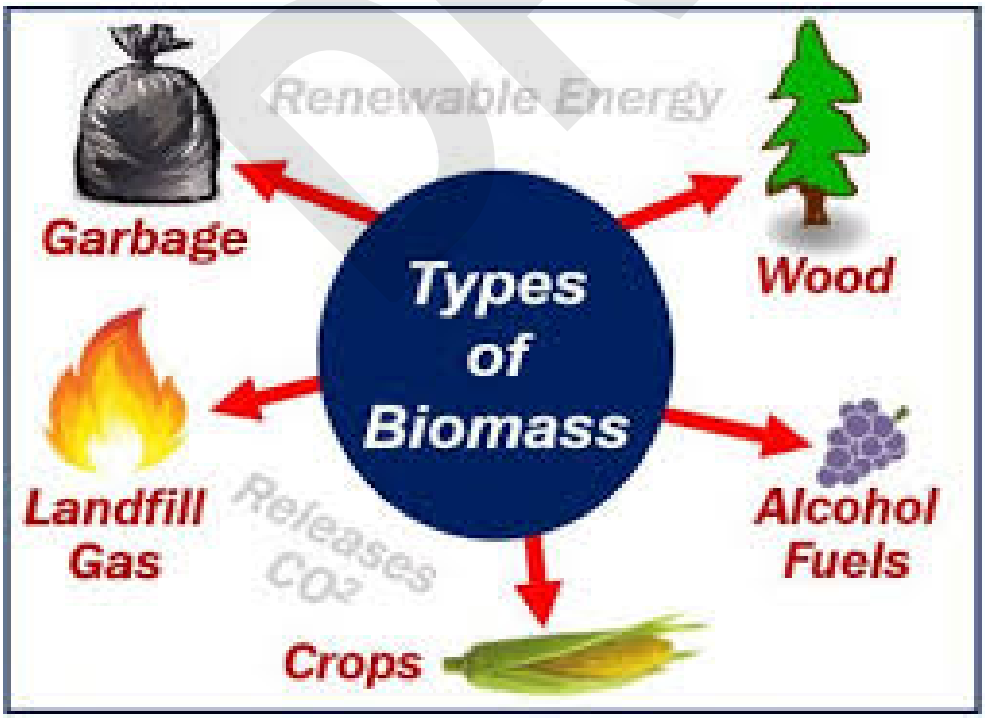
Hydro energy is the power that is produced when moving water rotates a turbine shaft.



Advantages of hydro-electric energy	Disadvantages of hydro-electric energy
Clean energy and regenerative	Danger to ecosystem
Available throughout the year	Floods and droughts
Do not emit greenhouse gases	Expensive
Low maintenance cost	Relocation of people

Biomass energy

Biomass energy is energy generated or produced by living or once-living organisms.



Advantages of biomass energy	Disadvantages of biomass energy
It is carbon neutral.	Biomass energy is not as efficient as fossil fuels
It reduces the overreliance of fossil fuels.	It is not entirely clean
Is less expensive	Can lead to deforestation.
Its production adds a revenue source for manufacturers.	Biomass plants require a lot of space.

Geothermal energy

Geothermal energy is heat derived within the sub-surface of the earth.

Advantages of geothermal energy	Disadvantages of geothermal energy
Geothermal energy is renewable energy	Location restricted and location specific.
It is considered environmentally friendly.	Surface instability (earthquakes)
Low operating costs.	Environmental side effects e.g. emission of toxic gases
More energy.	Reservoirs are not permanent, and they can be depleted.

Activity 2

1 Define solar energy.
2 List any THREE renewable sources of energy.
3 Describe TWO advantages and disadvantages of the following energy sources:
   3.1 Wind energy
   3.2 Solar energy

Non-renewable energy

Non-renewable energy comes from sources that will run out or will not be replenished in our lifetime.

Examples:

nuclear, coal, fossil fuel

Nuclear energy

Nuclear energy is energy stored in the nucleus (core) of an atom.

Advantages of nuclear energy	Disadvantages of nuclear energy
Clean energy Nuclear radiation accidents	
Creates jobs	Radioactive waste
Less fuel offers more energy	Require high capital cost
Relatively low cost	Threat to aquatic life (life in water)
Water pollutant	Threat to environment and human life.

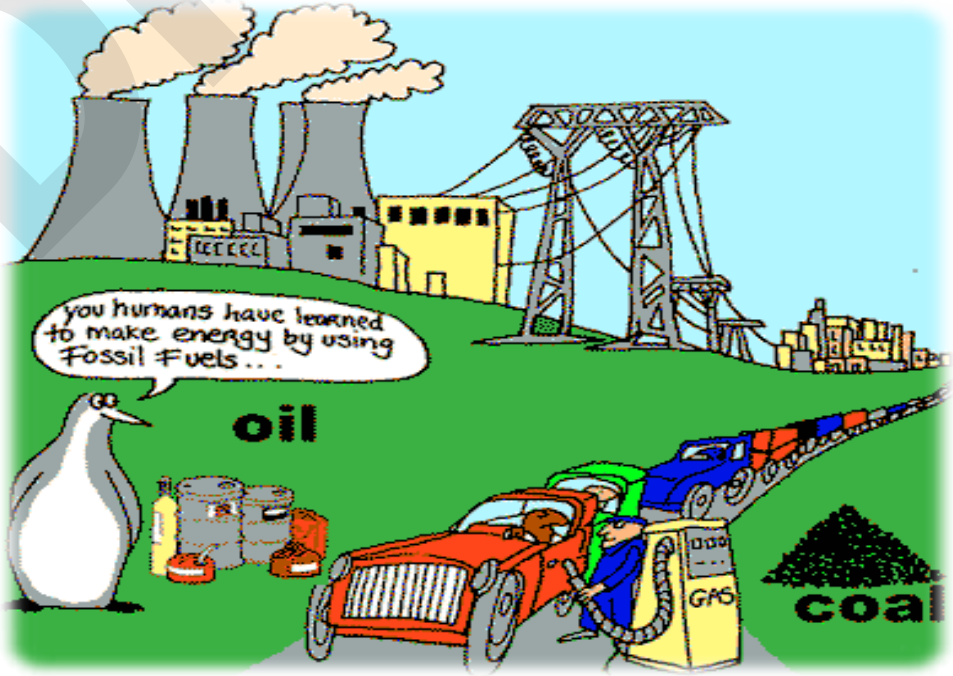
Coal energy

Coal energy- is the electric power made from energy stored in coal.

