LEARNER'S BOOK

ELECTRICAL TECHNOLOGY

GRADE 9

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

KAGISO TRUST
Overcoming poverty

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Electrical Technology Grade 9 Learner's Book

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Tango22: p.323 (seventh photo); John O'Neill: p.375; Mrs Cranfield: p.14

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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

CHAPTER

1

Occupational Health and Safety

LEARNING OUTCOMES

By the end of this chapter, learners should be able to use the electrical workshop safely and follow 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
- general safety rules
  - unsafe acts
  - unsafe conditions
- learning about different personal protective equipment (PPE)
- learning about good housekeeping
- identifying and learning about different safety signs
- fire prevention and protection
  - elements of fire
  - classification of fires
  - causes of fires
- types of firefighting equipment
- exploring basic first aid
- what is a first aid kit and what does it contain
- types of injuries
  - cuts
  - burns
  - fractures
  - trauma (shock)

1.1 Introduction to 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. All safety rules and procedures are regulated by the Occupational Health and Safety Act (OHS Act No. 85 of 1993).

1.2 General Safety rules

The basic regulations for safety rules are included in the OHS Act No. 85 of 1993. Each workshop has different safety rule requirements and therefore it is the employer who drafts the final safety rules for their own workshops which the workers in the workshop need to obey.

General safety rules:

- Do not enter or leave the workshop without the supervisor's permission.
- A workshop is not a playground, therefore 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 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 equipment or machinery without permission.
- Always use a guard when working on a machine.
- Keep 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 is allowed in the workshop.
- Wear the correct protective equipment for the tools you are using.
- Tie up long hair.
- Turn the machine off before cleaning it.
- No one is allowed in a workshop under the influence of illegal substances.
- No unauthorized person is allowed in the workshop.
- Never put sharp tools or instruments in your pocket.
- Return tools and equipment to their rightful places after use.
- Smoking is not allowed in the workshop.
- The workshop should be kept clean at all times.

Figure 1.1

Activity 1.1

Classroom Activity1.1

State which Act regulates health and safety in workshops.

Describe at least five general safety rules that must be adhered to when you are working in a workshop.

Accidents

What is an accident?

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

Causes of accidents

Accidents are mostly caused by human error. When safety rules and procedures are not observed, accidents can happen, which might cause physical injury or damage to property or equipment.

Prevention of accidents goes hand-in-hand with the adherence to general safety rules in the workshop. Causes of accidents go hand-in-hand with unsafe acts and unsafe conditions in the environment.

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. Unsafe acts may threaten the health and/or safety of workers and even result in permanent injury or death.

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 without permission.
- Working at unsafe speeds.
- Using equipment carelessly.
- Lack of, or improper use of Personal Protective Equipment (PPE).
- Bypass or removal of safety devices.
- Unsafe position or posture when working in the workshop.
- Wearing loose clothing near machines.
- Failure to put warning signs where they are needed.
- Entering or working in the workshop without permission.

Figure 1.2 Example of people who are working in unsafe conditions

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 flickering lights).
- Poor housekeeping.
- Unsafe constructed buildings.
- No machine guards on equipment.
- Wet or slippery floors.
- Working without personal protective equipment.
- Defective hand tools, equipment, machines, etc.
- Poor workshop layout or workflow.
- Failure to put warning signs where they are needed.
- It is estimated that unsafe acts account for 88% of accidents while unsafe conditions account for 10%. Below are some examples of unsafe acts and unsafe conditions.

Figure xx A man falling

Figure xx Being caught in or struck by moving machinery

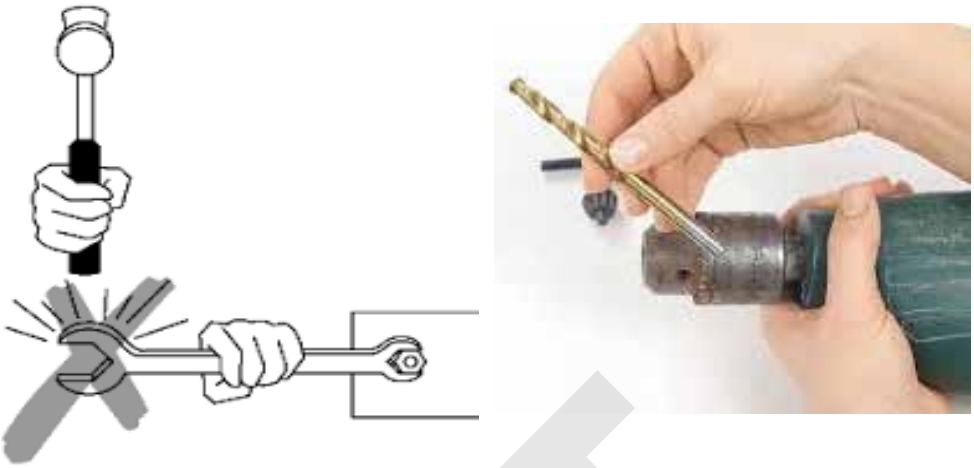


Figure xx Inaccurate setting or wrongful use of machinery

Figure1.3

Activity 1.2

Have you learnt something? Test your knowledge….

What is an unsafe act?

List three examples of an unsafe act.

What is an unsafe condition?

List three examples of an unsafe condition.

1.3 Use of Personal Protective Equipment (PPE)

Personal protective equipment is a collective name for all items worn or used to prevent or minimize injury or hazards, when performing a task. 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**. Every task needs PPE. It will protect you against possible injury or death in the workplace.

New words

electrical hazards dummy text dummy text dummy text dummy text

biohazards dummy text dummy text dummy text dummy text.

airborne particulate matter dummy text dummy text dummy text dummy text

Examples of PPE:

Safety gloves

Working with 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.

Safety gloves are used for protection against the following safety hazards:

- Puncture wounds.
- Cuts and scrapes.
- Heat and chemical burns.
- Hazardous substances that can irritate or be absorbed by the skin.
- Extreme heat or cold.
- Biological agents like bacteria and viruses.
- Loss of finger, nail and skin.
- Needle stick injuries.

Examples of safety gloves:

Figure 1.4 Nitrile chemical resistant gloves

Figure 1.5 General working safety gloves

Safety shoes

Safety shoes protect the feet from falling objects or compression, and against punctures from below. Safety shoes have the following safety features:

- a steel capped toe protection to protect your toes.
- a non-slip sole to prevent slipping when the floor surface is wet or oily.

Figure 1.6 Safety shoes.

Overalls

- Overalls protect the body and clothing worn under the overall from work hazards and limits the exposure of the body or skin against heat, chemicals and other risks.

Figure 1.7 Overalls

Protective eyewear

Protective eyewear usually encloses or protect the area surrounding the eye in order to prevent particles, water or chemicals striking the eyes to prevent injuries. The type of safety eye protection you should wear depends on the hazards in your workplace. If you are working in an area that has particles, flying objects, or dust, you must at least wear safety glasses with side protection (side shields), and if you are working with chemicals, you must wear goggles.

Safety glasses

Safety goggles

Figure 1.8 Protective eyewear

Safety helmet

A safety helmet protects the user's head from injury due to falling objects.

Figure 1.9 Safety helmet

Proper PPE

Figure 1.10 Proper PPE

Figure 1.11

The above illustration shows the proportion in probability in the relationship between a serious accident in relation to unsafe acts and conditions.

Activity 1.3

Classroom Activity1.3

Identify the protective clothing shown in (a) and (b):

(a)	(b)
	

Explain the purpose of the protective clothing shown in (a) and (b)

(a)	(b)
	

1.4 Good housekeeping

Figure 1.12

"A clean and orderly workshop is a safe workshop." Good housekeeping means working in an orderly way, and always returning tools and materials to their correct places.

This practice ensures that the workshop is always kept clean and tidy, making it a better 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, to fully realise the benefit of a clean workplace. It is recommended that good housekeeping be maintained throughout the course of the job and workday. To continually improve the safety culture, housekeeping is the responsibility of everyone.

Why is good housekeeping desirable?

- It saves time.
- It cuts costs.
- It ensures that the workplace is safe.

Good housekeeping can:

- Eliminate clutter which is a common cause of accidents, such as slips, trips, and 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).
- Help to keep the workshop inventory to a minimum (good housekeeping makes it easier to keep an accurate count of inventory).

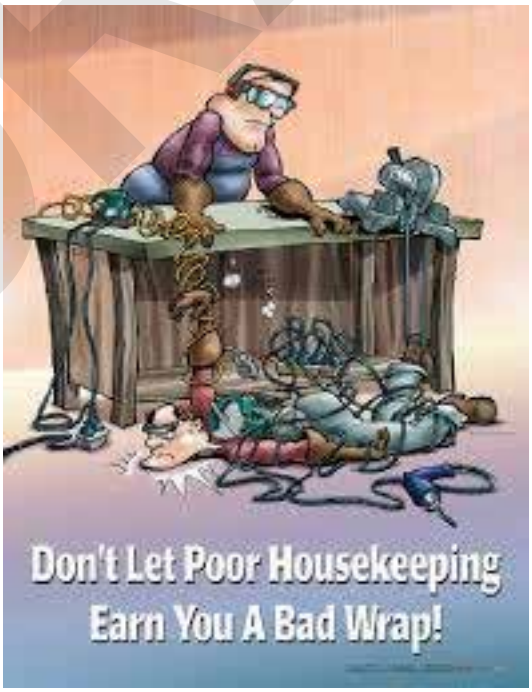


Figure 1.13 Poor house keeping

Figure 1.14 Depiction of poor housekeeping

Advantages of Good Housekeeping:

- Fewer accidents.
- Increased life of building, machinery, tools, equipment, etc.
- Improved employee morale.
- Increased production.
- Better product quality.
- Continuous cleaning reduces housekeeping costs because intermittent clean-up is more expensive.
- Little or no time is lost in searching for tools etc.
- Material handling and transportation pick up speed.
- Inspection, maintenance and production control functions become easier.
- Much floor space otherwise occupied by unused raw material and tools, etc. is released for production.

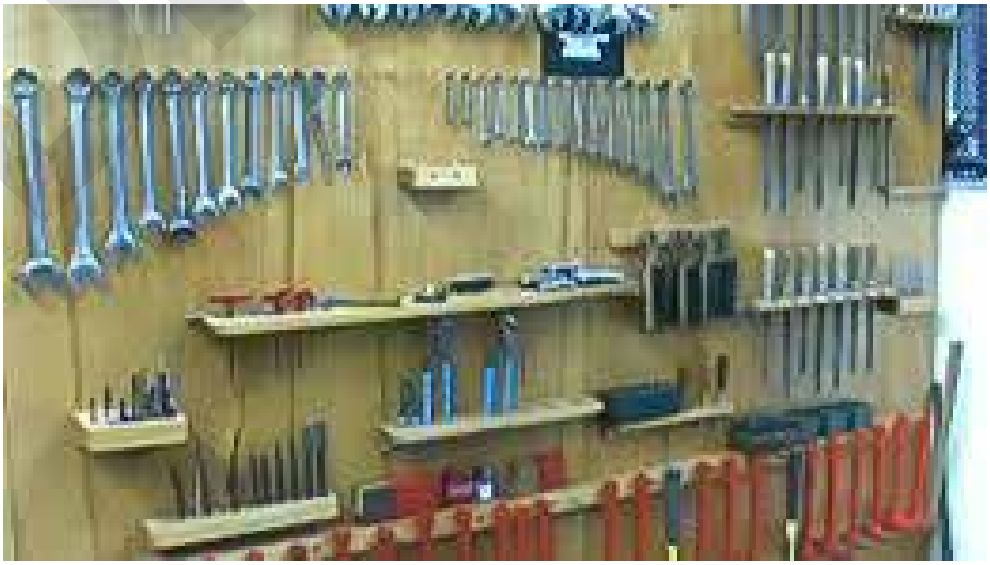


Figure 1.15 Example of good housekeeping

Effective housekeeping can help control or eliminate workplace hazards. It includes keeping work areas neat and orderly, maintaining floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas.

Good housekeeping also means every tool has got its place in the workshop. Tools or equipment lying around may result in an accident and even injuries.

Figure 1.16 Example of good housekeeping

Figure 1.17 Example of poor housekeeping

Slips, trips and falls account for one third of all personal injuries in the workplace and are a top cause of workers' compensation claims. The types of injuries incurred from slips, trips and falls include head and back injuries, broken bones, cuts and lacerations (a deep cut or tear in skin or flesh), sprains (stretching or tearing of ligaments) and pulled muscles.

The most common reasons for falls in the workplace are:

- ***Slips*** - Wet or oily surfaces, occasional spills, weather hazards, loose rugs or mats and flooring that lacks the appropriate degree of traction.

Figure 1.18 Wet floor with caution sign

- ***Trips*** - Obstructed view, poor lighting, clutter (untidy collection of things), wrinkled carpeting, uncovered cables, uneven walking surfaces and bottom drawers not being closed.

Figure 1.19 Tripping hazards in workshop

There are three keys to preventing workplace accidents due to slips, trips and falls, namely, good housekeeping, quality walking surfaces and proper footwear. Beyond that, employees should be reminded to take their time and pay attention to where they are going. They should also be encouraged to report areas where clutter and obstruction is, as well as where spillage or damage have occurred.

Machinery that's not properly guarded is a potential safety hazard. When body parts get caught in or struck by exposed moving parts or flying objects from machines without protective guards, the results are often disastrous. The long and horrifying list of machinery-related injuries includes crushed hands and arms, severed fingers, blindness and worse.

The most important rule in preventing mechanical hazards is to remember that any machine part, function or process that may cause injury must be safeguarded. Also, existing hazards must be controlled or eliminated, and proper operator training and protective clothing must be provided.

Figure 1.20

Activity 1.4

Have you learnt something? Test your knowledge….

Why it is important to maintain good housekeeping in the workshop?

List three advantages of good housekeeping.

List three key aspects to preventing workplace accidents due to slips, trips and falls.

Describe the golden rule in preventing mechanical hazards.

1.5 Safety signs

Safety signs must be used in the workshop to indicate safety regulations that must be adhered to.

Shape	Meaning	Colour	Example
Triangles: 	Warning: Indicates caution (potential hazards) or warning (definite hazards), for example toxic gas and electric shock.	Yellow: Notifies workers to take caution and be alerted of hazards, reducing necessary risks.	
Circles: 	Mandatory action: Mandatory or recommended actions and are normally used to depict an action you must do, for example wearing eye goggles and safety hard hats	Blue: Shows a particular action or behaviour, for example instruction to wear personal protective equipment.	
Squares or rectangles: 	Information about safe conditions: Shows information, i.e., general information and emergency information (first aid, firefighting).	Green: Designates the location of emergency measures or equipment like first aid kits, evacuation routes, fire exits, escape ladders, or assembly point.	
A Circle with a 45° diagonal slash across the middle from the upper left to the lower right: 	Prohibition: Points out forbidden or prohibited actions.	Red signs: Designates areas for emergency devices like firefighting equipment, or to emphasise unsafe or forbidden actions.	

Figure 1.21 Safety signs

Safety signs are being classified into different groups, namely:

- Informative signs -colour coded green/white/red/black
- Fire prevention signs - colour coded red/white
- Danger signs -colour coded yellow/black
- Mandatory (compulsory) signs -colour coded blue/white
- Prohibition signs -colour coded red/white/black.

Figure 1.22 Safety signs

Emergency stops

An emergency stop button is a manually controlled safety device that switches off all the machines in a workshop instantly when it is pressed. It enables anyone to switch off machines anywhere in a workshop in order to prevent an accident. Simply put, an emergency stop function is a function that is initiated by a human action and is intended to shut down equipment in the case of an emergency.

Figure 1.23 Emergency stop button

Figure 1.24 Emergency shut-off switch sign

Emergency exits:

An emergency exit is a clear and safe way to get out of a structure or building. It provides fast exit in case of emergency such as a fire. First responders may also use it as a way into the building, so it is very important to make sure they are ready to use at all times. Fire exit signs are part of an emergency evacuation system that guides people in residential, commercial or public buildings where there are many people, to the closest exit so they can leave the building safely.

Emergency exit signs must be installed on, above or adjacent to each door providing direct exit from a story to an enclosed or external stairway, passageway or ramp serving as a required exit; and on, above or adjacent to a door to an external access balcony leading to a required exit.

1.6 Fire prevention and protection.

Fires in the workplace are frequently caused by risk factors such as faulty gas lines, poor pipefitting, improperly stored combustible materials, flammable liquids, open flames and electrical faults. The resulting injuries incurred include damage to the respiratory system, varying degrees of burns, potential disfigurement and death. Fires account for 3% of workplace injuries and have the highest casualty rate of all probable workplace accidents.

Figure 1.25 Emergency exit sign

Every workplace should have a clearly communicated evacuation plan and an effective alert system in place to quickly inform every one of hazards and emergency situations.

Elements of fire:

- Heat,
- Fuel
- Oxygen

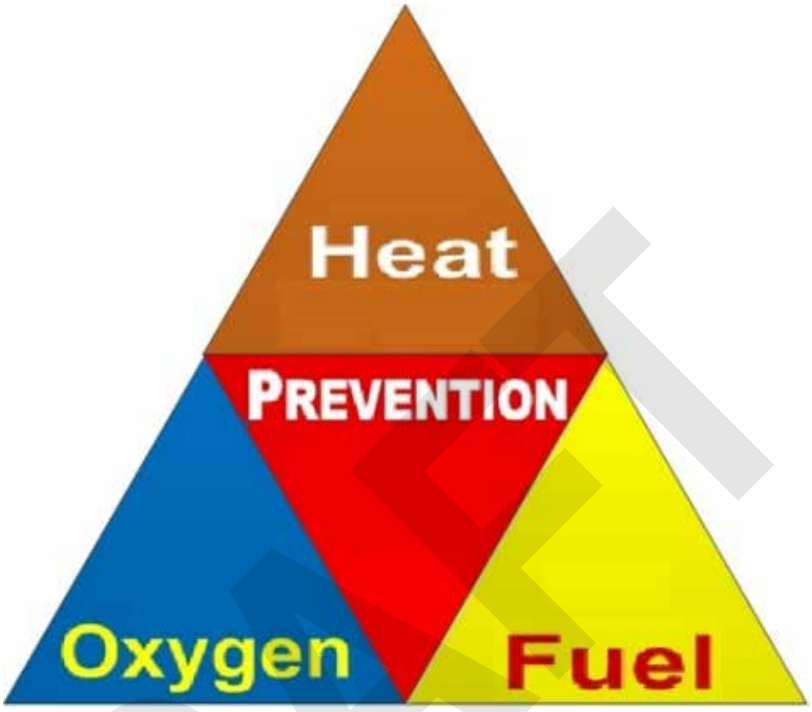


Figure 1.26 Elements of fire

Classification of fire, causes and types of fire extinguishers

Class	Causes	Type of fire extinguisher
A	Solid materials such as wood, plastic and paper.	Foam, water, wet chemicals and dry powder.
B	Flammable liquids such as petrol, diesel and oil.	Foam, CO2 and dry powder.
C	Flammable gases such as methane, argon, acetylene and propane	Dry powder.
D	Metals such as aluminium, magnesium and titanium.	L2 and M28 powder.
E	Electrical apparatus.	CO2 and dry powder.
F	Cooking oil and fats.	Wet chemicals or wet blanket.

Causes of fire in workshops

Some of the most common causes of fires at the workplace are the following:

- Faulty electrical equipment and static electricity
- Clutter.
- Combustible materials – e.g., uncontrollable spontaneous ignition, chemical reactions
- Human error – e.g., matches and cigarettes
- Negligence – e.g., open flames
- Arson
- Lightning.

Activity 1.5

Have you learnt something? Test your knowledge….

1 State three safety sign shapes.

2. State the meaning of a warning sign.

3. State the colour you would associate with a prohibition sign.

Figure 1.27 Electrical fire

1.7 Types of firefighting equipment.

Prevention of fire

Practical advice for preventing fires from spreading include:

- using fire safety equipment such as fire extinguishers or fire blankets.
- regularly checking smoke alarms.
- closing doors and windows.
- having a clean and tidy workplace.
- call emergency services as soon as possible.

Firefighting equipment:

One of the most important aspects of health and safety within any industry is the equipment used in the fight against fires. This includes all deterrent, detection, warning, and firefighting components, such as smoke detectors, fire alarm systems, fire extinguishers, safety doors, and emergency lighting.

Firefighting equipment is equipment designed to extinguish fires or protect the user from fire. It includes not only fire hoses and fire extinguishers but also fire-resistant protective clothing, fire-resistant gloves, respirators, and communication equipment.

Equipment used for firefighting:

- Fire extinguishers.
- Fire alarm systems.
- Smoke detectors.
- Fire suit.
- Fire extinguisher cylinders.
- Fire sprinklers.
- Fire hydrants.
- Fire safety service.

Figure 1.28 Firefighting equipment

Activity 1.6

Have you learnt something? Test your knowledge….

- What are the basic elements of a fire?
- What are the common causes of fires?
- What are the practical ways to prevent fires from spreading?
- List at least five fire equipment needed to conduct firefighting

Group Activity 1.1

Have you learnt something? Test your knowledge….

- In your groups, investigate the current situation in your own workshop and identify the firefighting equipment. Write a short report on the following:
- Type of extinguisher.
- Date of service.
- Current condition.
- Comment on placement of fire extinguisher.

Practical Activity 1.1

PRACTICAL: SAFETY SIGN

Design your own safety sign that will instruct and remind people who are entering the electrical workshop that they should wear PPE. The poster must include pictures of PPEs and their names.

1.8 Basic First Aid.

What is first aid?

First aid is the emergency 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.

First aid is conducted in three stages:

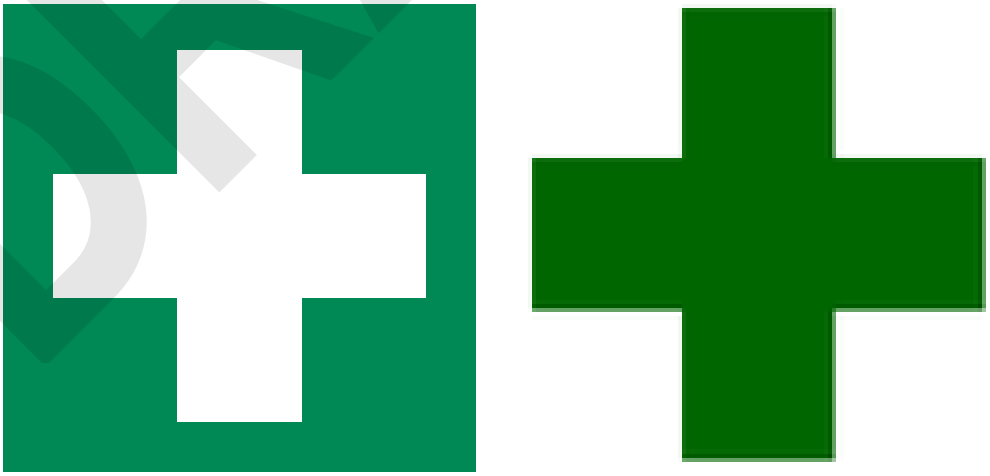
- Examination
- Diagnosis
- Treatment

Figure 1.29 First Aid Kits

Figure 1.30 First aid sign

The Health and Safety (First Aid) regulations require employers to provide enough and appropriate equipment, facilities and personnel to ensure that employees receive immediate attention if they are injured or ill at work before emergency medical treatment is available. The first-aid provider in the workplace should ensure that emergency care is given immediately to an injured person.

The International Organization for Standardization (ISO) sets a standard for first aid kits in order to make them easily recognizable to anyone requiring first aid. Colours used are green, with a white cross, or a green cross on its own.



ISO First Aid Symbol

Alternate version of the first aid symbol

Figure 1.31 First Aid Symbols

1.9 What is a first aid kit

A first aid kit is a collection of supplies and equipment that is used to give medical treatment.

A first aid kit should contain the following items:

- Adhesive tape
- Anaesthetic spray (Bactine) or lotion (Calamine, Campho-Phenique) - for itching rashes and insect bites
- 10 cm x 10 cm sterile gauze pads - for covering and cleaning wounds, as a soft eye patch
- Different sizes of bandages - for wrapping sprained or strained joints, for wrapping gauze on to wounds, for wrapping on splints
- Adhesive bandages (all sizes)
- Diphenhydramine (Benadryl) - oral antihistamine for allergic reactions, itching rashes. Avoid topical antihistamine creams because they may worsen the rash in some people.
- Exam gloves - for infection protection, and can be made into ice packs if filled with water and frozen
- Polysporin antibiotic cream - to apply to simple wounds
- Non-adhesive pads - for covering wounds and burns
- Pocket mask for CPR
- Resealable oven bag - as a container for contaminated articles, can become an ice pack
- Safety pins (large and small) - for splinter removal and for securing triangular bandage sling
- Scissors
- Triangular bandage - as a sling, towel, tourniquet
- Tweezers - for splinter or stinger or tick removal
- In case of a medical or trauma related emergency, a list of family member›s medical history, medications, doctors, insurance company, and contact persons should be readily available.

The most common injuries are trauma injuries. Trauma injuries, such as bleeding, bone fractures or burns, are usually the main focus of most first aid kits, with items such as bandages and dressings being found in most kits.

Basic First Aid-response and incident management

Basic First Aid is one of the critical survival skills that everyone should know. Many lives could be saved annually if everyone knew basic first aid skills.

First aid is defined as the initial care for the injured casualty on the scene where the injury happened. This care is usually done before the arrival of emergency medical service by people who are not medical professionals.

All the procedures done in First Aid are focused on achieving the following three aims or goals, known as the three Ps of First Aid.

You are the most important person on scene!

Preserve Life

The first aim when providing first aid is to save lives. Some of the most commonly known lifesaving first aid procedures are:

- Cardiopulmonary resuscitation (CPR): for keeping someone's heart working and brain alive,
- Heimlich manoeuvre: for dislodging an object that causes choking,
- Controlling heavy bleeding which prevents shock and death,
- Opening the airway in unconscious casualties, i.e., "prevent tongue swallowing",
- While saving other's person life, it's important to remember that your life and safety always come first.

Prevent worsening/deterioration

Sometimes you can't be a movie hero and save lives, but you can stop the situation from worsening or complicating. For example, if there's a casualty with suspected spine injury, you should not move them in order not to cause any further harm and deterioration of the condition.

Promote Recovery

In some cases, you can't save a life or prevent deterioration, but you can promote faster recovery. For example, if a child fell while riding a bike and got small wound with minor bleeding, you'll have to wash it with water and dress it.

This way you'll prevent wound infections which promotes faster recovery. If infection occurs, there will be need of additional medical procedures and that will significantly increase recovery time.

Incident Management in First Aid

The environment where an accident happened is often stressful and overwhelming, therefore it's important to carefully manage the incident and the risks.

1.10 Types of injuries

- **Cuts:** A cut refers to a skin wound with separation of the connective tissue elements.
- The treatment of a cut or laceration depends upon the severity of the wound. A cut refers to a skin wound with separation of the connective tissue elements. Unlike an abrasion (a wound caused by friction or scraping), none of the skin is missing the skin is just separated.

- **Burns:** Burns are tissue damage that results from heat, overexposure to the sun or other radiation, or chemical or electrical contact. Burns can be minor medical problems or life-threatening emergencies. The treatment of burns depends on the location and severity of the damage.
- **1st-degree burn**. This minor burn affects only the outer layer of the skin (epidermis). It may cause redness and pain.
- **2nd-degree burn**. This type of burn affects both the epidermis and the second layer of skin (dermis). It may cause swelling and red, white or splotchy skin. Blisters may develop, and pain can be severe. Deep second-degree burns can cause scarring.

- **3rd-degree burn**. This burn reaches to the fat layer beneath the skin. Burned areas may be black, brown or white. The skin may look leathery. Third-degree burns can destroy nerves, causing numbness.

Burns are caused by:

- Fire
- Hot liquid or steam
- Hot metal, glass or other objects
- Electrical currents
- Radiation, such as that from X-rays
- Sunlight or other sources of ultraviolet radiation, such as a tanning bed
- Chemicals such as strong acids, lye, paint thinner or gasoline

Fractures: A fracture is the medical term for a broken bone. It can range from a thin crack to a complete break. Bone can fracture crosswise, lengthwise, in several places, or into *many* pieces. Most fractures happen when a bone is impacted by more force or pressure than it can support.

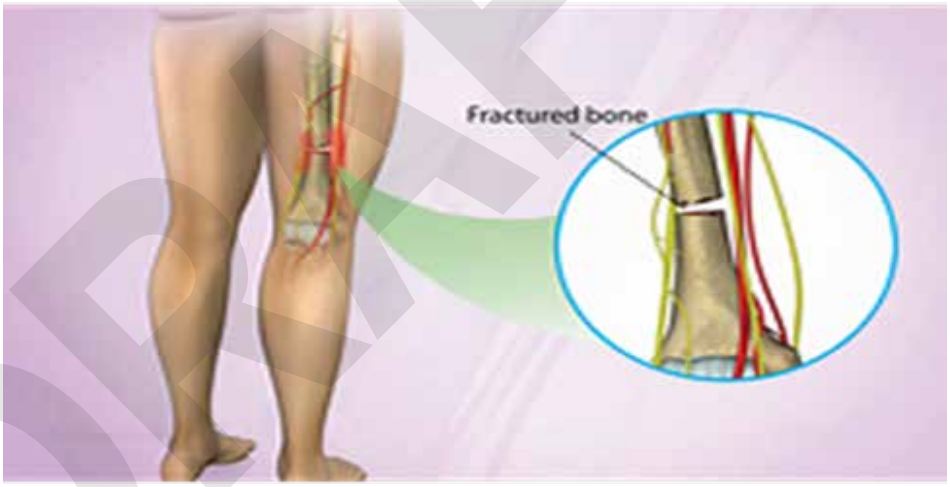


Figure 1.32 Bone fracture

Causes of fractures includes:

- Car accidents
- Falls
- Sports injuries
- Overuse such as in sports can cause stress fractures, which are very small cracks in the bone.
- Low bone density
- Osteoporosis which weakens bones.

