

LEARNER'S BOOK

MECHANICAL TECHNOLOGY

GRADE

9

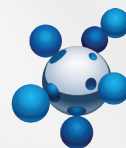


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Mechanical Technology Grade 9 Learner's Book

First published in 2023

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Cover design by ACP Project Management and Publishing Services

Cover image 123RF Stock Photos: Zoya Fedorova (Image ID 13654128)

Illustrations by Will Alves, Tina Nel and Shameema Dharsey

Layout and typesetting by Nazley Samsodien in ITC Stone Serif Std 10.5 pt over 13.5 pt

Editing, Proofreading and Project Management by ACP Project Management and Publishing Services

ISBN: 978-1-998982-83-7

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CHAPTER

7

Occupational Health and Safety

LEARNING OUTCOMES

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

- defining occupational health and safety
- learning about a safe workshop layout
- identifying unsafe acts and unsafe conditions
- learning about different personal protective equipment (PPE)
- learning about good housekeeping
- learning about fire prevention and protection
- learning about fire prevention and protection
- classifying different types of fires and causes of fire
- identifying and learning about different firefighting equipment
- exploring basic first aid

Workshop orientation

Occupation Health and Safety

Let's revise what we learnt in Grade 8. All safety rules and procedures are regulated by the Occupational Health and Safety (OHS) Act No. 85 of 1993. These regulations state that:

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

The code of good practice on HIV/AIDS and employment contains common guidelines on how employers, employees and trade unions should respond to HIV/AIDS in the workshop. It is everyone's responsibility to ensure that accidents and injuries do not occur. Good housekeeping and general safety rules need to be observed and obeyed to prevent these.

General safety rules

Safety is a precautionary measure that prevents injuries and accidents.



Figure 1.1 General safety rules

Each workshop has different safety rule requirements that need to be followed. It is everyone's responsibility to maintain a safe working environment by following the safety rules applicable to the workshop.

Follow these safety rule requirements:

- Do not enter or leave the workshop without your teacher's permission.
- Do not play or run around in the workshop.
- Know where the emergency stop buttons are positioned in the workshop.
- Wear an apron or an overall as it will protect your clothes and hold loose clothing.
- Always wear personal protective equipment (PPE) when in the workshop.
- Do not use a machine if you have not been shown how to operate it safely.
- Do not use machinery without permission.
- Wear goggles or a face shield when working on machines.
- Keep hands away from moving/rotating machinery.
- Use hand tools carefully, keeping both hands behind the cutting edge.
- Report any damage to machines/equipment as this could cause accidents.
- No food or drink are allowed in the workshop.
- Wear the correct protective equipment for the tools you are using.
- Tie up long hair.
- Turn off the machine before cleaning it.
- No one is permitted in a workshop under the influence of any illegal substance.
- No unauthorised people are allowed in the workshop.
- Never use tools and equipment without authority.
- Report any broken tools or machinery in the workshop.
- Never put sharp tools or instruments in your pocket.



Figure 1.2 Safety rule requirements

- Return tools to their correct places after use.
- No smoking or drinking is allowed in the workshop.
- Always clean your workbench or work space before leaving the workshop.

Personal protective equipment (PPE)

PPE is protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. PPE helps protect the wearer from physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. It will also protect you against possible injury or death in the workplace.



Figure 1.3 Proper PPE

Examples of PPE

Safety gloves: Protects the hands from various types of hazards, infection and contamination, a range of injuries from minor cuts and bruises to deep wounds and severe hand burns, as well as electric shock. Approximately 20% of injuries are handling-related, so making sure that you wear the correct safety gloves is important for avoiding injury, upholding the correct health and safety regulations, and avoiding days off due to injury.



Figure 1.4 Nitril chemical-resistant gloves



Figure 1.5 General working safety gloves

Here is a list of injuries that can be avoided by selecting the correct safety gloves and ensuring that they are worn at the right times:

- 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 fingers, nails and skin
- needle stick injuries.

Safety boots: Protects the feet from falling objects, compression and against punctures.



Figure 1.6 Safety boots

Safety boots have the following safety features:

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

Protective eyewear: Protective eyewear usually encloses or protects the area surrounding the eye to prevent particles, water or chemicals from striking the eyes to prevent injury. The type of eye protection you should wear depends on the hazards you are exposed to in the workshop. If working with chemicals goggles should be worn. If working in an area that has particles, flying objects or dust, safety glasses with side protection (side shields) should be worn.



Figure 1.7 Safety goggles



Figure 1.8 Safety glasses

Accidents

Definition of an accident

An accident is an unplanned and uncontrolled incident caused by unsafe acts and unsafe conditions. Accidents caused by unsafe acts are the result of human error.



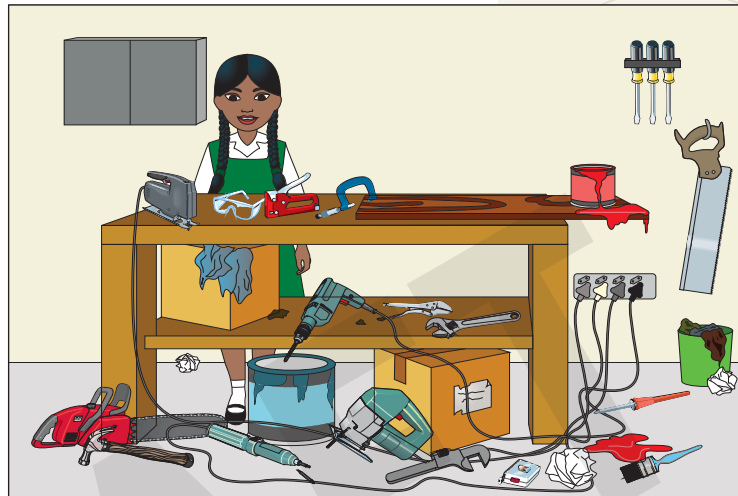
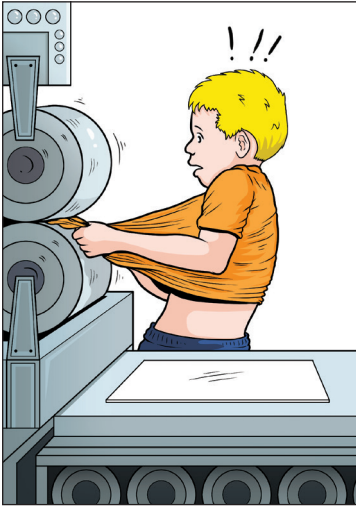
Figure 1.9 An accident is unplanned and uncontrolled

Causes of accidents

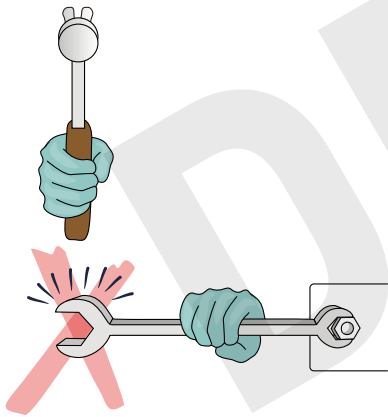
Accidents are caused mostly by human error. When safety rules and procedures are not observed, accidents that might be physically harmful can happen. Therefore, accidents can be prevented when safety rules are adhered to in the workshops.

Here are some of the main causes of accidents:

- Loose clothing
- Poor housekeeping



- Improper use of tools
- Inaccurate setting-up of machinery



Safe and unsafe acts or conditions

Damaged property and unsafe conditions are caused by an unsafe working environment. It is estimated that unsafe acts account for 88% of accidents while unsafe conditions account for 10%. The illustration shows the probability in the relationship between a serious accident concerning unsafe acts and conditions.

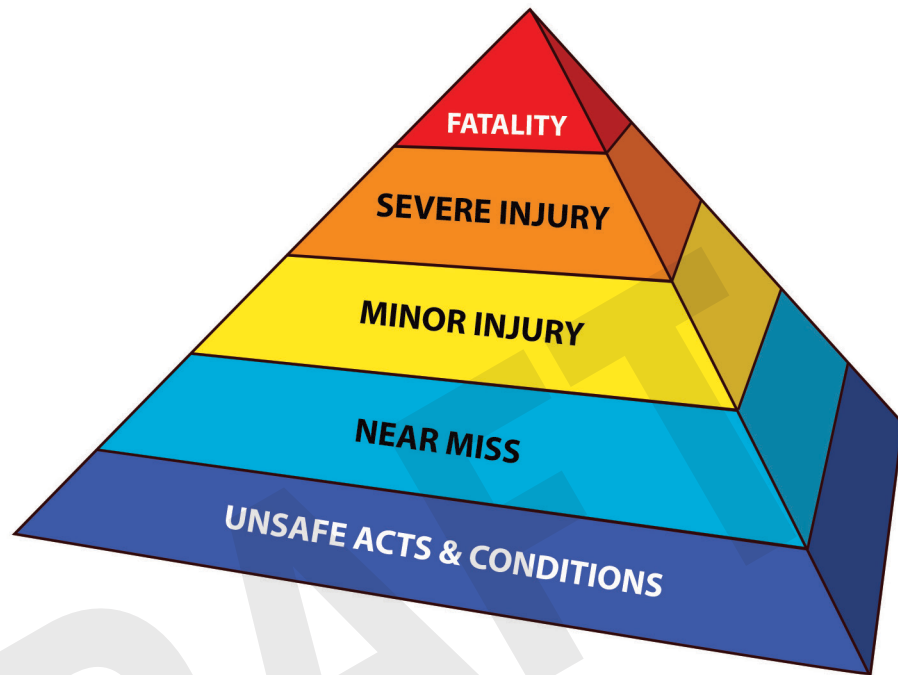


Figure 1.10 Unsafe acts and conditions versus serious injury

Here are examples of unsafe acts:

- fooling or teasing your fellow learners
- 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 PPE
- bypass or removal of safety devices
- unsafe position/posture
- wearing loose clothing near machines
- failure to put warning signs where they are needed
- entering the workshop without permission
- improper adjusting of machines while it is in operation.

Here are examples of unsafe conditions:

- overcrowding in the workshop
- poor workshop ventilation
- poor lighting (dull) and unsafe workshop lighting (flashing)
- poor housekeeping
- unsafe constructed buildings
- overcrowding in the workshop
- working without the correct PPE
- no machine guards on machines and equipment
- wet slippery floors
- defective hand tools, machines, equipment, etc.
- poor workshop layout or workflow.

ACTIVITY 1 Safety in the workplace

1. State the Act that regulates the health and safety in workshops.
2. Explain FIVE (5) general safety rules that must be adhered to when you are working in the workshop.
3. Define an accident.
4. List FOUR (4) causes of accidents in the workshop.
5. State FIVE (5) examples of unsafe acts in the workshop.
6. State FIVE (5) examples of unsafe conditions in the workshop.
7. Collect FIVE (5) or more pictures and paste them into your writing book showing different personal protective equipment needed in your workshop.
8. State the safety features you would find with safety boots.
9. List FIVE (5) injuries that can be avoided when wearing gloves in the workshop.

Housekeeping

Good housekeeping means working in an orderly way. Housekeeping is a general term embracing cleanliness, tidiness and a general state of repair. Tidiness in the workshop is an aid to productivity as well as a means of reducing accidents.

Good housekeeping

Good housekeeping ensures that the workshop is always kept clean and tidy thereby making it a safe place to work. Housekeeping helps prevent accidents and reduces the severity or consequences of accidents.



Figure 1.11 Good housekeeping



Take note

Good housekeeping should be maintained every day and is everyone's responsibility.

OHSA regulations require that each working surface is cleared of debris – including solid and liquid waste – at the end of each work shift or job. Effective housekeeping helps to control or eliminate workplace hazards. It includes keeping work areas neat and orderly, maintaining halls, and floors free of slip and trip hazards, and removing waste materials (for example, paper, cardboard), and other fire hazards from work areas.



Take note

The OHSA of 1995 regulates the workplace environment and has regulations and guidelines on employers' and employees' responsibilities regarding good housekeeping in the workplace. Visit <https://www.labourguide.co.za/health-and-safety>.

Good housekeeping:

- saves time to find and check goods, articles and tools
- saves space when everything is packed away tidily
- prevents injuries when passages and working areas are kept clear of unnecessary materials
- reduces fire hazards if combustible materials are kept in proper containers
- cuts costs
- ensures that the workplace is safe.

Good housekeeping can:

- eliminate clutter, which is a common cause of accidents such as slips, trips, falls, fires and explosions
- reduce the chances of harmful materials entering the body (for example, dust, vapours)
- improve productivity (the right tools and materials for the job will be easy to find)
- helps to keep the workshop inventory to a minimum (good housekeeping makes it easier to keep an accurate count of inventories).

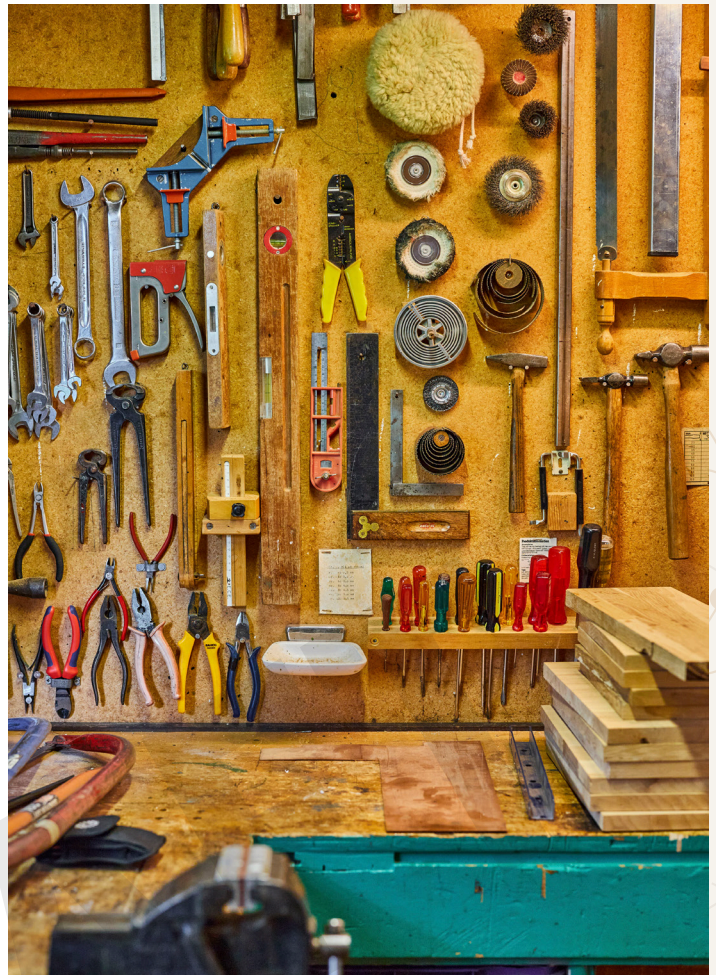


Figure 1.12 Good housekeeping

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.