Advantages of coal energy	Disadvantages of coal energy
Is affordable	Non-renewable.
Easy to burn	Burning coal causes pollution to the environment.
It is in abundance	Unstoppable damages could occur when mining coal.
Generate power in large scale	Underground mining is very hazardous because explosions are common.

Fossil fuel energy

Fossil fuel energy is a fuel formed by natural processes.



Advantages of fossil fuel energy	Disadvantages of fossil fuel energy
Generate vast amounts of electricity in just a single location.	Air pollution
quite easy to find	Coal gives off sulphur dioxide, a kind of gas that creates acid rain.
they are very cost effective	Use of natural gas can cause unpleasant odours.
Power plants that utilize gas are very efficient.	Crude oil contains toxic chemicals which cause air pollutants when combusted.

Activity 3

1. Define the term non-renewable energy.
2. List any three non- renewable sources of energy.
3. Describe two advantages and disadvantages of the following energy sources:
   - 3.1 Coal energy
   - 3.2 Fossil fuel energy

9.5 Storing energy

Energy cannot be created or destroyed, but it can be saved in various forms. One way to store it is in the form of chemical energy in a battery. When connected in a circuit, energy stored in the battery is released to produce electricity.

A **battery** for the purposes of this explanation will be a device that can store **energy** in a chemical form and convert that **stored** chemical **energy** into electrical **energy** when needed.

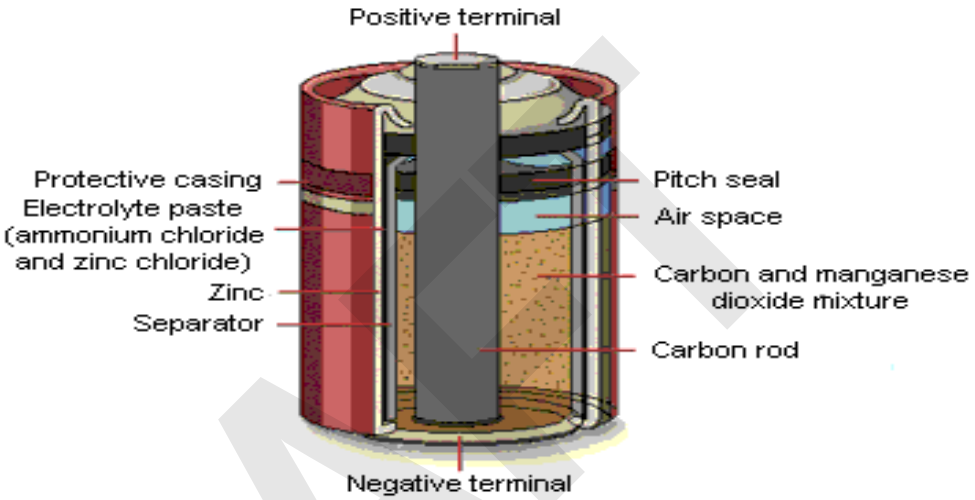
9.6 Primary cells vs Secondary cells

Primary cells:

A primary cell is a battery that is designed to be used once and cannot be recharged with electricity and re-used.

Examples of primary cells:

Dry cells, alkaline cell and Leclanché cell.



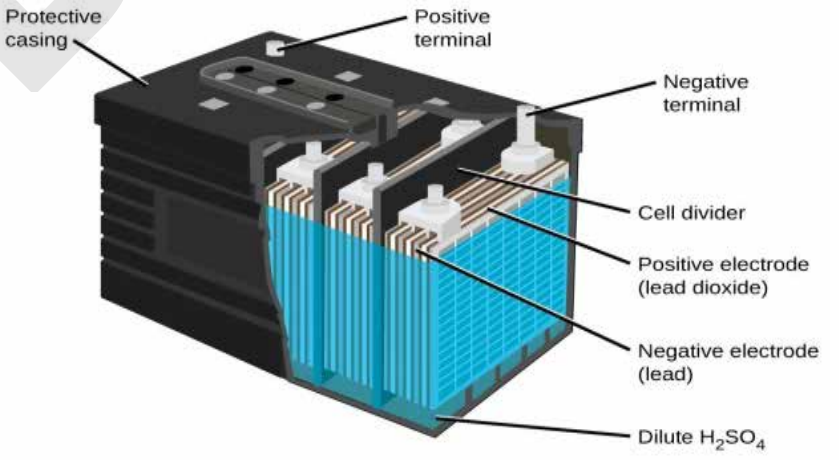
Zinc-carbon (Leclanché) cell

Secondary cells:

Chemical cell that produces electricity by reversible chemical reaction and can be reused as a new one after a recharging process.

Examples of a secondary cell:

Nickel-cadmium (NiCd), lead acid, and lithium ion



Lead acid battery

9.7 Difference between primary cell and secondary cell

Primary cell	Secondary cell
If charged once, cannot be recharged If discharged once, can be recharged	
They are light in weight	They are heavy
Mostly used for low current rate	They are used for heavy current rate
Low life because cannot be recharged	High life because can be recharged
Cheaper	Expensive

9.8 Advantages and disadvantages of secondary cells

Advantages	Disadvantages
They are rechargeable	Expensive
Low internal resistance	Cost of the charger may be high
Reliable	Poorer charge retention
More cost-efficient over the long term	
High power density	
High discharge rate	
Good low temperature performance	

9.9 Advantages and disadvantages of primary cells

Advantages	Disadvantages
They are cheaper	It is not rechargeable
Low discharge rate	High internal resistance
Convenient	
Requires minimal maintenance	

Activity 4

1 Explain the difference between primary cells and secondary cells.
2 List two examples of secondary cells.
3 List two examples of primary cells.

Practical Activity: Demonstrating the ability of a lemon to generate power

Aim: To demonstrate the ability of a lemon to generate power.

What you will need:

- 1 lemon
- 1 copper nail, screw, or wire, roughly 5 cm in length
- A zinc nail, screw, or galvanized nail, roughly 5 cm in length
- 1 small lightbulb with about 5 cm of electrical wire (enough wire to connect the two nails)

Procedure: Four simple steps to lemon battery success:

Step 1: Press down (gently) on your lemon and roll it around on a table to get the juices flowing inside it. You want it to be soft, but you do not want to break the skin.