There are several different ways in which a bone can fracture. For example, a closed fracture is a break to the bone that does not damage surrounding tissue or tear through the skin. By contrast, a compound fracture is one that damages surrounding tissue and penetrates the skin.

Simple Fracture. Also called closed fractures, they occur when your bone suffers breakage.

Compound Fracture. It is opposite to simple fracture and is also known as an open fracture.

Oblique Fracture. In this type of fracture, the fissure runs diagonal to the axis of your bone.

Transverse Fracture. This fracture is perpendicular to the axis of the bone.

Symptoms of fractures includes:

- Pain
- Swelling
- Snapping sound heard when bones break
- Deformed appearance of limb
- Skin bruising or bleeding

How to treat a fractured arm using first aid:

A simple and partial break might be treated with a sling, ice and rest. However, the bone may require realignment in the emergency room. A more complicated break might require surgery to realign the broken bone and to implant wires, plates, nails or screws to keep the bone in place during healing. If it is an open fracture, cover the wound with a sterile dressing or a clean non-fluffy cloth. Apply pressure around the wound and not over the protruding bone, in order to control any bleeding. Then secure the dressing with a bandage. Advise the casualty to keep still while you support the injured part to stop it from moving.

Trauma (Shock)

Traumatic shock, also known as acute stress disorder, is the body's defence mechanism or response to the overwhelming emotions post trauma. The brain is unable to fully process or respond to the traumatic event, therefore the mind and body freeze or dissociate to protect the psyche. Trauma is an acute medical condition associated with a fall in blood pressure, caused by such events as loss of blood, severe burns, allergic reaction, or sudden emotional stress. It is marked by cold, pallid skin, irregular breathing, rapid pulse, and dilated pupils.

Physical symptoms of traumatic shock:

- A sudden decrease in blood flow
- Dilated pupils
- Irregular heartbeat
- Light headedness

- Nausea
- Muscle tension
- Difficulty moving or functioning
- Unconsciousness.

How to treat a patient in shock:

Shock is a life-threatening condition that occurs when the body is not getting enough blood flow. Lack of blood flow means the cells and organs do not get enough oxygen and nutrients to function properly. Many organs can be damaged as a result. Shock requires immediate treatment and can get worse very rapidly

The following steps should be taken when a person is in shock:

- First call the emergency response team.
- Lay the person down, if possible,
- Elevate the person's feet about 30 centimetres unless head, neck, or back is injured or you suspect a broken hip or leg bones.

- Do not raise the person's head.
- Turn the person on their side if they are vomiting or bleeding from the mouth.
- Begin CPR, if necessary, when the person is not breathing or breathing seems dangerously weak. Continue CPR until help arrives or the person wakes up.

- Treat obvious injuries.
- Keep the person warm and comfortable.

- Loosen restrictive clothing.
- Cover with a coat or blanket.
- Keep the person still, and do not move him/her unless there is danger.
- Reassure the person.
- Do not give an injured person in shock anything to eat or drink.

Practical activity 1.2

Tutor to assist with the task and simulation

- How to treat a fractured arm using first aid.
- How to treat a person in shock.

Main safety principles in first aid response

Your own safety comes before anyone's else safety. You must keep yourself alive and healthy to help others. In case of severe fire or harmful chemicals, you must keep a safe distance from the burning object or dangerous scene. You can get closer only if you have special protective equipment and appropriate training. Otherwise, you will have to call and wait for the appropriate emergency services to manage the risk.

There's a risk of explosion, getting injured by sharp objects like broken glass, flying metal etc. Before going to help, you should appropriately manage all the risks.

Important aspects to consider in an emergency:

- Calling appropriate emergency service number.
- List of emergency telephone numbers.

- Make sure you have appropriate footwear as sharp objects are very common in workplaces.
- Keep in mind of exposed electrical wiring in workshop because of explosion or fire.
- Never place yourself between the casualty and the threat.
- Always keep safe distance during the incident.
- Be aware of the risk of more fire and explosions.

It is important to assess possible danger when approaching an accident scene, for example: aggressive behaviour, electrical shock, harmful chemicals, falling debris. If the scene is not safe, one should maintain a safe distance and call the appropriate emergency services. Precautions should be taken in case there is an electrical related incident. A piece of wood or any non-conducting material must be used to turn off the source of electricity.

Activity 1.7

Classroom Activity 2.1 …

Explain what basic first aid is.

Complete the following work sheet by identifying and giving the purpose of the equipment found inside a first aid kit. (Orally)

NAME	ITEM	PURPOSE
Bandage		2.1
2.2		Providing isolation from bodily fluids when assisting an injured person.
Antibiotic Ointment		2.3

NAME	ITEM	PURPOSE
2.4		Providing protection to an injured eye.
Cold pack		2.5

List three symptoms of electric shock.

Write down the steps to be followed when assisting somebody who is electrocuted.

Name four types of injuries that may occur in the workshop.

CHAPTER

2

Graphics Communication

LEARNING OUTCOMES

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:

- Introduction to Graphics Communication
- The purpose of Graphics Communication
- Safety precautions to be taken when using drawing instruments
- Correct use and care of drawing instruments
- Types of lines
- Printing/lettering, dimensions, and borders
- Freehand drawing
- Orthographic (2D) and pictorial drawings (3D)
- Scale drawing 1:1 and 1:2

2.1 Introduction to Graphics Communication

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:

- 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.
- 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 must be taken in the Graphics Communication classroom when working with sharp objects such as dividers and compasses to prevent injury and bleeding. Injuries and bleedings might lead to others contracting the Human Immunodeficiency Virus (HIV), which is the virus that causes Acquired Immunodeficiency Syndrome (AIDS). HIV attacks the human Immune system, making humans more vulnerable to diseases and infections.

2.4 Correct use and care of drawing instruments

Name	Use	Care
 drawing board	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	Used to draw horizontal lines and guides when drawing vertical lines.	Wipe with a clean cloth, preferably a yellow duster.
 45º set square	Used to draw parallel and perpendicular lines, and standard measure angles (45 º and 90º).	Wipe with a clean cloth preferably a yellow duster.

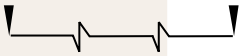
Name	Use	
 30º /60º set square	Used to draw parallel and perpendicular lines, and standard measure angles (30º /60º and 90º).	Wipe with a cl preferably a y
 scale rule	Used to measure length, width and height.	Wipe with a cl preferably a y
 protractor	Used to measure angles.	Wipe with a cl preferably a y
 compass	Used to draw circles and arcs.	The lead on th be kept sharp
 pencils	Used for lettering and drawing lines. Pencils come in different grades (H, B, F and HB).	Keep sharpen

Name	Use	Care
 pair of dividers	Used to transfer the measured distances on maps and drawings onto paper.	Always ensure that the points remain sharp for accuracy.
 eraser	Used to clean the dirt off the drawing and for making changes or correcting errors in a drawing.	Use a cotton cloth or soapy water to clean it. It must be totally 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:

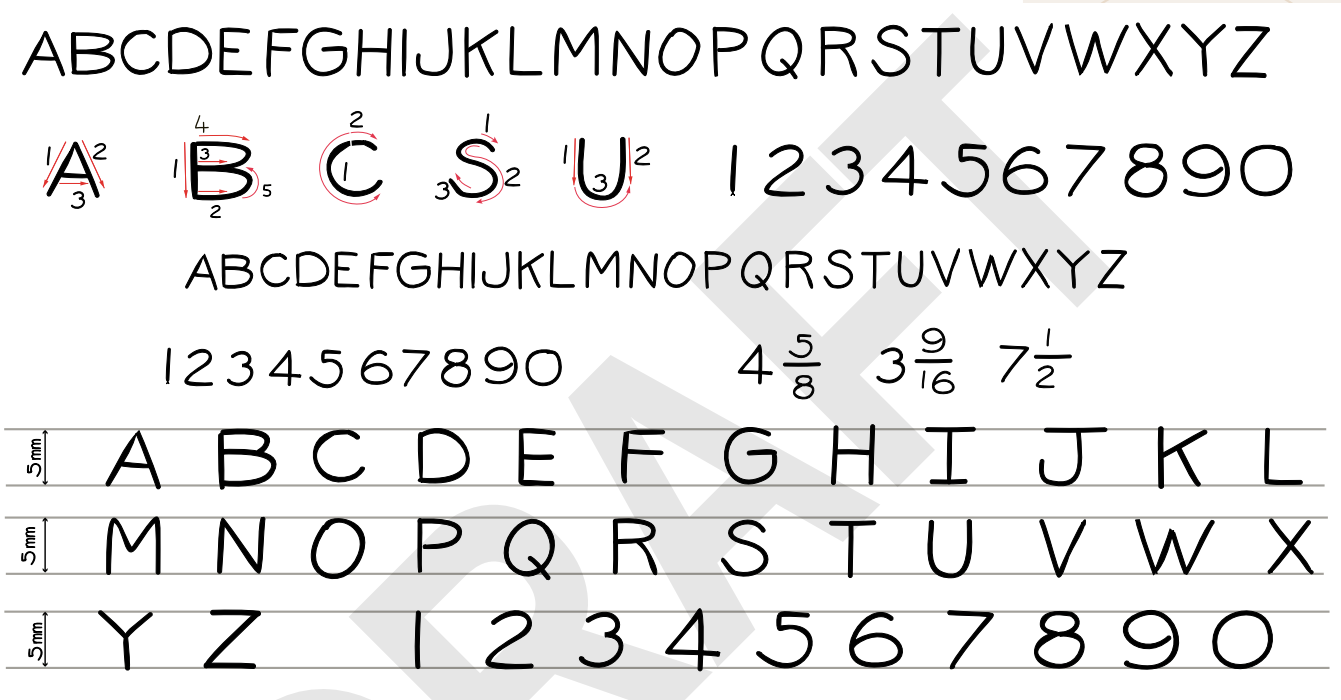
	Line type	Description	General application
A		continuous line – dark	Used for visible outlines and edges.
B		continuous line – light	Use for dimension lines, extension lines, hatching lines, and leader lines.
C		continuous line – very light	Used for construction lines, projection lines, and guidelines for printing.
D		dashed line – light	Used to show hidden details.
E		chain line – light	Used for centre lines, pitch lines and circles, and lines indicating symmetry.
F		chain line with dark ends	Used for cutting planes.
G		short break line	Used for irregular boundaries.
H		long break line	Used for limits of views and sections if the line is not an axis.

2.6 Printing

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.



Activity 2.1

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

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

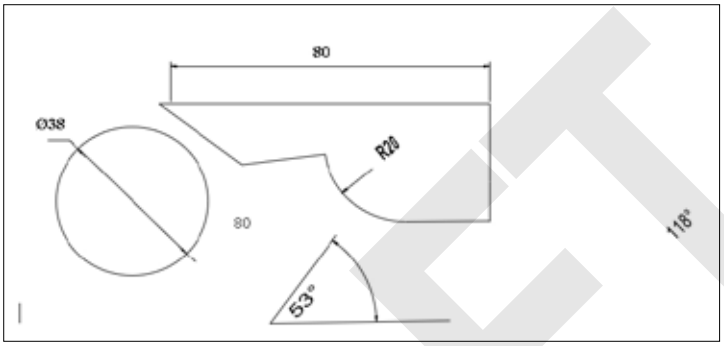
a b c d e f g h i j k l m n o p q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0

2.7 Dimensions

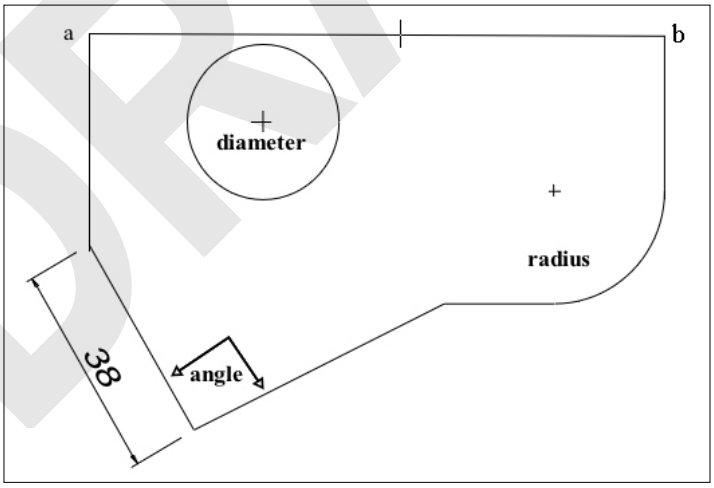
The application of dimensional line work for graphic communication must be in accordance with the South African National Standards (SANS 0111). Graphic communication as a language is composed of symbols, dimensions, notes, and different types of lines to convey the correct meaning.

The drawings below show different line types which are used in graphic communication:



Activity 2.2

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



2.8 Two-dimensional projection

Orthographic 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.

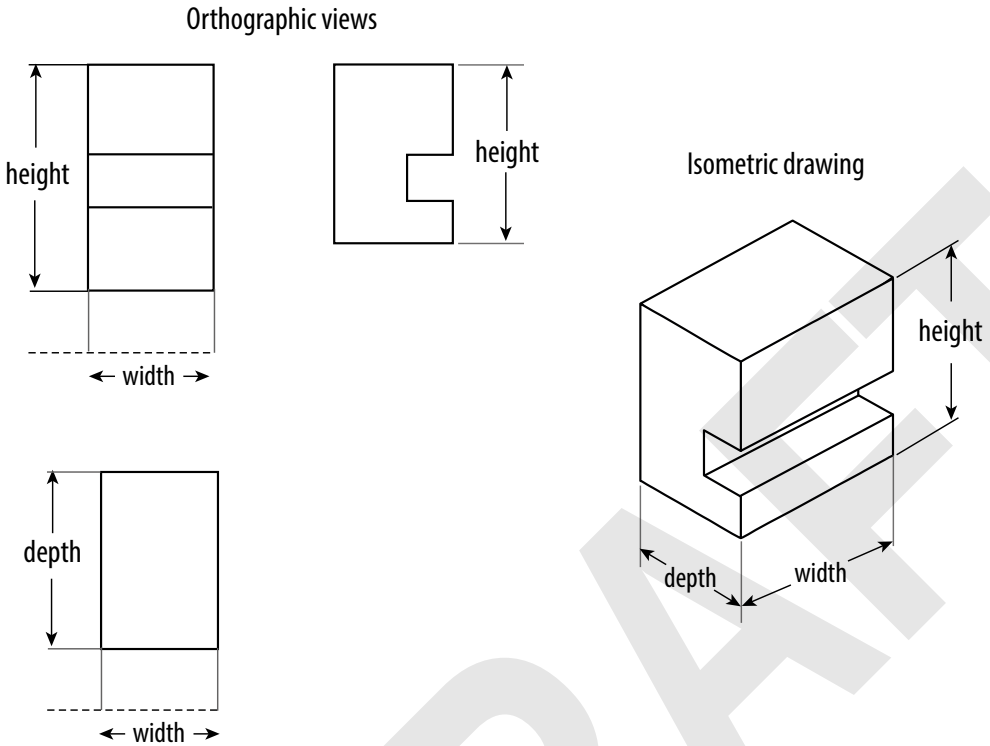


Figure 2.9 Orthographic projection of an object

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.

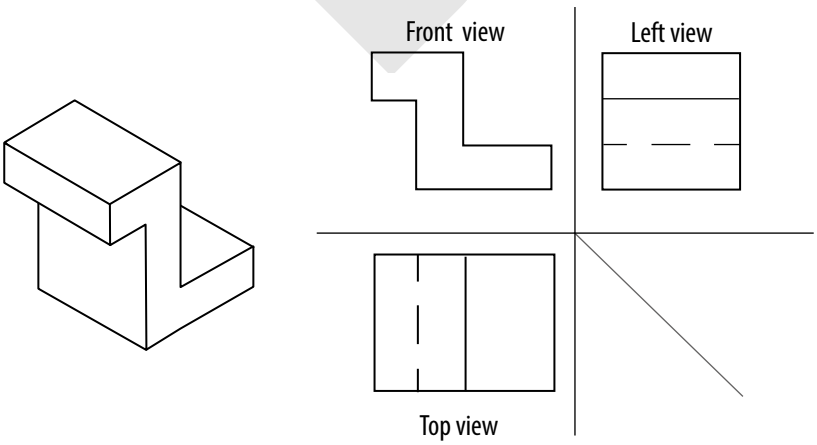
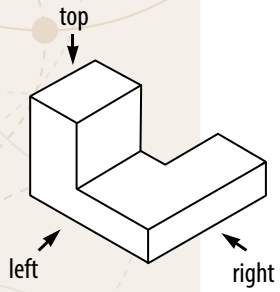
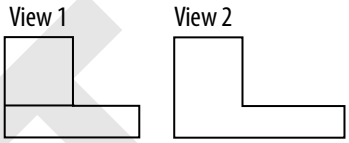
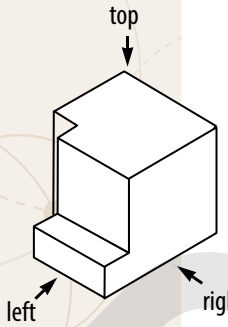
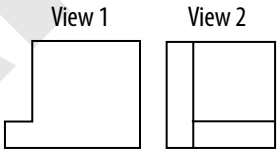
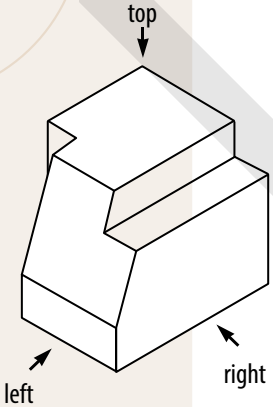
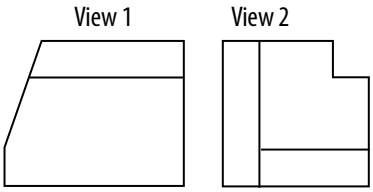


Figure 2.10 Orthographic projection of an object

Activity 2.3

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

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

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

2.9 Isometric drawing

Definition of Isometric drawing

An isometric drawing is a way 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 (90º angles). All isometric lines are drawn to scale.

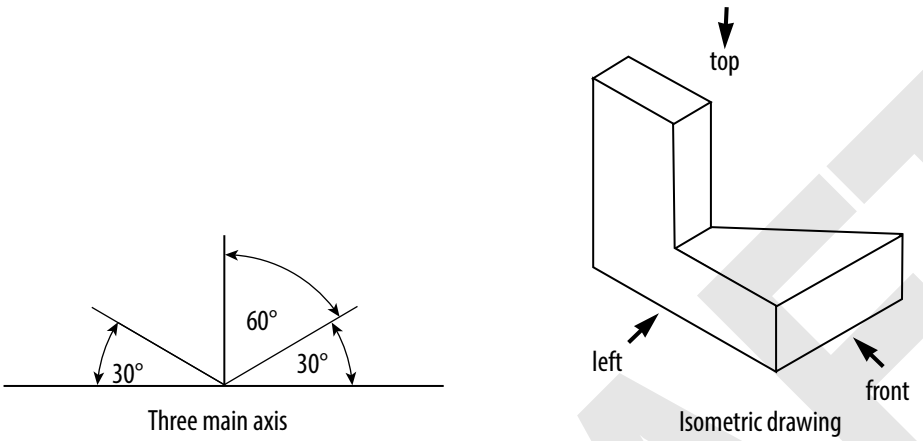


Figure 2.xx An isometric drawing of an object

It's All About the Angle

What makes an isometric drawing different from other 3-dimensional drawings?

The axes are drawn so that the two horizontal axes are at 30o angles. It is as if the vertical axis is in its true position, but the horizontal axes are bent 30o from their true position.

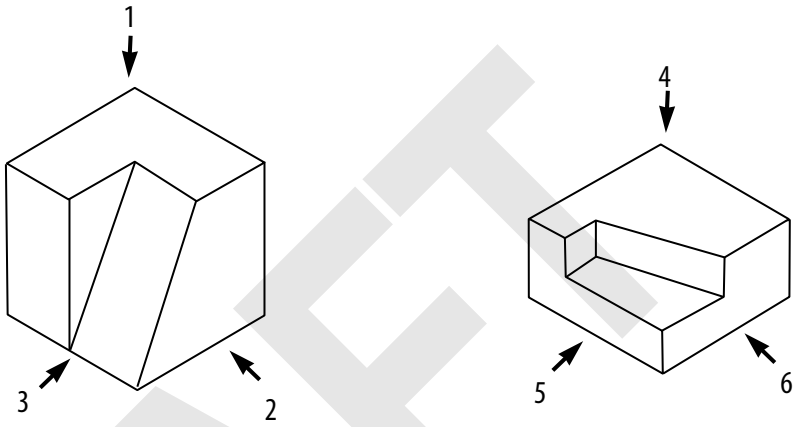
Although the isometric lines are drawn to scale, none of the isometric planes of the isometric drawing will be a true shape. The isometric drawing will appear distorted because all the vertical heights are drawn (projected) as vertical lines

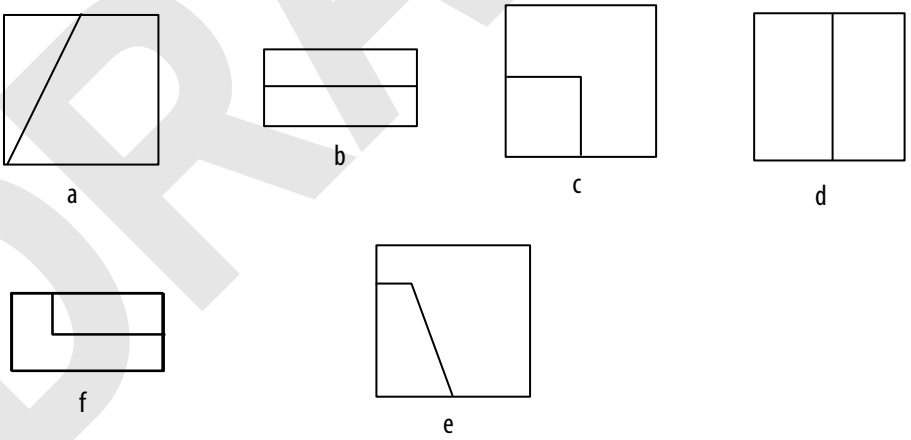
Activity 2.4

Study the isometric drawings in the upper block, below.

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.





Match the numbers with the letters		Front, left, right or top
1		
2		
3		
4		
5		
6		

CHAPTER

3

Tools and measuring instruments

LEARNING OUTCOMES

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

- Installation tools
- Bending spring
- Fish tape
- Reamer
- Hickey (Pipe bender)
- Stock and dies
- Soldering tools
- Soldering iron
- Solder sucker

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.

3.1 Introduction

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. Tools described in this section are quite safe if they are used as they were designed to be used. For example, a screwdriver is not meant to be a chisel, and a file is not meant to be a pry bar. Hacksaws should be held by the handle, not the frame. Fingers wrapped around the frame tends to get mashed. Files should never be used without a handle.

Revision of tools covered in Grade 8

In Grade 8 we dealt with following tools:

- Tightening / Loosening of screws
- Cutting tools
- Stripping tools
- Measuring tools
- Marking tools
- Electrical and Electronics Software

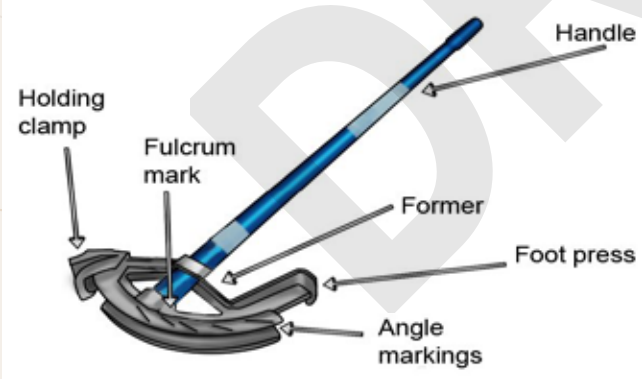
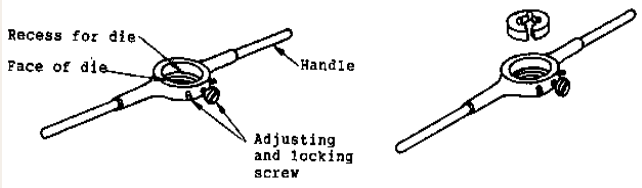
Activity 3.1

.1. State one example of the following types of tools:
   - » Tightening / Loosening of screws
   - » Cutting tool
   - » Stripping tool

3.1 Identification, functions and safe care of tools

3.1.1 Installation Tools

Picture	Function
Spring Bender 	A spring bender helps to not distort or crease the pipes during manual bending by providing a stable internal or external structure.

Picture	Function
Fish Tape  	A fish tape is a tool used by electricians to pull wires through electrical conduits. It is also known as a draw wire, draw tape, or an electrician's snake. Fish tapes is available in different lengths. To pull the tape out of the wheel, you press a button or pull a lever on or near the handle. This releases the tape and allows you to simply pull it out of the wheel. You then feed the tape into the conduit as you unwind it from the wheel. When the tape emerges from the other end of the conduit, a helper attaches wires to the end of the tape, which has a hook-like eye, then you pull the tape back through the conduit with the wires in tow. To wind the fish tape back in, grip the centre of the wheel with one hand and turn the handle with the other. This winds up the tape into the wheel.
Reamer  	A reamer is used to cut away the burrs (rough edges) inside the end of the conduit after it has been cut with a hacksaw or pipe cutter.
Hickey  	A hickey is used to bend conduit pipes. Conduit pipes are pipes used to run electrical wires through.
Stock and dies  	Stock and dies are cutting tools used to create threads on components such as screws, bolts, nuts and to create a threaded hole to screw components into. It is also used for making a thread on a pipe. The stock is designed to hold the die and guide the cutting of the thread.

Practical Activity 3.1

Use the stock and dies to make thread on steel conduit pipe

Aim: The learner will demonstrate an understanding and an ability to correctly use the stock and dies to make thread.

What you will need:

- Engineer vice
- Steel conduit pipe
- Stock and dies
- Reamer
- Hacksaw

What to do:

- It is important to choose the right thread cutting tool for the job.
- Always wear appropriate eye protection when using any of the thread cutting tools.
- Use a suitable cutting lubricant for all tapping, threading and reaming operations.
- The cutting action should be backed off every half turn to break off (and clear) the waste from the thread being created

3.1.2 Soldering Tools

Picture	Function
Soldering Sucker 	The Solder sucker is used to remove solder so that components may be removed, replaced or salvaged for recycling and when circuit board connections are redesigned or repaired.
Soldering Iron 	A soldering iron is used to melt solder so that when it flows, it joins two pieces of work (like wires) when it cools. This is done in electric circuits to join wires or components, for circuit boards and repairing of electrical installations or devices.

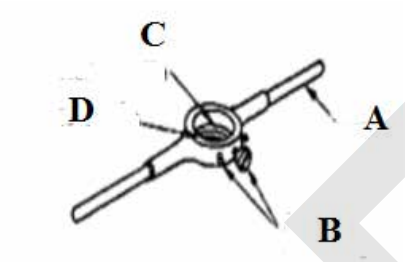
Activity 3.2 Have you learnt something?

Test your knowledge….

2.1 State the function of the following tools:

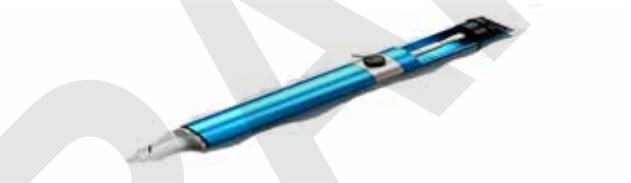
- 2.1.1 Spring bender
- 2.1.2 Fish tape
- 2.1.3 Reamer
- 2.1.4 Breadboard
- 2.1.5 Soldering iron

2.2 Label stock and dies below:



2.3 State how one would care for a pipe bender in a workshop environment.

2.4



- 2.4.1 Name the tool above in 2.4
- 2.4 2 State the function of this tool

2.5 State the function of the hickey.

Practical activity 3.2

Use the soldering iron and solder sucker to demonstrate soldering techniques to make a T joint)

Aim: The learner will demonstrate an understanding and an ability to correctly use the soldering iron and solder sucker.

What you will need:

- Combination Plier
- Soldering Iron
- Solder sucker
- Solder stand
- Solder
- Conductors (Panel wire 1.5 mm2)

What to do:

How To Solder Wires

For this process, it's recommended to use helping hands or other type of clamp device.

Begin by removing the insulation from the ends of both wires you are soldering together. If the wire is stranded, twist the strands together with your fingers.

Make sure your soldering iron is fully heated and touch the tip to the end of one of the wires.

Hold it on the wire for 3-4 seconds

Keep the iron in place and touch the solder to the wire until it's fully coated.

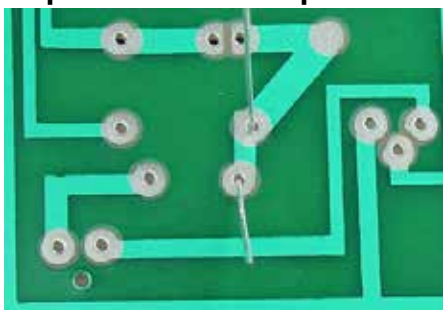
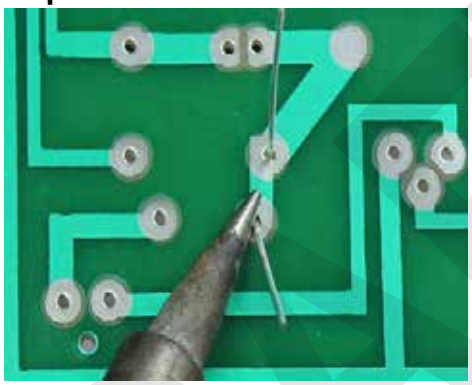
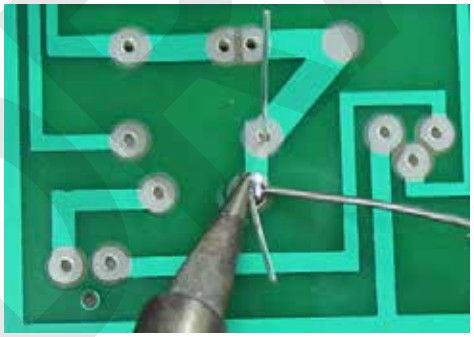
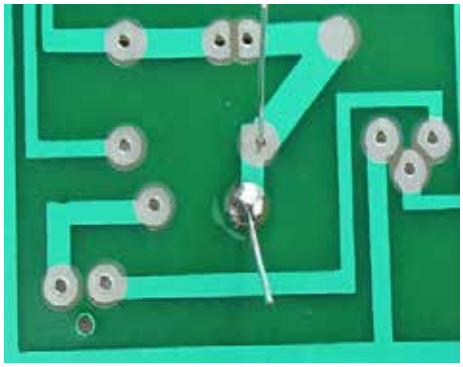
Repeat this process on the other wire.