Here are the advantages of good housekeeping:

- fewer accidents
- increased life of the building, machinery, tools, etc.
- improved morale
- increased production and decreased costs
- better product quality with less spoilage and rework
- reduced costs as occasional clean-up is more expensive
- little or no time is lost in searching for tools
- material handling and transportation pick-up speed
- supervision, inspection, maintenance and production control functions become easier
- better use of floor space.



Figure 1.13 Example of good housekeeping

Poor housekeeping

Slips, trips and falls account for one-third of all personal injuries in the workplace. These types of injuries include head and back injuries, broken bones, cuts and lacerations, sprains and pulled muscles.



Figure 1.14 Example of poor housekeeping



Figure 1.15 Tripping hazards in the workshop

Obstructed views, poor lighting, clutter, wrinkled carpeting, uncovered cables, uneven walking surfaces and bottom drawers not being closed properly can also cause trips.

There are three ways to prevent workplace accidents due to slips, trips, and falls. These are:

- good housekeeping
- quality walking surfaces
- proper footwear.

ACTIVITY 2 Housekeeping

1. Why is it important to maintain good housekeeping in the workshop?
2. State FIVE (5) advantages of good housekeeping.
3. List THREE (3) ways to prevent workplace accidents due to slips, trips, and falls.

PRACTICAL APPLICATION

Identifying unsafe conditions

Work in groups.

Aim: To identify possible unsafe conditions.

Resources:

- glass cutter
- the correct PPE
- T-square
- blanket

What to do:

1. Work in a group of 4 or 5.
2. Investigate the current situation in your workshop and identify possible unsafe conditions.
3. Write a short report on the unsafe conditions and provide possible solutions to the unsafe conditions.



Take note

Always pay attention to where you are going and report areas where clutter, obstruction, spillage, or damage have occurred.

Safety signs

Safety signs are used in the workshop to indicate safety regulations. Safety signs are classified into different groups:

- informative signage (colour code green/white/red/black)
- fire prevention signage (colour code red/white/)
- danger signage (colour code yellow/black)
- mandatory (compulsory) signage (colour code blue/white)
- prohibition signage (colour code red/white/black)



Figure 1.16 Different safety signs and classes

ACTIVITY 5 Safety signs

1. Classify each safety sign into its related group.

	Sign	Group
A		
B		
C		
D		
E		

Fire prevention and protection

Fires in the workshop

Fires account for 3% of workshop injuries and have the highest casualty rate of all possible accidents.

Figure 1.17 shows the different elements of fire.

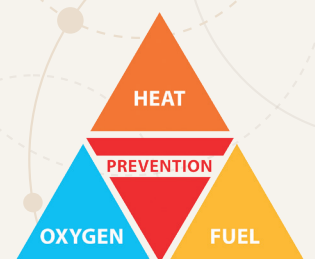


Figure 1.17 Elements of fire

Fires are often caused by risk factors such as faulty pipefitting, improperly stored combustible materials, flammable liquids, open flames, and electrical faults. The resulting injuries include damage to the respiratory system, varying degrees of burns, potential disfigurement, and death.

A suitable evacuation plan and effective alert system needs to be in place to quickly alert everyone in the workshop of hazards and emergencies.

Possible cause of fire in a workshop could include:

- faulty electrical equipment
- clutter
- combustible materials
- human error
- negligence
- arson.

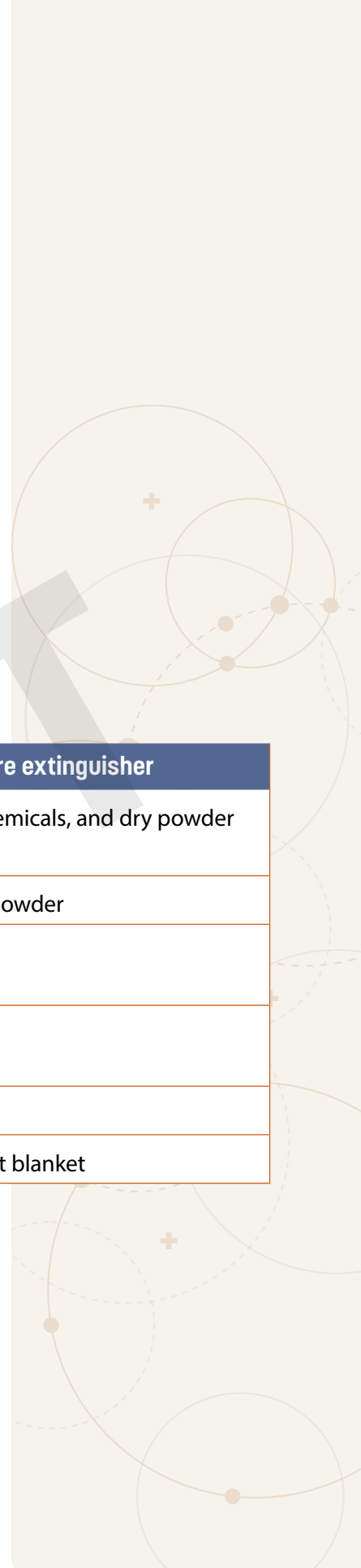


Figure 1.18 Electrical fire

Types of firefighting equipment

One of the most important aspects of health and safety is the equipment used in the fight against fires. This includes all deterrent, detection, warning and firefighting components. Firefighting equipment includes:

- fire extinguishers
- fire alarm systems
- smoke detectors
- fire extinguisher cylinder type
- fire suits
- fire sprinklers
- fire hydrants
- sand buckets.



Fire can be classified into different classes. The fire classes, causes and types of fire extinguishers are listed in Table 1.1.

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, CO ₂ , 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.	CO ₂ and dry powder
F	Cooking oil and fats.	Wet chemicals or wet blanket

If a fire occurs in the workshop, follow these practical steps to prevent it from spreading:

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Activity 6 Fire safety

1. What are the basic elements of a fire?
2. What are the common causes of fires in the workplace?
3. State the practical ways to prevent fires from spreading.
4. List FIVE (5) fire equipment needed to conduct firefighting.

PRACTICAL APPLICATION

Tiling, grouting and cleaning

Work in groups.

Aim: To investigate the current situation in your workshop and identify the firefighting equipment.

Resources:

- different extinguishers
- report sheet

What to do:

1. Write a short report on the following:
 - a) type of extinguisher
 - b) date of service
 - c) current condition
 - d) comment on the positioning/placement of the fire extinguishers.

Basic first aid

First aid stations

The Health and Safety Regulations require employers to provide adequate and appropriate equipment, facilities, and personnel to ensure that employees receive immediate attention if they are injured or are taken ill at work before emergency medical treatment is available.

A first aid provider should be trained to respond to medical emergency procedures using a limited amount of first aid equipment. They should be able to perform a primary assessment and intervention while waiting for medical personnel to arrive.



Figure 1.20 First aid sign

Response and incident management

First aid is defined as the initial care for an injured person when an injury happens. This is usually done by people who are not medical professionals, and happens before the medical staff arrive.

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

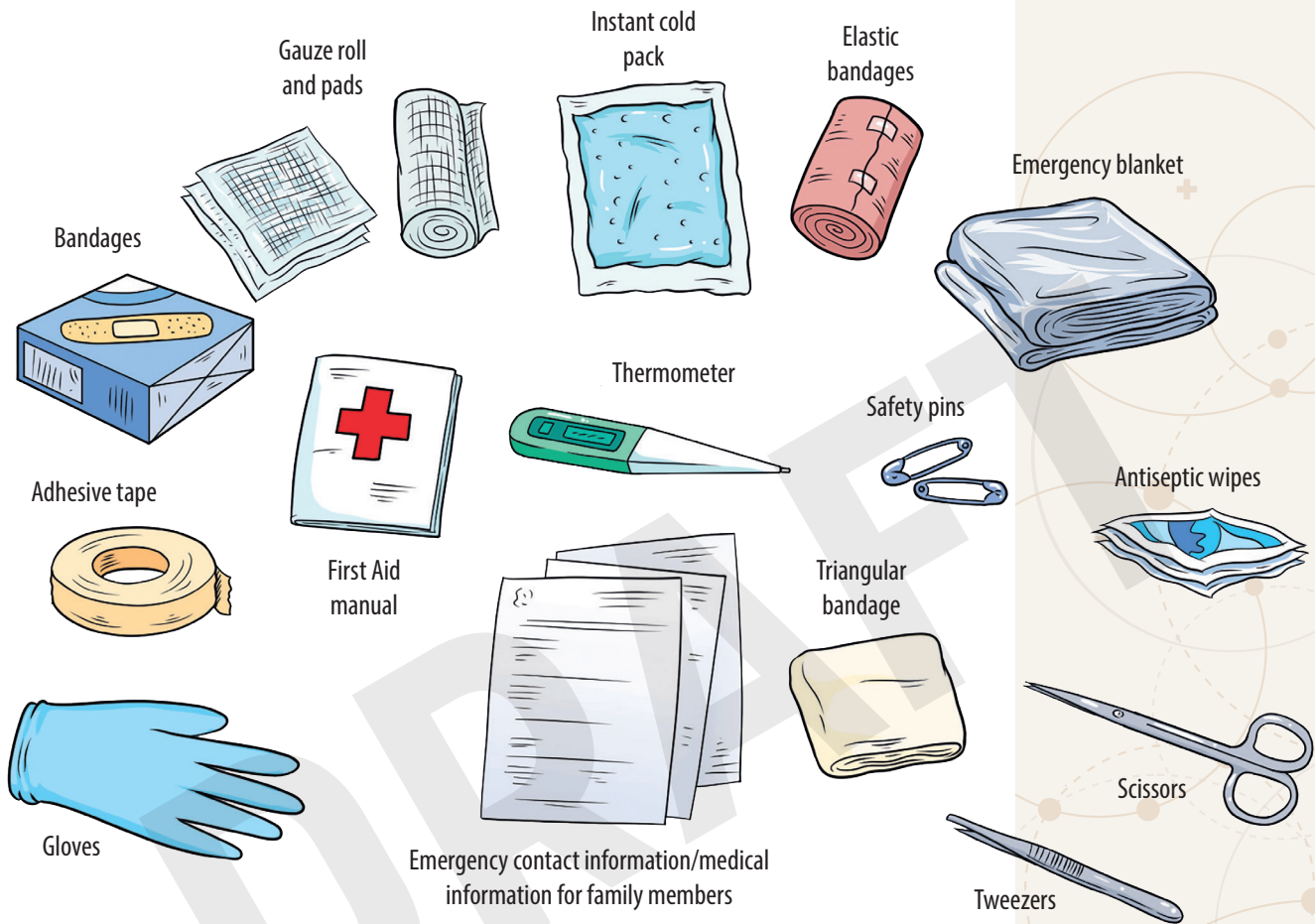





Figure 1.21 First aid kit checklist

Table 1.2 shows the basic first aid kit components and their functions:

Table 1.2 Basic first aid kit components

First aid supply	First aid kit components	Functions
	adhesive bandages	Covering open wounds and controlling bleeding wounds.
	adhesive tape	Holding bandages or dressings on wounds.
	antibiotic ointment	Preventing infections in minor cuts, scrapes, or burns and cleansing wounds before applying a bandage.
	antiseptic	Destroying micro-organism growth and cleansing wounds before applying a bandage.
	burn treatment	Treating burns and helping with pain associated with the burn.

First aid supply	First aid kit components	Functions
	cold pack	Reducing swelling and cooling burns to reduce the damage done to soft tissue.
	eye covering (with attachment)	Bandaging an injured eye.
	hand sanitiser	Killing germs and microorganisms on hands after caring for a patient.
	medical exam gloves	Providing body substance isolation to protect the rescuer from contacting blood-borne pathogens from a patient.
	scissors	Cutting bandages to the proper size.
	triangular bandage	Slinging and swathing limbs and wrapping around wounds to make a large pressure bandage.

Preserving life

All the procedures done in first aid are focused on achieving three aims/goals. They are known as the 3Ps of first aid.

Goals of First Aid

1P Preserve life

2P Prevent worsening

3P Promote recovery



Take note

While saving another person's life, it's important to remember that your life and safety always come first

Figure 1.22 The 3Ps of first aid

The first aim of first aid is to save lives. Some of the most 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 an unconscious person

Preventing deterioration

Sometimes you can stop an injury or accident from deteriorating or becoming complicated. For example, if a person has a suspected spine injury, do not move them because it could cause harm and deterioration of the condition.

Promoting recovery

In some cases, you can promote faster recovery. For example, if someone fell and has a small wound with minor bleeding, you can wash it with water and dress it. In this way you will prevent wound infections and promote faster recovery. If infection does occur, a medical practitioner should be consulted for additional medical procedures.

Incident management in first aid

The environment where an accident happened is often stressful and overwhelming. It is important to carefully manage the incident and the risks. The main principle of first aid incident management is that you are the most important person on the scene.



Figure 1.23 Assisting in first aid

Main safety principle in first aid response

Your safety comes before anyone's else safety – you should keep yourself alive and healthy to help others. In case of severe fire or harmful chemicals, keep a safe distance from the burning object or dangerous scene. Only get closer if you are wearing special protective equipment and have undergone appropriate training – otherwise call and wait for the appropriate emergency services to manage the risks.

Remember the following:

- call the appropriate emergency service number
- list all emergency telephone numbers for immediate access
- make sure you wear appropriate footwear – sharp object could be lying around
- there could be exposed electrical wiring in the workshop
- never place yourself between an injured person and the threat
- always keep a safe distance from the incident
- be aware of the risk of more fire and explosions.

It is important to assess possible dangers when approaching an accident scene, for example, electrical shock, harmful chemicals, and falling equipment or bricks. If the scene is not safe, maintain a safe distance and call the appropriate emergency service. Take precautions in case there is an electrically related incident. A piece of wood or any non-conducting material must be used to turn off the source of electricity.