Step 2: Insert both nails into the lemon, about 5 cm apart. Be sure they are not touching each other, and do not let them puncture through the other side of your lemon.

Step 3: Remove the insulation from around the electrical wire, exposing the bare wire beneath.

Step 4: Wrap the exposed wire around both the copper nail and zinc nail, and ta-da! Your lightbulb will light up.

Teacher Signature: …….. Date: ……..

Logics

CHAPTER

10

Learning objectives

By the end of this chapter the learner should be able to use and define logics, The following will be covered in this chapter:

- What is Digital?
- What is Analogue?
- The difference between digital and analogue
- Symbol, Circuit diagram and Truth table of the AND gate

Walther Bothe, inventor of the coincidence circuit, got part of the 1954 Nobel Prize in physics, for the first modern electronci AND gate in 1924. Konrad Zuse designed and built electromechanical logic gates for his computer Z1 (from 1935–38).

10.1 Introduction

Digital logic is the representation of signals and sequences of a digital circuit through numbers. It is the basis for digital computing and provides a fundamental understanding on how circuits and hardware communicate within a computer. Digital logic is typically embedded into most electronic devices, including calculators, computers, video games, and watches. This field is utilized by many careers that work with computers and technology, such as engineers and repair technicians.

10.2 What is Digital?

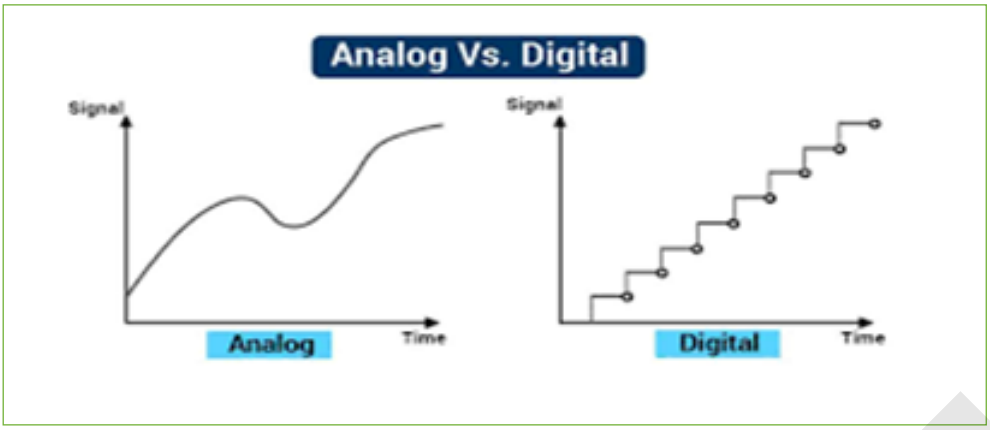
Digital describes electronic technology that generates, stores, and processes data in terms of two states: positive and non-positive, one and zero.

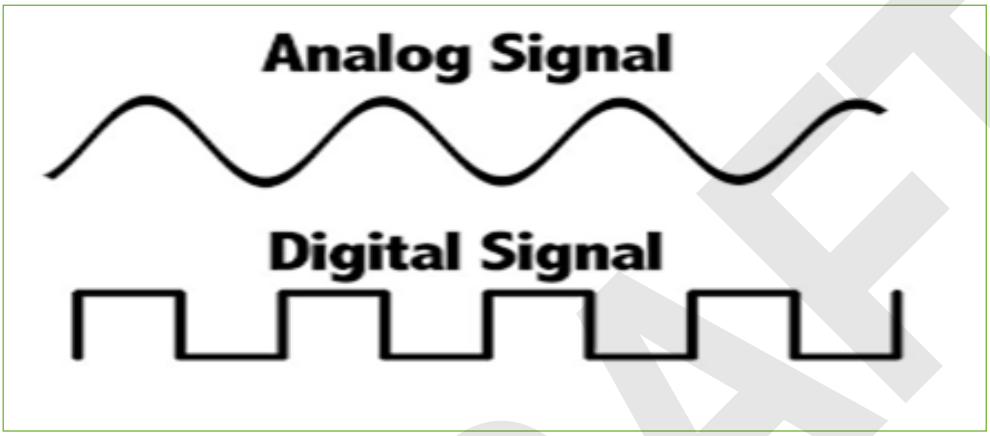
10.3 What is Analogue?

Analogue describe signals or information represented by a continuously variable physical quantity such as spatial position, voltage, etc.

10.4 The difference between digital and analogue

The main difference between analogue and digital signals is that the analogue signals have a gradual change from one level to the next, whereas digital signals vary between two logic states. (High = 5 volts and Low = 0 volts)





Activity 1

Draw the waveform of the following signals:

a) Analogue signal

b) Digital signal

Define the term digital.

Binary Logic – 0 and 1

Binary (or base-2 e.g., 1001_2) is a numeric system that only uses two digits — 0 and 1.

Computers operate in binary, meaning they store data and perform calculations using only zeros and ones.

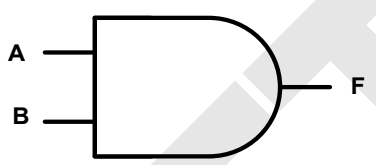
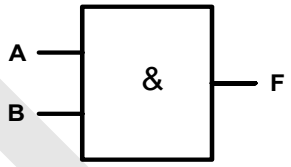
A single binary digit can only represent true (1) or False (0) in logic. This means a switch or circuit is ON = 1 (Logic High) and OFF = 0(Logic Low). In Logic circuits the Logic High= 1 is usually 5 V and the Logic Low = 0 is usually 0 V.

10.5 Symbol, circuit diagram and truth table of the AND Gate

Logic Gates

A Digital Logic Gate is an electronic device that makes logical decisions based on the different combinations of digital signals present on its inputs. Digital logic gates may have more than one input but only have one digital output.