Hold the two tinned wires on top of each other and touch the soldering iron to both wires.

This process should melt the solder and coat both wires evenly.

Remove the soldering iron and wait a few seconds to let the soldered connection cool and harden.

Use heat shrink to cover the connection

How to solder component on a Printed Circuit Board	
Step 1: Mount the Component. 	• Begin by inserting the leads of the LED into the holes of the circuit board. • Flip the board over and bend the leads outward at a 45° angle. • This will help the component make a better connection with the copper pad and prevent it from falling out while soldering.
Step 2: Heat the Joint. 	• Turn your soldering iron on and if it has an adjustable heat control, set it to 400'C. • At this point, touch the tip of the iron to the copper pad and the resistor lead at the same time. • You need to hold the soldering iron in place for 3-4 seconds in order to heat the pad and the lead
Step 3: Apply Solder to Joint. 	Continue holding the soldering iron on the copper pad and the lead and touch your solder to the joint. **IMPORTANT** – Don't touch the solder directly to the tip of the iron. You want the joint to be hot enough to melt the solder when it's touched. If the joint is too cold, it will form a bad connection.
Step 4: Snip the Leads. 	Remove the soldering iron and let the solder cool down naturally. Don't blow on the solder as this will cause a bad joint. Once cool, you can snip the extra wire from leads.

Desoldering

The good thing about using solder is the fact that it can be removed easily in a technique known as desoldering.

This comes in handy if you need to remove a component or make a correction to your electronic circuit.

To desolder a joint, you will need solder wick which is also known as desoldering braid.

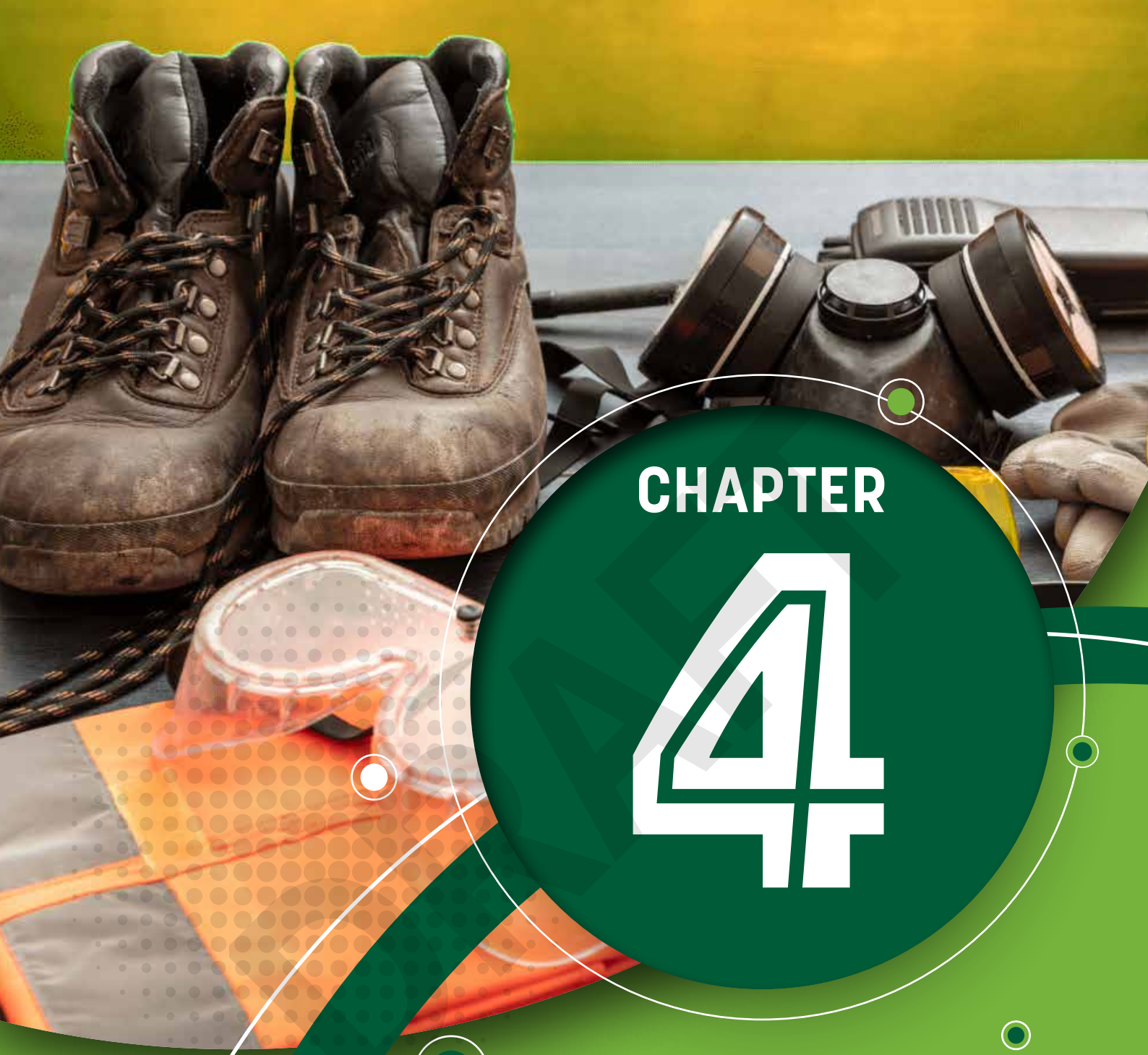
Step 1 Place a piece of the desoldering braid on top of the joint/solder you want removed.

Step 2 Heat your soldering iron and touch the tip to the top of the braid.

This will heat the solder below which will then be absorbed into the desoldering braid.

You can now remove the braid to see the solder has been extracted and removed.

Be careful touching the braid when you are heating it because it will get hot.



CHAPTER

4

Entrepreneurship

LEARNING OUTCOMES

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

- What is entrepreneurship?
- Advertising on media platforms
- Sourcing of funds
- Costing
- Business plan

4.1 What is Entrepreneurship?

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

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 struggles 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

Figure 4.1

Importance of Entrepreneurship

What is entrepreneurship about? And why's 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 is entrepreneurship, 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 commercialisation, of innovations. "Leapfrog" innovation, research, and development are being contributed by entrepreneurship.

Thus, entrepreneurship nurses innovation that provides new ventures, products, technology, market, quality of goods, etc. to the economy that increases Gross Domestic Products and standard of living of people.

Entrepreneurs give to society: While some have a 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.

https://www.oberlo.com/blog/how-to-make-money-online)

Activity 4.1 Have you learnt something?

Test your Knowledge …

1. Who is an entrepreneur?
2. Why are entrepreneurs important for society?

4.2 Why Do People Become Entrepreneurs?

Figure 4.2

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 ultimately build a brand in service of others. Some entrepreneurs use their business to raise capital quickly 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. Ultimately, 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 are able to. 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 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 do not often thrive in corporate environments as 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.

Types of entrepreneurship

There's a difference between types of entrepreneurship and the types of entrepreneurs.

There are four major types of entrepreneurship:

Small business entrepreneurship. Small businesses are the bread and butter of entrepreneurship. It makes up a large proportion of all companies and employs more than half of the non-government workforce.

These are the people you see in the community like plumbers, carpenters, grocers, pharmacy owners etc. and either do not have the skill or motivation to expand their business. As a result, they are usually barely profitable.

Figure 4.3

Scalable start-up entrepreneurship. Their mission from day one is to find a business model that's **scalable**. Not all of them are successful in that regard which is why investors must bet big and often to make up for the losers. A traditional, growth-minded business adds to both sides of the scale somewhat proportionately, although the obvious goal is for profits to exceed revenues, even slightly. With a scalable business model, the end result isn't 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."*

Figure 4.4

New words

scalable Dummy text dummy text dummy text dummy text.

Large company entrepreneurship. This type of entrepreneurship is based within huge organisations 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.

Figure 4.5

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 organizations, 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.

Figure 4.6

Activity 4.2 Have you learnt something?

Test your Knowledge …

1 Why do people become entrepreneurs?

2. List the different types of entrepreneurs.

4.3 Factors affecting entrepreneurship

Entrepreneurship is essential for the development of any economy. Countries which have flourished attribute their rise to the growth of entrepreneurship. Therefore, governments and people all over the world want to encourage this concept. Below are the factors which contribute to the growth of entrepreneurship and therefore to the growth of the economy of any given area.

Political Factors

Political factors play a huge role in the development of entrepreneurship in different geographical areas. This is because politicians decide the type of market that is in place. The market could be capitalistic, communist or some countries have adopted a mixed economy. Each of these three markets has very different implications for the way in which entrepreneurs are required to function. Capitalism requires breakthrough innovation whereas communism requires entrepreneurs to be well connected with the political class. Therefore, it has been observed that the more capitalistic any country is, the more entrepreneurship flourishes in the region.

Legal Factors

Entrepreneurs are dependent upon law for a wide variety of factors. The strength and fairness of the legal system of a nation affect the quality of entrepreneurship to a large extent. This is because entrepreneurs require a wide variety of legal services to function. For instance, entrepreneurs would require the courts to enforce the contracts that were entered to between parties. In many countries such contracts are not enforceable and therefore the resultant risk prohibits the development of entrepreneurship. Then again, the entrepreneurs are dependent on the courts for the protection of their property rights. Also, many advanced countries have noticed that the provision of declaring bankruptcy has been positively associated with the development of entrepreneurship. Entrepreneurs do fail a few times before they find the right innovation that leads to their success. The United States is amongst the countries with the highest rate of entrepreneurial development, and it is also known to have one of the most advanced bankruptcy laws! Even business legends like Henry Ford had declared bankruptcy in their early days.

Taxation

The government can also influence a high degree of control on the market through provisions of taxation. Some amount of taxation is necessary for the government to maintain the legal and administrative systems in place for the entire economy. However, a lot of times governments resort to excessive taxation. They usually adopt the policy of beggaring the rich and giving it off to the poor. This goes against the basic tenets of entrepreneurship which believes in survival of the fittest. Therefore, countries where tax regimes are restrictive find an outflow of entrepreneurs. In short, entrepreneurs want to set up shop in places where there is minimal interference from the government.

Availability of capital

The degree to which the capital markets of a nation are developed also play a huge role in the development of entrepreneurship in a given region. Entrepreneurs require capital to start risky ventures and require instant capital to scale up the business quickly if the idea is found to be successful. Therefore, countries which have a well-developed system of providing capital at every stage i.e., seed capital, venture capital, private equity and well-developed stock and bond markets experience a higher degree of economic growth led by entrepreneurship.

Labour Markets

Labour is an important factor of production for almost any kind of product or service. The fortunes of the entrepreneurs are therefore dependent on the availability of skilled labour at reasonable prices. However, in many countries labour has become unionized. They demand higher wages from the entrepreneurs and prohibit other workers from working at a lower price. This creates an upward surge in the costs required to produce and as such has a negative effect on entrepreneurship.

With the advent of globalization, entrepreneurs have witnessed the freedom to move their operations to countries where labour markets are more favourable to them. This is the reason why countries like China, India and Bangladesh have witnessed a huge rise in entrepreneurial activity in their countries.

Raw Materials

Just like labour, raw material consisting of natural resources is also an essential product required for any industry. In some countries this raw material is available through the market by paying a fair price. However, in some countries, seller cartels gain complete control over these natural

resources. They sell the raw materials at inflated prices and therefore usurp most of the profit that the entrepreneur can obtain. Therefore, countries where the supply of raw material faces such issues witness depletion in the number of entrepreneurial ventures over time.

4.4 Creation of a business plan

Every business needs to have a written business plan. Whether it's to provide direction or attract investors, a business plan is vital for the success for your organization.

1. A business plan should include the following:

- Executive summary - a snapshot of your business
- Company description - describes the main function of the business
- Market analysis - research on your industry, market and competitors
- Organisation and management - the business and management structure
- Service or product - the products or services that the business are offering
- Marketing and sales - how you will market your business and your sales strategy
- Funding request - how much money the business will need for next 3 to 5 years
- Financial projections - supply information like balance sheets
- Appendix - an optional section that includes résumés and permits

However, getting started may be difficult to do. So, here are seven steps for writing a perfect business plan.

(https://www.entrepreneur.com/article/247574).

2. Research, research, research

Research and analyse your product, your market and your objective expertise. To write the perfect plan, you must know your company, your product, your competition and the market intimately.

In other words, it's your responsibility to know everything you can about your business and the industry that you're entering. Read everything you can about your industry and talk to your audience.

3. Determine the purpose of your plan.

A business plan, as defined by ***Entrepreneur*** is a "written document describing the nature of the business, the sales and marketing strategy, and the financial background, and containing a projected profit and loss statement." However, your business plan can serve several different purposes.

(https://www.entrepreneur.com/encyclopedia/business-plan)

As Entrepreneur notes, it's "also a road map that provides directions so a business can plan its future and helps it avoid bumps in the road." That's important to keep in mind if you're self-funding or bootstrapping your business. But, if you want to attract investors, your plan will have a different purpose and you'll have to write a plan that targets them so it will have to be as clear and concise as possible. When you define your plan, make sure you have defined these goals personally as well.

(https://www.insightly.com/blog/2019/04/4-customer-relationship-lessons-from-women-entrepreneurs/)

4. Create a company profile.

Your company profile includes the history of your organization, what products or services you offer, your target market and audience, your resources, how you're going to solve a problem and what makes your business unique.

(https://due.com/about)

Company profiles are often found on the company's official website and are used to attract possible customers and talent. However, your profile can be used to describe your company in your business plan. It's not only an essential component of your business plan; it's also one of the first written parts of the plan.

Having your profile in place makes this step a whole lot easier to compose.

5. Document all aspects of your business.

Investors want to make sure that your business is going to make them money. Because of this expectation, investors want to know everything about your business. To help with this process, document everything from your expenses, cash flow and industry projections. Also, don't forget seemingly minor details like your location strategy and licensing agreements.

Figure 4.7

6. Have a strategic marketing plan in place.

A great business plan will always include a strategic and aggressive marketing plan. This typically includes achieving marketing objectives such as:

- Introducing new products
- Extending or regaining market for existing products
- Entering new territories for the company
- Boosting sales in a particular product, market or price range. Where will this business come from? Be specific.
- Cross-selling (or bundling) one product with another
- Entering into long-term contracts with desirable clients
- Raising prices without cutting into sales figures
- Refining a product
- Having a content marketing strategy
- Enhancing manufacturing/product delivery

	(https://www.johnrampton.com/content-marketing-guide/)

"Each marketing objective should have several goals (subsets of objectives) and tactics for achieving those goals," states ***Entrepreneur***.

	(https://www.entrepreneur.com/article/43026)

"In the objectives section of your marketing plan, you focus on the 'what' and the 'why' of the marketing tasks for the year ahead. In the implementation section, you focus on the practical, sweat-and-calluses areas of who, where, when and how. This is life in the marketing trenches."

Of course, achieving marketing objectives will have costs. "Your marketing plan needs to have a section in which you allocate budgets for each activity planned," ***Entrepreneur*** says. It would be beneficial for you to create separate budgets for internal hours (staff time) and external costs (out-of-pocket expenses).

7. Make it adaptable based on your audience.

"The potential readers of a business plan are a varied bunch, ranging from bankers and venture capitalists to employees," states ***Entrepreneur***.

(https://www.entrepreneur.com/article/43026)

"Although this is a diverse group, it is a finite one. And each type of reader does have certain typical interests. If you know these interests up-front, you can be sure to take them into account when preparing a plan for that audience."

For example, bankers will be more interested in balance sheets and cash-flow statements, while venture capitalists will be looking at the basic business concept and your management team. The manager on your team, however, will be using the plan to "remind themselves of objectives."

Because of this, make sure that your plan can be modified depending on the audience reading your plan. However, keep these alterations limited from one plan to another. This means that when sharing financial projections, you should keep that data the same across the board.

8. Explain why you care.

Whether you're sharing your plan with an investor, customer or team member, your plan needs to show that you're passionate and dedicated, and you care about your business and the plan. You could discuss the mistakes that you've learned, list the problems that you're hoping to solve, describe your values, and establish what makes you stand out from the competition.

By explaining why you care about your business, you create an emotional connection with others so that they'll support your organization going forward!

Activity 4.3 Have you learnt something?

Test your Knowledge …

1 Name the factors that has an influence on entrepreneurship?

2. What content must be included in a business plan?

Activity 4.4 Have you learnt something?

Test your Knowledge …

CONDUCT RESEARCH

Do research on business plans making use of the links below:

https://www.bplans.com/sample-business-plans/

https://www.entrepreneur.com/article/281416

https://blog.pandadoc.com/write-a-business-plan/

https://www.score.org/resource/business-plan-template-startup-business

Practical tasks

Conduct research through the links provided above, or your own research, start to draft a business. You must create a full business plan whereby you need to present to your possible investors in order to obtain funding for your business. Your business plan must include all 9 requirements you have learnt in this chapter.

CHAPTER

5

Material Conductors and Cables

LEARNING OUTCOMES

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

- Conductors and cables
  - » Define a conductor
  - » Define a cable
  - » Types of household cables
  - » Twin flex
  - » Suffix (two core and earth)
  - » Cab tire
  - » GP wire
  - » Panel wire
- Installation of cables
  - » Underground cables
  - » Overhead / open-air cables
  - » Trunking cables (wall mounted ducts)
  - » Advantages and disadvantages of cables
- Solid core and multi-stranded cables
  - » Advantages and disadvantages of multi-strand cables

In 1734 Stephen Gray (c. 1666-1736), an English experimenter, discovered that electric charge could be conductive over distance. He also classified various substances into conductors and insulators.

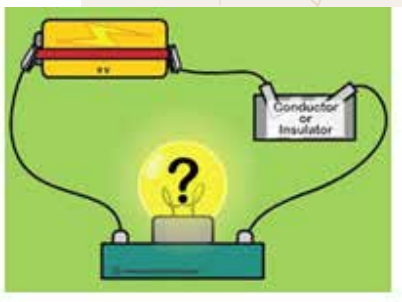


Figure 5.1

5.1 Introduction to basic principles of conductors and cables

Different materials have different properties. Think of the difference between the engine of a car and its wheels, the metal in a wire and its insulator. All these objects can only be made from 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 Conductors and Cables

Materials can be classified based on their physical and chemical properties, or on their geological origin or biological function.

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

Conductors

A Conductor is a material which conducts electrical current very easily because of their free electrons. Some common conductors are gold, silver, copper and aluminium.

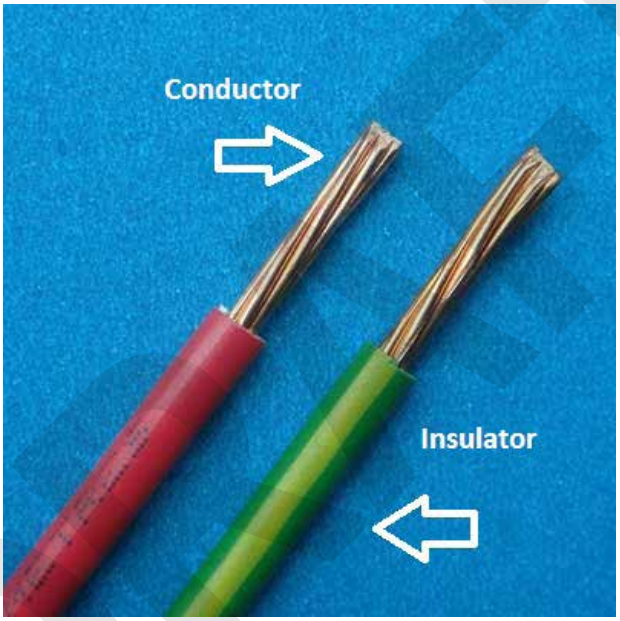


Figure 5.2

Cables

An electrical cable is an assembly of one or more wires running side by side or bundled, which is used to carry electric current.

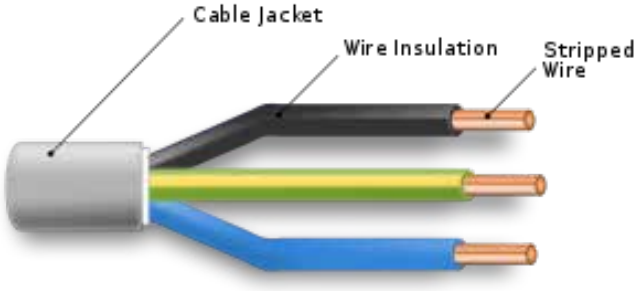


Figure 5.3

- Types of household cables
- Twin Flex Cable

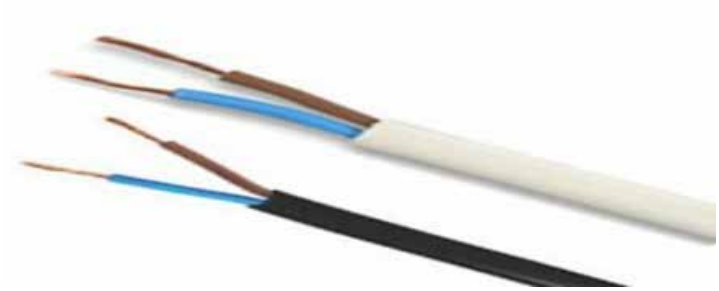


Figure 5.4

Flexible cables are electrical cables specifically designed to cope with bending and physical stress associated with moving around.

Suffix Cable or Norsk Cable (two core and earth)

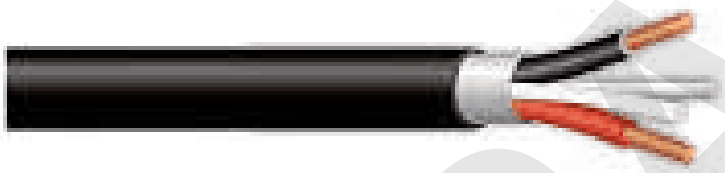


Figure 5.5

This type of cable is used for domestic wiring applications. They are available in either flat or round and are commonly referred to as “twin and earth”. They have two single copper strands insulated with PVC and a bare single copper earth wire. Norsk cable has the earth wire between the two strands.

Cab Tire

Figure 5.6

This type of electric wire is normally used in wiring portable electric appliances.

GP Wire

Figure 5.7

GP wire is a general purpose wire cable ideal for lighting installations. It also has line voltage stability which makes it suitable for audio systems, along with many other items.

Panel Wire

Figure 5.8

Panel wire is electrical wire used for the wiring of main electrical panels in distribution boards.

5.3 Installation cables

It is an assembly of one or more wires running side by side or bundled together, which is used to carry electric current.

Underground cables

Figure 5.9

Underground cables are cables used to transmit power where the cables are buried under the ground.

Overhead Cables

Figure 5.10

Overhead cables are cables used to transmit power where the cables are mounted on poles or pylons.

Cable Trunking

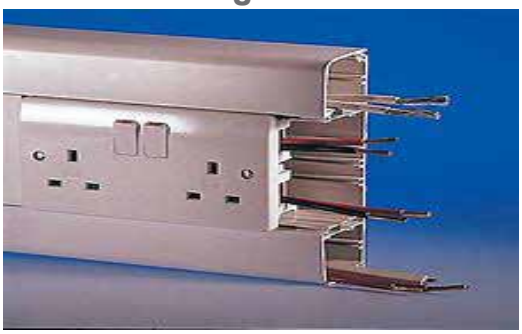


Figure 5.11

Cable trunking is an enclosure for managing cabling. It provides both protection and concealment of cables.

Solid Core

Figure 5.12

Solid core cable utilises a single solid wire for each conductor with eight sold wires being found in a four pair cable. They are intended for permanent installations.

Multi-Stranded Cable

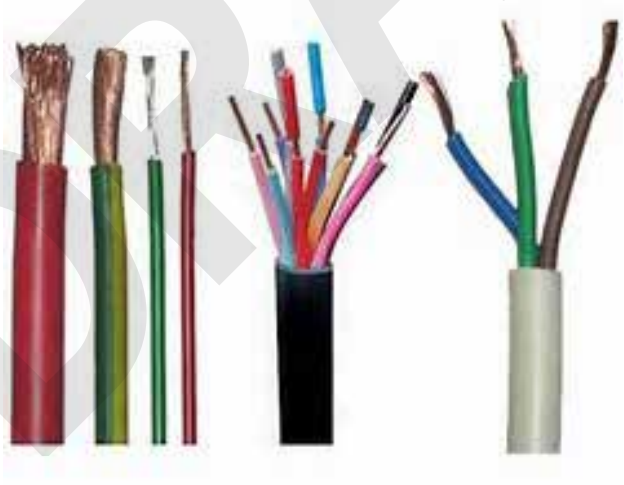


Figure 5.13

Multi stranded wire is composed of a number of small wires bundled or wrapped together to form a larger conductor. Stranded wire is more flexible than solid wire of the same total cross-sectional area.

Activity 5.1 Have you learnt something?

Test your Knowledge …

1 Define the following terms:
   - » Material
   - » Conductor
   - » Cable
2 Explain the difference between a solid core cable and stranded core cable?
3. Explain what the term cable trunking means?

5.4 Advantages and disadvantages of cables

	Advantage	Disadvantage
Underground cables	Suitable for congested urban areas and they require low maintenance as damage rate is low.	Underground cables are - at installation - more expensive.
Overhead cables	Overhead installation is much cheaper to erect and maintain than underground cables.	They are more susceptible to damage, and they sometimes look untidy.
Cable Trunking	Cable trunking is an ideal way of hiding, disguising and managing cables and wires.	They are expensive, and sometimes occupy bigger area on the wall.
Solid core cable	Solid cables are often favoured because they are more affordable, cheaper to manufacture and durable.	They are not flexible, therefore not easy to use.
Stranded cable	Stranded wires are relatively more flexible, intricate, and delicate.	They have more power loss than solid core.

Activity 5.2 Have you learnt something?

Test your Knowledge …

1. State TWO advantages of the cables below:
   - Solid core cable
   - Underground cable
   - Overhead cable
2. Refer to image 5.14 and answer the question below.

Figure 5.14

Which type of installation cable should be used in this area?
Give a reason for your answer.

Practical activity 5.2

Testing continuity in cables

Aim: Use connectors to correctly join the cables.

What will you need:

- 1 x 100mm (3 core cable)
- Side cutter
- Wire stripper
- Multi meter .

What to do:

Step 1:

Each group of learners should be given 1 x 100mm of 3 core cables.

Step 2:

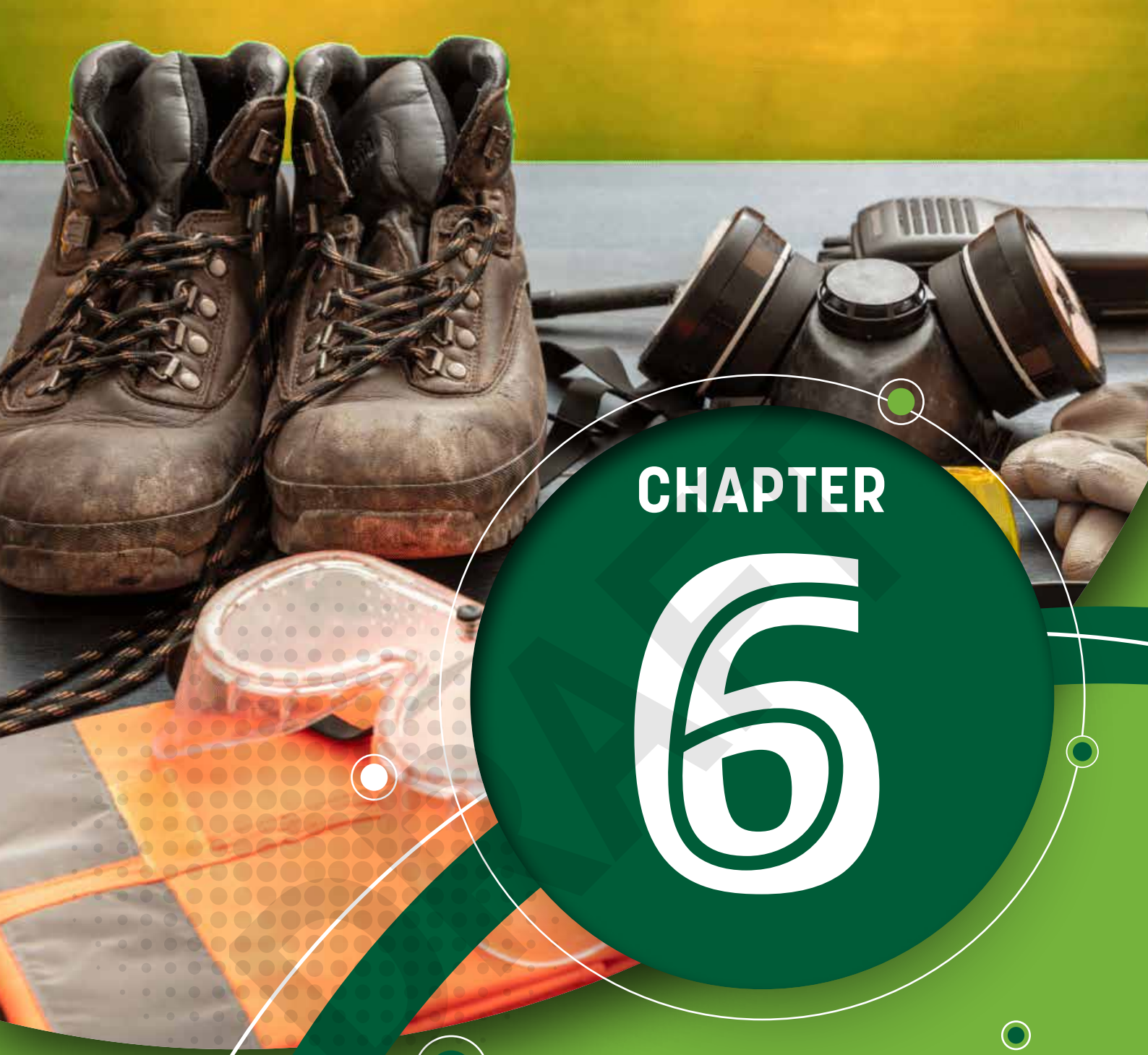
Remove 10mm of insulation from one end of each cable.