Take note

If there is a risk of explosion or injury by sharp objects like broken glass, flying metal, etc., apply appropriate safety precautions before going for help.

Fractures

A bone fracture occurs when there is a partial or complete break in a bone.

Causes of fractures include:

- falls from heights
- falls resulting from oil spills or water spills
- tripping over electrical wiring
- equipment falling on you
- accidentally putting a limb in a machine.

Symptoms of fractures include:

- pain
- swelling
- a snapping sound heard when bones break
- the deformed appearance of a limb
- skin bruising or bleeding.

How to treat a fractured arm using first aid

A simple break can be treated using a sling, ice and rest. However, the bone may need realignment in the emergency room. A worse break might need surgery to fix 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, the wound needs to be covered using a sterile dressing or a clean, non-fluffy cloth.

Pressure should be applied around the wound (not over the protruding bone) to control any bleeding. Then the dressing should be secured using a bandage. Advise the injured person to keep still while you support the broken limb to stop it from moving.

Trauma (shock)

Trauma or shock could happen because of a sudden event or experience. It could be caused by a fall in blood pressure caused by loss of blood, severe burns, allergic reaction, or sudden emotional stress; and could be marked by cold, pale skin, irregular breathing, rapid pulse, and dilated pupils.

How to treat a patient in shock

Shock is a life-threatening condition. It happens when the body is not getting enough blood flow, and this lack of blood flow means the cells and organs are not getting 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:

1. Call the emergency response team.



2. Lay the person down, and if possible:
 - » elevate the person's feet about 30 cm unless the head, neck, or back is injured or you suspect broken hip or leg bones

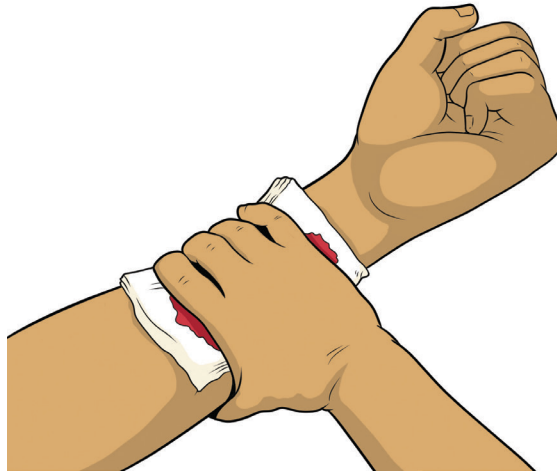


- » do not raise the person's head.
 - » turn the person on the side if they are vomiting or bleeding from the mouth.
3. Begin CPR, if the person is not breathing or breathing seems weak.



- » Continue CPR until help arrives or the person wakes up.

4. Treat obvious injuries.



5. Keep the person warm and comfortable.



- loosen restrictive clothing
- cover with a coat or blanket
- keep the person still – do not move the person unless there is danger
- reassure the person
- do not give them anything to eat or drink.

Activity 7 First aid

1. Define the term first aid.
2. Explain the 3Ps for first aid.
3. What is the main principle in first aid response?
4. Name FIVE (5) appropriate factors that should be considered when providing first aid.
5. Explain how you would treat an open wound.
6. State THREE (3) causes of fractures.
7. List FIVE (5) symptoms of a person who suffers from a fracture.
8. Explain how you would assist a person in shock while providing first aid treatment.

PRACTICAL APPLICATION

Treating a person using suitable First Aid

Work in groups.

Aim: To demonstrate how to treat a person using suitable first aid.

Resources:

- first aid box
- relevant first aid equipment

What to do:

1. Make a poster to explain how to treat a fractured arm using first aid.
2. Make a poster to treat a person experiencing shock.

The background of the cover features a technical drawing of a mechanical part, likely a bracket or a base, on a drafting table. The drawing includes various dimensions and labels such as R1, R3, R5, R10, and A (12). A metal ruler and a compass are visible on the left side of the table. The entire scene is overlaid with a large green circle containing the text 'CHAPTER 2' and a large, stylized '2' in white. The bottom right corner has an orange background with the text 'Graphic Communication' in white.

CHAPTER

2

Graphic
Communication

LEARNING OUTCOMES

By the end of this chapter, learners should be able to use graphic communication and symbols such as images and drawings. The following will be covered in this chapter:

- defining graphic communication
- learning about the purpose of graphic communication
- discussing general drawing principles
- learning about safety precautions when using drawing instruments
- learning about the correct use and care of drawing instruments
- discussing and drawing different types of lines
- learning how to do freehand sketches
- learning how to print (use freehand lettering)
- discussing dimensions, lettering and borders (SANS 0111 Guidelines)
- differentiating between pictorial drawing (using drawing instruments)
 - » 1st angle orthographic drawings
 - » isometric drawings

Introduction to graphic communication

What is graphic communication?

Graphic communication can be defined as a language that enables us to describe the exact size and shape of physical objects used in engineering. It is an international language, which integrates the cognitive and manipulative skills that are used to design and communicate graphically.

The purpose of graphic communication in the technological world

Graphic communication enables us to learn specific basic knowledge and various drawing techniques and skills that we can use to interpret and produce engineering drawings. It aims to explain and teach us the vocabulary and terminology used in drawing. This year we will focus on the following:

- technological drawings as a primary means of communication in the technological world
- visualisation and interpretation of drawings
- accurate application of given dimensions
- graphically representing objects.

Drawing and drawing instruments

General drawing principles

Drawings help engineers represent the main features of a product or structure. It may communicate some details using lines, ignoring whole parts of an object (showing less detail), while other parts may be shown in greater detail. Here are some general drawing principles we will focus on this year:

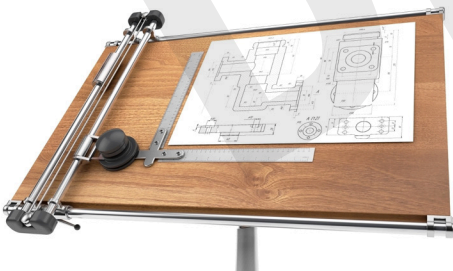

- using different line types
- correct printing and dimensioning techniques
- freehand drawing techniques and skills
- instrument drawing techniques and skills
- the principles of basic 1st angle orthographic projection
- the principles of basic isometric drawings.


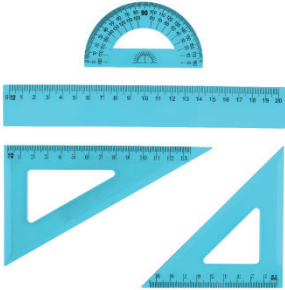



Safety precautions when using drawing instruments

When working with drawing instruments, it is important to work safely. Some instruments, for example, dividers and compasses, are sharp and could cause injury or bleeding if incorrectly used. Injuries and bleeding 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.

Let's look at how to correctly use and care for drawing instruments and equipment.

Table 2.1 The correct use and care of drawing instruments and equipment

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.

Name	Use	Care
 45° set square	Used to draw parallel and perpendicular lines, and standard measure angles (45 ° and 90°).	Wipe with a clean cloth preferably a yellow duster.
 30° /60° set square	Used to draw parallel and perpendicular lines, and standard measure angles (30° /60° and 90°).	Wipe with a clean cloth preferably a yellow duster.
 scale rule	Used to measure length, width and height.	Wipe with a clean cloth, preferably a yellow duster.
 protractor	Used to measure angles.	Wipe with a clean cloth, preferably a yellow duster.
 compass	Used to draw circles and arcs.	The lead on the compass must be kept sharp.

Name	Use	Care
 pencils	Used for lettering and drawing lines. Pencils come in different grades (H, B, F and HB).	Keep sharpened at all times.
 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.

Types of lines

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

Here are examples of different lines:

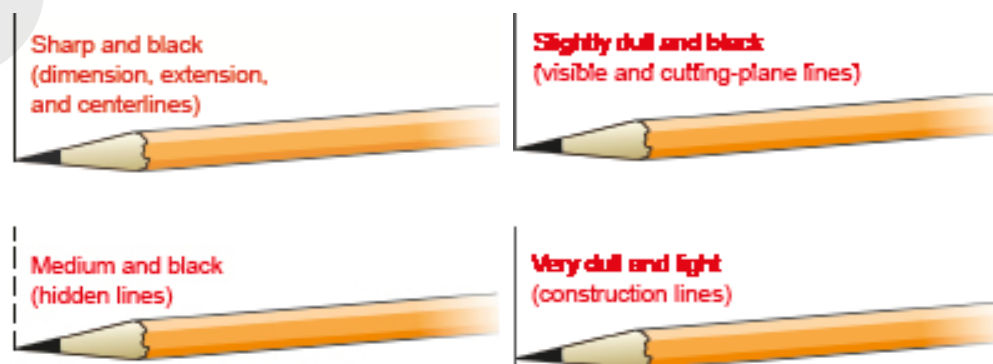










Figure 2.1 Different lines used in graphic communication

Let's look at the different types of lines by focussing on their description and general application in drawing:

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.

Dimensions, lettering and borders

The illustrations below show different line types which are used in graphic communication.

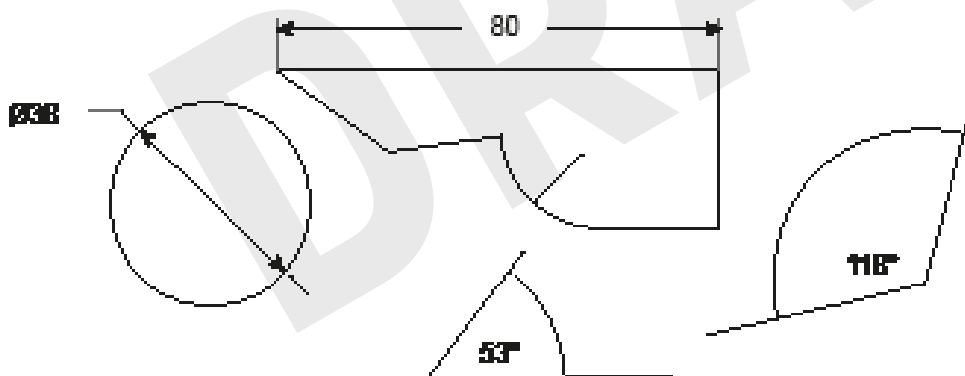


Figure 2.2 a) – d) Different line types used in graphic communication

Activity 2.1 Types of lines

1. Measure and insert dimensions on:

- line ab
- the diameter
- the radius
- the angle

New words

guide lines barely visible and very feint lines.

Printing (freehand lettering)

Illegible lettering and figures can ruin a good drawing. Follow these useful suggestions and hints when lettering:

- all lettering should be done freehand and in print
- all lettering should be done between **guide lines** (preferably, within 5 mm type C lines)
- use capital letters rather than lowercase letters – they appear neat and less congested.

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

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

5mm A B C D E F G H I J K L
5mm M N O P Q R S T U V W X
5mm Y Z 1 2 3 4 5 6 7 8 9 0

Activity 2.2

1. Print the given alphabet letters in capitals and print the given numbers. Use very feint **5 mm** guide lines.

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 print the given numbers.

Use very faint **3 mm** guide lines.

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

Freehand drawing

Freehand drawing is a simple drawing done by hand without using any drawing equipment such as templates, stencils or tracing copies. Only pencils and an eraser are used for freehand drawing. This technique can be mastered by practicing and drawing regularly. Look at the examples of freehand drawings shown in Figure 2.3, Figure 2.4 and Figure 2.5.



Take note

Freehand drawing can be used to quickly present an idea using graphical communication to a non-technical person.

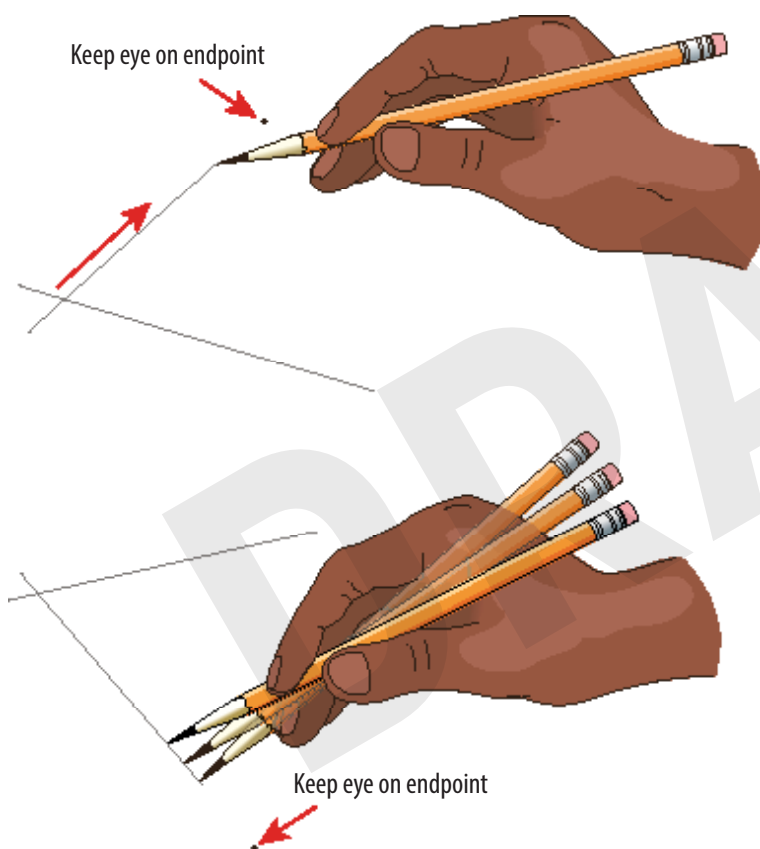


Figure 2.3 Example of a freehand drawing

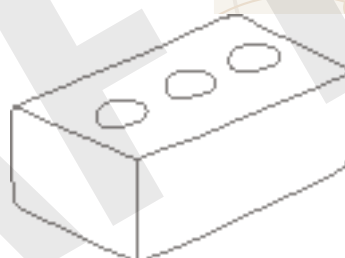


Figure 2.4 Freehand drawing of a brick

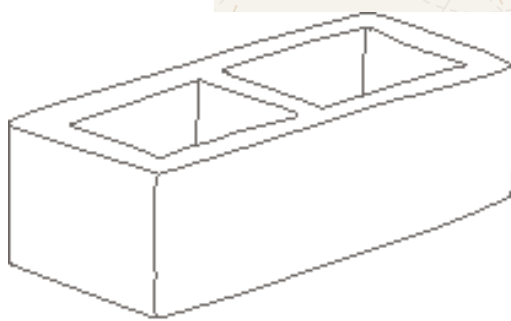


Figure 2.5 Freehand drawing of a brick block

Here are some drawing instruments that you can use when doing freehand drawings:

- different pencils
- eraser
- sharpener
- drawing sheet/graph paper.