The AND gate

<table>
<tr><td>Symbol</td><td colspan="2">AMERICAN
 
</td><td>IEC
 
</td></tr>
<tr><td>Switch Circuit</td><td colspan="3"> 
</td></tr>
<tr><td>Operation</td><td colspan="3">• When switch A is Open and switch B is Open the lamp will be OFF
• When switch A is Open and switch B is Closed the lamp will be OFF
• When switch A is Closed and switch B is Open the lamp will be OFF
• When switch A is Closed and switch B is Closed the lamp will be ON</td></tr>
<tr><td>Truth Table</td><td colspan="2"><table><tr><th>A</th><th>B</th><th>X</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table></td><td>A truth table consists of ALL variables at the input with the expected result at the output. A truth table is a table that help us to understand the behaviour of logic gates. They show how the inputs of a logic gate relate to its outputs.</td></tr>
</table>

Activity 2

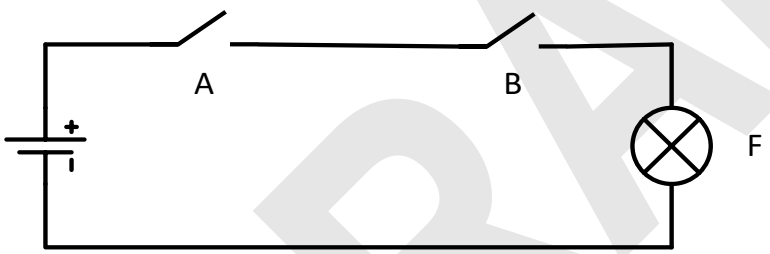
1. Name the 2 logic states for digital circuitry.
2. State the voltage level for the Logic High state.
3. Explain the purpose of a truth table.
4. Draw an AND Gate equivalent logic circuit using two switches and a bulb.
5. Draw the IEC symbol for the AND gate.
6. Draw the Truth Table for the AND gate.

Practical Activity 1

Aim: To build a logic circuit using switches to prove the theory of an AND gate.

What will you need:

- 2 x SPST switches
- Connecting wires
- 1 × 9V PP3 and battery snap
- 1 × Bulb and bulb holder



What to do:

Step 1:

Carefully construct the following circuit.

Do not connect the battery until the circuit has been checked by the educator.

Step 2:

After the circuit has been checked by the educator and permission given to continue:

- Connect the battery and test the circuit
- Complete the Truth Table below using the following information:

Switch A **(ON)** = **1**, Switch A**(OFF)** = 0

Switch B **(ON)** = **1**, Switch B**(OFF)** = 0

Bulb **(ON)** = **1**, Bulb **(OFF)** = **0**

0	0
0	1
1	0
1	1

Step 3:
Study your completed table and write down your observations about the circuit.

Teacher Signature: …….. Date: ……..

Practical Activity 2: Building an AND gate circuit using 7408 IC

Aim: To build a logic circuit using 7408 IC to prove the theory of an AND gate.

What will you need:

- 2 x switches
- Connecting wires
- 1 × 9 V PP3 and battery snap
- LED
- Breadboard
- 7408 IC

0	0
0	1
1	0
1	1

Domestic Installation

CHAPTER

11

Learning objectives

By the end of this chapter the learner should be able to use demonstrate the knowledge of a simpledomestic installation. The following will be covered in this chapter:

- Electrical energy distribution from the supplier to the consumer
- Sequence of Connection from Supplier to Consumer: Block Diagram
- Components used in a Domestic installation:
  - Earth leakage
  - Circuit breakers
  - Isolator
  - Socket outlet
  - Switches
  - Cables
- Cable installation:
  - Gland
  - Purpose of the Gland
  - Types of glands
- Connection boxes (domestic)
- Cables
  - Surface mounting (on trays)
  - Underground cables
  - Overhead cables
  - Cable sizes
  - Wiring conductors, sizes and uses
- The 3-pin plug pins identification.

The fundamental principles of **electricity generation** were **discovered** in the 1820s and early 1830s by British scientist Michael Faraday. His method, still used today, is for **electricity** to be generated by the movement of a loop of wire, or Faraday disc, between the poles of a magnet.

11.1 Introduction

Domestic electrical installations are within the scope of the Building Regulations. All new domestic electrical installations, together with specific alterations and additions to current installations, will have to be inspected and comply with strict electrical safety performance standards. The standards cover the design, installation, inspection and testing of domestic electrical work and the provision of information.

The main reason for the change was the need to reduce the hazards posed by

unsafe domestic electrical installations and thereby help to reduce injuries from electrical shocks and burns. It is also hoped to reduce injuries arising from fires in dwellings due to electrical components overheating or arcing.

11.2 Electrical energy distribution from the supplier to the consumer

Electricity is produced at a generating station (power station), is carried over high-voltage transmission lines to deliver to the local points that distribute the power. The electricity passes through cables which are suspended from towers (electrical pylons). These towers are arranged in series from the generating station to the substations and transformers are used to reduce voltage to the levels that can be used by the consumers: homes and businesses. Figure 1 below shows an example of an electrical energy distribution from generating station to the consumers.

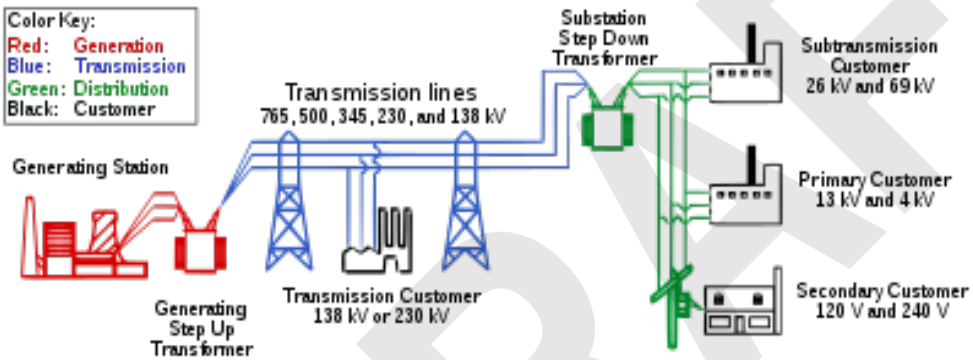
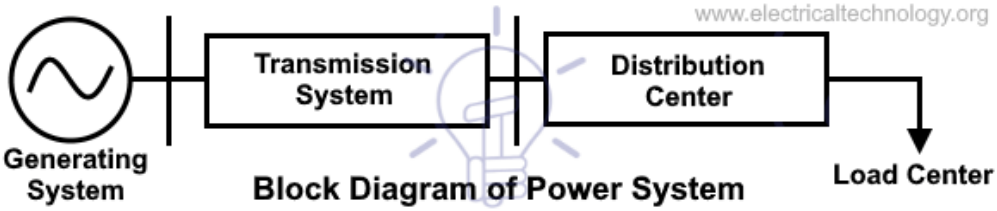