Step 3:

Check for continuity between conductors. Record your findings

Complete the table using the 3-core cable above:

Conductors	Continuity (Yes or No)
Red to Red (R1 – R2)	
Red to Black (R1- B1)	
Red to Yellow (R2 – Y2)	
Black to Yellow (B2- Y1)	
Black to Black (B1- B2)	
Yellow to Yellow (Y1- Y2)	
Write your conclusion	



CHAPTER

6

Basic Principles of Electricity

LEARNING OUTCOMES

By the end of this chapter the learner should be able to understand the basic principles of electricity and electrical measuring instruments. The following will be covered in this chapter:

- Atomic theory
  - Simple Ohms law calculations
  - Power
- Definitions of some electronic concepts:
  - Electron current flow
  - Conventional current flow
  - Resistors in series
  - Resistors in parallel
  - Resistor calculations
  - Resistors connected in series
  - Resistors connected in parallel

Alessandro Volta

Italian physicist Alessandor 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.

Figure 6.1

6.1 Basic principles of Electricity and Electrical Measuring Instruments

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,
- liquids e.g., water.

Water may be in three forms, namely:

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

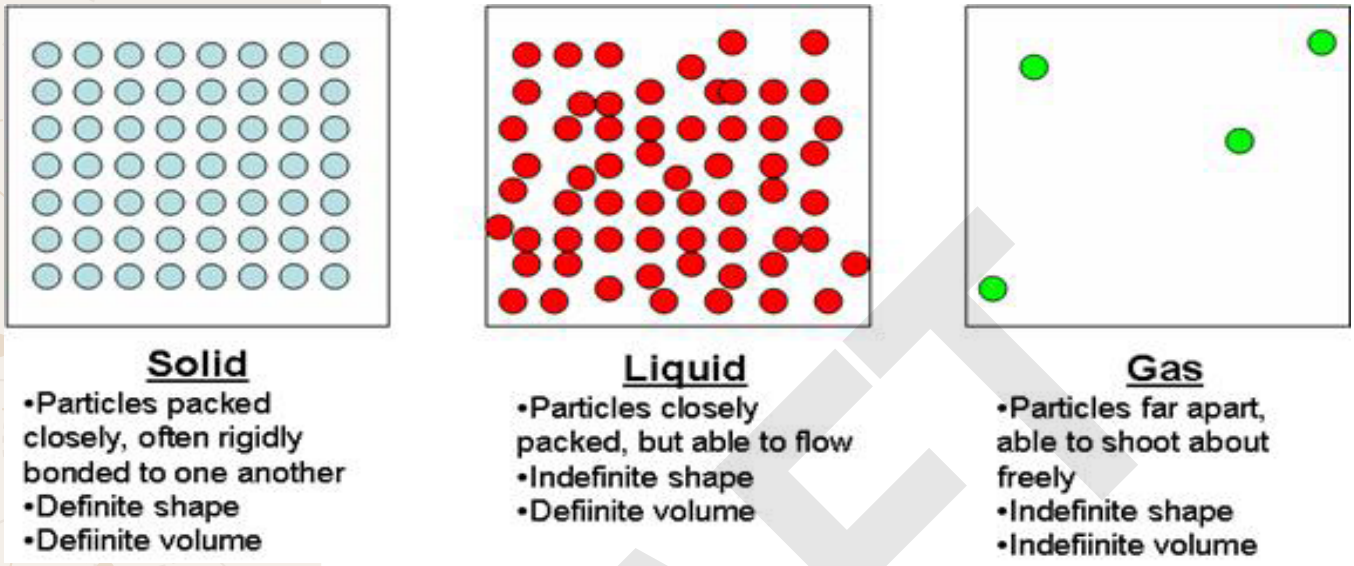


Figure 6.

Composition of Matter

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

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

Molecules: A molecule is 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: An atom is the smallest particle that an element can be reduced to and 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

A basic atomic structure is 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).

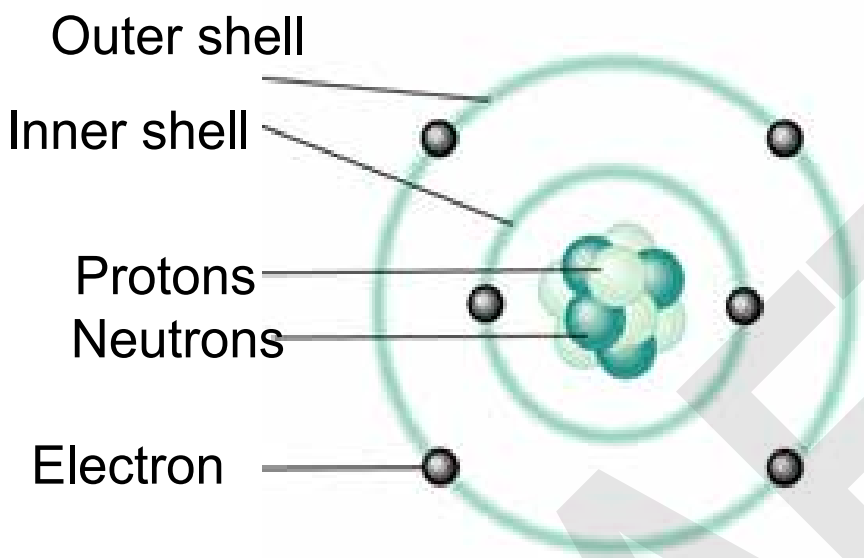


Figure 6.3 Atomic Structure

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)

Multimeter

The digital multimeter is useful in basic fault finding in installations, to troubleshoot electrical problems, and electronic circuit repairs. A multimeter is a measuring instrument for current, voltage, and resistance. It is also used to check continuity in the windings, circuit etc.

Figure 6.4 Multimeter

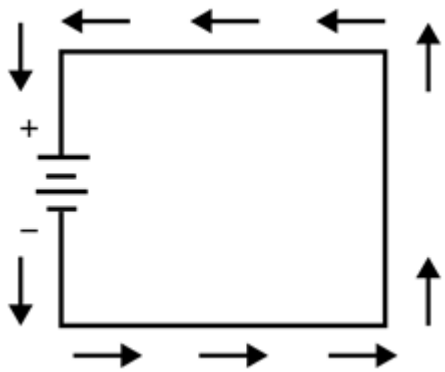
Care and safe use of a multimeter:

- Completely isolate the circuit electrically before using it for continuity testing or when you are measuring resistance.
- Do not immerse in water or use it in wet conditions.
- Ensure that you set the multimeter dial and the probes to the correct function before using it.
- Always start with the highest scale if you are not sure of the range of the values to be read.
- Switch it off after use to preserve battery life.
- Store the multimeter in its place of storage after use.

6.2 Definitions of some electronic concepts

Electron current flow

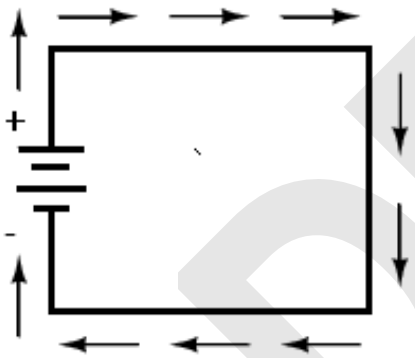
Electrons flow out of the negative terminal through the circuits and into the positive terminal of the source.



Electron charge moves from the negative (surplus) side of the battery to the positive (deficiency) side.

Convectional current flow

Conventional current is the flow of a positive charge from positive to negative of the voltage source.



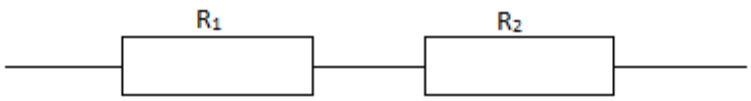
Electric charge moves from the positive (surplus) side of the battery to the negative (deficiency) side.

Resistors connected in series

Connecting resistors together, end to end in line is called a series connection.

Important points to remember about resistors connected in series

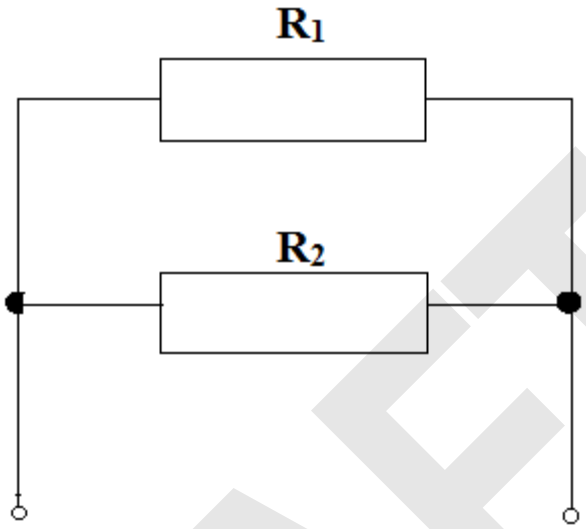
Connecting resistors in series means connecting resistors one after another on the same line of conductor.
In electronic symbol form, the connection would be drawn as follows:



Parallel connected resistors

Important points to remember about resistors connected in parallel

Resistors are connected parallel when each resistor is connected on its own line of conductor.

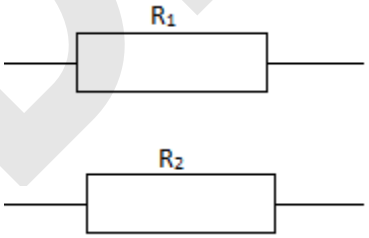


Activity 6.1 Have you learnt something?

Test your Knowledge …

1 Define the following terms:
   - » Electron current flow
   - » Convectional current flow

2 Redraw the resistors as shown below and connect them in series:



Redraw the resistors as shown below and connect them in parallel:

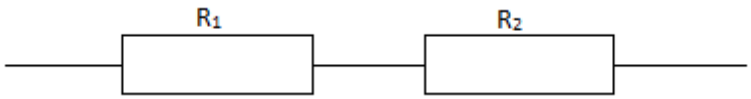
Resistor calculations (maximum 2 resistors)

Resistors connected in series

Important points to remember about resistors connected in series

- Connecting resistors in series means connecting resistors one after another on the same line of conductor.
- Their combined total resistance is always greater than any of single values.

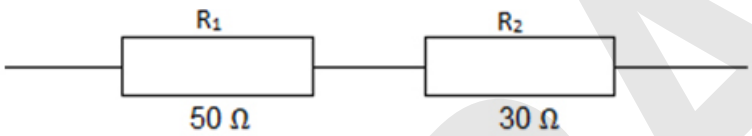
See below two resistors connected in series:



The total resistance value of the series connection is calculated by:
$R_T = R_1 + R_2$ ..... Ω

Example 6.1

Calculate the total resistance of the resistors below:



Solution: *RT=R1+R2*

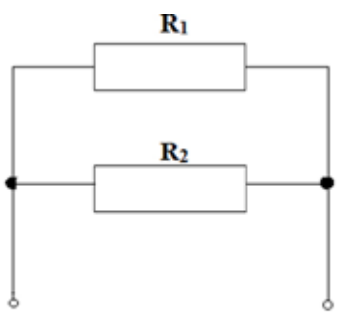
=50+30

=80 Ω

Resistors connected in parallel

Important points to remember about resistors connected in parallel

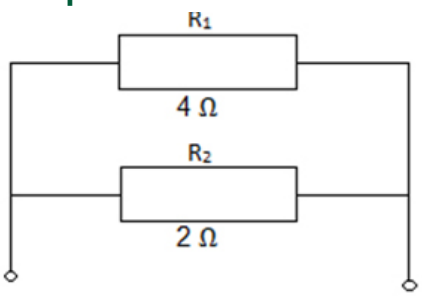
- Resistors are connected parallel when each resistor is connected on its own line of conductor.
- The combined total resistance is always less than any individual values



The total resistance value of the parallel connection is calculated by:

$$1/R_T = 1/R_1 + 1/R_2 \ldots\ldots \Omega$$

Example 6.2.2



Solution: $1/R_T = 1/R_1 + 1/R_2$

$1/R_T = 1/2 + 1/4$

$1/R_T = (2+1)/4$

$1/R_T = 3/4$

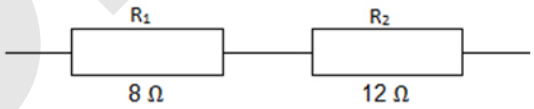
$R_T = 4/3$

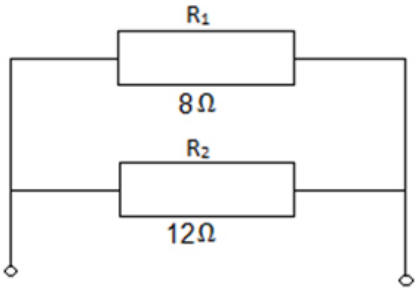
$R_T = 1.33\ \Omega$

Activity 6.2 Have you learnt something?

Test your Knowledge …

1 Calculate the total resistance for the circuits below.





1.2 Explain the difference between the answer in Question 1 a) and 1 b).

2 Give a reason for your answer in Question 1.2.

6.3 Simple Ohm's law calculations including power

Ohm's Law

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

$V = I \times R$

$V = R \times I$

It is sometimes easier to remember the Ohms law relationship by using the Ohms Law Triangle illustrated below:

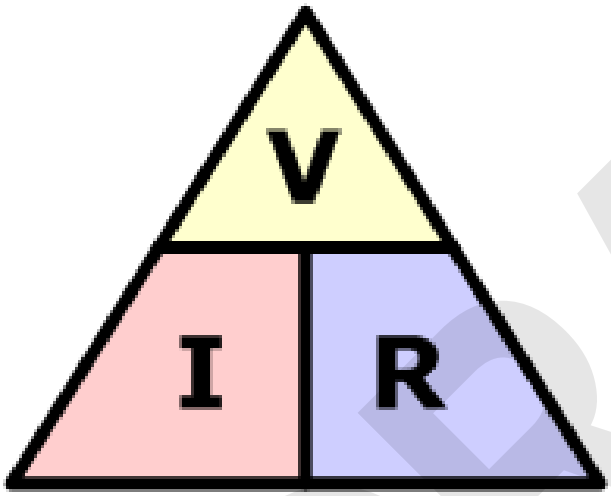


Figure 6.5 Ohms Law Triangle

How to use the Ohm's law triangle

The horizontal line inside the triangle represents division sign.

The vertical line represents multiplication sign.

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

Refer to the figure below, and notice how each of the quantities **V**, **I** and **R** is made the subject of the following:

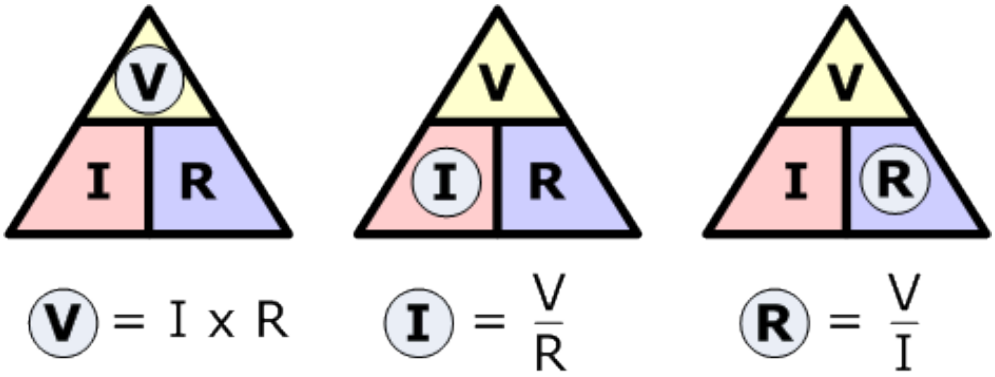


Figure 6.6 Using Ohm's triangle

Example 6.3.1

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 $R=50\ \Omega$

Given: $V = 200\ V$

$I = ?$

$I = V/R$

$=200/50$

$=4A$

Example 6.3.2

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

Solution $R = 20\Omega$

Given: $I = 5.5\ A$

$V = ?$

$V = I\ x\ R$

$=5.5A\ x\ 20$

$=110V$

Example 6.3.3

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 $V = 220\ V$

Given: $I = 4.5\ A$

$R = ?$

$R = V/I$

$= 220/4.5$

$= 48.9\Omega$

Activity 6.3 Have you learnt something?

Test your Knowledge …

1. A circuit consists of a voltage source of 24 V, a switch and a resistor. Calculate the value of the resistor if the current of 1.6 A is flowing in the circuit.
2. A resistor of 470 ohms is connected across a 12 V battery. Calculate the current flowing through the resistor.

Power

All power is defined as *"the rate of doing work"* and is measured in *watts*. For work to be done energy is expended (used up or consumed). Consider a circuit in which a certain potential difference (PD) is applied across a resistor. This will result in current flow.

If the voltage across the resistor is increased the rate of flow of current and power is increased. The power is increased by increasing the (PD) (or applied voltage, V) which in turn causes the current flow to increase.

From this it can be said that the power consumed in a resistor is proportional to the voltage applied across it and the current flowing through it.

1. $P = V \times I$
   $P = Power\ in\ watts(W)$
   $V = applied\ Pd\ in\ Volts(V)$
   $I = current\ in\ amps(A)$

If V is unknown, power can be calculated as follows:

$P = (IR) \times I$

1. $P = I^2 \times R$

And if I is unknown, power can be calculated as follows:

2. $P = V \times V/R$

$= V^2/R$

Energy

Energy is the results of the power developed over a certain period. The unit for energy is the joule (J). Since this value is relatively small, it is more convenient to express energy in kilojoule (Ki) or even mega joule (MJ).

Energy = Power × Time

Where:

Power is in **watts (W)**
Time is in **seconds (s)**

Example 6.3.4

Calculate the power consumption of a 220 V electric kettle which draws 5 amps when connected to the correct supply.

Solution $V = 220\ V$

Given: $I = 5\ A$

$P = ?$

$P = V \times I$

$= 250/5$

$= 250W$

Calculate the power dissipated by a 50-ohm resistor while 2A of current is flowing through it.

Example 6.3.5

Calculate the power dissipated by a 50-ohm resistor while 2A of current is flowing through it.

Solution $R = 50\ \Omega$

Given: $I = 2\ A$

$P = ?$

$P = I^2 \times R$

$= 2^2 \times 50$

$= 400W$

Activity 6.4 Have you learnt something?

Test your Knowledge …

1 Calculate the power dissipated by an electric circuit which is supplied by a 220V DC generator while feeding a current of 5A.

2 An LED light bulb is rated at 7 W/230 V. Calculate the current flowing through the LED light bulb if it is switched on.

2.1 Calculate the energy consumed if a 100 W bulb is switched on for 10 hours

PRACTICAL ACTIVITY 6.5

Measure current and voltage using a multimeter to prove ohm's law

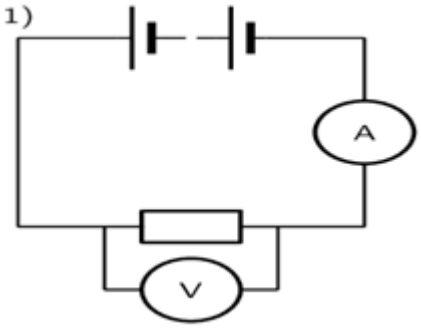
AIM:

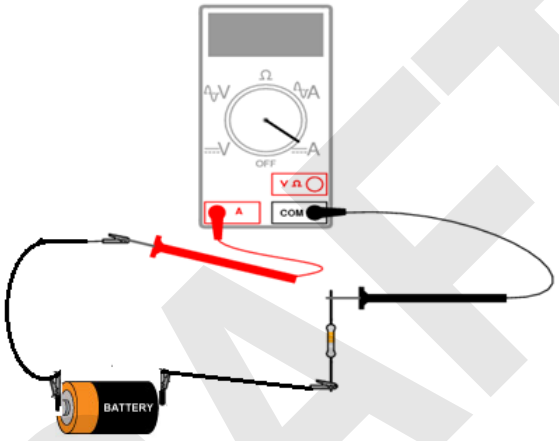
To determine the relationship between the current going through a resistor and the potential difference (voltage) across the same resistor

What you will need:

- 3 x 1.5 V cell
- 1 x Resistor
- Connecting wires
- Battery/Cell holder
- Multimeter
- Breadboard

DIAGRAM:





Procedure and Observation:

What do you need to do this practical?

- Ammeter (Multimeter)
- Wire leads
- Light bulb with light fitting
- 9V Battery
- Single pole switch

What you must do:

Connection to single battery cell

Connect the probe leads of the digital multimeter as follows

Plug the red probe into + (red) slot and the black probe into the – (black) socket.

Set the multimeter range to DC current before connecting the battery cell

Construct the circuit as shown in the figure above

Write the value of current displayed on the multimeter _____

Disconnect the battery cell

Set the multimeter range to DC Voltage

Connect the positive terminal of the battery cell to one side of the resistor. The negative terminal should be connected to the other side of the resistor

Connect the positive probe of the multimeter to the side of the resistor connected to the positive terminal of battery cell. The negative probe should be connected to the other side of the resistor

Write the value of voltage displayed on the multimeter _____

Connection to two battery cells

Disconnect the circuit and add the second battery cell

Repeat steps 7 & 8 above

Write the value of voltage displayed on the multimeter _____

Disconnect the circuit

Repeat steps 1-3 above

Write the value of current displayed on the multimeter _____

Connection to three battery cells

Disconnect the circuit and add the third battery cell

Repeat steps 6-8 above

Write the value of voltage displayed on the multimeter _____

Repeat steps 1-3 above

Write the value of current displayed on the multimeter _____

Disconnect the circuit and do housekeeping.

Write the measured values in the table below:

Number of Battery cells	Voltage	Current
Single battery cell		
Two battery cells		
Three battery cells		

Conclusions

When voltage is increased, current _____

29. Give reason for you answer in No 28

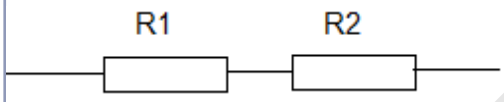
PRACTICAL ACTIVITY 6.6

Resistors connected in series

Aim: To demonstrate Ohm's law in a series circuit.

What will you need:

- 3 x Resistors.
- Multimeter.
- Connecting wires.
- breadboard



What you must do:

Connect the two resistors on breadboard as shown above.

Plug the red probe into + (red) slot and the black probe into the – (black) socket.

Set the multimeter range to Ohms (Resistance)

Connect multimeter probes across R1.

Write the value of resistance displayed on the multimeter _____

Remove multimeter probes and connect them probes across R2.

Write the value of resistance displayed on the multimeter _____

Write the sum of the measured values of resistance _____

Remove multimeter probes and connect them probes across all the three resistors.

Write the value of resistance displayed on the multimeter _____

Conclusion

The total resistance of the two resistors is _____ to the sum of all resistances in the circuit.

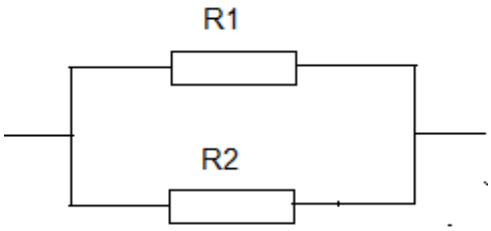
PRACTICAL ACTIVITY 6.7

Resistors connected in parallel

Aim: To demonstrate Ohm's law in a series circuit.

What will you need:

- 2 x Resistors.
- Multimeter.
- Connecting wires.
- breadboard



What you must do:

Connection to single battery cell

Connect the two resistors on breadboard as shown above.

Plug the red probe into + (red) slot and the black probe into the – (black) socket.

Set the multimeter range to Ohms (Resistance)

Connect multimeter probes across R_1.

Write the value of resistance displayed on the multimeter _____

Remove multimeter probes and connect them probes across R_2.

Write the value of resistance displayed on the multimeter _____

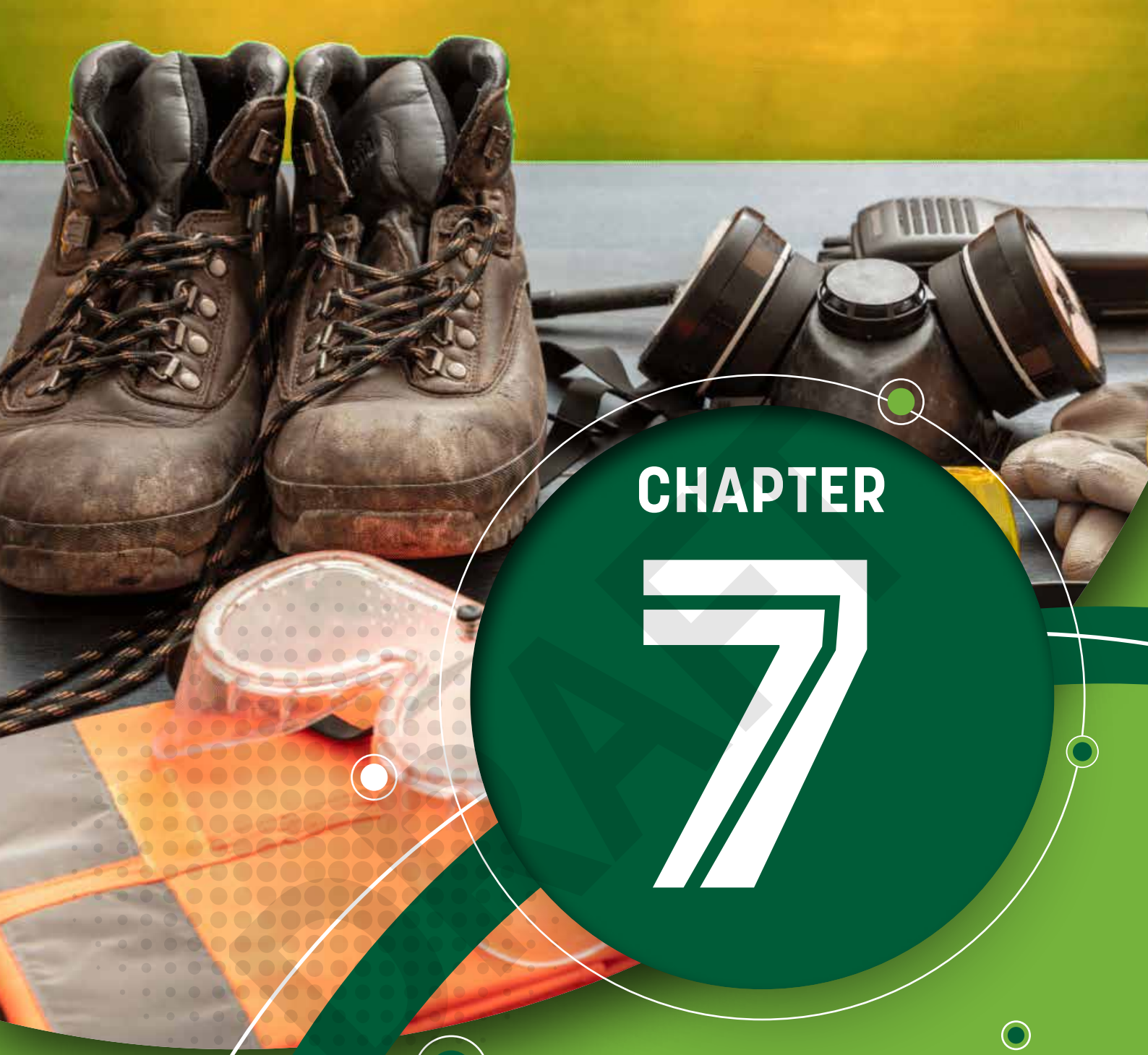
Write the sum of the measured values of resistance _____

Remove multimeter probes and connect them across all the three resistors.

Write the value of resistance displayed on the multimeter _____

Conclusion:

The total resistance of the three resistors is _____ than the least resistance in the circuit.



CHAPTER

7

Principles of Magnetism

LEARNING OUTCOMES

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

- Magnetic field around a current carrying conductor
- Right hand grip rule / Screw rule
- Ways of strengthening the magnetic field / flux.

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.

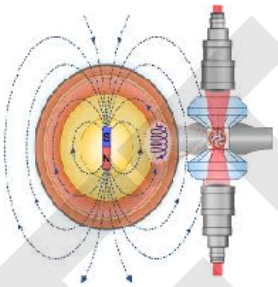


Figure 7.1

7.1 Direction of magnetic field around a current carrying conductor

Let us investigate the ways of finding the direction of magnetic field around the current carrying conductor.