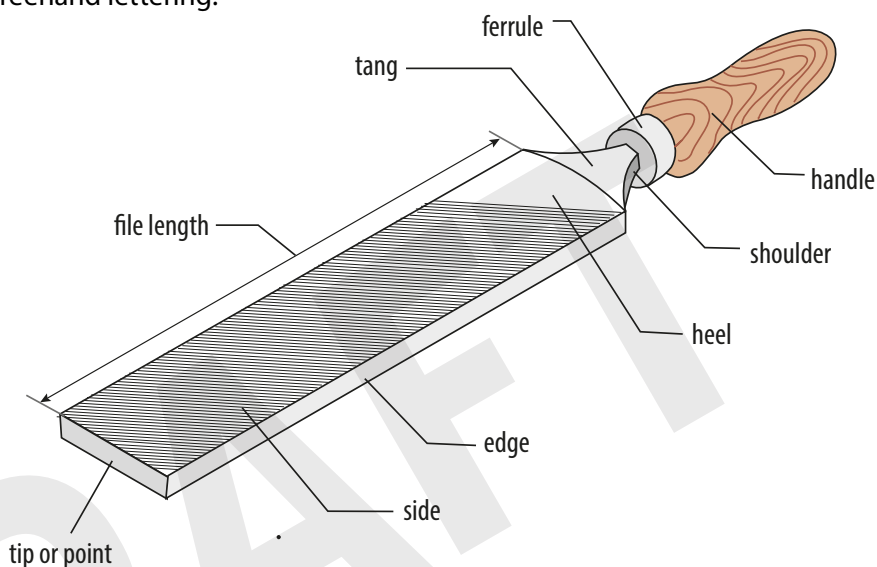
**Take note**

Straight lines can be oblique, horizontal or vertical lines. When drawing straight lines, remember that the movement of your arm should be controlled.

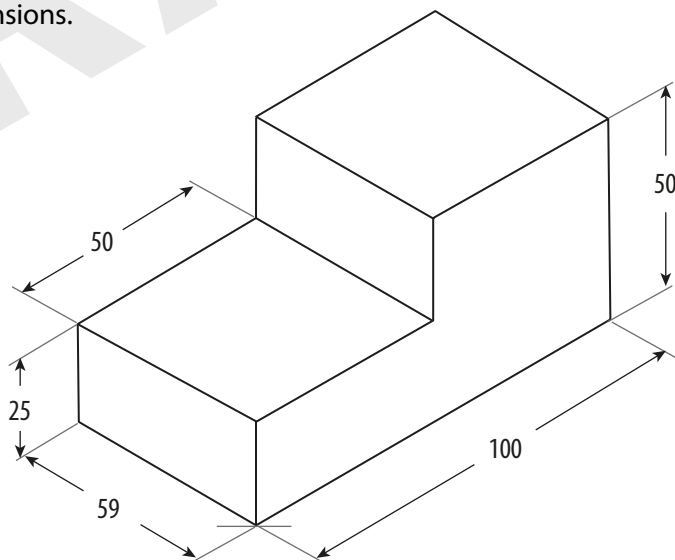
When doing a freehand drawing, remember to carefully consider the object that you are drawing. Once you have looked at all the details of the object, you can decide which aspects you want to emphasise, and which aspects are not so important. Use faint lines for the details you may want to erase on your final drawing. Remember to consider the size and angle of the object, and use clear lines to fill in the details on your drawing.

Activity 2.3

1. Using a freehand drawing, redraw the following tool and label it using freehand lettering.



2. Using a freehand drawing, redraw the following figure and insert freehand dimensions.



Scale drawing 1:1, 1:2 and 2:1

A drawing that shows a real object with accurate sizes reduced or enlarged by a certain amount is called a scale drawing. The scale is shown as the length in the drawing, then a colon (“:”), then the matching length on the real object.

The drawing below has a scale of 1:1. Anything drawn with the size of “1” would have same size, “1” in the real world. So a measurement of 10 mm on the drawing would be 10 mm on the real object.

Ratio 1:1

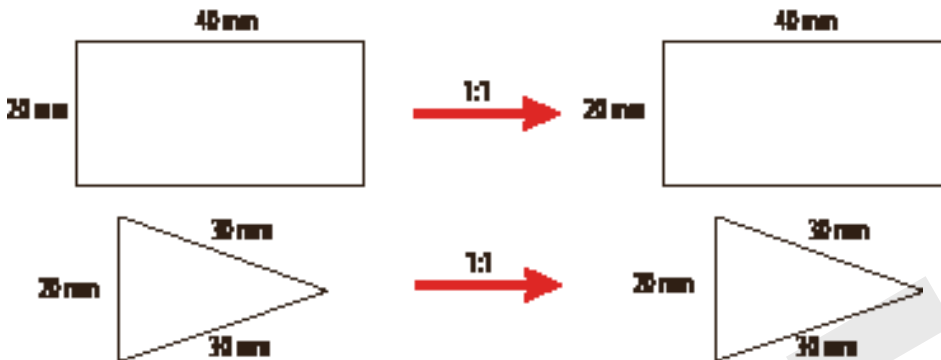


Figure 2.6 A drawing with a scale of 1:1

The drawing below has a scale of 1:2. Anything drawn with the size of “1” would have a size of “2” in the real world. So a measurement of 10 mm on the drawing would be 20 mm on the real object.

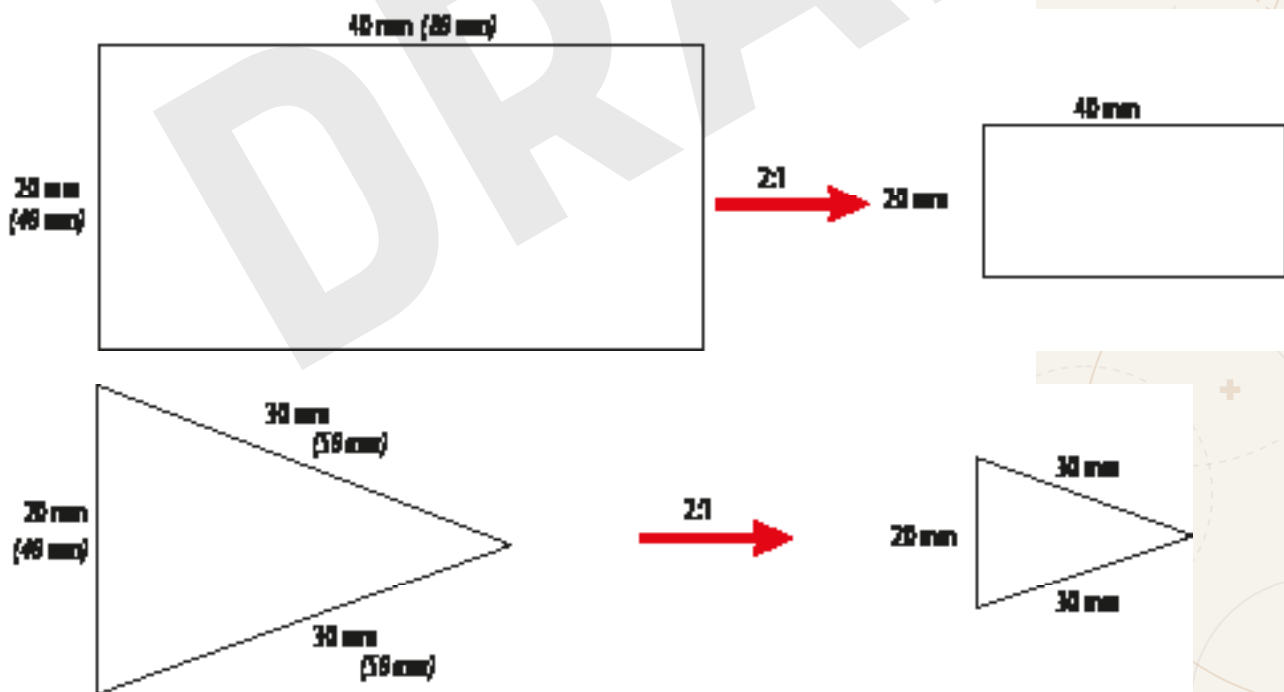


Figure 2.7 A drawing with a scale of 1:2

The drawing below has a scale of 2:1. Anything drawn with the size of “2” would have a size of “1” in the real world. So a measurement of 100 mm on the drawing would be 50 mm on the real object.

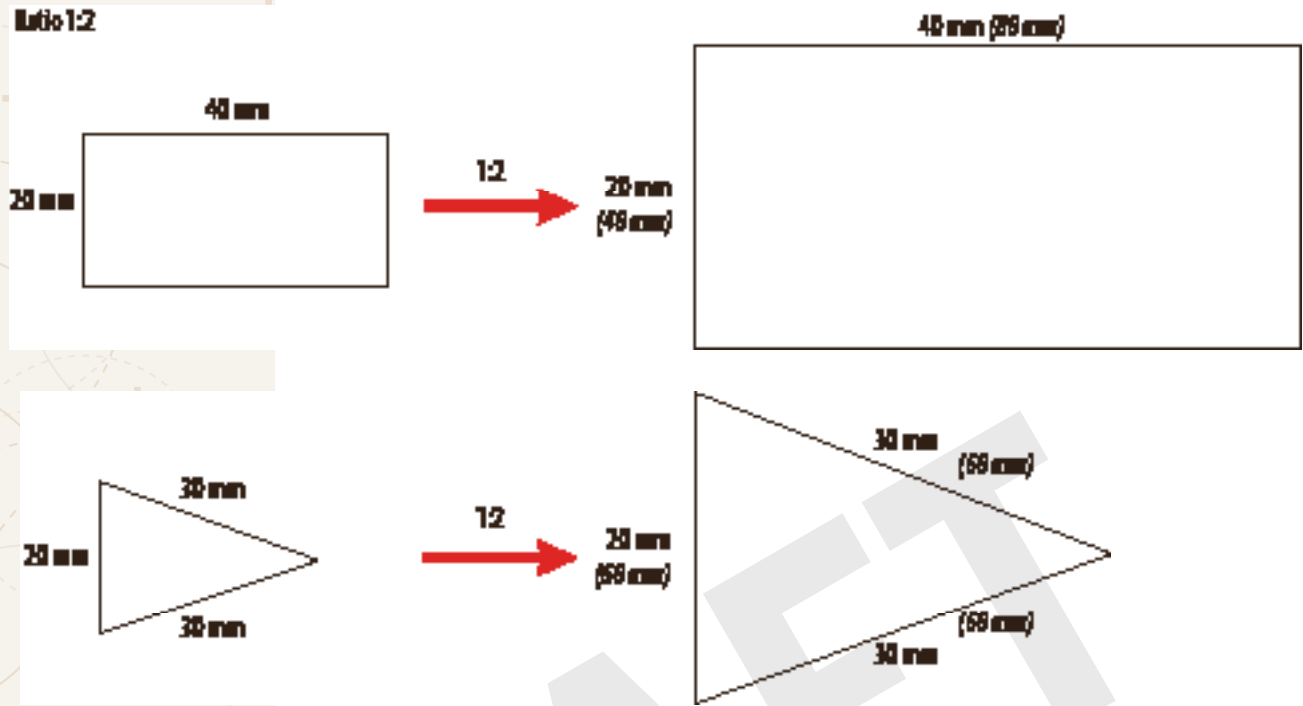


Figure 2.8 A drawing with a scale of 2:1

Pictorial drawings (using drawing instruments)

Orthographic projection

An orthographic projection gives the actual measurements of an object. The projection lines are parallel to 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. It describes the width and height of the object. The left view describes the depth and height, and the top view describes the width and depth of the object.

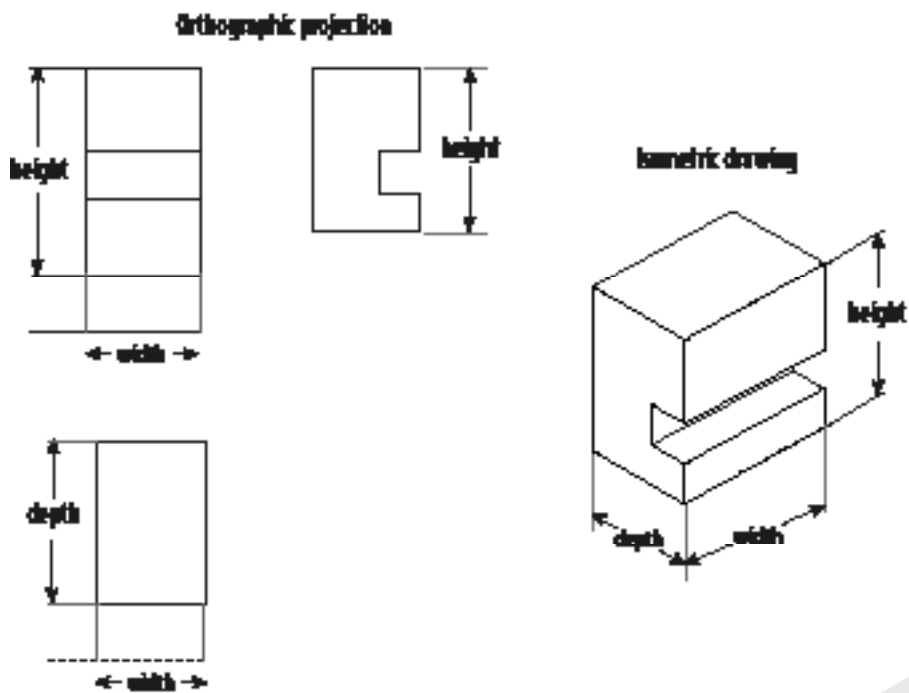


Figure 2.9 Orthographic projection of an object

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

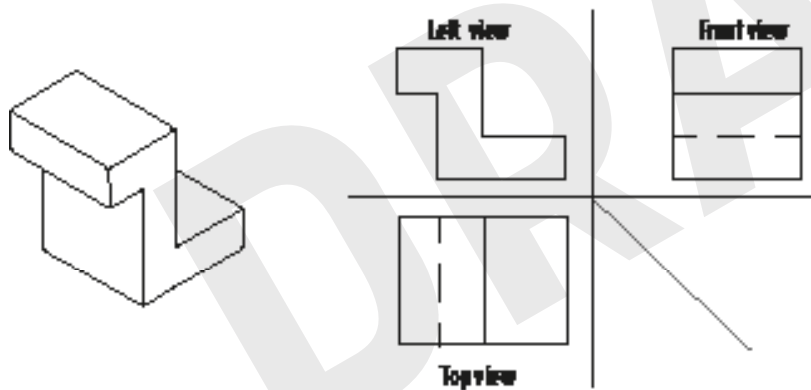


Figure 2.10 Orthographic projection of an object

Isometric drawings

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 30° angles and all the vertical heights are drawn (projected) as vertical lines (90° angles). All isometric lines are drawn to scale.