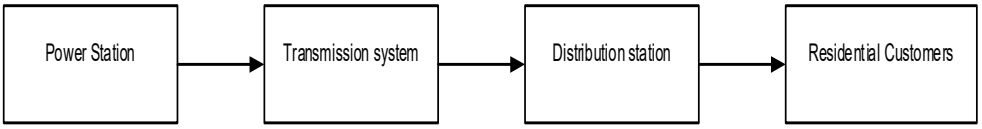
Figure 1: Electrical energy distribution supplier to consumer

11.3 Sequence of Connection from Supplier to Consumer

Electricity is produced at a power station (Generating System), is carried over high-voltage transmission lines (Transmission System) to deliver to the local points that distribute the power (Distribution centre). The electricity passes through cables which are suspended from towers (electrical pylons). These towers are arranged in series from the generating station to the substations and transformers are used to reduce voltage to the levels that can be used by the consumers: homes (Load centre)



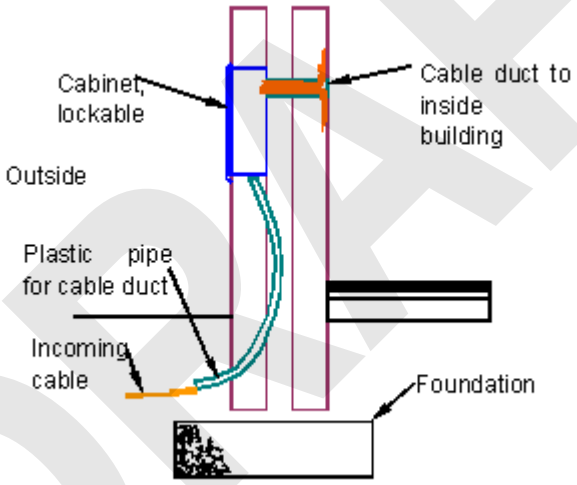
or



Block diagram: Supplier to Consumer

Domestic Installation

Domestic installation refers to the electrical installation of the house, commonly called house wiring. Most domestic premises are supplied with 220 Volts or 240 Volts, the current of 60 Amperes and frequency of 50 Hertz. The electricity supplied in a domestic installation comes through the main cable (supplier cable), underground or overhead supply goes to supplier circuit breaker (fuse) which is locked out in an external cabinet on the consumer outside house wall. See figure below:



11.4 Components used in domestic installation

Earth leakage:

An **earth-leakage** circuit breaker (ELCB) is a safety **device** used in electrical installations with high **earth** impedance to prevent electrical shock and electrical fires. It detects small stray voltages on the metal enclosures of electrical equipment and interrupts the circuit if a dangerous voltage is detected. Below are two types of earth leakage circuit breakers:

Single Phase ELCB

Three Phase ELCB

Circuit breakers:

A circuit breaker is an electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. This opens or stops the circuits based on relays. Below are different types of circuit breakers.

Figure 4 Circuit Breakers

Isolator

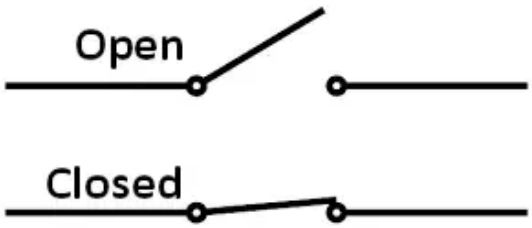
Isolators are used to open a circuit under no load. Its main purpose is to isolate one portion of the circuit from the other and is not intended to be opened while current is flowing in the line.

Socket outlet

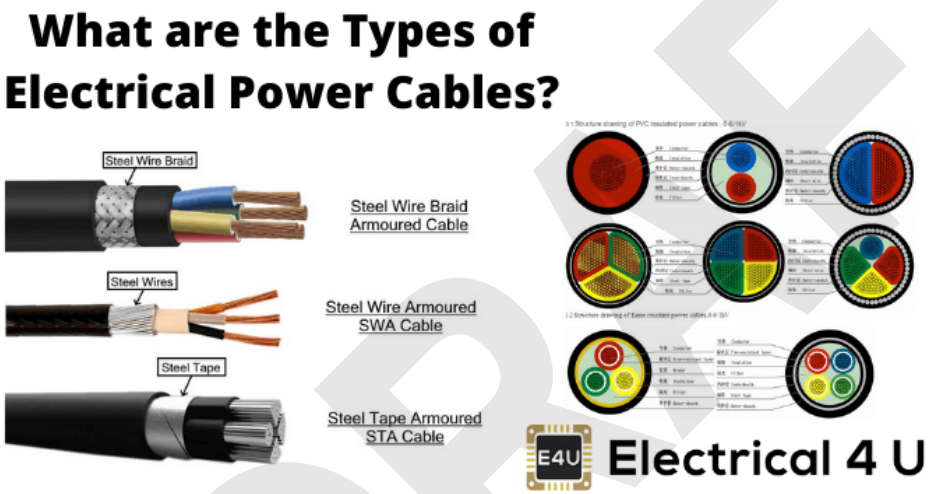
Electrical outlets (also known as electrical sockets, plugs, and wall plugs) allow electrical equipment to connect to the electrical grid. The electrical grid provides alternating current to the outlet. There are two primary types of outlets: domestic and industrial. While not obvious from looking at them, the two sides of an electrical outlet represent part of a ‹loop of wire' and plugging an electrical device into that outlet completes that loop, which allows electricity to flow through the device so it can operate. In other words, each side of an electrical outlet acts as a terminal.

Switches

In electrical engineering, a switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another



Cables



Cable installation

Cable installation can be done in two ways

- Open wiring (surface wiring). Open means exposed. This type of wiring method using cleats, knobs, saddles, tubes and flexible tubing for the protection and support of insulated conductors running on walls and are not concealed or hidden under any elements of the building.
- Concealed wiring (flush conduit wiring). Concealed means "hidden". So, this wiring is done inside the floors/walls and it is further concealed or hidden by plastering the wall.