Magnetic field around the current carrying conductor

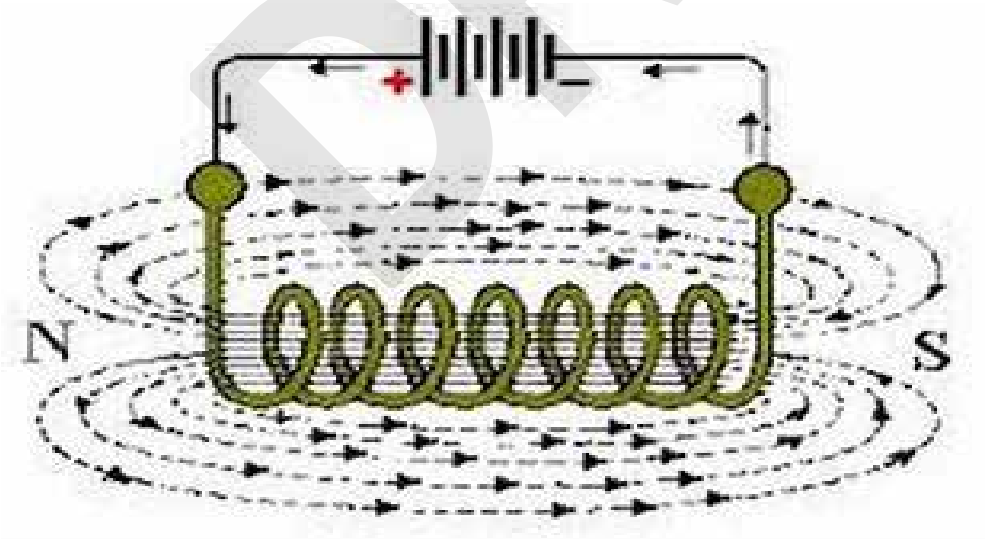


Figure 7.2

Right Hand Grip rule/Screw rule

Used for finding direction of magnetic field around a conductor.

The right- hand is used to determine the direction of the field when conventional current flow is considered. Wrap your hand around the conductor. If you point your thumb towards the direction of flow of current, then the direction of curled fingers will indicate the direction of magnetic field lines.

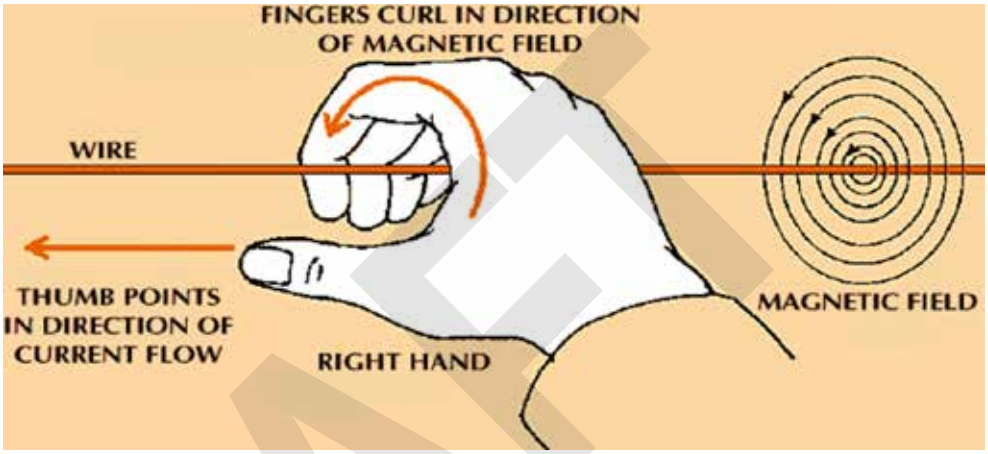


Figure 7.3

7.2 Ways of strengthening the magnetic field / flux

- The strength of magnetic field increases if the magnitude of current passing through the solenoid is increased.
- Number of turns of copper wire: Magnetic field can be increased by increasing the number of turns of copper wire in the solenoid.
- Nature of core: Magnetic field of a solenoid can be increased by using soft iron as core in the centre of solenoid.
- Strength of current: The strength of magnetic field produced in a solenoid is directly proportional to the magnitude of current passing.
- The ratio of length of the coil to the diameter of the coil.

Activity 7.1 Have you learnt something?

Test your Knowledge …

1 Draw a diagram to show a current carrying conductor.

2 State the 3 ways of strengthening the magnetic field.

3 Refer to the sketch below, and answer the questions:

3.1 With the right-hand rule, the fingers show _____

_____.

3.2 The thumb shows _____

_____.

PRACTICAL ACTIVITY 7.2

Build a circuit to form an electromagnet

Aim: Constructing an electromagnet.

What will you need:

- Connecting wires
- Insulated copper wire
- 1 × 9V PP3 and battery snap
- 1 × Nail
- Paper clips
- Sheet of paper.

What to do:

Step 1: Wind an insulated copper wire around the nail. Do not connect the battery until the circuit has been checked by the educator.

Step 2: Connect the two ends of the copper wire to the battery using connecting wires.

Step 3: Use the switch to open and close the circuit.

Step 4: Spread the paper clips on a sheet of paper.

Step 5: With the switch open, draw the nail closer to the paper clips and write your observation.

Step 6: Now close the switch, draw the nail closer to the paper clip and write your observation.

Step 7: Open the switch and observe what happens to the paper clips.

Write your conclusion:

_____
_____
_____
_____
_____
_____

7.3 Practical application of an electromagnet

- Electric bell
- Industrial lifting magnet
- Loudspeaker
- Magnetic doorbell
- Motor and generator
- Generators, motors, and transformers
- Electric buzzers and bells
- Headphones and loudspeakers
- Relays and valves
- Data storage devices like VCRs, tape recorders, hard discs, etc.
- Induction cooker
- Magnetic locks
- MRI machines
- Particle accelerators
- Mass spectrometer

CHAPTER

8

Electrical Circuits and Components

LEARNING OUTCOMES

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

- Capacitor
- Diode
- LED
  - » Diode and LED in the forward bias mode
  - » Diode and LED in the reverse bias mode
- Resistor
- Incandescent light
- Fuse
- Coil
- Variable resistor

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.

Figure 8.1

8.1 Introduction

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

In order to draw and interpret a basic electrical circuit, you should know electrical wiring symbols.

8.2 Identify components, symbols, units and functions

8.2.1 Capacitor

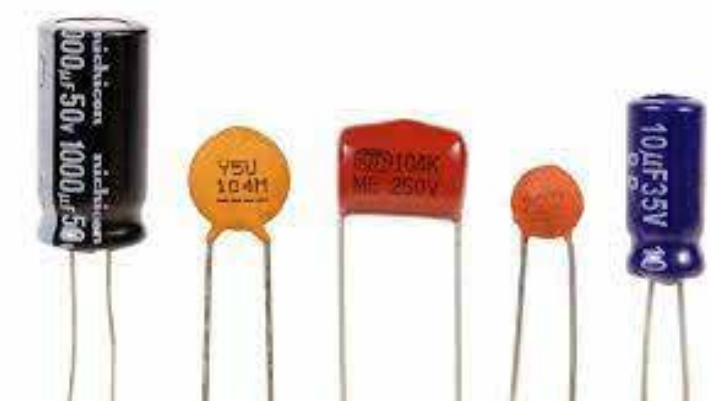
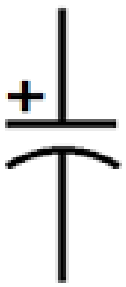


Figure 8.1

Function

Capacitors are components designed to store an electric charge and the ability of the capacitor to store electric charges is the capacitance. The capacitance is measured in farads.

Component symbol



Unit Symbol F (Farad)

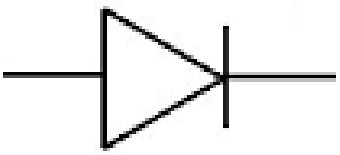
Diode

Figure 8.2

Function:

A diode will either allow or prevent the flow of current through the circuit.

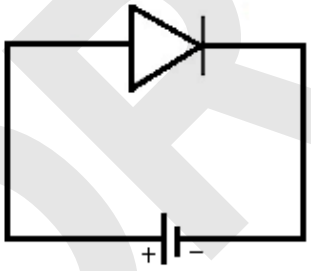
Component Symbol



The diode has two terminals namely, anode and cathode as shown on the diode and symbol below. The side of the diode with silver band is the cathode and the other side is the anode.

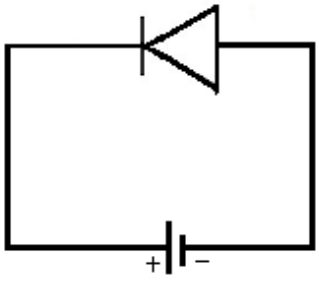
Figure 8.3

Forward bias



The diode is said to be forward bias when the anode is connected to the positive terminal of the battery and the cathode is connected to the negative terminal of the battery.

Reverse bias



The diode is said to be reverse bias when the anode is connected to the negative terminal of the battery and the cathode is connected to the positive terminal of the battery.

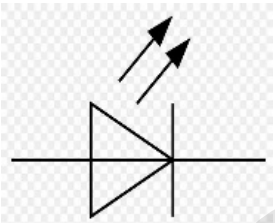
LED (Light Emitting Diode)

Figure 8.4

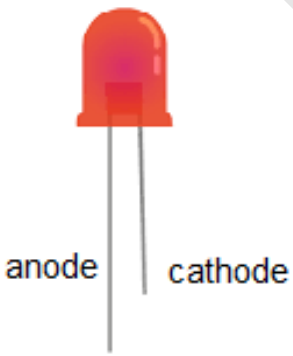
Function:

An LED shows light when voltage is applied across it.

Component symbol



The LED has two terminals namely, anode and cathode as shown on the LED and symbol below. The long terminal of the LED is the anode, and the shorter or flat side is the cathode.



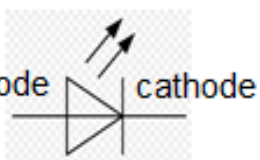
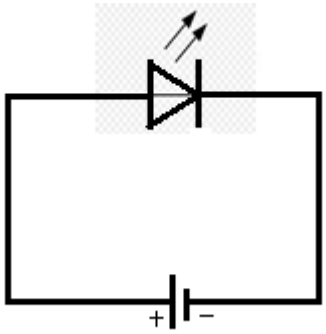


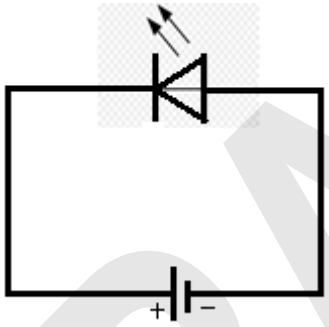
Figure 8.5

Forward bias



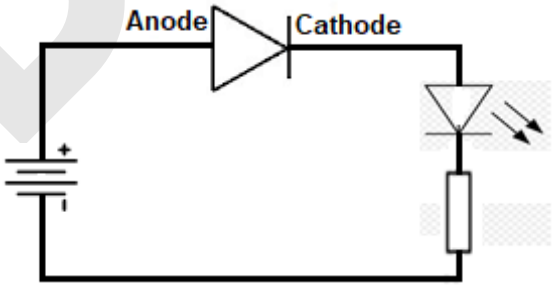
The LED is said to be forward bias when the anode is connected to the positive terminal of the battery and the cathode is connected to the negative terminal of the battery. In this way the LED will show light.

Reverse bias



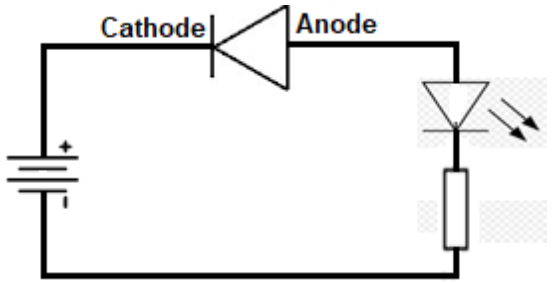
The LED is said to be reverse bias when the anode is connected to the negative terminal of the battery and the cathode is connected to the positive terminal of the battery. In this way, the LED will not show light.

Connect a diode and LED in the forward bias mode



If both the LED and diode are forward biased as shown in the circuit above, the LED will show light.

Connect a diode and LED in the reverse bias mode



If the LED is reverse bias and LED forward biased as shown in the circuit above, the LED will show light.

Resistor

Figure 8.6

Function

To reduce or limit current flowing in the circuit.

Component Symbol

Unit of measurement
Ω (ohm)

Incandescent Light

Figure 8.7

Function

The incandescent light bulb or lamp is a source of electric light.

Component symbol

Fuse

Figure 8.8

Function

Protects circuits from high currents that may damage electric components.

Component symbol

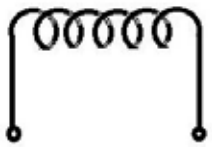
Coil

Figure 8.9

Function

Is used to produce a magnetic field or to provide electrical resistance when current is flowing through it.

Component Symbol



Unit Symbol
H (Henry)

Variable Resistor

Figure 8.10

Function

Is used to reduce or limit current. The resistance can be changed from minimum to maximum resistance.

Component symbol

Unit Symbol
Ω (ohm)

PRACTICAL ACTIVITY 8.1 Have you learnt something?

Test your Knowledge …

1.1 Identify the components below:.

1.1.1

1.1.2

1.1.3

1.2 State the functions of the components below:

- 1.2.1 Capacitor.
- 1.2.2 Fuse
- 1.2.3 Diode

1.3 Draw a labelled symbol of the following components.

- 1.3.1 Coil
- 1.3.2 LED

1.4 Draw a labelled diagram to show the diode connected in:

- 1.4.1 Reverse bias
- 1.4.2 Forward bias

PRACTICAL ACTIVITY 8.2

Identify/test/measure different components with a multimeter

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

What you will need:

- Fuse
- Measuring Instrument: Multimeter

Testing of a fuse:

Set the multimeter to (Ω) resistance mode using the selector switch.

1 Connect leads in the correct slots on the multimeter.
2 Connect the leads of the multimeter across the fuse.
3 Write the reading displayed on the multimeter _____

Conclusion: if the multimeter reading is low, the fuse is working. if the multimeter reading is high or infinity, this means that the fuse is damaged and cannot be used anymore. Simply replace with a spare or buy a new fuse.

Testing of a coil:

Set the multimeter to (Ω) resistance mode using the selector switch.

1. Connect leads in the correct slots on the multimeter.
2. Set the multimeter to highest range on the scale
3. Connect the leads of the multimeter across the coil.
4. Write the reading displayed on the multimeter _____

Testing of a resistor:

Set the multimeter to (Ω) resistance mode using the selector switch.

1. Connect leads in the correct slots on the multimeter.
2. Set the multimeter to highest range on the scale
3. Connect the leads of the multimeter across the terminals of the resistor.
4. Write the reading displayed on the multimeter _____
5. If the reading is too high or infinity, adjust scale to lower range until a reading appears.
6. Write the reading displayed on the multimeter and the unit symbol. Also include the prefix before unit symbol if the selector switch is on prefix _____

Conclusion:

Testing of the diode:

Set the multimeter to Diode mode using the selector switch.

1. Connect leads in the correct slots on the multimeter.
2. Connect the positive lead of the multimeter to the side with the white/ silver band and the negative lead on the other side of the diode.
3. Observe the reading on the multimeter?
4. Write the reading displayed on the multimeter

   _____
5. Now swap the probe leads across the diode.
6. Observe the reading on the multimeter?
7. Write the reading displayed on the multimeter _____

Conclusion: if the multimeter reading is low, the diode is forward biased. This means that the diode is working. If the multimeter reading is high or infinity, the diode is reverse biased. The diode does not allow the flow of current when connected in reverse bias.

Testing of the LED:

Set the multimeter to Diode mode using the selector switch.

1. Connect leads in the correct slots on the multimeter.
2. Connect the red lead of the multimeter to the flat side of LED and the black probe to the other side of the LED.
3. Observe the LED. What do you see on the LED?_____
4. Swap the leads of the multimeter
5. Observe the LED. What do you see on the LED?

Conclusion: if the multimeter reading is high or infinity, the LED is reverse biased and will not show light

PRACTICAL ACTIVITY 8.3

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.

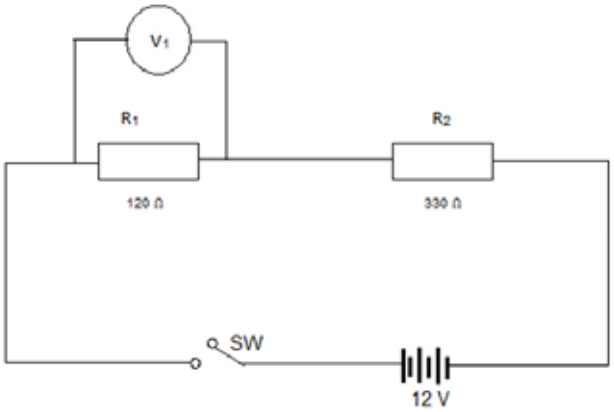
What you will need:

- 1 × 120 Ω resistor
- 1 × 330 Ω resistor
- Power Supply
- Connecting wires
- Multimeter
- Breadboard

What to do:

Refer to the circuit diagram below to build a circuit. Follow the steps below to measure values of current and voltage.

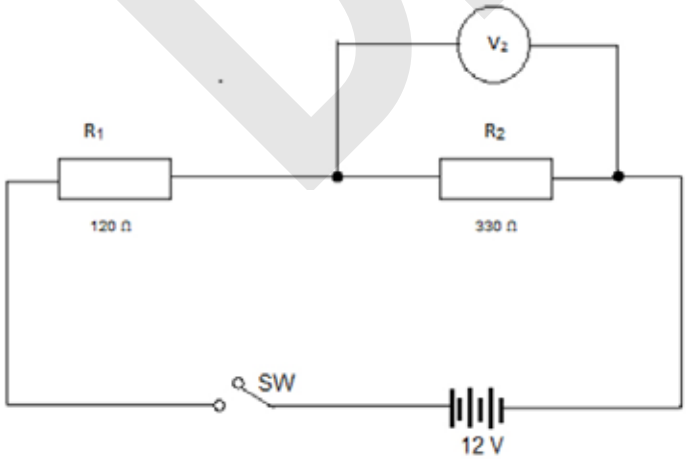
Measuring V.



Connect the circuit as shown above.

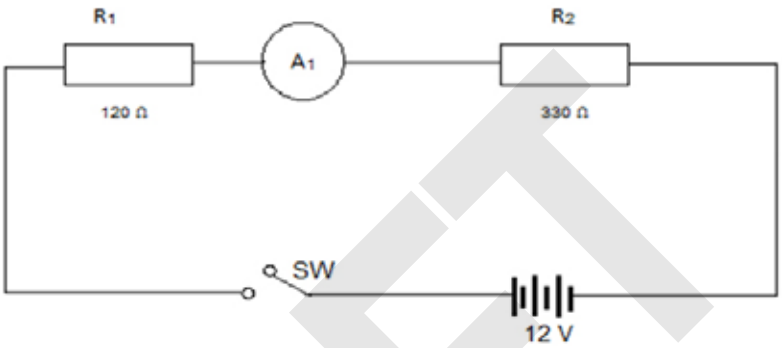
1. Set the multimeter range to DC voltage before connecting to the circuit
2. Plug the red probe in the slot written "VΩ" and black on the slot written "COM"
3. Connect the red probe of multimeter to the side of R1 connected to positive terminal of the battery and connect the black probe on the other side of R1.
4. Observe the multimeter reading and write the value of the voltage in the table at the bottom of this practical.

Measuring V2

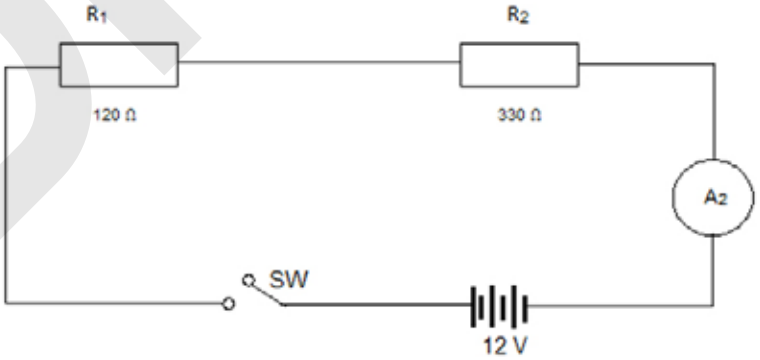


Set the multimeter to (Ω) resistance mode using the selector switch

1. Remove the multimeter leads and connect them across R2. Note that the black lead must be connected to the side of R2 connected to the negative terminal of the battery. The red lead be connected to the other side of R2.
2. Observe the multimeter reading and write the of the voltage in the table at the bottom of this practical.
3. Switch off circuit and remove the multimeter leads from the circuit.



1. Set the multimeter range to DC current before connecting to the circuit
2. Break the circuit between R1 and R2 and connect the red lead of the multimeter to the side of the break connected to R1.
3. Connect the black lead of the multimeter to the side of the break connected to R2.
4. Close the switch and observe the multimeter reading
5. Write the of the current in the table at the bottom of this practical.
6. Switch off the circuit, remove multimeter from the circuit and connect the broken wires.



1. Set the multimeter range to DC current before connecting to the circuit
2. Break the circuit between R2 and battery and connect the red lead of the multimeter to the side of the break connected to R2.
3. Connect the black lead of the multimeter to the side of the break connected to the battery.
4. Close the switch and observe the multimeter reading.

5. Write the of the current in the table below

	Measured Values
V1	
V2	
V1 + V2	
A1	
A2	

Conclusion: The values of both A1 and A2 is the_____. The _____voltage is equal to the _____of V1 and V2.

PRACTICAL ACTIVITY 8.4

Build a simple parallel circuit containing two resistors

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

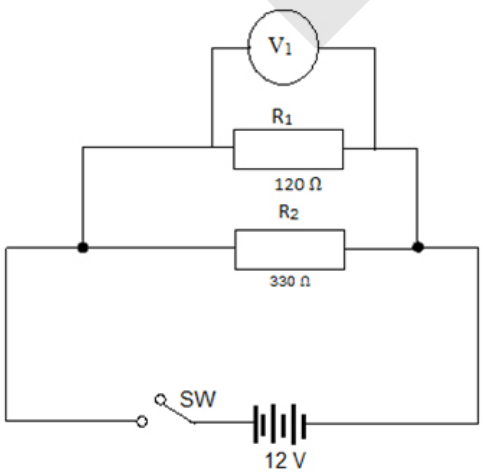
What you will need:

- 1 × 120 Ω resistor
- 1 × 330 Ω resistor
- Cell batteries / Power Supply
- Connecting wires
- Multimeter
- Breadboard

What to do:

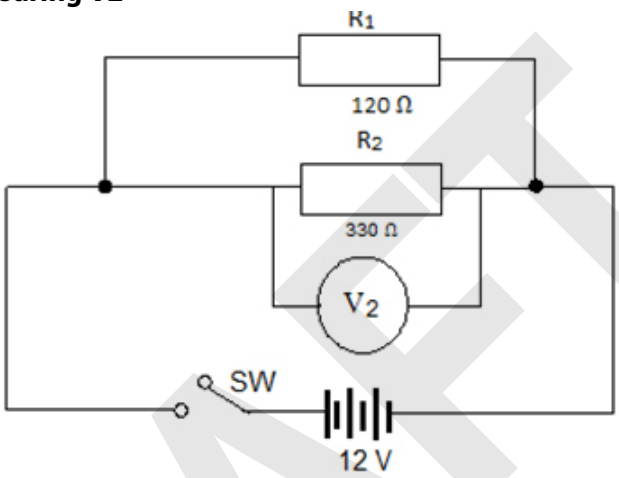
Refer to the circuit diagram below to build a circuit. Follow the steps below to measure values of current and voltage.

Measuring V1



1. Set the multimeter range to DC voltage before connecting to the circuit
2. Plug the red wire in the slot written "VΩ" and the black on the slot written "COM"
3. Connect the red wire of multimeter to the side of R1 connected to the switch and connect the black wire on the other side of R1.
4. Observe the multimeter reading and write the value of the voltage in the table at the bottom of this practical.

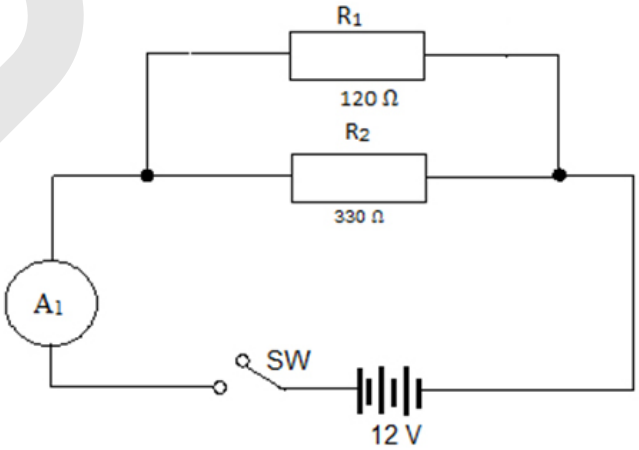
Measuring V2



Set the multimeter to (Ω) resistance mode using the selector switch

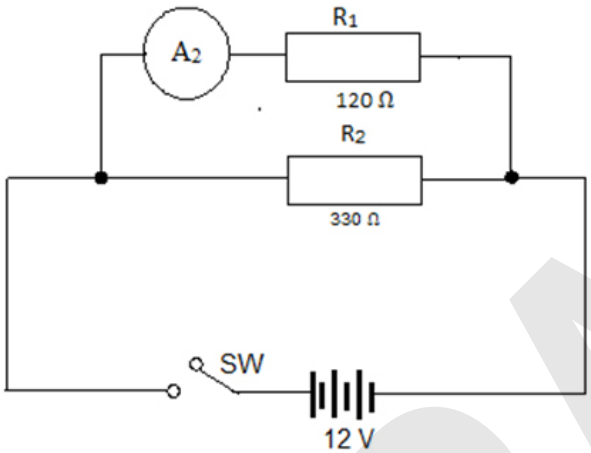
1. Remove the multimeter leads and connect them across R2. Note that the black lead must be connected to the side of R2 connected to the negative terminal of the battery. The red lead be connected to the other side of R2.
2. Observe the multimeter reading and write the of the voltage in the table at the bottom of this practical.
3. Switch off circuit and remove the multimeter leads from the circuit.

Measuring A1



1. Set the multimeter range to DC current before connecting to the circuit
2. Break the circuit between switch and resistors (R1and R2).
3. Connect the red lead of the multimeter to the side of the break connected to the switch.
4. Connect the black lead of the multimeter to the side of the break connected to the resistors.
5. Close the switch and observe the multimeter reading.
6. Write the of the current in the table at the bottom of this practical activity.
7. Switch off the circuit, remove multimeter from the circuit.

Measuring A2



1. Set the multimeter range to DC current before connecting to the circuit
2. Break the circuit between R1 and side of the bridge.
3. Connect the red lead of the multimeter to the side of the break connected to the bridge.
4. Connect the black lead of the multimeter to the side of the break connected to the R1.
5. Close the switch and observe the multimeter reading.
6. Write the of the current in the table in the table at the bottom of this practical activity.

	Measured Values
V1	
V2	
I_1	
I_2	
I_3	

Conclusion: The values of both A1 and A2 is the_____.
The _____voltage is equal to the _____ of V1 and V2.

PRACTICAL ACTIVITY 8.5

Build a simple circuit containing diode and LED

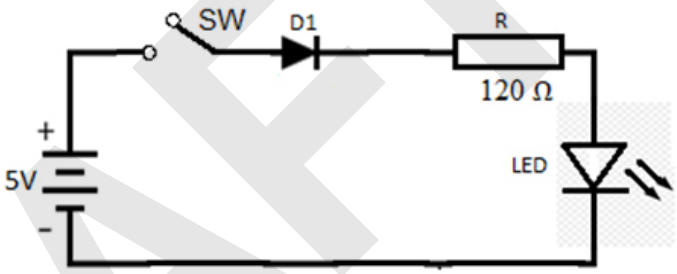
Aim: The learner will demonstrate an understanding of forward bias and reverse bias.

What you will need:

- 1N4007 Diode
- LED
- Resistor 120 Ω tolerance ±5%
- Multimeter

What to do:

Refer to the circuit diagram below to build a circuit. Follow the steps below to measure values of current and voltage.



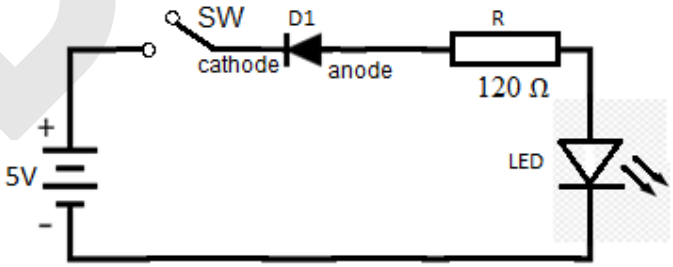
Forward bias.

1. Connect the circuit as shown in the circuit diagram above.
2. Close switch and observe the LED.
3. Is the LED showing light? _____
4. If Yes or No, give a reason for your answer. _____

_____

_____

Reverse bias.



1. Connect the circuit as shown in the circuit diagram above.
2. Close switch and observe the LED.
3. Is the LED showing light? _____
4. If Yes or No, give a reason for your answer. _____

_____

_____

CHAPTER

9

Power Sources

LEARNING OUTCOMES

By the end of this chapter the learner should be able to demonstrate a basic understanding of energy and the components of a basic solar power system. The following will be covered in this chapter:

- The different types of energy sources
- Primary and secondary cells
- Basic solar power system
  - » Block diagram of basic DC solar system
  - » Components of basic DC solar system
  - » Function of each component of basic solar system

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.

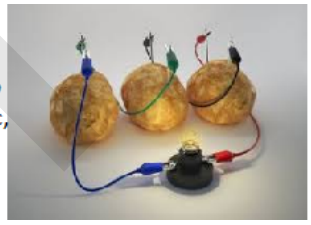


Figure 9.1

9.1 Energy

Energy can be broken down into renewable and non-renewable energy sources.