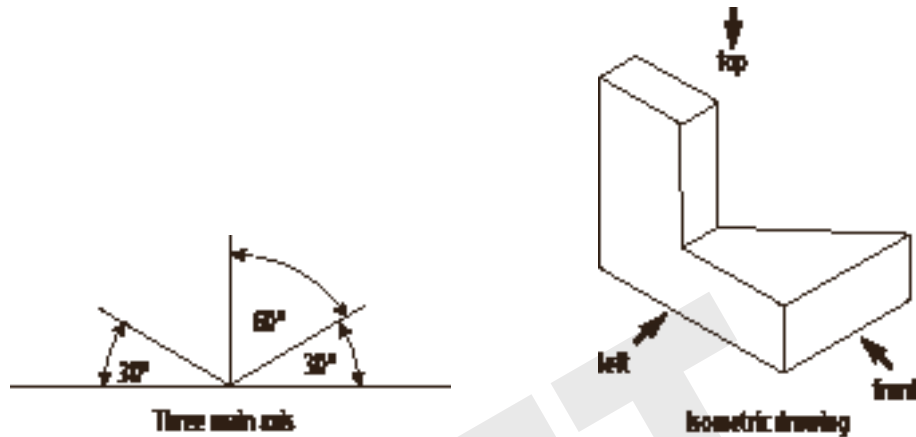


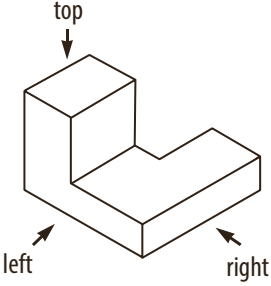

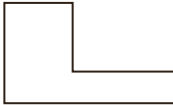
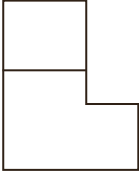
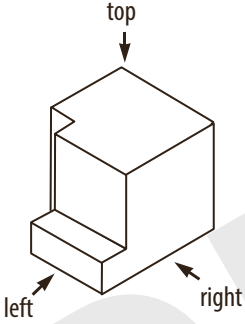


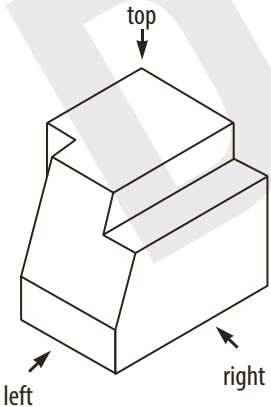
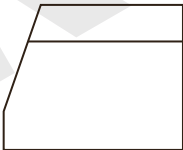
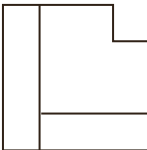
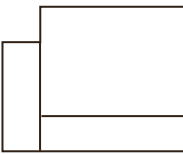
Figure 2.11 An isometric drawing of an object

What makes an isometric drawing different from other 3-dimensional drawings is that the axis is drawn so that the two horizontal axes are at 30° angles. It is as if the vertical axis is in its true position, but the horizontal axis is bent 30° from its 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 Orthographic projections and isometric drawings

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

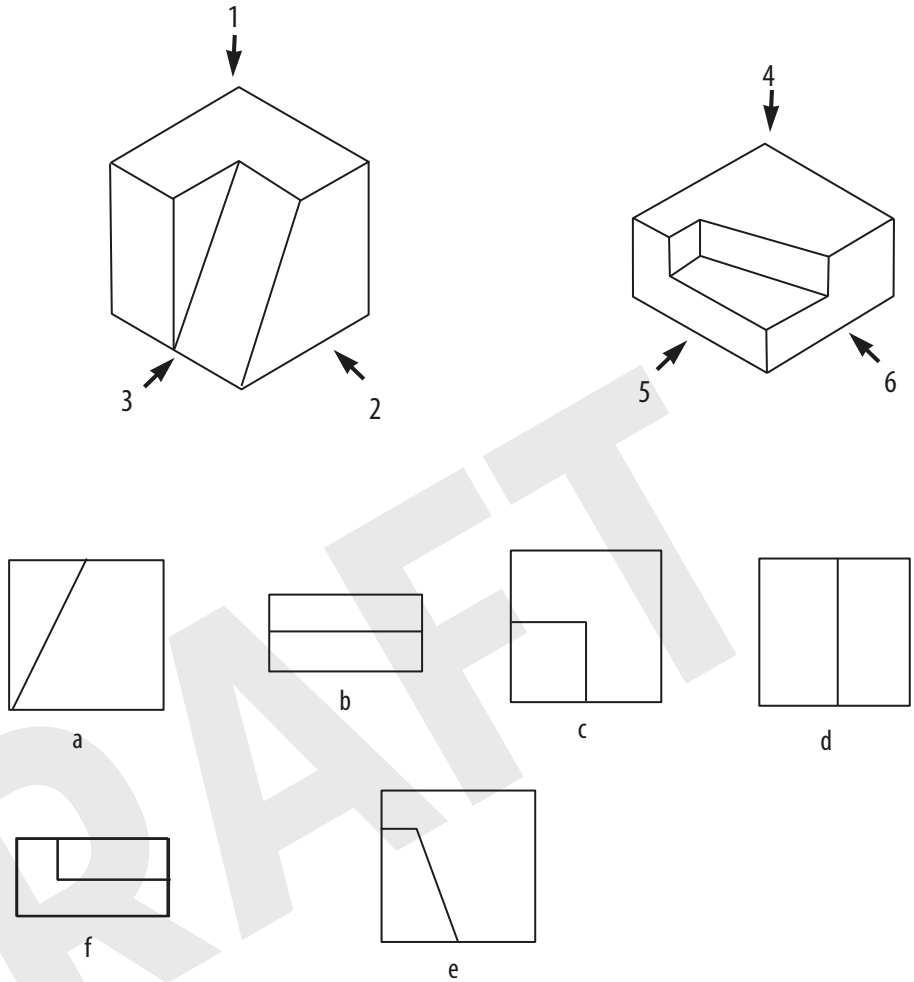
Pictorial view	Orthographical view								
	<div> View 1  </div> <div> View 2  </div> <div> View 3  </div> <table border="1"> <thead> <tr> <th colspan="2">Identify and name each view</th></tr> </thead> <tbody> <tr> <td>View 1</td><td></td></tr> <tr> <td>View 2</td><td></td></tr> <tr> <td>View 3</td><td></td></tr> </tbody> </table>	Identify and name each view		View 1		View 2		View 3	
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	<div> View 1  </div> <div> View 2  </div> <div> View 3  </div> <table border="1"> <thead> <tr> <th colspan="2">Identify and name each view</th></tr> </thead> <tbody> <tr> <td>View 1</td><td></td></tr> <tr> <td>View 2</td><td></td></tr> <tr> <td>View 3</td><td></td></tr> </tbody> </table>	Identify and name each view		View 1		View 2		View 3	
Identify and name each view									
View 1									
View 2									
View 3									

Identify the views and present your answer in a table as shown.
Write one of the following: Front, Left, Right or Top.

2. Study the isometric drawings in the upper block, below.

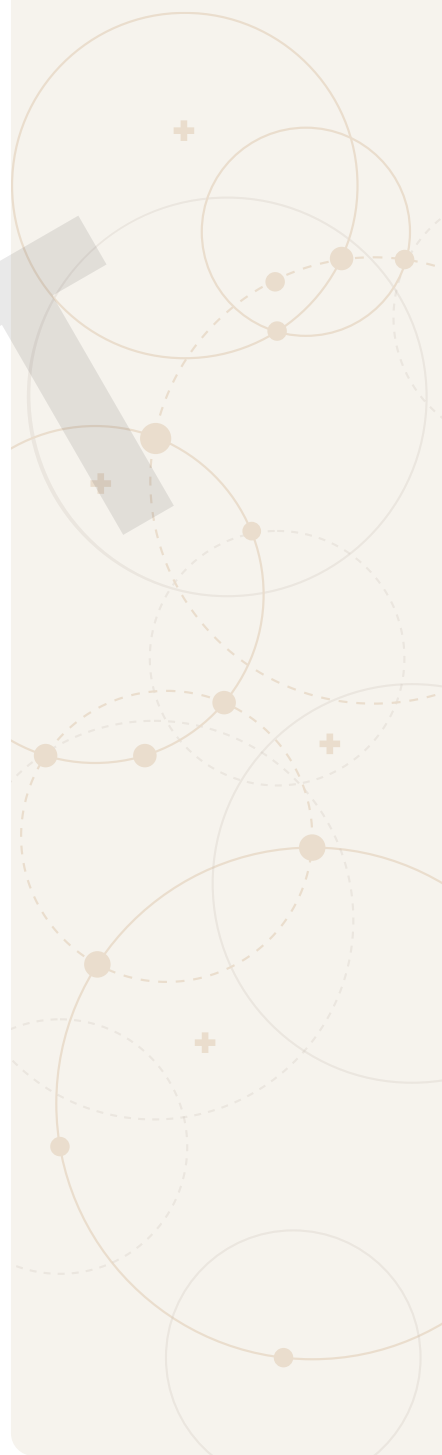
The lower block shows letters on orthographic views, which can be linked to the numbers on the isometric drawings.

Match the letters with the corresponding numbered isometric drawing.



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

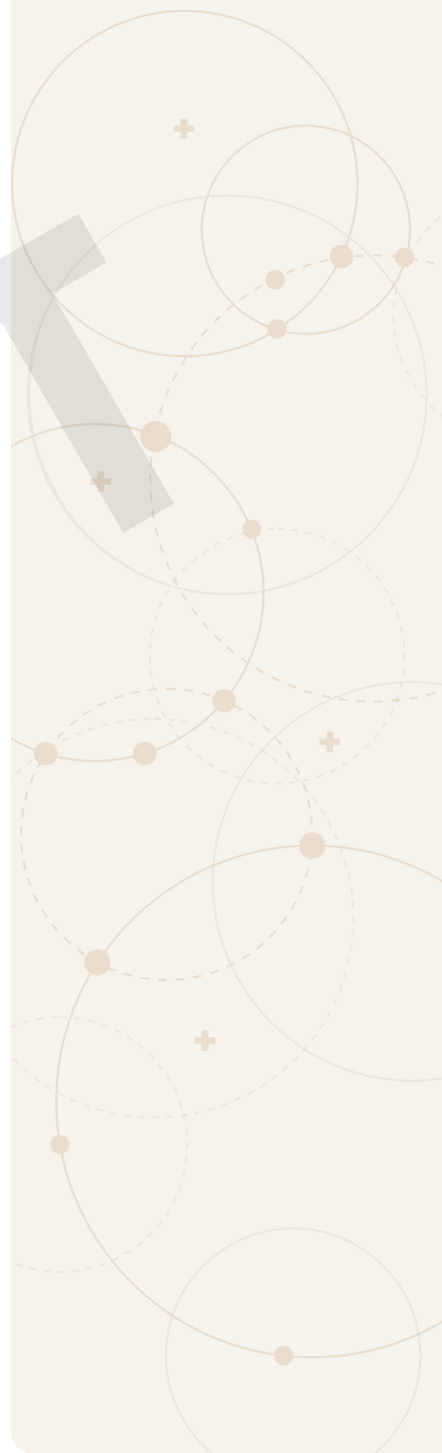
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CHAPTER

3

Tools, instruments
and equipment

LEARNING OUTCOMES

By the end of this chapter, learners should be able to identify and use tools, instruments and equipment safely. The following will be covered in this chapter:

- understanding the classification and application of hand tools: screwdrivers, spanners, pliers, cutting tools, marking off tools, hammers
- understanding the classification and application of measuring equipment: vernier caliper, inside micrometer, outside micrometer, combination set, thread pitch gauge
- identifying, using and caring for power tools: pedestal drill press, angle grinder
- understanding the care and use of vehicle lifting equipment: vehicle hoist, trolley jack, trestles
- demonstrating the practical skill of removing and fitting a vehicle wheel

Introduction

Tools are devices or instruments used to carry out a particular function with ease. Without tools in the workshop, no service and operation can be done effectively.

Let's look at some of the tools that you will use in the Mechanical Technology workshop.

Screwdrivers

A screwdriver consists of a handle and a shaft. The handle is made from an insulating material such as plastic, while the shaft is made from cast or silver steel. This cast or silver steel can withstand bending or twisting. The tip of the screwdriver is hardened to resist wear, and is treated with a dark tip coating so that you can see the difference between the tip and screw.

Screwdrivers should only be used to loosen and tighten screws. When selecting a screwdriver ensure the tip fits correctly in the screw slot and is not wider than the head of the screw.

Screwdrivers are classified by the length of the blade and the shape of their tip. They are available in a variety of shapes and sizes. Here are the different types of screwdrivers:

- Philips screwdriver – star-like tipped screwdriver used mostly in the automobile industry.



Take note

Never as a chisel or crowbar!

- flat screwdriver/straight type – mostly used for general work in the workshop.



Figure 3.1 Flat screwdriver



Figure 3.2 Phillips screwdriver

- Offset screwdriver –used where space is limited and where ordinary screwdrivers will not reach or fit.



Figure 3.3 Offset Phillips screwdriver



Figure 3.4 Offset flat screwdriver

Caring for screwdrivers

Follow these guidelines to care for your screwdrivers:

- never use the screwdriver as a chisel
- do not put the screwdriver in your pocket
- do not use the screwdriver on screws that are hard to turn
- clean the tool after use and oil lightly.