Activity 1

1. State the four main stages in the process of supplying electricity from the supply to consumers.
2. Explain the term domestic installation?.
3. Draw the block diagram of a distribution from supplier to consumer.
4. Explain the purpose of a circuit breaker.

11.5 Gland

When a cable enters a junction box or distribution board it is common practice for it to first pass through a gland called a pressure gland or a compression gland.

Purpose of the gland:

- It provides the cable extra protection from the sharp edges around the entry hole of the box.
- It reinforces the cable against over-bending on entry.
- To form a liquid-tight seal to prevent any moisture from entering the junction box.
- It acts as a strain relief holding the cable in a fixed position preventing stress from pulling or twisting.

Types of glands

Plastic cable glands

Galvanized cable gland

PVC cable gland

Flameproof cable gland

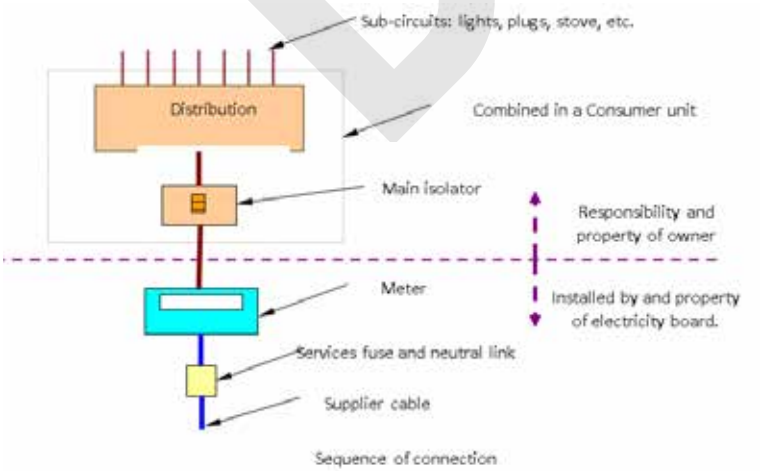
11.6 Connection boxes (domestic)

Item	Description	Application
	Conduit box: 1way	Used at the end of conduit
	Conduit box: 2 ways	Used for junction, also wires changing different directions
	Conduit box: 3 ways	Used for junction, also when wires changing different directions
	Conduit box: 4 ways	Used for junction, also when wires changing different directions

What is an electrical installation?

An electrical installation is Electrical wiring of cabling and associated devices such as distribution boards, switches, socket-outlets and light fittings in a structure.

An electrical installation is usually invisible to the consumer, with cables concealed and out of sight behind walls and plaster and only the outlet like sockets and switches being seen. It does not include appliances such as kettles, stoves, TV's and washing machines, which are connected to the installation through its socket-outlets

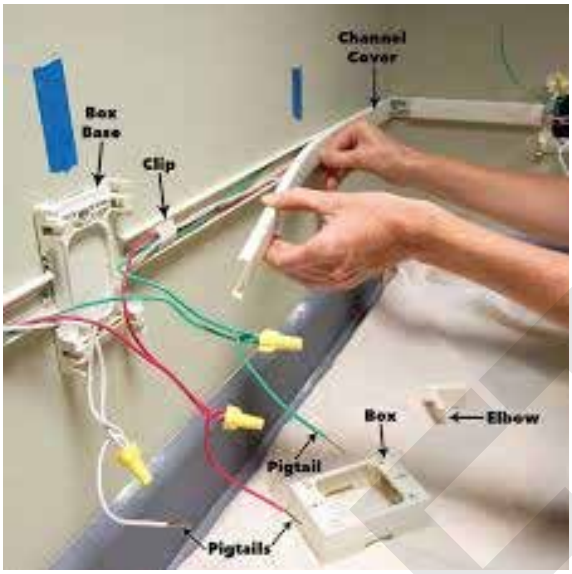


(Pipex)

Figure 2 Domestic electrical installation

11.7 Cables

Surface mounting



What is Surface-Mounted Wiring?

Surface-mounted wiring, also known as electrical raceways, are wires that run across walls (and are already connected to electrical boxes behind the walls) that allow you to add a new light fixture or ceiling fan without having to cut into the wall to add a new electrical box. They are quite convenient for people wanting to add an electrical unit without all the hassle.

Underground cable/ armour cable

What are underground cables:

An underground cable is a cable that is buried below the ground. They distribute electrical power or telecommunications. Such cables are an alternative to overhead cables, which are several meters above the ground. Overhead cables are often replaced with underground cables. Downtown

areas with many tall buildings usually have few or no cables above ground, This is mainly for aesthetic purposes because underground cables cannot be seen. They are also less dangerous to people because they are out of the way. They cost more to install, but last longer.

Overhead cables:

An *overhead cable* is a *cable* for the transmission of information, laid on utility poles. Telephone lines and streetlamp lines are also examples of overhead cables.

Cable sizes

The proper wire size is critical to any electrical wire installation. Wire sizing indicates the diameter of the metal conductor of the wire. The gauge of a wire relates to the wire's current-carrying capacity, or how much amperage the wire can safely handle. When choosing the right size of the wire, you must consider the gauge of the wire, the wire capacity, and for what the wire will be used.