9.1.1 Renewable energy

A renewable energy source means energy that will not run out, or is endless, like the sun.

Types of renewable energy are:

- Solar energy
- Wind energy
- Hydro energy
- Tidal energy
- Geothermal energy
- Biomass energy

Solar energy

Energy provided by sunlight. It is also heat provided by the sun.

Wind energy

Energy provided by windmills and wind turbines

Hydro energy

Energy that uses the water stored in dams, as well as flowing in rivers to create electricity in hydropower plants

Tidal energy

Energy produced by the surge of ocean waters during the rise and fall of tides.

Geothermal energy

Heat energy that is continuously produced inside the earth.

Biomass energy

Energy from organic matter used as a fuel, especially in a power station for the generation of electricity

9.1.2 Non-renewable energy

Non-renewable energy comes from sources that will run out or will not be replenished for thousands or even millions of years.

Types of non-renewable energy resources are:

- Petroleum
- Hydrocarbon gas liquids
- Natural gas
- Coal
- Nuclear energy

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.

9.1.3 Primary cells and secondary cells

Primary cells

A primary cell cannot be recharged once it has been used.

Examples of primary cells:

Figure 9.2 Primary cells

Dry cells

Dry cells are used in devices such as flashlights and portable radios.

Alkaline cells

Alkaline cells are used in toothbrushes, toys and game controllers.

Leclanché cell

The Leclanché is used for telegraphy, electric bell and signalling work

Secondary cells

Secondary cells are the ones that are rechargeable once they have been used.
Examples of secondary cells: Nickel-cadmium (NiCd), lead acid, and lithium ion

Figure 9.3 Lead acid cell

Use of secondary cells:

- Starting ignition in vehicles
- Lighting in vehicles.

Activity 9.1 Have you learnt something?

Test your Knowledge …

9.1 Name four types of renewable energy.

9.2 Name three types of non-renewable energy.

9.3 Define:

- 9.3.1 Renewable energy
- 9.3.2 Non-renewable energy

9.4 Define the following:

- 9.4.1 Primary cells
- 9.4.2 Secondary cells

9.5 Name three examples of primary cells

9.6 Explain where each of the examples of primary cells above are used

9.2 Basic Solar Power system

Block diagram

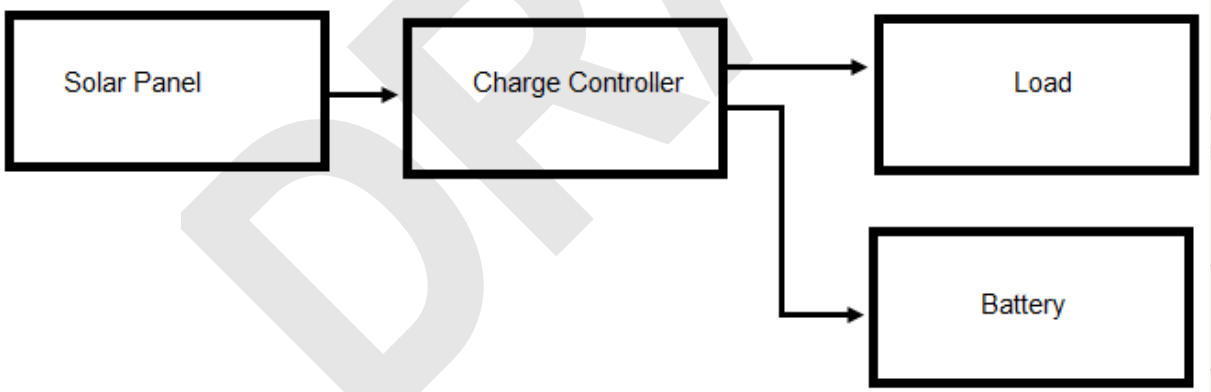


Figure 9.4

Solar panel

The solar panel changes sun rays into electrical energy.

Charge controller

The charge controller is used to charge the battery and keep electric cells from overcharging.

Battery

During the day the sunlight charges the battery, and the stored energy will be used during the night and when there is no sufficient sunlight.

Activity 9.2 Have you learnt something?

Test your Knowledge …

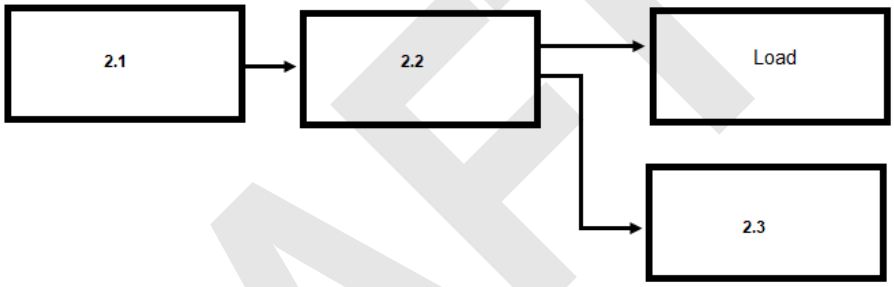
1 Name the blocks of a basic solar power system below.

1.1

1.2

1.3

2 Describe the function of the blocks of a basic solar power system below.



2.1

2.2

2.3

PRACTICAL ACTIVITY 9.3

Demonstration of generating power using a lemon.

Aim: Demonstrating the ability of a lemon to generate power.

DIAGRAM

What you will need:

- 1 lemon
- 2 zinc or galvanized nail
- Connecting wires
- 1 Digital Multimeter

What to do:

First make the lemon softer by squeezing or bump it against the wall so that the juice can flow within it. Do not peel off the lemon.

Insert both nails into the lemon so that they don't appear on the other side of the lemon, and make sure you leave space between the nails so that they don't touch.

Connect the light bulb across the two nails with connecting wires.

Connect multimeter across the two nails to measure voltage.

Write the value of voltage shown on the multimeter _____

PRACTICAL ACTIVITY 9.4

How to connect cells in series and measure voltage.

Aim: Demonstrating the ability to measure voltage across cells connected in series.

DIAGRAM

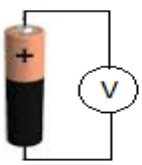


Figure 1

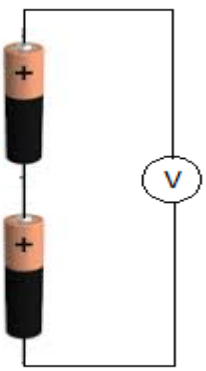


Figure 2

What you will need:

- 2 battery cells
- Battery holder
- Connecting wires

What to do:

Connect probes in the correct slots on the multimeter.

Set the multimeter range to DC Voltage

Connect the red wire to the positive terminal of the cell and the black wire on the negative terminal of the cell as shown in Figure 1.

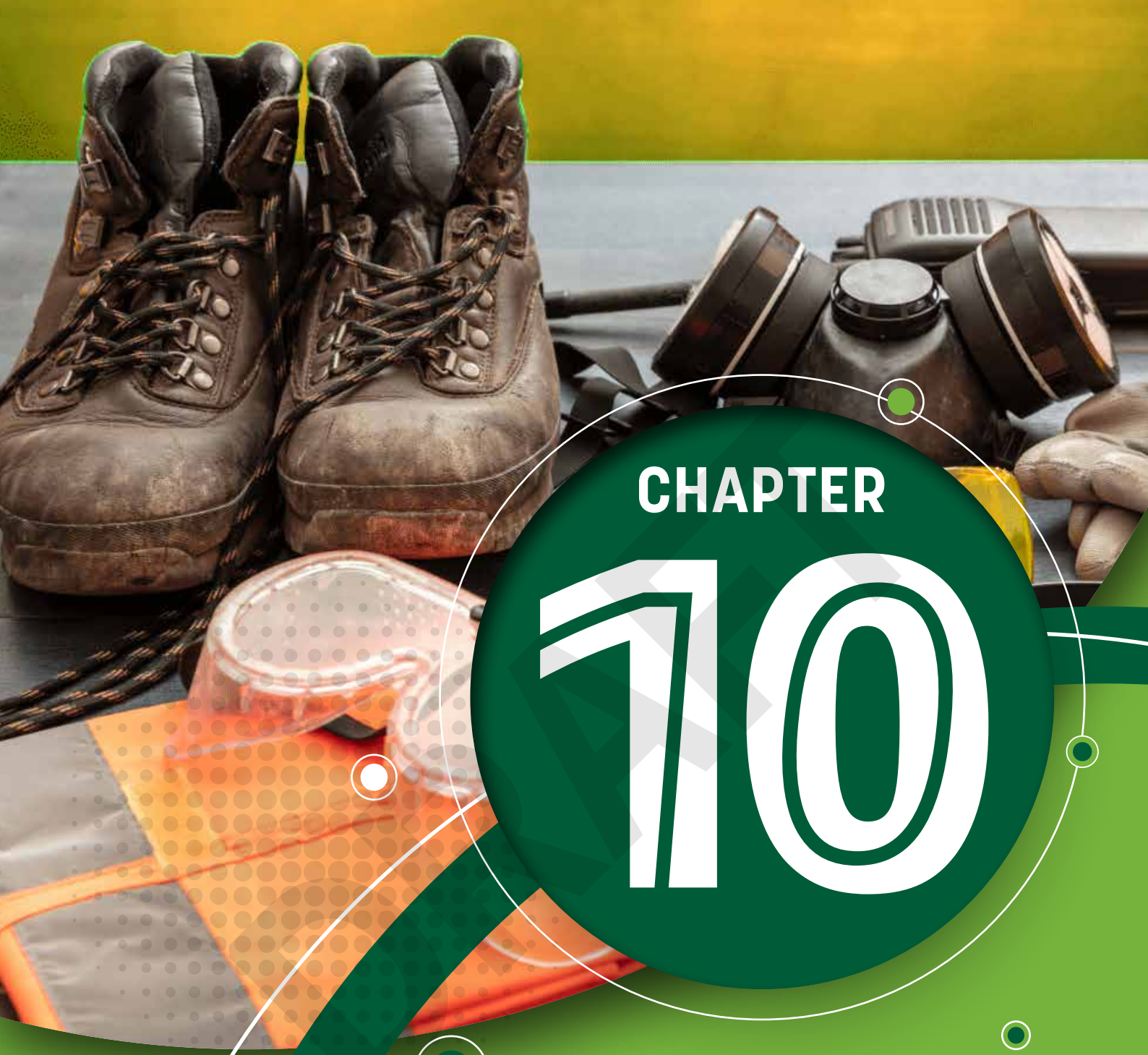
Write the reading shown on the multimeter _____

Remove the wires from the cell and add the second cell as shown in Figure 2.

Write the reading shown on the multimeter _____

Conclusion:

When cells are connected in series, _____ increases.



CHAPTER

10

Logic Gates

LEARNING OUTCOMES

By the end of this chapter the learner should be able to demonstrate an understanding of logic gates. The following will be covered in this chapter:

- Symbols and truth table of two input logic gates
- The AND gate
- The OR gate and basic circuits where it is used
- Electric circuit equivalents using switches

10.1 Introduction to logic gates

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 utilised by many careers that work with computers and technology, such as engineers and repair technicians.

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 generally only have one digital output. There are many Logic Gates that are used in electronic devices.

Types of Logic Gates:

- AND Gate
- OR Gate
- NOT Gate
- NAND Gate
- NOR Gate
- XOR Gate
- XNOR Gate

In this chapter we will focus on the following logic gates:

- AND Gate,
- OR Gate

10.2 The AND-gate

The AND-gate logic is where the output of a logic circuit is on (HIGH) only when **all inputs are on** (HIGH).

HIGH means On
LOW means Off

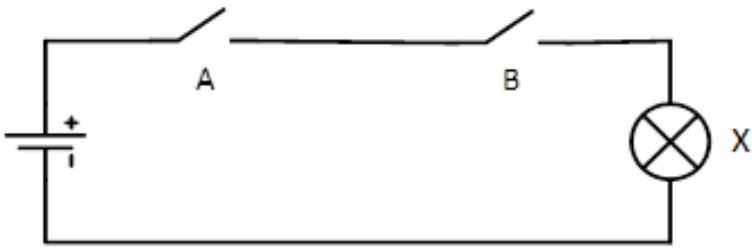


Figure xx Electric circuit equivalents using switches

Refer to the circuit diagram above for operation of AND gate:

- When switch A is **Open** and switch B is **Open** the lamp will be **OFF** because the current flowing in the circuit does not complete the circuit.
- When switch A is **Open** and switch B is **Closed** the lamp will be **OFF** because of the same reason as in the first bullet
- When switch A is **Closed**, and switch B is **Open** the lamp will be **OFF** because of the same reason as in the first bullet.
- When switch A is **Closed**, and switch B is **Closed** the lamp will be **ON**. **Since both switches are closed**, the current is completing the circuit.
- Symbol and truth table of two input AND gate.

Truth Table

A truth table shows the possible input combinations and corresponding outputs of a logic circuit. It gives you an understanding of the logic operation of a circuit.

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Activity 10.1 Have you learnt something?

Test your Knowledge …

1.1 Define the AND gate logic.

1.2 Draw a symbol of the AND gate logic.

1.3 Draw a circuit diagram consisting of two switches, a lamp and a voltage source to show the AND gate logic.

1.4 Draw the truth table for the circuit in 1.3.

10.3 The OR-gate

The OR-gate logic is where the output of a logic circuit is on (HIGH) when either of the inputs is on (HIGH).

HIGH means On
LOW means Off

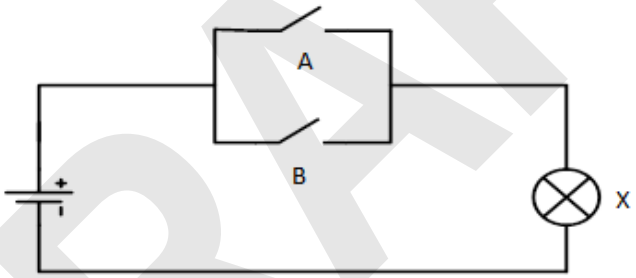


Figure xx Electric circuit equivalents using switches

Refer to the circuit diagram above for operation of OR gate:

- When switch A is Open and switch B is Open the lamp will be OFF because the current flowing in the circuit does not complete the circuit.
- When switch A is Open and switch B is Closed the lamp will be OFF because the current is completing the circuit through the closed switch B.
- When switch A is Closed, and switch B is Open the lamp will be OFF because the current is completing the circuit through the closed switch A.
- When switch A is Closed, and switch B is Closed the lamp will be ON because the current is completing the circuit through both closed switches.

Figure xx Symbol and truth table of two input AND gate.

Truth Table

A truth table shows the possible input combinations and corresponding outputs of a logic circuit. It gives you an understanding of the logic operation of a circuit.

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Activity 10.2 Have you learnt something?

Test your Knowledge …

1.1 Define the OR gate logic.

1.2 Draw a symbol of the OR gate logic.

1.3 Draw a circuit diagram consisting of two switches, a lamp and a voltage source to show the OR gate logic.

1.4 Draw the truth table for the circuit in 1.3.

10.4 Practical

Activity 10.3 Have you learnt something?

Test your Knowledge …

Build an AND Gate circuit using switches and a bulb

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:

Connect the circuit as above

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

Switch A	Switch B	Bulb
0	0	
1	0	
0	1	
1	1	

Step 3

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

_____

_____

_____

_____

_____

Activity 10.4 Have you learnt something?

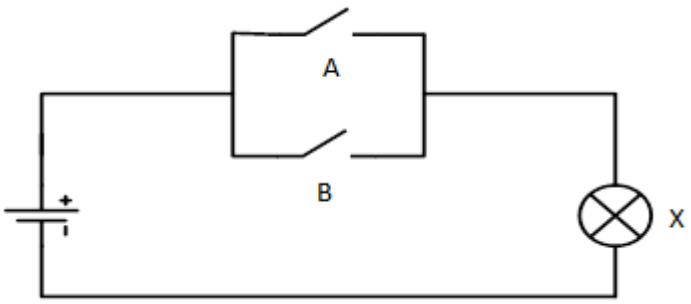
Test your Knowledge …

Build an OR Gate circuit using switches and a bulb

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

What will you need:

- 2 × 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

Switch A	Switch B	Bulb
0	0	
1	0	
0	1	
1	1	

Step 3:

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

_____
_____
_____
_____
_____
_____

10.5 Demonstration (by the teacher)

Practical tasks

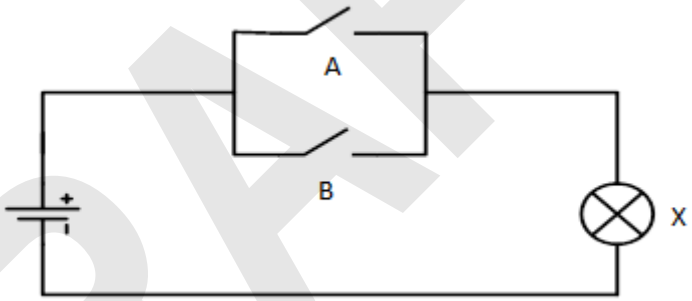
Demonstration of OR Gate using an integrated circuit

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

What will you need:

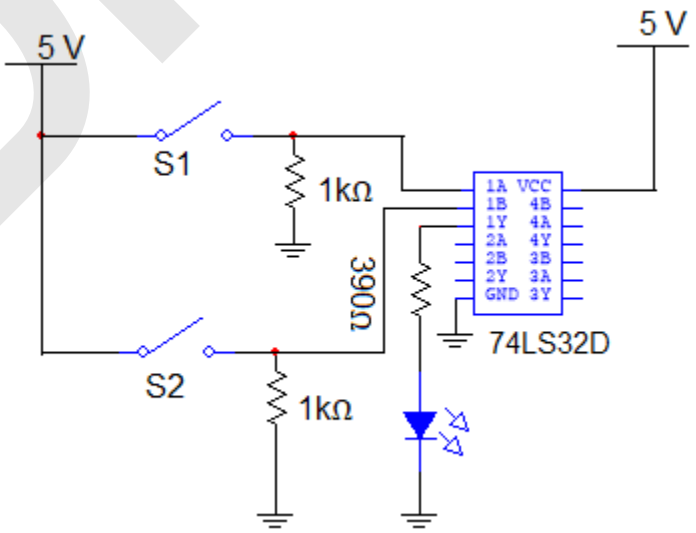
Materials and equipment:

- Breadboard / Logic Trainer
- 1 × 4011/7400 NAND – GATE IC
- 5V Battery / Power Supply
- 2 × SPDT Switches
- 1 × LED
- 2 × 1k5Ω resistor
- 1 × 1 kΩ resistor.



Purpose

To investigate the combinational circuits



Materials and equipment:

- Breadboard / Logic Trainer
- 1 × 74LS32D OR – GATE IC
- 5V Battery / Power Supply
- 2 × SPST Switches
- 1 × LED
- 2 × 1kΩ resistor
- 1 × 390 Ω resistor

Instructions

Connect the circuit as above on your Electronic snap circuit kit / Breadboard / Logic Trainer.

The teacher must first check your circuit before you switch on the supply.

Use the truth table provided below and complete it by switching switch A and switch B to the positions according to the truth table

TRUTH TABLE

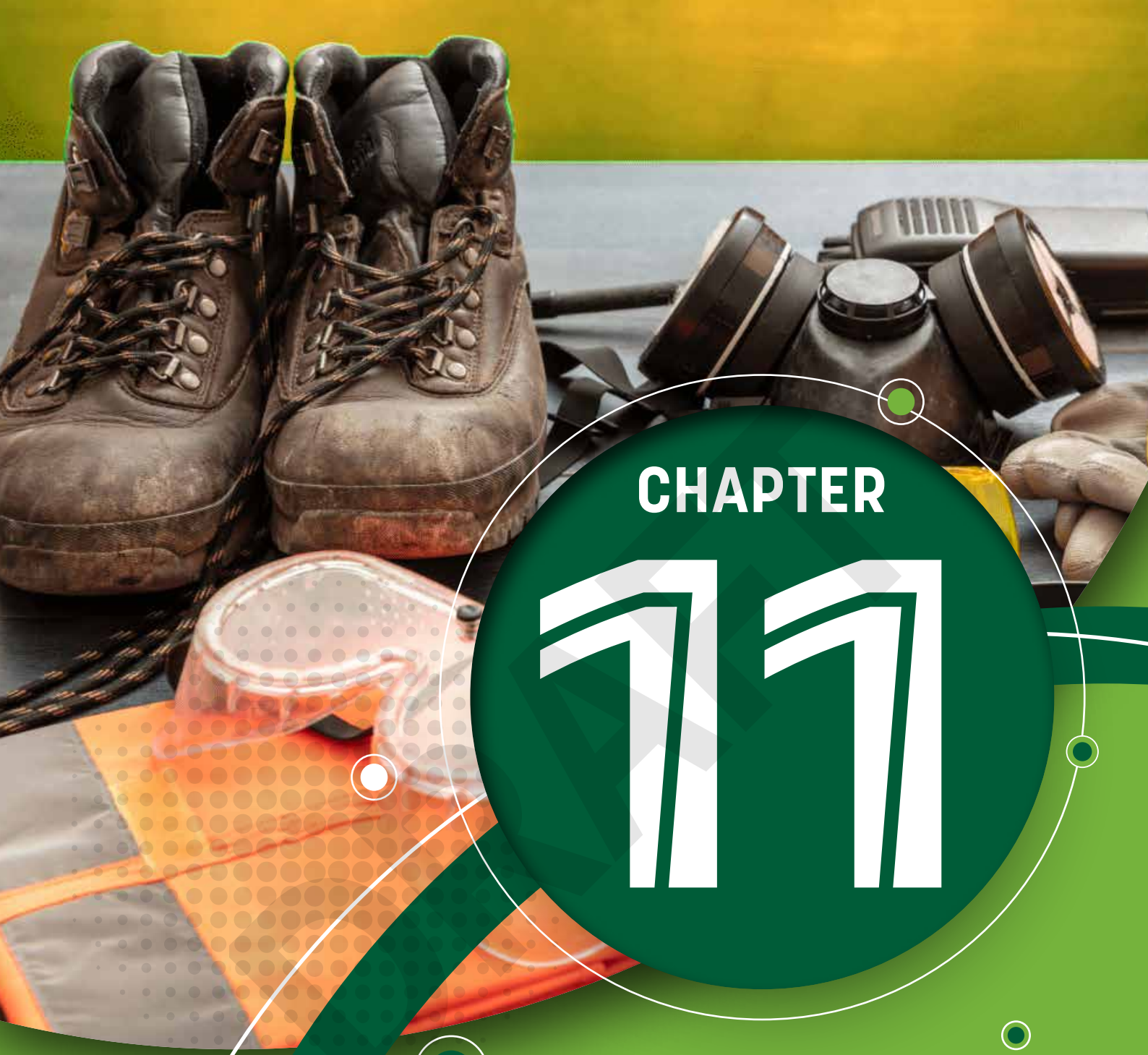
A = S1 B = S2	X = LED
Open switch = 0	LED OFF = 0
Closed switch = 1	LED ON = 1

A	B	X
0	0	
0	1	
1	0	
1	1	

The truth table represents_____ gate

_____

_____



CHAPTER

11

Domestic Installations

LEARNING OUTCOMES

By the end of this chapter the learner should be able to demonstrate a basic understanding of an electrical domestic installation. The following will be covered in this chapter:

- Electrical energy distribution from the supplier to the consumer
- Block diagram of the sequence of connections from supplier to consumer
- SANS 10142-1 Installation regulations
- The electrical distribution board
  - » Wiring of the distribution board
  - » Distribution board wiring principles
- PVC conduit and fittings
- Wiring of sub-circuits
  - » Lighting circuit
  - » Plug circuit
  - » Testing of sub-circuits after installation

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.

Figure 11.1

11.1 Introduction

Installation is to put the equipment or material at the permanent position, or make ready to use, or ready for operation.

Domestic installations mean the construction or installation of electrical wiring and the permanent attachment or installation of electrical products such as switches, distribution boards, sockets, and light fittings in a building or structure.

11.2 Electrical energy distribution from supplier to the consumer

The diagram below shows the stages of generation of electricity from the power station to the consumer.

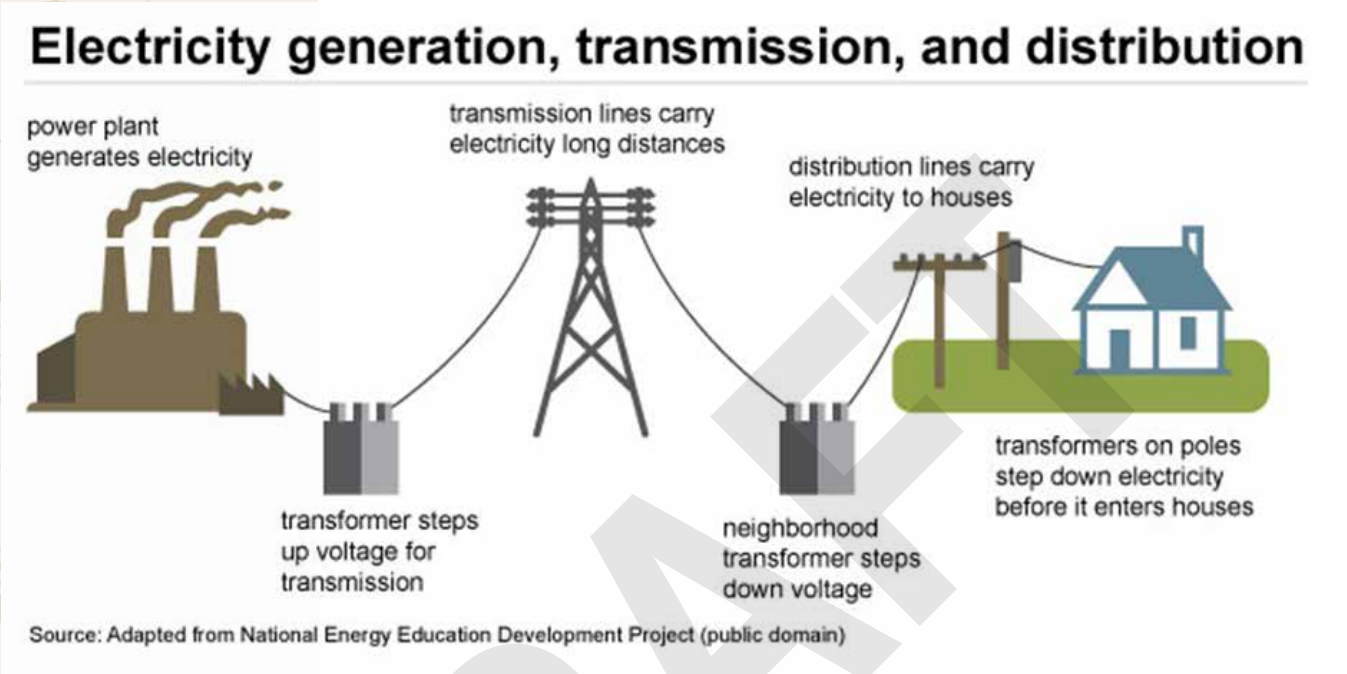
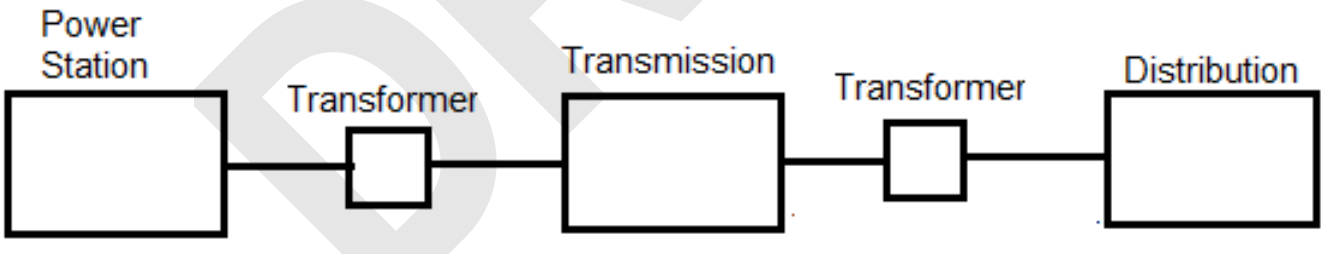


Figure 11.2 Electrical energy distribution

Three main stages of electrical energy



Stage 1: Generation

Electrical energy is generated from the different power stations e.g., Coal power station, Hydro-electric power station, wind power station, nuclear power station, solar power station etc.

Stage 2: Transmission

Electricity is transported over long distances through the overhead power lines.

Stage 3: Distribution

On arriving to local sub-stations, the high voltage electric power is reduced to required voltage and supplied to consumers e.g., factories, offices, homes, etc.

11.3 The sequence of connection from the supplier to the consumer

The sequence of connection from the supplier to consumer is as follows:

Generating system where electricity is generated.

Transmission system where overhead transmission lines carry high voltage over long distances to the distribution station

Distribution station/centre where distribution lines carry electricity to the local centre.

The local centre that is the commercial customers, industrial customer and residential customers receiving the electricity from the distribution centre.

11.4 SANS 10142-1 Installation regulations.

The rules and standards of installations are found in the document called South African National Standards (SANS).

The main purpose of standards and regulations is to ensure the basic safety of electrical installations and the safety of people, animals and property.

The table below shows the rating current of electrical sub-circuits (SANS 10142):

Sub-circuits	Sectional	Rating current
Light	1,5 mm^2	10 A
Socket outlet	2,5 mm^2	20 A
Earth leakage	16 mm^2	63 A
Stove	6 mm^2	40 A
Geyser	2,5 mm^2	20 A

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

11.5 The Distribution Board

11.5.1 What is the Distribution Board

A distribution board (DB) is where the electrical supply is distributed from within the building.

The main supply cable comes into the board and is then distributed to the breakers and from there to all the circuits, e.g., lights, plugs.

The distribution board (DB) usually houses all the contact breakers, earth leakage unit and may house items such as a doorbell transformer and timers. Various sizes of distribution boards are available.