Activity 1 Screwdrivers

1. Name the three parts of the screwdriver and state what materials are those parts made of.
2. Explain FOUR (4) ways to care for screwdrivers.
3. State the use of offset screwdrivers.

Spanners

Spanners are available in different sizes and can be used to tighten or loosen nuts and bolts of different sizes. Most spanners are made from a chrome-vanadium alloy.

There are different types of spanners for different applications. These are:

- open-ended spanners
- ring spanners
- combination spanners
- socket spanners

Table 3.1 Different types of spanners



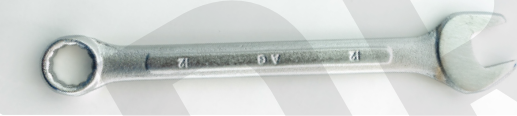

Types of spanners	Description and uses
Open-ended spanner/flat spanner 	<ul style="list-style-type: none"> • Single-piece tools used for general work like loosening or fastening bolts and nuts. • Can be used in the tubing fitting.
Ring spanner 	<ul style="list-style-type: none"> • A simple, double-headed, single-piece spanner with a profile set in a looped head. • Used to loosen or tighten bolts and nuts and cannot open and slip.
Combination spanner 	<ul style="list-style-type: none"> • A double-ended tool that serves as two spanners in one. One end is an open-ended spanner, and the other end is a ring spanner. • Used for only one size of fastener, as both the profile heads are of the same fastener size.
Socket spanner  <div style="background-color: yellow; padding: 2px; display: inline-block;">artwork missing</div>	<ul style="list-style-type: none"> • A cylindrical tool that is designed to fit perfectly on a nut or bolt that has to be removed or tightened. • A ratchet is used to loosen and tighten bolts and nuts, without taking it out to turn it again. • Components that are used with sockets: <ul style="list-style-type: none"> • ratchet • T-handle • speed handle/the brace • extension • universal coupling • sockets



Figure 3.5 Socket set]



Take note

When working with a spanner, DO NOT push the spanner. Instead pull the spanner towards yourself as this will avoid injuries to your hands. Always use the spanner for its intended purpose. Clean it after use and return it to the storage area.




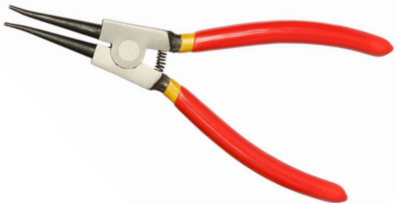


Activity 2 Spanners

1. When would you use an open-ended/flat spanner?
2. Why would you use a ratchet?
3. Which accessories would you use with ratchets?
4. Choose the correct answer to make the following statement correct.
When working with hand tools, always...
 - a) push the wrench – do not pull toward you.
 - b) pull a wrench – do not push a wrench.

Pliers

Pliers are made of steel alloys, with vanadium or chromium added to improve their strength and prevent corrosion. They are used to grip, position, tighten, loosen, and cut certain metal elements. They have a metal handle that is insulated for better handling and to prevent electrical shock.

Table 3.2 Different types of pliers

Types of pliers generally used in the workshop		
 <p>1. Combination plier – used to hold objects in position, tighten things and cut wire.</p>	 <p>2. Side cutter – used for cutting wire and split pins.</p>	 <p>3. Long nose plier – used in confined spaces where your hands cannot fit into.</p>
 <p>4. Circlip plier – used to fit or remove inside or outside circlips in/from grooves.</p>	 <p>5. Vice grip – used to clamp objects and is adjustable to fit objects of different sizes.</p>	 <p>6. Water pump plier – used to grip pipes, hold, tighten or loosen larger objects.</p>

To care for pliers, follow these guidelines:

- either hang pliers on the pegboard or put them in the toolbox
- keep the pliers in a dry place
- clean the plier after each use
- prevent corrosion and rust as it shortens the lifespan of tools
- oil the pliers on the pivot joint.

Activity 3 Pliers

1. What are circlip pliers generally used for?
2. Name the pliers used to cut split pins.
3. Name the reasons why the handles of pliers are insulated.
4. Give FOUR (4) uses of pliers.
5. Explain how the lifespan of pliers can be enhanced.

Cutting tools

Chisels

Cold chisels are used to cut and shape 'cold' metals. The length of the chisel and its shape depends on the work for which it is needed.

Chisels are made of hardened and **tempered** cast steel and are usually made up of octagonal sections. Their cutting edges are ground on a grinding wheel for the metal to be cut or chipped:

- aluminium: 35°
- copper and brass: 40°
- mild steel: 50°
- cast iron: 60°
- cast steel: 70°

Here are the different types and uses of chisels:

- Flat chisels – also known as a cold chisel. It is used for general dressing, chipping, and cutting.



Figure 3.6 A flat chisel.

- Cross-cut chisels – used for cutting grooves, slots, recesses, and keyways.

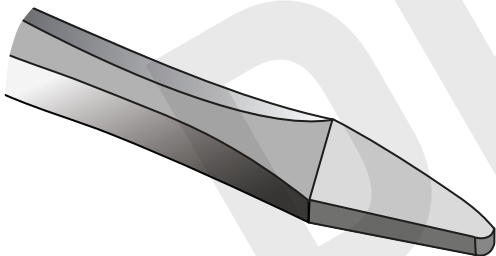


Figure 3.7 A cross-cut chisel.

- Round nose chisels – used for cutting oil grooves on a long flat or convex surface, the curved type is used for cutting oil grooves along the curved surface of a bearing.

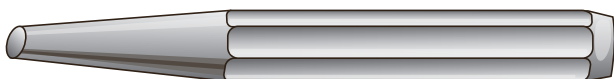


Figure 3.8 A round nose chisel



Take note

Cold chisels are only occasionally used in a modern workshop.

New words

tempered ????

- Diamond point chisels – used for finishing off and cleaning out corners, and for cutting “v” grooves.

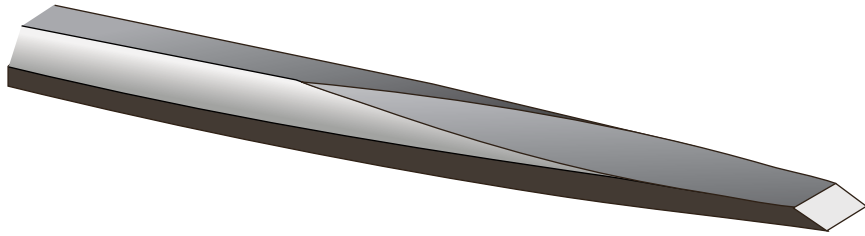


Figure 3.9 A diamond chisel

Remember these guidelines when chipping

- wear goggles to protect your eyes
- place a guard in front of the work to protect others from injury
- grind or file the mushrooming material away on the end of a punch or chisel
- when chipping, watch the cutting edge and not the head of a chisel.

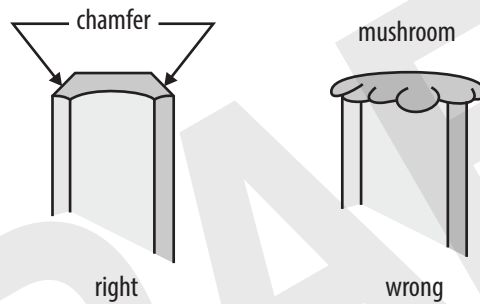


Figure 3.10 The right and wrong punch/chisel end.

Activity 4 Chisels

1. Explain the uses of the following chisels.
 - a) flat chisel
 - b) crosscut chisels
 - c) round nose chisel
 - d) diamond chisel
2. The term mushroomed refers to the damage the hammer does to the chisel head. Draw a freehand sketch to show a mushroomed head.

Hacksaws

A hacksaw is used to cut metals and composites by hand. It consists of a frame, handles, and a renewable blade. The blade is held by two blade holders and a wing nut for tensioning the blade.

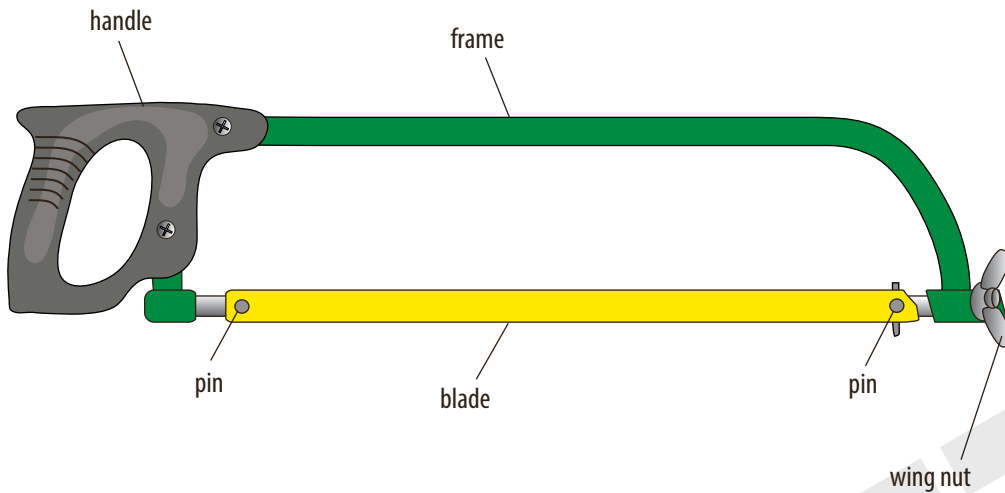


Figure 3.11 A hacksaw

Hacksaws have two kinds of frames: a fixed frame and an adjustable frame. A fixed frame cannot be adjusted and takes only one size blade. Smaller (junior hacksaws) use blades with pegs at both ends that fit into slots in the frame.

Hacksaw handles are either the straight or comes in a pistol grip type. The pistol grip type is preferred because it is more comfortable.

There are two types of blades: high-speed steel blades are used on harder metals; medium carbon steel blades are used on softer metals such as copper. The length of the blade is measured between the outside edges of the holes in the blade.

Sometimes blades break. Some reasons for blades breaking could include:

- skewed sawing motion
- incorrect tension
- cutting at sharp angles
- metals not firmly clamped
- blade binding in the cut.

To care for a hacksaw, follow these guidelines:

- face the cutting teeth of the blade to the front
- never over-tighten the blade
- use the correct blade for the type of material that must be cut.

Activity 5 Hacksaws

1. The type of hacksaw blade will determine what material you can cut. Indicate the type of blade needed to cut the following material:
 - a) copper pipe
 - b) high carbon steel
2. Name THREE (3) reasons that will cause a hacksaw blade to snap or break.

Files

A file is a cutting tool made of a hardened steel with sharp ridges or teeth stamped onto its surface. Files have diagonal rows of teeth and the blade is heat-treated to be very hard.

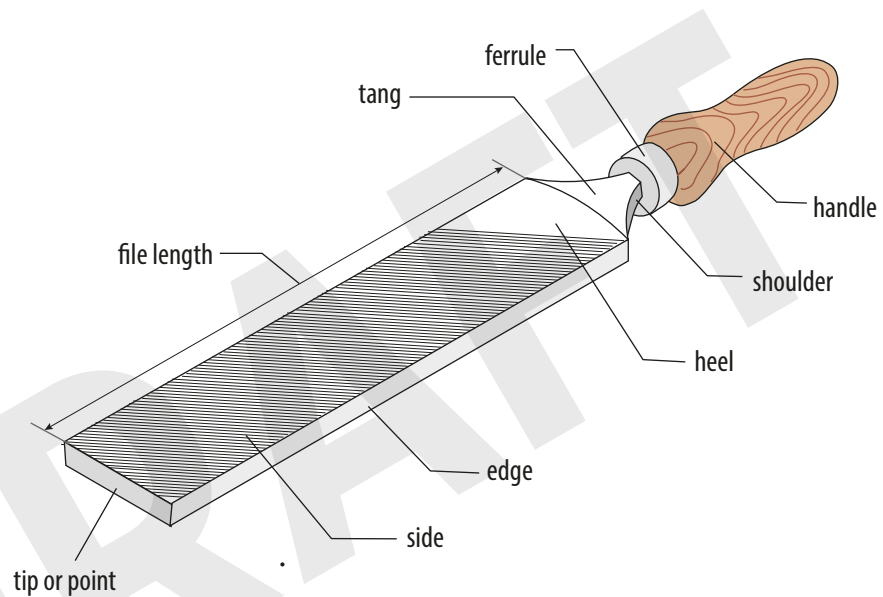


Figure 3.12 An example of a file

The length of a file is measured from the shoulder to the tip.

File handles can be made of plastic or wood, and it has a steel ferrule at the end.



Figure 3.13 A plastic handle



Figure 3.14 A wooden handle.

It is important to make sure that the file tang fits tightly into the handle, because a file with a loose handle is liable to cause serious injury.

Files are classified according to their grades of toughness (coarseness). The number of teeth per 25 mm for a given coarseness depends on the length of the file. The teeth on a 300 mm bastard file will be coarser than the teeth on a 150 mm bastard file.