Sizes

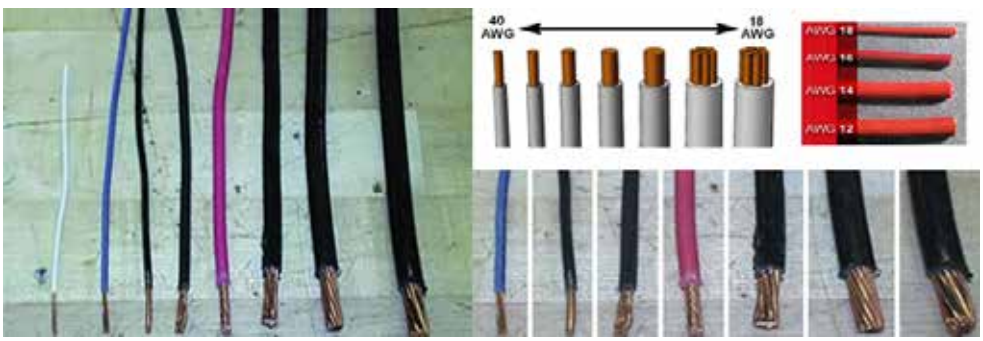
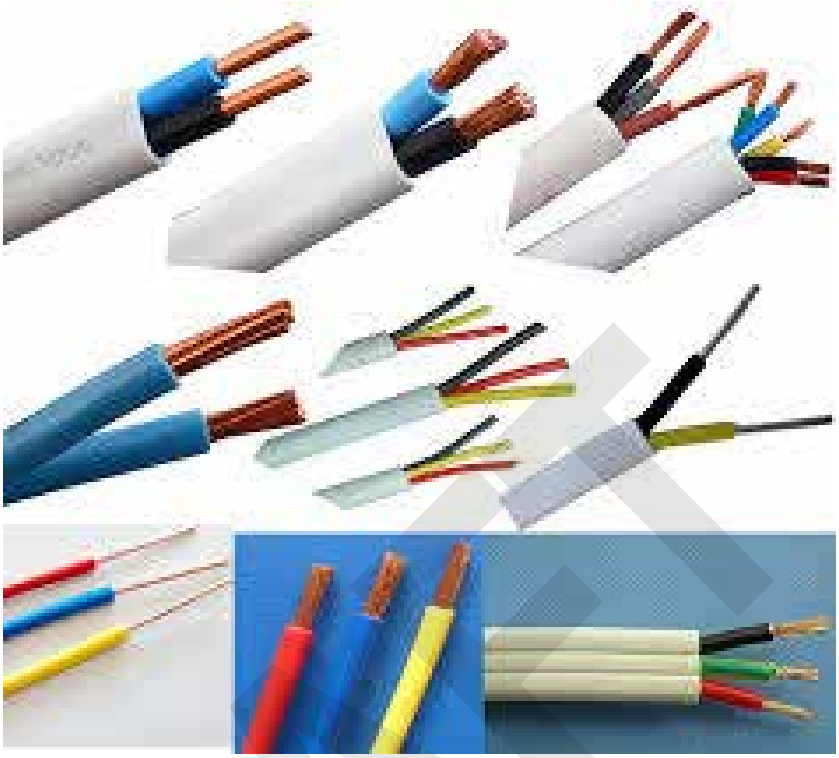


Figure 5 Different wire sizes

Wiring conductors



What are wiring conductors:

Electrical wires may be made of copper or aluminium metal, both of which conducts electricity, but copper is a much better conductor than aluminium and a safer option. When electricity flows from one point to another through something such as an electrical wire, it is called conductivity. The wire would then be called the conductor.

In the electrical system (or installation), conductors are identified with specific colour codes as outlined by SANS:

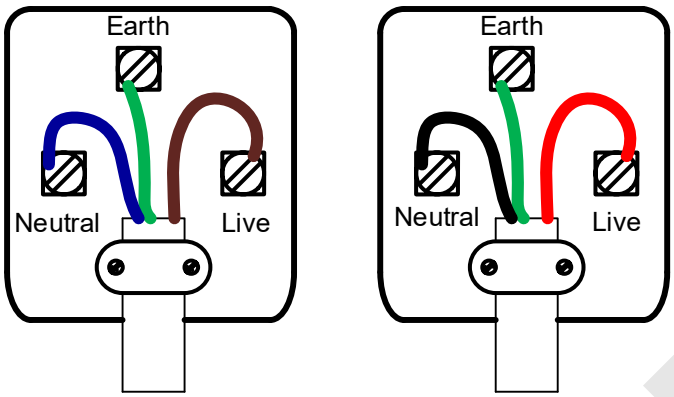
- Live: red, white, or blue
- Neutral: black
- Earth: green-yellow or bare copper wire

Sub-circuit	Conductors size	Ratings
Lighting circuits	1.5mm^2	10 A
Plug circuit	2.5mm^2	20 A
Geyser circuits	2.5mm^2	20 A
Stove	6mm^2	40A
Earth leakage sub-circuit	16mm^2	63 A

Table 1 showing conductor sizes and current ratings for various sub-circuit

11.8 Three pin plug pins identification

A plug is usually used to connect household appliances, such as kettle and ions and other equipment to the electric supply. The plug carries three brass pins which connects with corresponding contacts in the socket. The standard size plug used in houses are the 16 amps 3 pin plug



Activity 2

1. Explain the purpose of a gland.
2. List two components used in domestic installation.
3. Explain the use of the different coloured wires /cables in a Distribution Board: (Red wire, Black wire, and Green / yellow wire).
4. List three types of cables used in domestic installation.
5. Complete the table below to show the cable size and rating current:

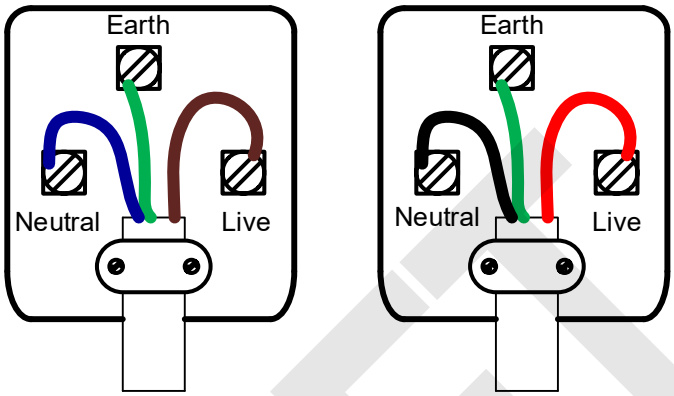
Sub-circuit	Size or sectional area	Rating current
Sub-circuits		
Light		
Plug circuits		
Geyser circuits		
Stove		
Earth leakage sub-circuit		

Practical Activity 1: Wiring a three-pin plug

Aim: Demonstrate an understanding of the procedure of wiring a three-pin plug

What you will need:

- Tools: flat screwdriver, Phillips screwdriver, side cutter, wire stripper
- Cable: approximately 1m length of: 10mm^2 red, green, and black cable



What to do:

Step 1: Use a screwdriver to open the plug

Step 2: Loosen the Earth (E), Live (L) and Neutral (N) screws on the plug.

Step 3: Place the Red cable into the Live (L) pin of the plug

Step 4: Place the Black cable into the Neutral(N) pin of the plug

Step 5: Place the yellow and green cable into the Earth pin of the plug.

Teacher Signature: …….. Date: ……..