Figure 11.2 Different types of electrical distribution boards

The main distribution board is usually in the house where the main electrical cable enters. Various types of distribution boards are available as surface mounted, flush mounted or floor standing; with closing doors or see-through plastic covers or doors and in different sizes.

11.6 PVC conduit and fittings and their application

PVC CONDUIT AND FITTINGS

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
	Conduit box lid (cover)	Used to cover the conduit box
	Conduit box: 4 knock out loops	Used for wire junctions (plugs)
	Female adaptor	Used to join the conduit box and the conduit pipe.
	Male adaptor	Used to join the conduit box and the conduit pipe.

11.7 Wiring of a distribution board

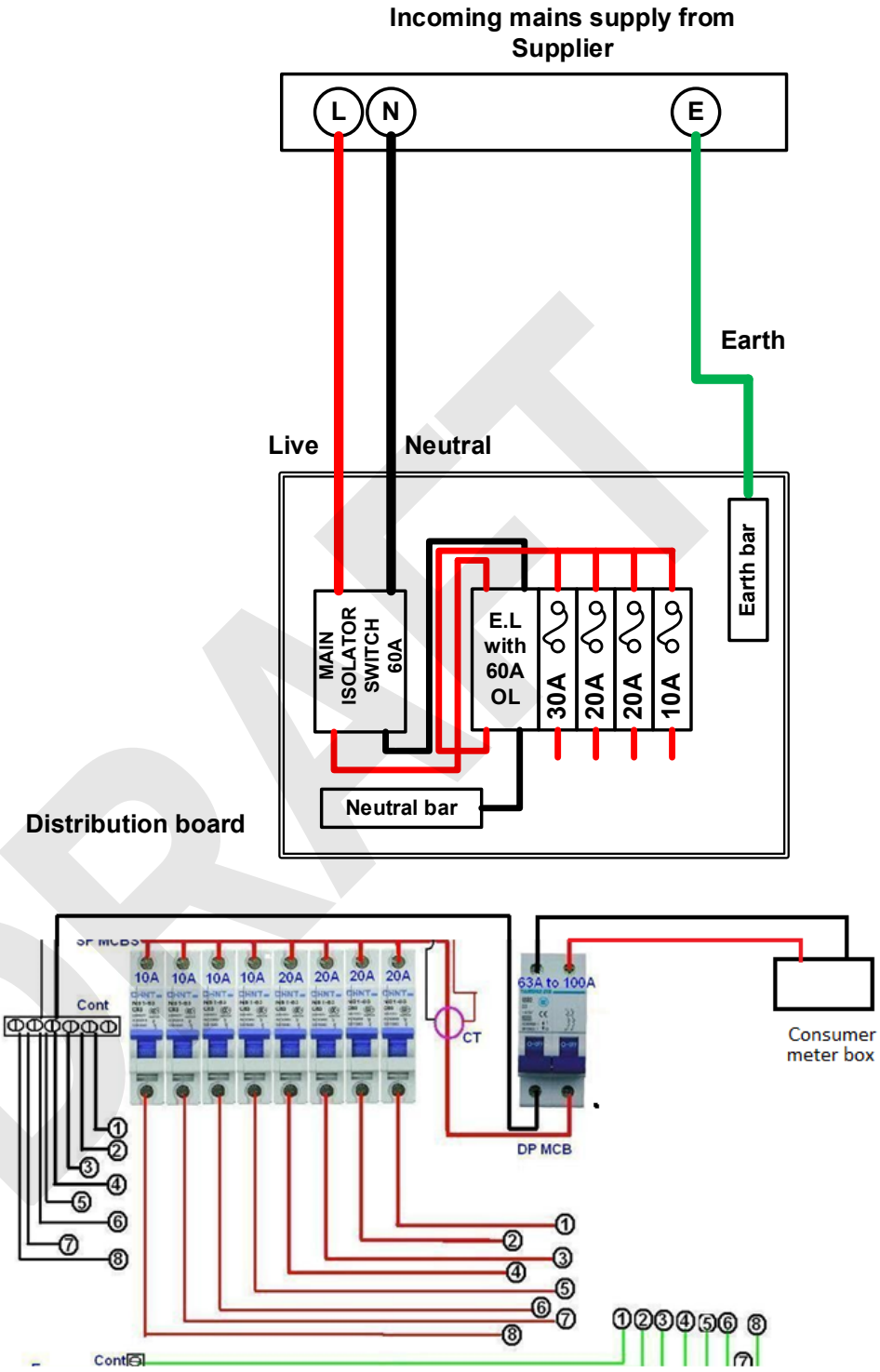


Figure 11.3 Examples of wiring of a distribution board

11.8 Distribution Board wiring principles

General rules to follow when wiring a distribution board are:

- Ensure the main feeder cable is of the correct cross-sectional size to handle the premises full load demands.
- All cables for each sub-circuit are to meet the regulations for minimum cross-section size.
- All switch gear installed is to meet the regulations for current ratings.
- Ensure that on entry to the board, both live and neutral feeder cables are first fed to the master circuit breaker.
- All sub-circuits must have a separate equi-potential bonding wire and that these wires are all coupled together using a separate bus bar.
- Ensure that the earth bus bar is directly coupled to the earth spike.

11.9 Wiring of subcircuits

Connection of the light circuit

In domestic installations, lights are normally connected in parallel so that each light bulb is supplied with full supply voltage as shown below.

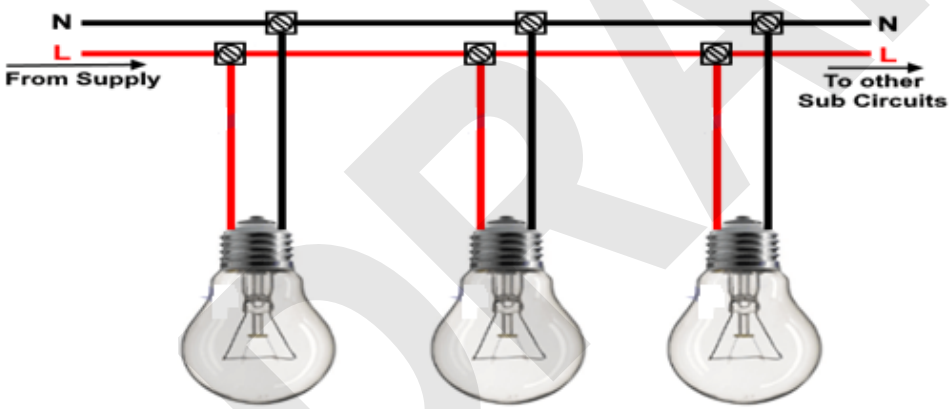


Figure 11.3 Diagram of 3 light bulbs connected in parallel

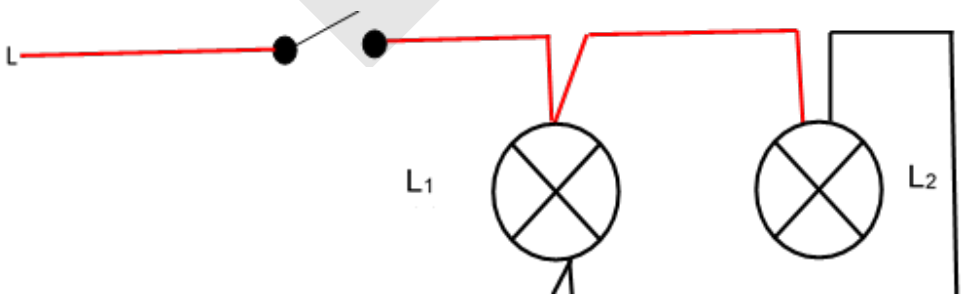


Figure 11.4 Two light bulbs with wiring symbols connected in parallel

Plug Circuit

Schematic diagram of plug sockets connected in parallel.

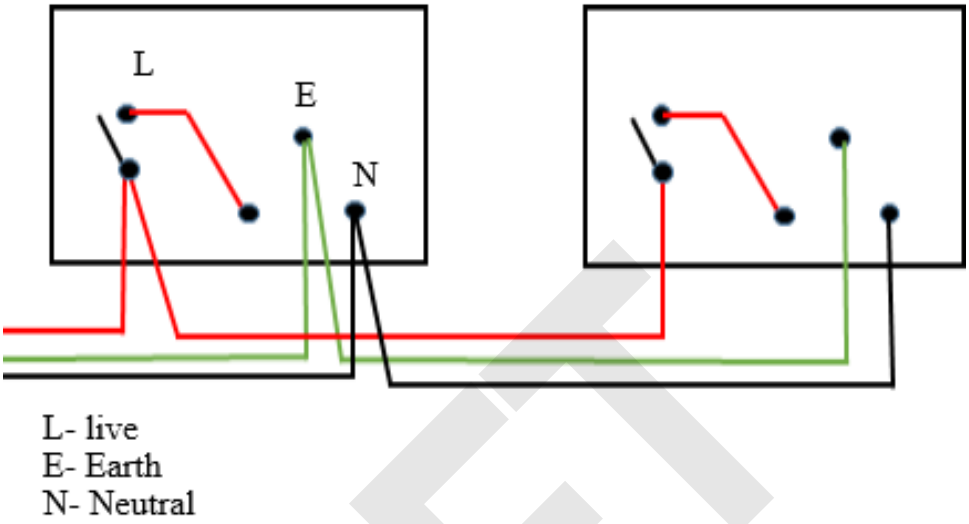


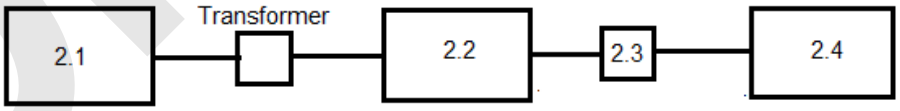
Figure 11.5 Two plug sockets connected in parallel

Activity 11.1 Have you learnt something?

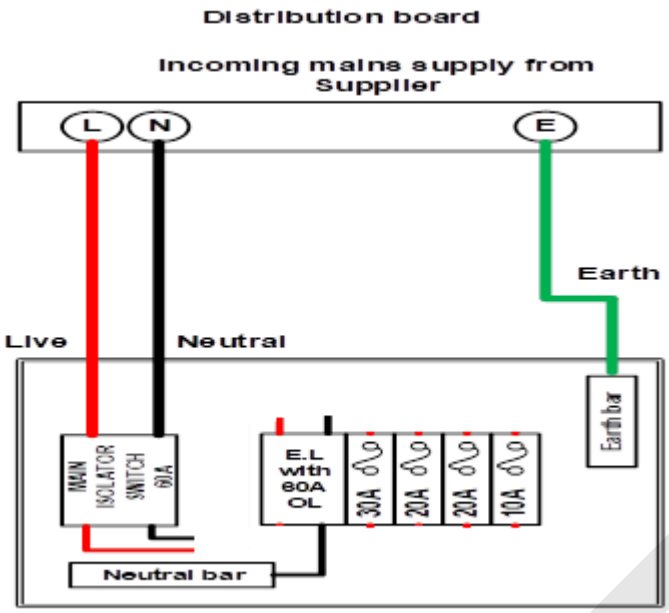
Test your Knowledge …

Aim: Wiring circuit of plug sockets in parallel.

1. State the three main stages in supplying of electricity from the power station to Consumers.
2. The diagram below, shows the stages of generation of electricity from power station to the consumer. Name the blocks 2.1 to 2.4.



3. Domestic installations mean the installation of _____ and the permanent attachment of_____
4. Write the abbreviation SANS in full.
5. What is the purpose of SANS?
6. Define the Distribution Board (DB)?
7. The diagram below shows a distribution board. Use pencil to complete the wiring of the distribution.



8. List the colours of wiring cables that can be used for a domestic installation.
   - 5.1 Live
   - 5.2 Neutral
   - 5.3 Earth

11.9.3 Testing in the sub-circuits (After Installation)

To ensure safety precautions, all electrical installations irrespective of new or alteration should satisfy the inspection and testing procedures as indicated by SANS 10142-1 installation regulations. If the installations are not installed correctly, by not referring to SANS 10142 wiring code, or referring to the manufacturer's specifications, terrible accidents could occur. Remember that electricity can kill, and fire could be caused by electrical faults which could be prevented. You must work responsibly.

To prevent damage, ensure that voltage-sensitive electronic equipment such as dimmer switches, touch switches, timer delays, power controllers, electronic starter for fluorescent lamps, earth leakage units, surge arrestors and certain appliances are disconnected so that they are not subjected to the test voltage.

Before an installation may be connected permanently to the supply the following tests must be carried out:

Insulation Resistance Tests between conductors

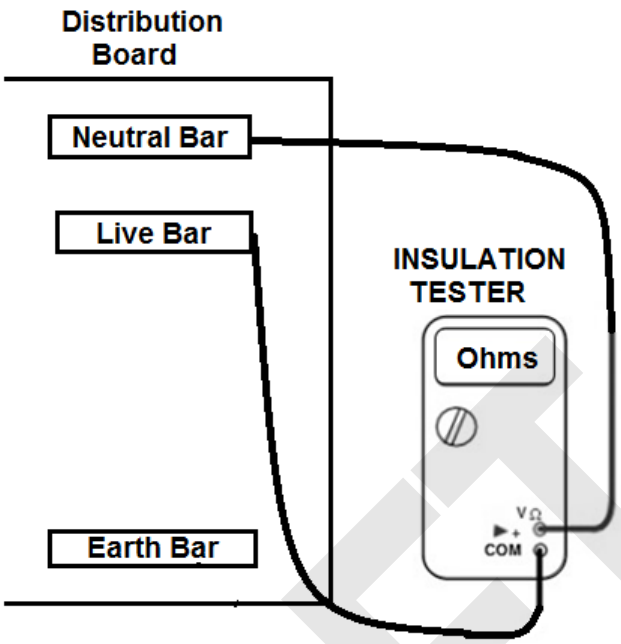


Figure 3 Insulation resistance between conductors

This test is carried out by connecting one lead of the megger or insulation tester to the live bar and the other to the neutral bar.

When testing the insulation resistance between conductors:

- The main supply and switch disconnector must be off,
- All switches and MCBs (miniature circuit breakers) must be on,
- All lamps must be out, and
- All appliances must be disconnected,
- Insulation reading should be at least 1 mega ohm
- Insulation Resistance Tests between conductors and earth

This test is carried out by connecting one lead of the test instrument (insulation tester) to the earth terminal in the distribution board and the other lead to the live busbar or neutral bar. The live busbar must be bridged to the neutral bar. The minimum reading value must be at least 1 mega Ohm.

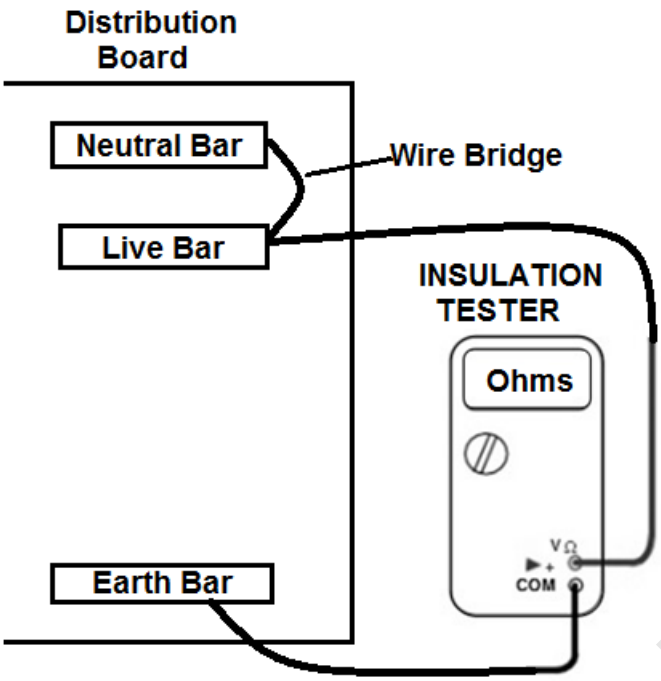
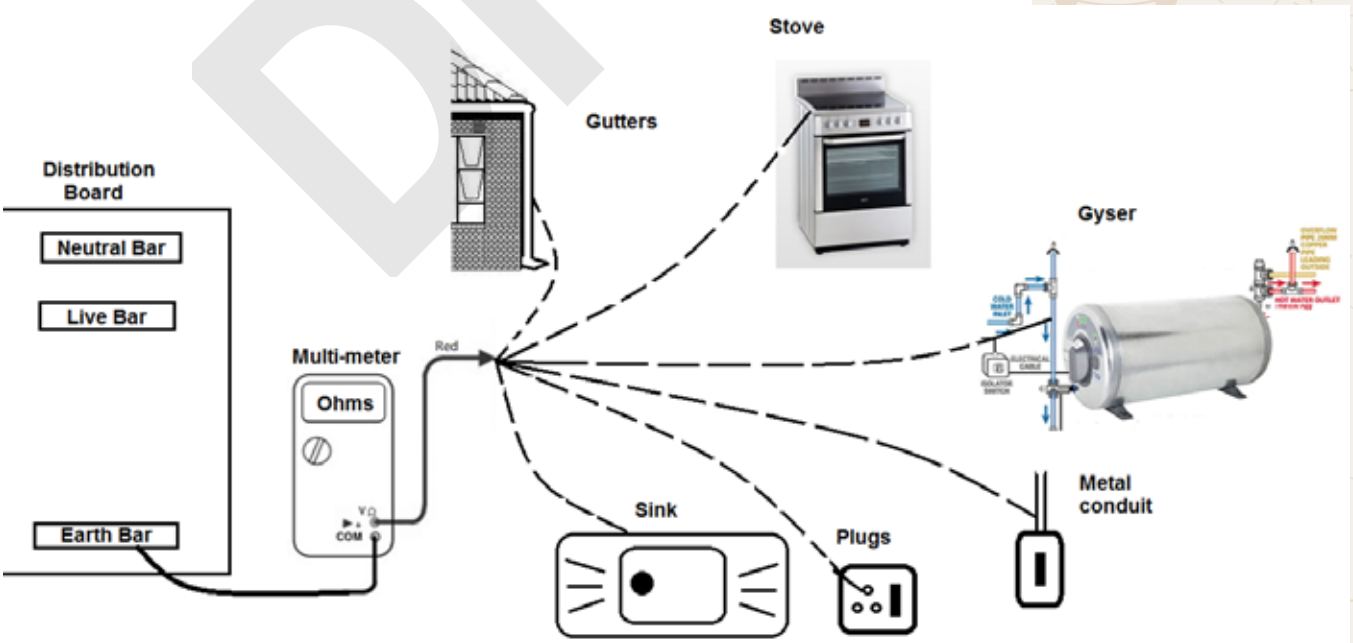


Figure 4 Insulation Resistance test between conductors and earth

When testing the insulation resistance to earth, always ensure that:

- The main supply and switch disconnector are off,
- All switches and MBCs are on,
- Live and neutral bars are bridged, and
- The resistance is at least 1 mega ohm.

Earth Continuity Testing



This test can be carried out with a tester that has an Ohm scale or an earth continuity tester. In this test we measure the resistance of the earth continuity conductors between the consumer's earth terminal and the earthing terminal of all points of consumption and switches. Items to be tested include:

Metal conduits, Water pipes, Metal switch boxes, Plugs, Exposed metal of appliances, Metal roofs, Gutters, Down pipes, Metal sinks, Basins, Copper lintel, Outlet pipes on the geyser, Aerial conductors.

The reading (values) must be in accordance with SANS regulations (table 8, sections 8.7.2), and must not exceed the values in the table that follows:

Maximum resistance of earth continuity conductor	
Rated current of protective device (A)	**Maximum resistance of earth continuity path (Ω)**
6,3	1,7
10	1,1
16	0.70
20	0.55
25	0.53
32	0.41
40	0.33
50	0.26
63	0.24
80	0,19
100	0.14
125	0.12
160	0,096
200	0.077
250	0.062
315	0.049

NOTE: In the case of metallic roofs, gutters, down pipes and waste pipes the resistance of the earth continuity path shall not exceed 0, 2 Ω.

Activity 11.2 Have you learnt something?

Test your Knowledge …

1.1 List three types of cables used in domestic installation.

1.2 Complete the table below to show the cable size and rating current:

Sub-circuits	Size or sectional area	Rating current
Light	1.5 mm^2	
Plug circuit	2.5 mm^2	
Geyser circuit	2.5 mm^2	
Stove	6 mm^2	
Earth leakage sub-circuit	16 mm^2	

1.3 List three tests that can be conducted in an installation.

PRACTICAL ACTIVITY 11.1

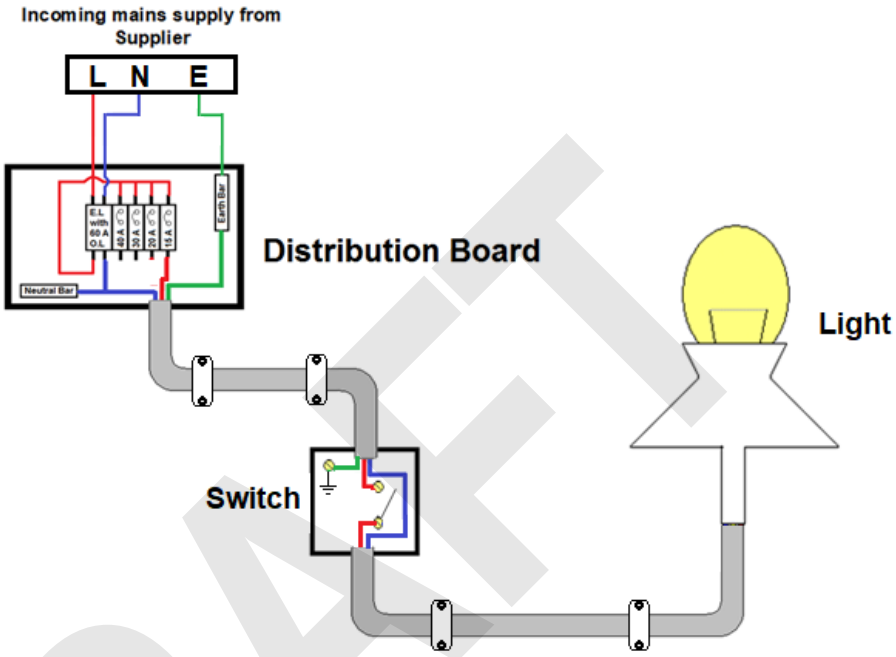
Wire a lighting circuit with a switch

Aim: Demonstrate an understanding and an ability to correctly install PVC conduit and end fittings for a domestic installation. This will include the cutting, bending and preparation of PVC conduit.

What will you need:

- 1 × 1,5m × 1,5m wood board (for fixing all items)
- 1 × consumer distribution
- 2m × 20mm PVC conduit
- 1 × 1 way conduit box
- 4 × PVC female adaptors
- 4 PVC saddles
- 1 × 3-way conduit box
- 2 × plug socket
- 1 × 60 A Earth Leakage
- 1 × 20 A Circuit breaker
- 1 × Flat screwdriver
- 1 × Phillips screwdriver
- 1 × Side cutter
- 1 × Wire stripper
- 1 × 10 mm^2 Red cable wire (at least 2m)
- 1 × 10 mm^2 Blue cable wire (at least 2m)

- 1 × 10 mm^2 Green and Yellow cable wire (at least 2m)
- 1 × Multimeter
- 1 × Hacksaw
- 1 × Spring bender
- Set of fixing screws



Practical tasks

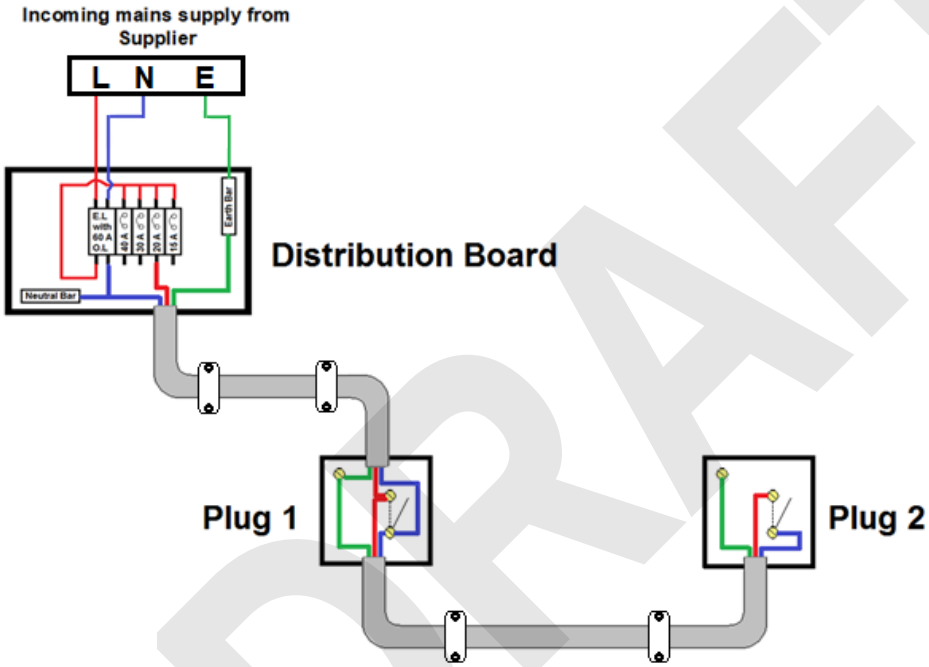
Wiring of two plugs into the sub-circuit

Aim: Demonstrate an understanding and an ability to correctly install PVC conduit and end fittings for a domestic installation. This will include the cutting, bending and preparation of PVC conduit:

What will you need:

- 1 × 1,5m × 1,5m wood board (for fixing all items)
- 1 × consumer distribution
- 2m × 20mm PVC conduit
- 1 × 1 way conduit box
- 4 × PVC female adaptors
- 4 PVC saddles
- 1 × 3-way conduit box
- 2 × plug socket
- 1 × 60 A Earth Leakage
- 1 × 20 A Circuit breaker

- 1 × Flat screwdriver
- 1 × Phillips screwdriver
- 1 × Side cutter
- 1 × Wire stripper
- 1 × 10 mm^2 Red cable wire (at least 2m)
- 1 × 10 mm^2 Blue cable wire (at least 2m)
- 1 × 10 mm^2 Green and Yellow cable wire (at least 2m)
- 1 × Multimeter
- 1 × Hacksaw
- 1 × Spring bender
- Set of fixing screws



What to do:

Wire the distribution board according to the figure below.

Do a continuity testing on the wires

Glossary

A See Ampere

AC Abbreviation for alternating current. See Alternating Current

AC coupling Circuit that passes an AC signal while blocking a DC voltage.

AC/DC Equipment that will operate from an AC or DC power source.

AC generator Device that transforms mechanical energy into AC electrical power.

AC load line A graph representing all possible combinations of AC output voltage and current for an amplifier.

AC power supply Power supply that delivers AC voltage.

Active component A component that changes the amplitude of a signal between output and input.

Active filter A filter that uses an amplifier as well as reactive components to pass or reject selected frequencies.

Active region The region of BJT (bipolar junction transistor) operation between saturation and cut-off used for linear amplification.

AC voltage A voltage with alternating polarity

ADC Analog to Digital Converter

Admittance Measure (in Siemens) of how easily AC will flow through a circuit. Admittance is the reciprocal of impedance. Symbol = Y.

AF Audio Frequency

Alkaline cell Also known as an "alkaline manganese cell", a primary cell that delivers more current than a carbon-zinc cell.

Alligator clip Spring clip on the end of a test lead for making temporary connections.

Alternating current An electric current that rises to a maximum in one direction, falls back to zero and then rises to a maximum in the opposite direction and then repeats. Abbreviation = AC.

Alternator another name for an AC generator (device used to transform mechanical energy into AC electrical power).

AM see amplitude modulation

Ammeter A meter used to measure current.

Ampere a unit of electrical current, also referred to as amp.

Amplifier A circuit that increases the voltage, current, or power of a signal.

Amplitude Magnitude or size of a signal voltage or current.

Amplitude modulation The encoding of a carrier wave by variation of its amplitude in accordance with an input signal. Abbreviation = AM

Analog Information represented as continuously varying voltage or current rather than in discrete levels as opposed to digital data varying between two discrete levels.

Anode A positively charged electrode, as of an electrolytic cell, storage battery, or electron tube.

Apparent power Power attained in an AC circuit as a product of effective voltage and current which reach their peak at different times.

Autotransformer A single winding transformer where the output is taken from taps on the winding.

AWG Abbreviation for "American wire gauge". A gauge that assigns a number value to the diameter of a wire.

Balanced bridge Condition that occurs when a bridge circuit is adjusted to produce a zero output.

Band-pass filter A tuned circuit designed to pass a band of frequencies between a lower cut-off frequency (f1) and a higher cut-off frequency (f2). Frequencies above and below the pass band are heavily attenuated.

Band-stop filter A tuned circuit designed to stop frequencies between a lower cut-off frequency (f1) and a higher cut-off frequency (f2) of the amplifier while passing all other frequencies.

Bandwidth The numerical difference between upper and lower frequencies of a band of electromagnetic radiation. Abbreviation = BW

Base The region that lies between the emitter and collector of a bipolar junction transistor (BJT).

Battery A DC voltage source containing two or more cells that convert chemical energy to electrical energy.

Baud A unit of signalling speed equal to the number of signal events per second. Not necessarily the same as bits per second.

Bias A DC voltage applied to a device to control its operation.

Binary A number system having only two symbols, 0 and 1. A base 2 number system.

Bipolar junction transistor (BJT), A three terminal device in which emitter to collector current is controlled by base current.

Bits per second A measure of data speed for the number of bits transmitted or received each second.

Breakdown voltage Voltage at which the breakdown of a dielectric or insulator occurs.

Breakover voltage Minimum voltage required to cause a DIAC to break down and conduct.

Bridge rectifier A circuit using four diodes to provide full wave rectification. Converts an AC voltage to a pulsating DC voltage.

Buffer An amplifier used to isolate a load from a source.

BW See Bandwidth.

Byte Group of eight binary digits or bits.