The grades are called:

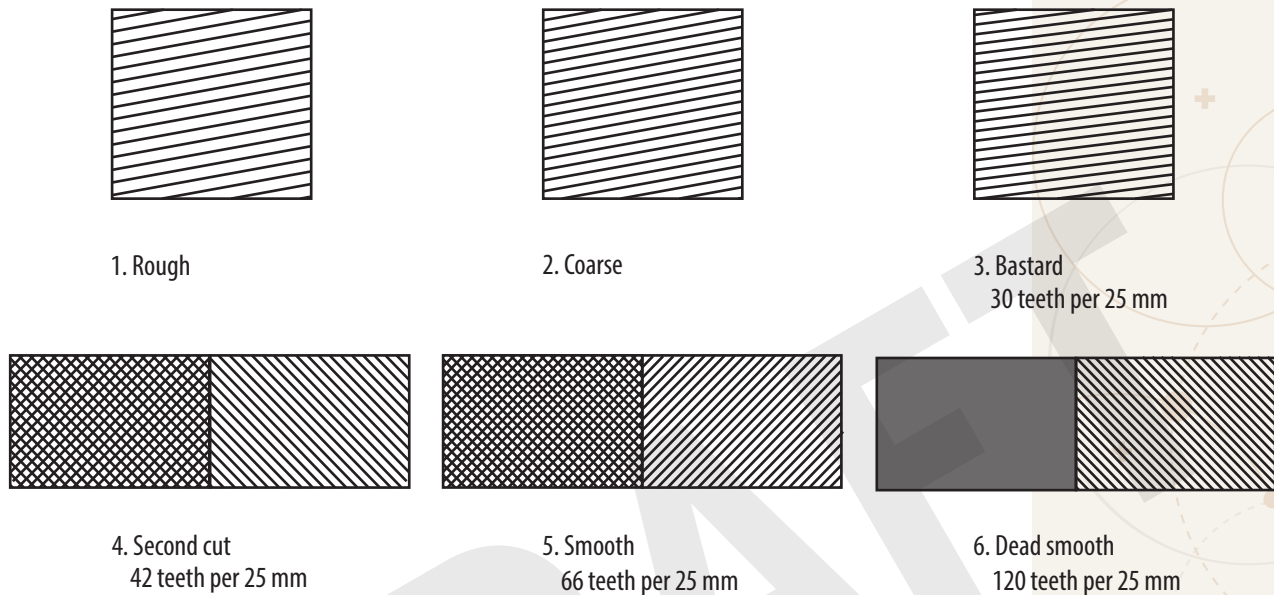







Figure 3.15 Different grades of files

Table 3.2 shows the different types of files used in the workshop.

Table 3.2 Different types of files

File	Name	Uses
	triangular file	Used to sharpen saw teeth and to file corners less than 90°.
	square file	Used for filing corners, slots, and square holes.
	round file	Used for open-up holes and for filing round corners.

File	Name	Uses
	flat file	Used for general work.
	half-round file	Used for filing corners of less than 90° and concave surfaces.

To care for a file, follow these guidelines:

- never use a file without a handle
- never leave a file on water or coolant
- use only a wire brush to clean the file.

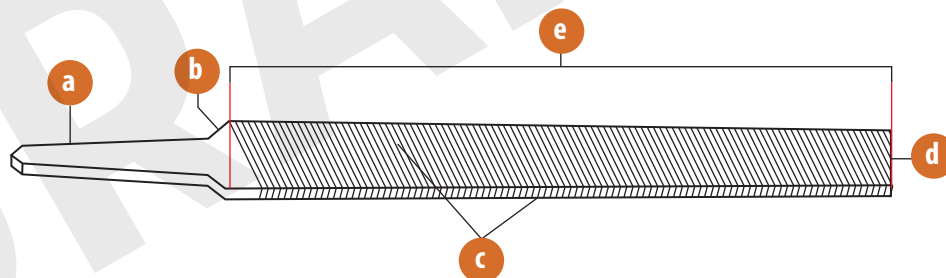


Take note



For additional information follow the link to File Basics: How to select and use files for metalworking <https://www.youtube.com/watch?v=IOR2UwZRBws>

Activity 6 Files




1. Label the parts on a file A – E.



2. Name TWO (2) materials that file handles are made of.
3. Complete the following table by inserting the file name and stating their use.

File	Name	Uses
		
		

continued on next page →

File	Name	Uses
		
		
		

Stocks and Dies

Stocks and dies are used to cut external threads on tubes, bolts, rods, etc.

Stocks

A stock is made from a mild steel. It is the die-holder and is double-handed.

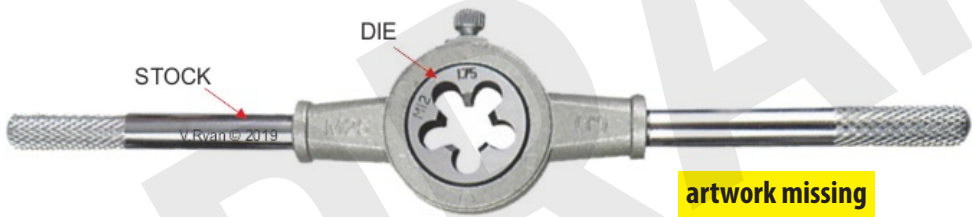


Figure 3.16 Stock

Dies

Dies are made from carbon steel or high-speed steel, which is hardened and tempered. A die is placed in a stock to cut external threads.

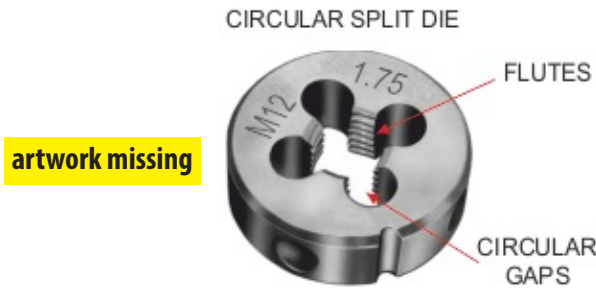


Figure 3.19 Die

The circular split die is the most used. The flutes of the die produce the cuts and the circular gaps allow chippings of waste material to escape from the die and prevents clogging of the cutting tool. The die nuts can also be used for rethreading damaged threads – this is called chasing.

Taps

A tap is used to cut internal thread. The taps are used in three different stages to ensure an accurate and clean cut.

Stage 1 – taper tap is used to start a tap or used in a blind hole.



artwork missing

Figure 3.20: a taper tap

Stage 2 – second or intermediate tap is used to cut more deeply where the taper tap could not reach



artwork missing

Figure 3.21: a second tap

Stage 3 – plug or bottoming tap is used as a final tap threading to the bottom of the hole.



artwork missing

Figure 3.22: the plug tap

Take note

Before taps are used, a hole must be drilled to cut desired threads.

To care for taps, stocks and dies, follow the following guidelines:

- inspect the cutting edges to see that they are sharp or free of nicks
- do not attempt to sharpen them
- keep them clean and well-oiled.

Activity 7: Stocks and dies

1. Name the tool used to cut external threads.
2. Name the tools used to cut internal threads in their correct sequence.
3. What tool is used to hold the taps?

Marking off tools

Engineer's square

An engineer's square consists of stock and blade at right angles to each other. It is made in sizes from 50 mm up to 600 mm. The stock is made of steel and the blade is hardened and tempered.



Figure 3.23 An engineer's square

To care for an engineer's square, follow these guidelines:

- never drop an engineer's square on the floor as it will lose accuracy
- oil it with a thin coating of oil to prevent rust
- store in its place after each use.

Dividers and calipers

Calipers

Calipers are used to take measurements when a steel rule cannot be used.

There are two types of calipers: inside caliper and outside caliper

- **Inside caliper** – used to measure the inside diameter of a hole. When transferring a measurement with a caliper, adjust the caliper so that it slides easily
- **Outside calipers** – used to measure outside shapes such as round or square workpieces. Learning to adjust the caliper to a snug fit against the object to be measured will assure more accurate measurement.



Figure 3.24 An inside caliper



Figure 3.25 An outside caliper

Dividers

Dividers are tools with two legs joined at one end. There are two types of dividers: straight dividers and hermaphrodite dividers.

A straight divider:

- has two straight pointed legs.
- is a layout tool and is used to lay out circles and curves for late drilling, cutting, or shaping.
- should have each point extended to the same length.



Figure 3.26 A straight divide

After the dividers are opened in the desired setting, the setting is compared for measurement against a ruler.

An odd leg or hermaphrodite divider:

- is half the divider and half the outside caliper.
- is used to find the centre of round objects as well as to scribe lines parallel to the edge of the stock.



Figure 3.27 An odd leg or hermaphrodite divider

When using the hermaphrodite divider, hold it between the thumb and the first finger and parallel along the edge of the stock as the stock is held flat on a table.

To care for a divider, follow the following guidelines:

- keep dividers clean and dry
- protect the points against damage
- store dividers where they will not become bent or broken.

Activity 8 Dividers and calipers

1. Name TWO (2) methods to care for an engineer's square.
2. When will a caliper be used?
3. Which caliper is used to measure?
 - a) internal dimensions
 - b) outside shapes
4. What are the following dividers used for?
 - a) straight divider
 - b) odd leg/hermaphrodite divider



Hammers


Hammers are very important tools in the automotive industry. When using hammers:

- make sure it has a well-fitted handle
- make sure that the head is firmly wedged in the shaft before use
- wear safety goggles to protect your eyes from flying chips or nails
- store them safely or on a peg board after each use.

Table 3.3 shows different types of hammers and their uses.

Table 3.3 Different types of hammers

Hammer	Uses
ball peen 	<ul style="list-style-type: none">• Has a face and the peen.• The face is used for hitting and the peen is used for riveting.
cross peen 	<ul style="list-style-type: none">• Has a cross-peen and a face.• It is used in metalworking for forging and riveting.

Hammer	Uses
<p>mallet</p> 	<ul style="list-style-type: none"> • A soft-face hammer made of materials such as plastic, rubber, and copper. • It is good for working on gearboxes, final drive components, and surfaces that may be damaged by using a metal hammer.

Activity 9 Hammers

1. Name THREE (3) types of hammers and their uses.
2. Which materials are commonly used on the head of a mallet?
3. Why must you wear safety goggles when using a hammer?

Classification and application of measuring tools

Vernier calliper

A vernier calliper is a precision measuring instrument, named after Pierre Vernier. It is made of alloy steel and is accurately finished by grinding and lapping. It can measure up to 0,002 mm.

There are three types of vernier calipers:

Dial-type vernier calliper



Figure 3.28 A digital vernier calliper

Dial-type vernier calliper

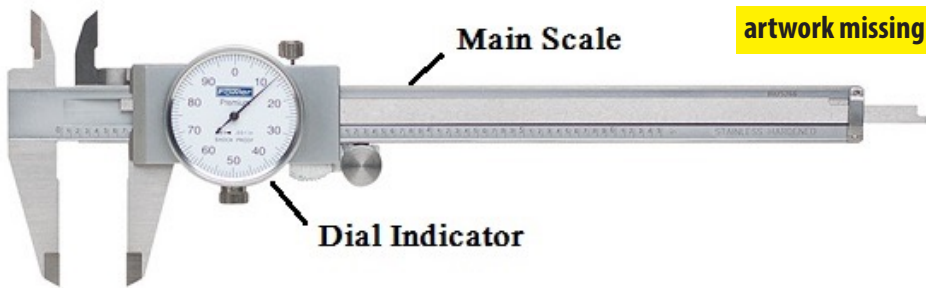


Figure 3.29 A dial-type vernier caliper

Vernier scale calliper

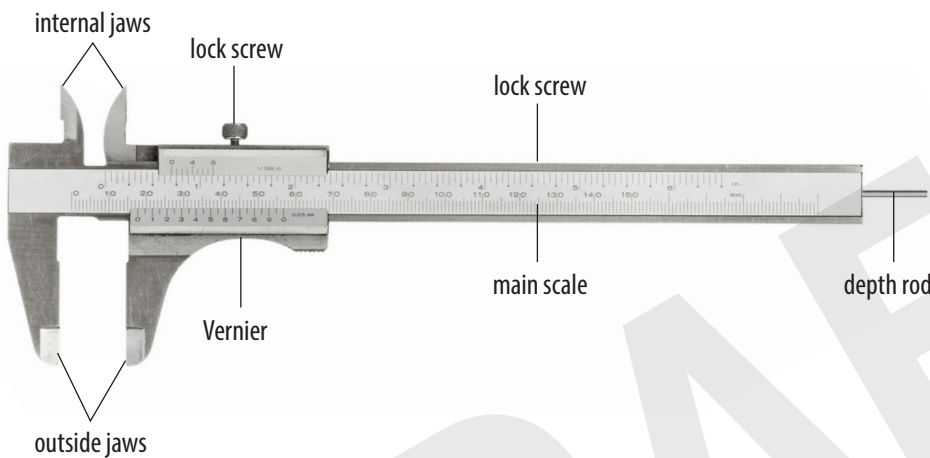


Figure 3.30 A scale vernier calliper

Vernier callipers can be used to measure:

- outside diameter
- depth of holes
- inside diameter.

To care for a vernier calliper, follow these guidelines:

- clean it after each use
- close it after use
- return it to its casing after each use.

Micrometre

The micrometre is a precision measuring instrument in which a threaded spindle passing through a nut in the form of a tube can be made to pass through very precise distances from a fixed point when it is turned.

Many micrometres are used for different purposes. They are used to: measure external diameter; and measure outside parallel sides of a square workpiece.



Take note

This year we will only look at the inside and outside micrometre.

Inside micrometer

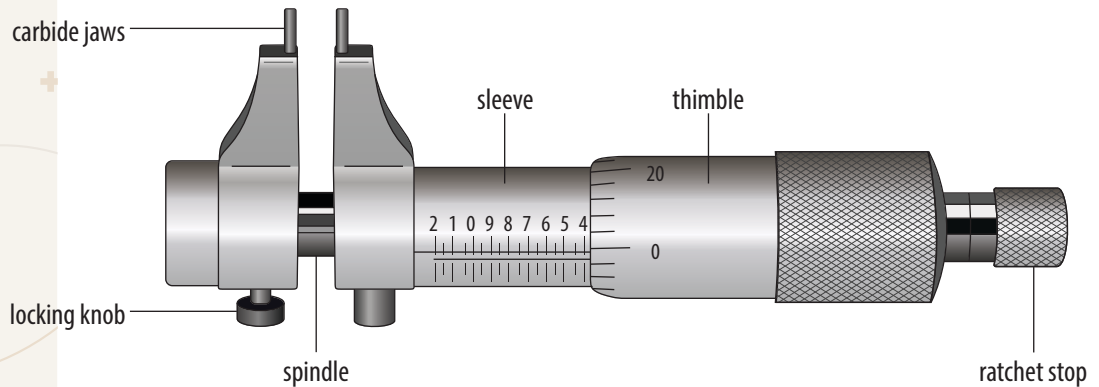


Figure 3.31 An inside micrometer

Outside micrometer

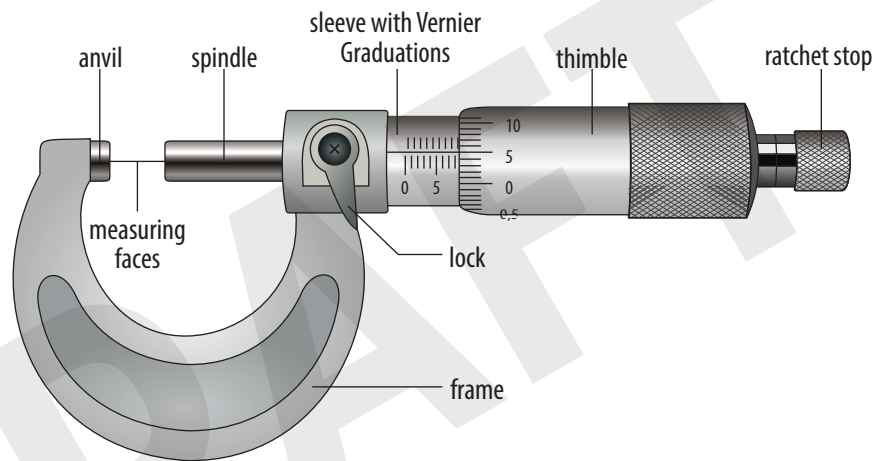


Figure 3.32 An outside micrometer

To care for a micrometre, follow these guidelines:

- only use the micrometre as an accurate measuring instrument
- never use the micrometer as a G-clamp
- clean it and place it in its protective box after use
- it must be used at room temperature which is 20 °C.