Practical Activity 2: Wiring a 3-pin plug to a lamp

Aim: To demonstrate an understanding of the procedure of wiring a 3-pin plug to a lamp

What you will need:

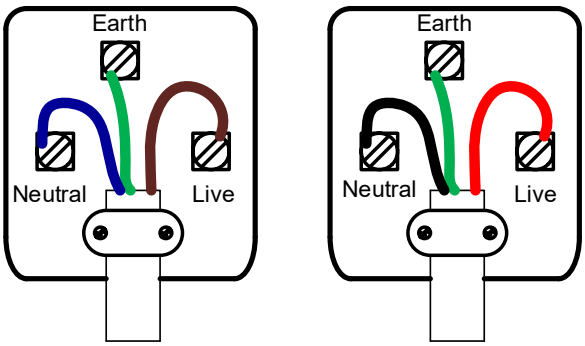
- 1 x side cutter
- 3 core cable 1 m
- 1 x wire stripper
- Screwdriver
- 1 x switch
- Multimeter
- Bulb holder
- 220 v Bulb

What to do:

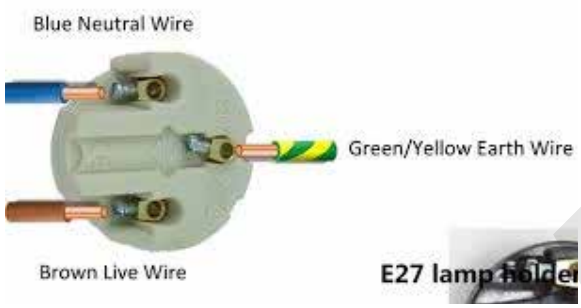
Cut the required length of the cable.

Prepare the cable by removing the cable insulation 10 mm on both ends.

Connect the one end of the cable to the 3-pin plug as shown below.

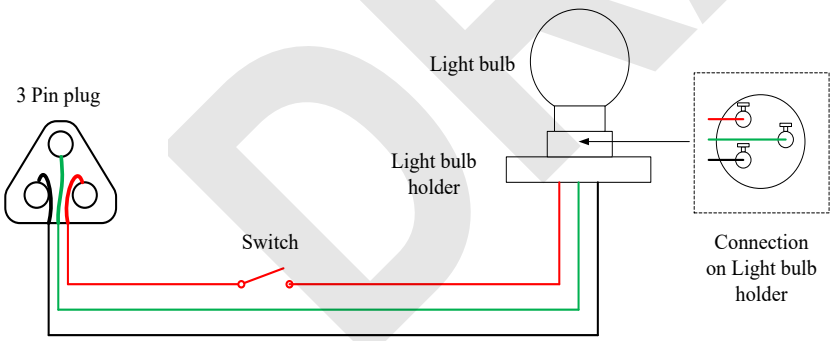


Connect the other end of the cable to the bulb holder.



Test for the continuity between the terminals of the 3-pin plug also the ends of the cables.

Plug the 3-pin plug into socket and switch ON.



Q: Of the three cables that are connected to a globe holder:

Where will the red cable be connected to?

A: ……

Where will the black cable be connected to?

A: ……

Where will the green/yellow cable be connected to?

A: ……

Teacher Signature: …… Date: ……

Practical Activity 3: Wiring a distribution board

Aim: The learner will demonstrate an understanding of the procedure of wiring a distribution board

What you will need:

- 1 x Consumer Distribution board complete with earth and neutral bus bars
- 1 x 60A earth leakage
- 1 x 40A circuit breaker
- 1 x 30A circuit breaker
- 1 x 20A circuit breaker
- 1 x 15A circuit breaker
- 1 x multimeter
- Tools: flat screwdriver, Phillips screwdriver, side cutter, wire stripper
- Cable: approximately 1m length of: 10mm2 red, green, and black cable

What to do:

Follow the wiring diagram below carefully install the earth leakage device and the four circuit breakers.

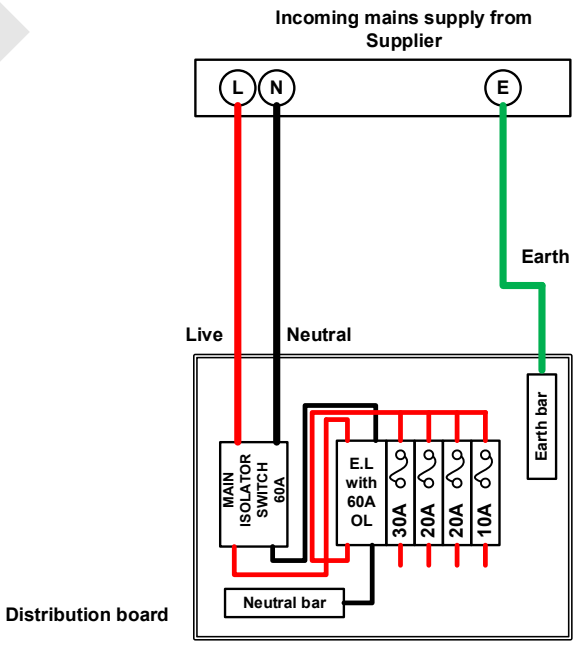
Using the red cable, connect each circuit breaker together to the earth leakage device.

Using the black cable, connect the neutral bus bar to the earth leakage.

To complete the wiring run three cables out of the distribution board: a red and black from the earth leakage and a green/yellow from the earth bus bar.

During this procedure you must demonstrate that you are able to use a wire stripping tool to correctly prepare the cable ends.

Using the multimeter demonstrate that you are able to perform a continuity test on your completed wiring assembly.



Questions: Of the three cables that leave the distribution board:

1. Where will the red cable be connected to?

A: ……

2. Where will the black cable be connected to?

A: ……

3. Where will the green/yellow cable be connected to?

A: ……

Teacher Signature: …….. Date: ……..

Practical Activity 4: Connecting a three-core cable to a gland

Aim: Connect a three-core cable to a gland

Components needed:

- 3 core cable
- PVC gland
- Combination plier
- Wire stripper
- Steel ruler

Procedure:

Cut 600 mm length of the cable

Remove the insulation around the conductors.

Loosen and remove the nut of the gland, pull through the gland 150 mm of the uninsulated cable, tighten the gland using the nut.

The teacher will assess neatness and correct measurement of the cable.

Teacher Signature: …….. Date: ……..