Cable Group of two or more insulated wires.

CAD Abbreviation for "computer aided designs"

Calibration To adjust the correct value of a reading by comparison to a standard.

Capacitance The ability of a capacitor to store an electrical charge. The basic unit is a Farad.

Capacitor An electronic component having capacitive reactance.

Carbon-film resistor Device made by depositing a thin carbon film on a ceramic form.

Carbon microphone Microphone whose operation depends on pressure variation in carbon granules causing a change in resistance.

Carbon resistor Resistor of fixed value made by mixing carbon granules with a binder which is moulded and then baked.

Cathode A negatively charged electrode, as of an electrolytic cell, a storage battery, or an electron tube.

Centre tap Midway connection between the two ends of a winding.

Centre tapped rectifier A circuit that make use of a centre tapped transformer and two diodes to provide full wave rectification.

Centre tapped transformer A transformer with a connection at the electrical centre of a winding.

Ceramic capacitor Capacitor in which the dielectric is ceramic.

Charge Quantity of electrical energy.

Charge current Current that flows to charge a capacitor or battery when voltage is applied.

Chassis Metal box or frame to mount components.

Chassis ground Connection to a chassis.

Choke Inductor used to oppose the flow of alternating current.

Circuit Interconnection of components to provide an electrical path between two or more components.

Circuit breaker A protective device used to open a circuit when current exceeds a maximum value. In effect a reusable fuse.

Clock A square waveform used for synchronizing and timing of several circuits.

Closed circuit Circuit having a complete path for current flow.

Coaxial cable Transmission line in which the signal carrying conductor is covered by a dielectric and another conductor.

Collector The semiconductor region in a bipolar junction transistor (BJT) through which a flow of charge carriers leaves the base region.

Colour code Set of colours used to indicate value of a component.

Common-anode display A multi-segment light emitting diode (LED) with a single positive voltage input connection. Separate cathode connections are provided for each individual segment.

Common cathode display A multi-segment light emitting diode (LED) with a single negative voltage input connection. Separate anode connections are provided for each individual segment.

Comparator An op-amp circuit that compares two inputs and provides a DC output indicating the polarity relationship between the inputs.

Computer aided design Software used to create 2D or 3D computer models.

Constant current circuit Circuit used to maintain constant current to a load having resistance that changes.

Contact Current carrying part of a switch, relay or connector.

Continuity Occurs when a complete path for current exists.

Conventional current flow Concept of current produced by the movement of positive charges towards the negative terminal of a source.

Copper loss Power lost in transformers, generators, connecting wires and other parts of a circuit due to current flow through the resistance of copper conductors.

Coupling To electronically connect two circuits so that signal will pass from one to the other.

Crowbar Circuit used to protect the output of a source from a short circuited load. Load current is limited to a value the source can deliver without damage.

Crystal Natural or synthetic piezoelectric or semiconductor material with atoms arranged with some degree of geometric regularity.

Crystal-controlled oscillator Oscillator that uses a quartz crystal in its feedback path to maintain a stable output frequency.

Current Measured in amps, it is the flow of electrons through a conductor. Also known as electron flow.

Cut-off Condition when an active device is biased such that output current is near zero or beyond zero.

Cycle When a repeating wave rises from zero to a positive maximum then back to zero and on to a negative maximum and back to zero it is said to have completed one cycle.

DAC Abbreviation for "digital to analogue converter."

Damping Reduction in magnitude of oscillation due to energy being dissipated as heat.

Darlington pair An amplifier consisting of two bipolar junction transistors with their collectors connected together and the emitter of one connected to the base of the other. Circuit has an extremely high current gain and input impedance.

DC Abbreviation for Direct Current. See direction current.

DC load line A graph representing all possible combinations of voltage and current for a given load resistor in an amplifier.

DC offset The change in input voltage required to produce a zero output voltage when no signal is applied to an amplifier.

DC power supply Any source of DC power for electrical equipment.

Dead short Short circuit having zero resistance.

Decade A frequency factor of ten.

Decibel (dB) a logarithmic representation of gain or loss.

Delay time The time for collector current to reach 10% of its maximum value in a BJT switching circuit.

DIAC A diode that conducts electrical only after its breakover voltage has been reached.

Differential amplifier An amplifier in which the output is in proportion to the differences between voltages applied to its two inputs.

Digital Relating to devices or circuits that have outputs of only two discrete levels. Examples: 0 or 1, high or low, on or off, true or false etc.

Diode A two terminal device that conducts in only one direction.

DIP Abbreviation for "dual in line package".

Direct coupling Where the output of an amplifier is connected directly to the input of another amplifier or to a load. Also known as DC coupling because DC signals are not blocked.

Direct current Current that flows in only one direction.

Discharge Release of energy stored in either a battery or a capacitor.

Discrete component Package containing only a single component as opposed to an integrated circuit containing many components in a single package.

Dry cell DC voltage generating chemical cell using a non-liquid (paste) electrolyte.

Dual in-line package Integrated circuit package having two rows of connecting pins. Abbreviation = DIP

Eddy current An electric current induced within the body of a conductor when that conductor either moves through a non-uniform magnetic field or is in a region where there is a change in magnetic flux.

Electric charge Electric energy stored on the surface of a material. Also known as a static charge.

Electron A subatomic particle of an atom, with a negative charge, that orbits the positively-charged nucleus.

Electron flow Electrical current produced by the movement of free electrons toward a positive terminal; the direction of electron flow is opposite to that of current.

Electric polarization A displacement of bound charges in a dielectric when placed in an electric field.

Electrolytic capacitor A capacitor having an electrolyte between the two plates. A thin layer of oxide is deposited on only the positive plate. The oxide acts as the dielectric for the capacitor. Electrolytic capacitors are polarized and so must be connected in correct polarity to prevent breakdown.

Electromagnet A coil of wire usually wound on a soft iron or steel core. When current is passed through the coil a magnetic field is generated. The core provides an easy path for the magnetic lines of force. This concentrates the field in the core.

Emitter The semiconductor region from which charge carriers are injected into the base of a bipolar junction transistor.

Enhancement-mode MOSFET A field effect transistor in which there are no charge carriers in the channel when the gate source voltage is zero.

Farad The basic unit of capacitance.

Ferrite A powdered, compressed and sintered magnetic material having high resistivity. The high resistance makes eddy current losses low at high frequencies.

Ferrite bead Ferrite composition in the form of a bead. Running a wire through the bead increases the inductance of the wire.

Ferrite-core inductor An inductor wound on a ferrite core.

Ferrites Compound composed of iron oxide, a metallic oxide and ceramic. The metal oxides include zinc, nickel, cobalt or iron.

Fibre optics Laser's light output carries information that is conveyed between two points by thin glass optical fibres.

Field effect transistor A voltage-controlled transistor in which the source to drain conduction is controlled by gate to source voltage. Abbreviation = FET.

Filament Thin thread of carbon or tungsten which produces heat or light with the passage of current.

Filter Network consisting of capacitors, resistors and/or inductors used to pass certain frequencies and block others.

Flip flop A bistable multivibrator. A circuit which has two output states and is switched from one to the other by means of an external signal (trigger). Abbreviation = FF

Flux Material used to remove oxide films from the surface of metals in preparation for soldering.

Forward bias A PN junction bias which allows current to flow through the junction. Forward bias decreases the resistance of the depletion layer.

Frequency Rate of recurrence of a periodic wave. Measured in Hertz (cycles per second).

Full wave rectifier Rectifier that makes use of the full AC wave in both the positive and negative half cycles.

Function generator Signal generator that can produce sine, square, triangle and saw tooth output waveforms.

Fuse A protective device in the current path that melts or breaks when current exceeds a predetermined maximum value.

Generator Device used to convert mechanical energy to electrical energy.

Giga Metric prefix for 1 billion.

Ground An intentional or accidental conducting path between an electrical system or circuit and the earth or some conducting body acting in place of the earth. A ground is often used as the common wiring point or reference in a circuit.

Half wave rectifier A diode rectifier that converts AC to pulsating DC by eliminating either the negative or the positive alternation of each input AC cycle.

Henry The basic unit of inductance.

Hertz Unit of frequency equal to one cycle per second. Abbreviation = Hz.

IC Abbreviation for integrated circuit. See integrated circuit.

IC voltage regulator Three terminal device used to hold the output voltage of a power supply constant over a wide range of load variations.

IGFET Insulated gate field effect transistor. Another name for a "MOSFET."

Impedance The total opposition to the flow of current offered by a circuit. Impedance consists of the vector sum of resistance and reactance. Measured in ohms (Z).

Incandescence State of a material when heated to the point where it emits light (red hot or white hot).

Inductor Length of conductor used to introduce inductance into a circuit. The conductor is usually wound into a coil to concentrate the magnetic lines of force and maximize the inductance. While any conductor has inductance, in common usage the term inductor usually refers to a coil.

Infrared Electromagnetic heat radiation whose frequencies are above the microwave frequency band and below red in the visible band.

Input impedance Opposition to the flow of signal current at the input of a circuit or load.

Insulated When a non-conducting material is used to isolate conducting materials from one another.

Insulating material Material that will prevent the flow of current due to its chemical composition.

Insulation resistance Resistance of insulating material. The greater the insulation resistance, the better the insulation.

Integrated circuit Also known as a chip, a small electrical device made of semiconductor material.

Internal resistance Every source has some resistance in series with the output current. When current is drawn from the source some power is lost due to the voltage drop across the internal resistance. Usually called output impedance or output resistance.

Inverting amplifier An amplifier that has a 180° phase shift from input to output.

Inverting input In an operational amplifier (op amp) the input that is marked with a minus sign. A signal applied at the inverting input will be given 180° phase shift between input and output.

Jack Socket or connector into which a plug may be inserted. (Back to top)

JFET Abbreviation for "junction field effect transistor".

Joule The unit of work and energy.

Junction Contact or connection between two or more wires or cables. The area where the p-type material and n-type material meet in a semiconductor.

Junction diode A semiconductor diode in which the rectifying characteristics occur at a junction between the n-type and p-type semiconductor materials.

Kilo Metric prefix for 1000.

Kilovolt-ampere 1000 volts at 1 ampere.

Kilowatt-hour 1000 watts for 1 hour.

Kilowatt-hour meter A meter used by electric utility companies to measure the amount of electric power used by a customer.

Kinetic energy Energy associated with motion.

Kirchhoff's current law The sum of the currents flowing into a point in a circuit is equal to the sum of the currents flowing out of that same point.

Kirchhoff's voltage law The algebraic sum of the voltage drops in a closed path circuit is equal to the algebraic sum of the source voltages applied.

Lead-acid cell Cell made up of lead plates immersed in a sulphuric acid electrolyte. An automobile battery usually consists of six lead-acid cells.

Leakage Small undesirable flow of current through an insulator or dielectric. (Back to top)

Light-emitting diode (LED) A semiconductor diode that converts electric energy into electromagnetic radiation at a visible and near infrared frequencies when its p-n junction is forward biased.

Limiter Circuit or device that prevents some portion of its input from reaching the output. A clipper.

Linear Relationship between input and output in which the output varies in direct proportion to the input.

Linear scale A scale in which the divisions are uniformly spaced.

Line regulation The ability of a voltage regulator to maintain a constant voltage when the regulator input voltage varies.

Load A source drives a load. Whatever component or piece of equipment is connected to a source and draws current from a source is a load on that source.

Load current Current drawn from a source by a load.

Load impedance Vector sum of reactance and resistance in a load.

Loading effect Large load impedance will draw a small load current and so loading of the source is small (light load). A small load impedance will draw a large load current from the source (heavy load).

Load regulation The ability of a voltage regulator to maintain a constant output voltage under varying load currents.

Load resistance Resistance of a load.

Logic Science of dealing with the principle and applications of gates, relays and switches.

Maxwell Unit of magnetic flux. One maxwell equals one magnetic line of force.

Mercury cell Primary cell using a mercuric oxide cathode, a zinc anode and a potassium hydroxide electrolyte.

Metal film resistor A resistor in which a film of metal oxide or alloy is deposited on an insulating substrate.

Metal Oxide Semiconductor Field Effect Transistor A field effect transistor in which the insulating layer between the gate electrode and the channel is a metal oxide layer. Abbreviation = MOSFET.

Metal oxide resistor A metal film resistor in which an oxide of metal (such as tin) is deposited as a film onto the substrate.

Meter Any electrical or electronic measuring device. In the metric system, it is the unit of length equal to 39.37 inches.

Mica capacitor Capacitor using mica as the dielectric.

Microphone Electro acoustic transducer that converts sound energy into electric energy.

Modulation Process by which an information signal (audio for example) is used to modify some characteristic of a higher frequency wave known as a carrier (radio for example).

MOSFET Abbreviation for "metal oxide field effect transistor" (also known as an "insulated gate field effect transistor"). See metal oxide field effect transistor.

Multimeter Electronic test equipment that can perform multiple tasks. Typically, one capable of measuring voltage, current and resistance. More sophisticated modern digital multimeters also measure capacitance, inductance, current gain of transistors and/or anything else that can be measured electronically.

Multi segment display Device made of several light emitting diodes arranged in a numeric or alphanumeric pattern. By lighting selected segments numeric or alphabet characters can be displayed.

Mutual inductance Ability of one inductor's lines of force to link with another inductor.

Network Combination of interconnected components, circuits or systems. (Back to top)

Neutral A terminal, point or object with balanced charges. Neither positive or negative.

Neutral atom An atom in which the number of negative charges (electrons in orbit) is equal to the number of positive charges (protons in the nucleus).

Neutral wire The conductor of a polyphase circuit or a single-phase three wire circuit that is intended to have a ground potential. The potential difference between the neutral and each of the other conductors are approximately equal in magnitude and equally spaced in phase.

Neutron Subatomic particle in the nucleus of an atom and having no electrical charge.

Nickel-cadmium cell A secondary cell that uses a nickel oxide positive electrode and a cadmium negative electrode.

Node Junction or branch point in a circuit.

Noise Unwanted electromagnetic radiation within an electrical or mechanical system.

Normally closed Designation which states that the contacts of a switch or relay are closed or connected when at rest. When activated, the contacts open or separated.

Normally open Designation which states that the contacts of a switch or relay are normally open or not connected. When activated the contacts close or become connected.

npn transistor A bipolar junction transistor in which a p-type base element is sandwiched between an n-type emitter and an n-type collector.

Nucleus Core of an atom. The nucleus contains both positive (protons) and neutral (neutrons) subatomic particles.

Ohm Unit of resistance symbolized by the Greek capital letter omega (W).

Op-amp Abbreviation for operational amplifier. See operational amplifier.

Open loop gain The gain of an amplifier when no feedback is present.

Open loop mode An amplifier circuit having no means of comparing the output with the input. (No feedback.)

Operational amplifier A high gain DC amplifier that has a high input impedance and a low output impedance. Op-amps are the most basic type of linear integrated circuits.

Oscilloscope An instrument used to display a signal graphically. Shows signal amplitude, period and wave shape in addition to any DC voltage present. A multiple trace oscilloscope can show two or more waveforms at the same time for phase comparison and timing measurements.

Output Terminal at which a component, circuit or piece of equipment delivers current, voltage or power.

Output impedance Impedance measured across the output terminals of a device without a load connected.

Output power Amount of power a component, circuit or system can deliver to a load.

Overload Condition that occurs when the load is greater than the system was designed to handle. (Load resistance too small, load current too high.) Overload results in waveform distortion and/or overheating. Overload protection Protective device such as a fuse or circuit breaker that automatically disconnects a load when current exceeds a predetermined value.

Parallel Circuit having two or more paths for current flow. Also called shunt. (Back to top)

Peak inverse voltage (PIV) The maximum rated value of an AC voltage acting in the direction opposite to that in which a device is designed to pass current.

Peak to peak Difference between the maximum positive and maximum negative values of an AC waveform.

Period Time to complete one full cycle of a periodic or repeating waveform.

Phase Angular relationship between two waves.

Phase angle Phase difference between two or more waves, normally expressed in degrees.

Phase shift Change in phase of a wave form between two points, expressed as degrees of lead or lag.

Phase shift oscillator An oscillator that uses three RC networks in its feedback path to produce the 180° phase shift required for oscillation.

Phosphor Luminescent material applied to the inner face of a cathode ray tube that when bombarded with electrons will emit light of various colours.

Photoconductive cell Material whose resistance decreases or conductance increases when exposed to light.

Photoconduction A process by which the conductance of a material is change by incident electromagnetic radiation in the visible light spectrum.

Photo detector Component used to detect or sense light.

Photodiode A semiconductor diode that changes its electrical characteristics in response to illumination.

Photon Discrete portion of electromagnetic energy. A small packet of light.

Photoresistor Also known as a photoconductive cell or light dependent resistor (LDR). See photoconductive cell.

Piezoelectric crystal Crystal material that will generate a voltage when mechanical pressure is applied and conversely will undergo mechanical stress when subjected to a voltage.

Piezoelectric effect The production of a voltage between opposite sides of a piezoelectric crystal as a result of pressure or twisting. Also, the reverse effect which the application of a voltage to opposite sides causes a deformation to occur at the frequency of the applied voltage. (Converts mechanical energy into electrical energy and electrical energy into mechanical energy.)

Plastic film capacitor Capacitor in which alternate layers of aluminium foil are separated by thin films of plastic dielectric.

pnp transistor A bipolar junction transistor with an n-type base and p-type emitter and collector.

Polarity The property of having a positive or negative charge.

Polarized A component which must be connected in correct polarity to function and/or prevent destruction. Example: Electrolytic capacitor.

Potential difference Voltage difference between two points which will cause current to flow in a closed circuit.

Potential energy Energy that has potential to do work because of its position relative to others.

Potentiometer A variable resistor with three terminals. Mechanical turning of a shaft can be used to produce variable resistance and potential. Example: A volume control is usually a potentiometer.

Power Amount of energy converted by a circuit or component in a unit of time, normally seconds. Measured in units of watts (joules/second).

Power amplifier An amplifier designed to deliver maximum power output to a load. Example: In an audio system, it is the power amplifier that drives the loudspeaker.

Power dissipation Amount of heat energy generated by a device in one second when current flows through it.

Power factor Ratio of actual power to apparent power.

Power loss Ratio of power absorbed to power delivered.

Power supply Electrical equipment used to deliver either AC or DC voltage.

Power supply rejection ratio A measure of an op-amps ability to maintain a constant output when the supply voltage varies.

Primary First winding of a transformer. Winding that is connected to the source as opposed to secondary which is a winding connected to a load.

Primary cell Cell that produces electrical energy through an internal electrochemical action. Once discharged a primary cell cannot be reused.

Printed circuit board Insulating board containing conductive tracks for circuit connections.

Programmable UJT Unijunction transistor with a variable intrinsic stand-off ratio.

Protoboard Board with provision for attaching components without solder. Also called a breadboard. Primarily used for constructing experimental circuits.

Pulse Rise and fall of some quantity (usually voltage) for a period of time.

Pulse fall time Time for a pulse to decrease from 90% of its peak value to 10% of its peak value.

Pulse width Time interval between the leading edge and trailing edge of a pulse at a point where the amplitude is 50% of the peak value.

Radar Acronym for "radio detection and ranging". A system that measures the distance and direction of objects.

RC time constant Product of resistance and capacitance in seconds.

Reactance Opposition to current flow without the dissipation of energy. Example: The opposition provided by inductance or capacitance to AC current. Symbol "X".

Reactive power The power value in "volt amps" obtained from the product of source voltage and source current in a reactive circuit. Also called imaginary power or wattles power.

Receiver Unit or piece of equipment used to receive information.

Recombination Process by which a conduction band electron gives up energy (in the form of heat or light) and falls into a valence band hole.

Rectangular coordinates A Cartesian coordinate of a Cartesian coordinate system whose straight-line axes or coordinate planes are perpendicular.

Rectangular wave Also known as a pulse wave. A repeating wave that only operates between two levels or values and remains at one of these values for a small amount of time relative to the other value.

Rectification Process that converts alternating current to direct current.

Rectifier Diode circuit that converts alternating current into pulsating direct current.

Regulated power supply Power supply that maintains a constant output voltage under changing load conditions.

Regulator Device or circuit that maintains a desired output under changing conditions.

Relay Electromechanical device that opens or closes contacts when a current is passed through a coil.

Relative Not independent. Compared with or with respect to some other measured quantity.

Relaxation oscillator Free running circuit that outputs pulses with a period dependent or one or more RC time constants.

Reluctance Resistance to the flow of magnetic lines of force.

Resistance Opposition to current flow and dissipation of energy in the form of heat. Symbolized "R" and measured in ohms.

Resistive power Amount of power dissipated as heat in a circuit containing resistive and reactive components. True power as opposed to reactive power.

Resistor Component made of material that opposes flow of current and therefore has some value of resistance.

Resistor colour code Coding system of coloured stripes on a resistor to indicate the resistor's value and tolerance.

Resonance Circuit condition that occurs at the frequency where inductive reactance (XL) equals capacitive reactance (XC).

Reverse bias Bias on a PN junction that allows only leakage current (minority carriers) to flow. Positive polarity on the n-type material and negative polarity to the p-type material.

Reverse breakdown voltage Amount of reverse bias that will cause a PN junction to break down and conduct in the reverse direction.

RF Abbreviation for "radio frequency."

Rheostat Two terminal variable resistors used to control current.

RL differentiator An RL circuit whose output voltage is proportional to the rate of change of the input voltage.

RL filter Selective circuit of resistors and inductors that offers little or no opposition to certain frequencies while blocking or attenuating other frequencies.

RL integrator RL circuit with an output proportionate to the integral of the input signal.

rms Abbreviation for "root mean square"

rms value rms value of an AC sine wave is 0.707 times the peak value. This is the effective value of an AC sine wave. The rms value of a sine wave is the value of a DC voltage that would produce the same amount of heat in a heating element.

Rotary switch Electromechanical device that has a rotating shaft connected to one terminal capable of making or breaking a connection to one or more other terminals.

Saturation Condition in which a further increase in one variable produces no further increase in the resultant effect. In a bipolar junction transistor, the condition when the emitter to collector voltage is less than the emitter to base voltage. This condition puts forward bias on the base to collector junction.

Saw tooth wave Repeating waveform that rises from zero to maximum value linearly drops back to zero and repeats. A ramp waveform.

Schematic diagram Illustration of an electrical or electronic circuit with the components represented by their symbols.

Schmitt trigger Circuit to convert a given waveform to a square wave output.

Schottky diode Also known as a "hot-carrier diode" or "surface barrier diode", a high-speed diode that has very little junction capacitance.

Secondary Output winding of a transformer. Winding that is connected to a load.

Secondary cell Electrolytic cell used to store electricity. Once discharged may be restored by recharging by putting current through the cell in the direction opposite to that of discharge current.

Self-biasing Gate bias for a field effect transistor in which source current through a resistor produces the voltage for gate to source bias.

Semiconductor An element which is neither a good conductor nor a good insulator, but rather lies somewhere between the two. Characterized by a valence shell containing four electrons. Silicon, germanium and carbon are the semiconductors most frequently used in electronics.

Series circuit Circuit in which the components are connected end to end so that current has only one path to follow through the circuit.

Seven segment display Device made of several light emitting diodes arranged in a numeric or alphanumeric pattern. By lighting selected segments numeric or alphabet characters can be displayed.

Shield Metal grounded cover used to protect a wire, component or piece of equipment from stray magnetic and/or electric fields.

Short circuit Low resistance connection between two points in a circuit typically causing excessive current. Also called a "short."

Silicon-controlled rectifier (SCR) Three terminal active device that acts as a gated diode. The gate terminal is used to turn the device on allowing current to pass from cathode to anode.

Silicon controlled switch An SCR with an added terminal called an anode gate. A positive pulse either at the anode gate or the cathode gate will turn the device on.

Silicon transistor A bipolar junction transistor using silicon as the semi conducting material.

Silver mica capacitor Mica capacitor with silver deposited directly onto the mica sheets instead of using conductive metal foil.

Single in-line package Package containing several electronic components (generally resistors) with a single row of connecting pins.

Single pole double throw (SPDT) Three terminal switch in which one terminal can be connected to either one of the other terminals.

Single pole single throw (SPST) Two terminal switch or relay that can open or close one circuit.

Single throw switch Switch containing only one set of contacts which can be either opened or closed.

Sink Device such as a load that consumes power or conducts away heat.

Sinusoidal Varying in proportion to the sine of an angle or time function. AC voltage in which the instantaneous value is equal to the sine of the phase angle times the peak value.

SIP Abbreviation for "single in-line package." See single in-line package.

Solder Metallic alloy used to join two metal surfaces.

Soldering Process of joining two metallic surfaces to make an electrical contact by melting solder (usually tin and lead) across them.

Soldering iron Tool with an internal heating element used to heat surfaces being soldered to the point where the solder becomes molten.

SPDT Abbreviation for single pole double throw. See single pole double throw.

SPST Abbreviation for single pole single throw. See single pole single throw.

Square wave Wave that alternates between two fixed values for an equal amount of time.

Step-down transformer Transformer in which the output AC voltage is less than the input AC voltage.

Step-up transformer Transformer in which the output AC voltage is greater than the input AC voltage.

Supply voltage Voltage provided by a power source.

Switch Electrical device having two states, on (closed) or off (open). Ideally having zero impedance when closed and infinite impedance when open.

Switching transistor transistor designed to change rapidly between saturation and cut-off.

Tantalum capacitor Electrolytic capacitor having a tantalum foil anode. Able to have a large capacity in a small package.

Temperature coefficient of frequency Rate at which frequency changes with temperature.

Tera (T) Metric prefix that represents 1012.

Terminal Point at which electrical connections are made.

Thermal stability The ability of a circuit to maintain stable characteristics despite increased temperature.

Thermistor Temperature sensitive semiconductor that has a negative temperature coefficient of resistance. As temperature increases, resistance decreases.

Thermocouple Temperature transducer consisting of two dissimilar metals welded together at one end to form a junction that when heated will generate a voltage.

Thermometry Relating to the measuring of temperature.

Thermostat Device that opens or closes a circuit in response to changes in temperature.

Thick film capacitor Capacitor consisting of two thick-film layers of conductive film separated by a deposited thick-layer dielectric film.

Thick film resistor Fixed value resistor consisting of thick-film resistive element made from metal particles and glass powder.

Thin film capacitor Capacitor in which both the electrodes and the dielectric are deposited in layers on a substrate.

Time constant (t) Time required for a capacitor in an RC circuit to charge to 63% of the remaining potential across the circuit. Also, time required for current to reach 63% of maximum value in an RL circuit. Time constant of an RC circuit is the product of R and C. Time constant of an RL circuit is equal to inductance divided by resistance.

Toggle switch Spring-loaded switch that is put in one of two positions either on or off.

TO package Cylindrical, metal can type of package of some semiconductor components.

Transducer Device that converts energy from one form to another.

Transformer Inductor with two or more windings. Through mutual inductance, current in one winding called a primary will induce current into the other windings called secondaries.

Transformer coupling Also called inductive coupling. Coupling of two circuits by means of mutual inductance provided by a transformer.

Transistor Term derived from "transfer resistor." Semiconductor device that can be used as an amplifier or as an electronic switch.

Transmission Sending of information.

Transmitter Equipment used to achieve transmission.

Triac Bidirectional gate-controlled thyristor similar to an SCR (silicon-controlled resistor), but capable of conducting in both directions. Provides full wave control of AC power.

Triangular wave A repeating wave that has equal positive going and negative going ramps. The ramps have linear rates of change with time.

Trigger Pulse used to initiate a circuit action.

Trimmer Small value variable capacitor, resistor or inductor used to fine tune a larger value.

UJT Abbreviation for unijunction transistor. See unijunction transistor.

Unijunction transistor A three terminal device that acts as a diode with its own internal voltage divider biasing circuit. Abbreviation = UJT.

VA Abbreviation for "volt ampere"

Variable capacitor Capacitor whose capacitance can be change by varying the effective area of the plates or the distance between the plates.

Variable resistor Resistor whose resistance can be changed by turning a shaft. See also "potentiometer and rheostat."

Volt Unit of potential difference or electromotive force. One volt is the potential difference needed to produce one ampere of current through a resistance of one ohm.

Voltage (V) Term used to designate electrical pressure or force that causes current to flow.

Voltage divider Fixed or variable series resistor network connected across a voltage to obtain a desired fraction of that voltage.

Voltage drop Voltage or difference in potential developed across a component due to current flow.

Voltage rating Maximum voltage a component can withstand without breaking down.

Voltage regulator Device or circuit that maintains constant output voltage (within certain limits) in spite of changing line voltage and/or load current.

Voltage source Circuit or device that supplies voltage to a load.

Voltaic cell Primary cell having two unlike electrodes immersed in a solution that chemically interacts to produce a voltage.

Volt-ampere Unit of apparent power in an AC circuit containing capacitive or inductive reactance. Apparent power is the product of source voltage and current.

Voltmeter Instrument used to measure difference in potential between two points.

Watt Unit of electrical power required to do work at the rate of one joule per second. One watt of power is expended when one ampere of direct current flows through a resistance of one ohm. In an AC circuit, true power is the product of effective volts and effective amperes, multiplied by the power factor.

Wavelength (l) Distance between two points of corresponding phase and is equal to waveform velocity divided by frequency.

Winding One or more turns of a conductor wound in the form of a coil.

Wire Single solid or stranded group of conductors having a low resistance to current flow. Used to make connections between circuits or points in a circuit.

Wire gauge American wire gauge (AWG) is a system of numerical designations of wire diameters.

Wireless Term describing radio communication that requires no wires between two communicating points.

Wire wound resistor Resistor in which the resistive element is a length of high resistance wire or ribbon usually nichrome wound onto an insulating form.

Work Work is done any time energy is transformed from one type to another. The amount of work done is dependent on the amount of energy transformed.

X Symbol for reactance. See reactance.

Y Symbol for admittance. See admittance.

Zener Diode Semiconductor diodes in which reverse breakdown voltage current causes the diode to develop a constant voltage. Used as a clamp for voltage regulation.