Combination set

A combination set consists of a robust ruler with a groove cut along its centre to take three different heads:

- 90° – 45°
- a protractor
- centre head.

Take note

Micrometers come in set for measuring different sizes.

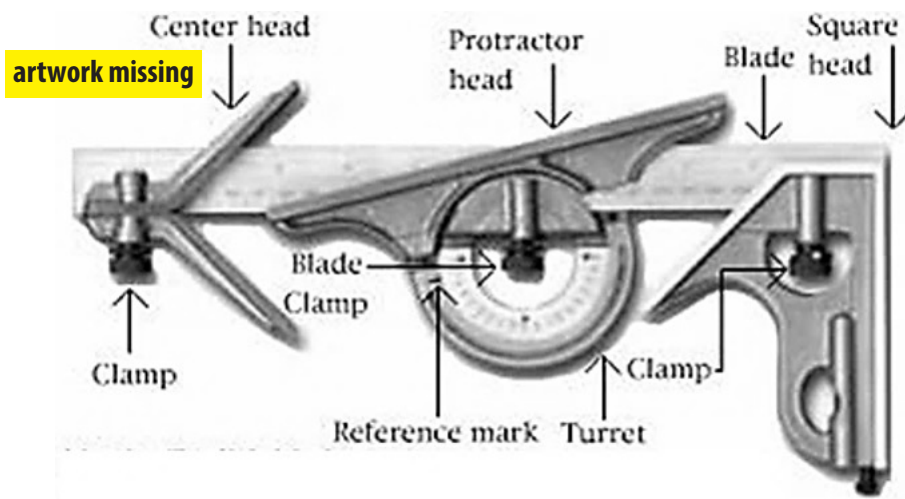


Figure 3.33 A combination set

The square and blade are used:

- for checking and marking off external and internal right angles
- as a depth gauge
- checking and marking off 45° angles
- the square head may be used alone as a spirit level.

To care for a combination set, follow these guidelines:

- never drop the combination set
- return it to the casing after each use
- oil it regularly.

Thread pitch gauge

A pitch gauge (also known as a screw gauge or thread gauge) is used to measure the pitch or lead and depth of screw thread. It allows the user to determine the profile of the thread and saves time for measuring and calculating the pitch of a thread.



Figure 3.31 A pitch gauge

A thread pitch gauge can be used to:

- match the type of thread to the gauge
- select the correct gauge that fits according to the trial-and-error method

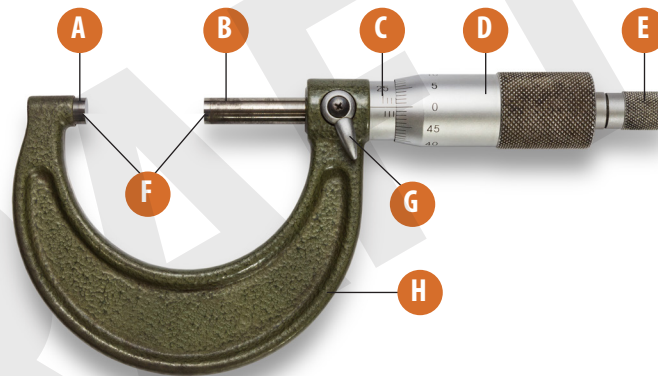
- extend the leaf of the tool and press it against the thread
- if the fit is good read the thread pitch stamped on the leaf.

To care for a thread pitch gauge, follow these guidelines:

- clean them after each use
- oil them so that they do not rust
- store in a dry place
- only used them for what they are intended for
- store them separated from hand tools
- store them so that they do not contact each other.

Activity 10: Measuring tools

1. Name THREE (3) types of vernier calipers.
2. Which THREE (3) measurements can be measured using the vernier caliper?
3. What tool is used to find the thread pitch?
4. Below is the inside micrometre. Label it from A – H.



Power tools

Power supply and connection to equipment

Always make sure that the plug of a power tool is correctly wired before you use it. Check the connection to ensure that it is correct. Make sure that there are no frayed or loose wires. DO NOT use the tool if there are loose wires. Make sure that the area in which you are working is dry – there must be no oil or water spills on the floor.

Three-point plugs are usually fitted to power tools. The figure below shows the correct connection of the three-point plug for power tools.

3 Pin plug

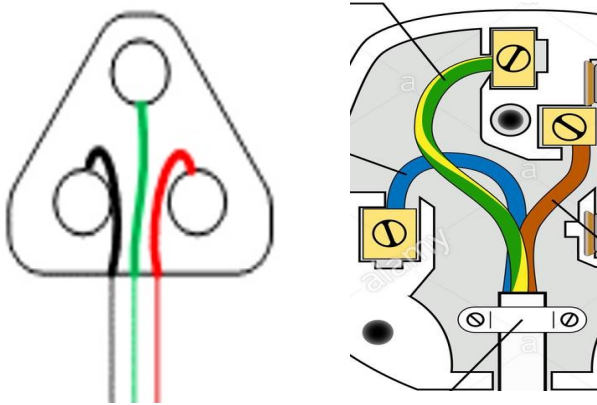


Figure 3.32 A cross-sectional view of a three-point plug

Drill press machine

A drill press machine is used for drilling holes quickly and accurately. A drill bit is inserted in the chuck to drill different diameters.

Figure 3.33 shows an example of a pedestal drilling machine.

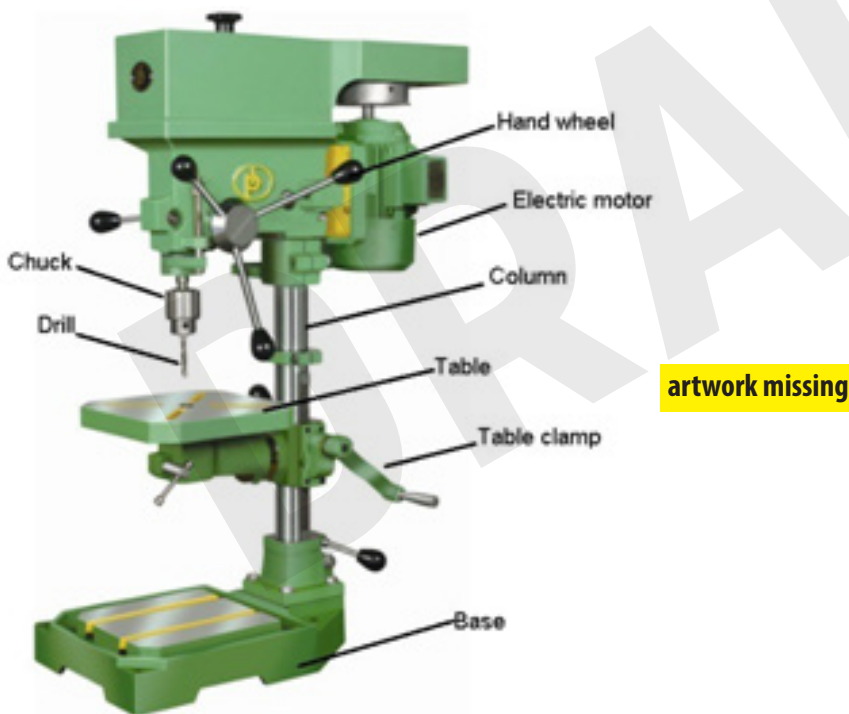


Figure 3.33 A pedestal drilling machine

The pedestal drilling machine has either a belt or gear-driven spindle head. It is used to drill holes ranging from medium to large holes.

To care for drill press, follow the following guidelines:

- ensure that you do not use excessive force when drilling
- use coolant to keep the tool cool
- ensure the drill press is switched off after each use
- clean the machine after each use.

Angle grinder

An angle grinder is a grinding or cutting machine used to grind or cut metal to the desired shape and size or to remove unwanted metal.

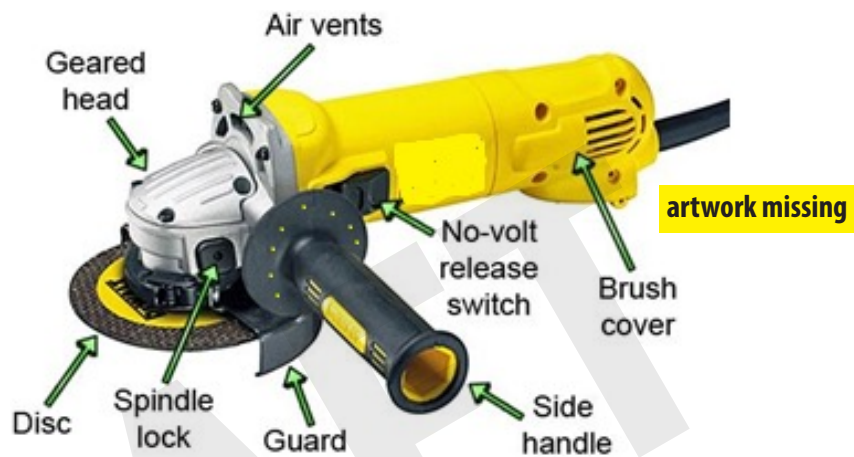


Figure 3.34 An angle grinder

An angle grinder uses two types of discs:

- a grinding disc
- a cutting disc.

Grinding discs are suitable for metal and stone applications across a range of machine sizes. The main use of such discs is in the removal of materials. However, they can also be used for the finishing and preparation of stone and metal surfaces. These discs allow for the effective removal of paint and rust.

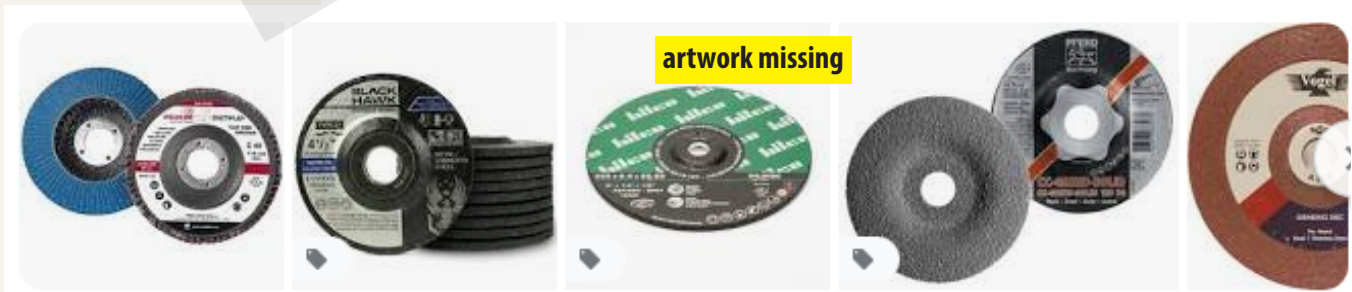


Figure 3.35 Grinding discs

Cutting discs are solid abrasive discs made of an abrasive mix of grit and adhesive that is formed into a thin, rigid disc with fibre webbing running through it for strength. They are often used for cutting metal.



Figure 3.36 Cutting discs

To use an angle grinder safely, follow these guidelines:

- always wear goggles when using an angle grinder
- use only the front of the cutting disc while the workpiece is on a workbench vice
- ensure the safety guard is in place
- never leave the angle grinder on after the task is done
- after switching the angle grinder off, wait until the disc stops rotating to prevent damage to the machine.

To care for an angle grinder, follow these guidelines:

- always check the grinding/cutting disc for cracks
- use a ring test to ensure the grinding/cutting disc is not cracked
- never leave the disc submerged in any liquid.

Activity 11 Power tools

1. Draw a neat sketch of the correct wiring and the colour of a three-point plug.
2. State FOUR (4) safety rules that you must apply before you can work with a power tool.
3. State FOUR rules (4) to observe when working on the drill press.
4. Name TWO (2) pre-checks that you should do before using a grinding or cutting disc.
5. Name THREE (3) safety rules to observe when working with an angle grinder.

Vehicle lifting equipment

The word “hoist” is used to describe many different types of equipment that lift and lower loads. In an automotive workshop, we use the four and two-post hoist. This year we will learn about the four-post hoist and the jack (trolley, bottle, and scissor) that enables us to lift vehicles so that repairs can be done on the vehicle.

Hydraulic trolley jack

The hydraulic trolley jack is mobile – it can be moved to the needed jacking points to raise a vehicle off the ground on one side. Hydraulic jacks come in various sizes, and the one that you use will depend on the vehicle’s mass.



Figure 3.37 Hydraulic trolley jack

To operate a hydraulic jack safely, follow these guidelines:

- secure the wheels using chocks
- do not exceed the permissible weight of the jack
- check for leaks on the jack
- secure the vehicle on trestles before doing work under the vehicle.

Four-post hoist

The four-post hoist has four pillars or posts that are fixed to the floor. It can be operated using air (pneumatic), liquid (hydraulic), or cable (mechanical). It has platforms to support the weight of the vehicle.



artwork missing

Figure 3.38 Four-post hoist

To safely operate a four-post hoist, follow these guidelines:

- do not exceed the manufacturer's recommended weight
- never raise a vehicle if there is still a person in it
- align the wheel of the vehicle with the platforms of the hoist before the vehicle is directed onto the hoist
- secure the wheels of the vehicle on the platform using chocks
- before working under the vehicle, ensure that the safety locking mechanism is engaged
- when lowering the hoist make sure that there is nothing and no-one underneath the hoist.

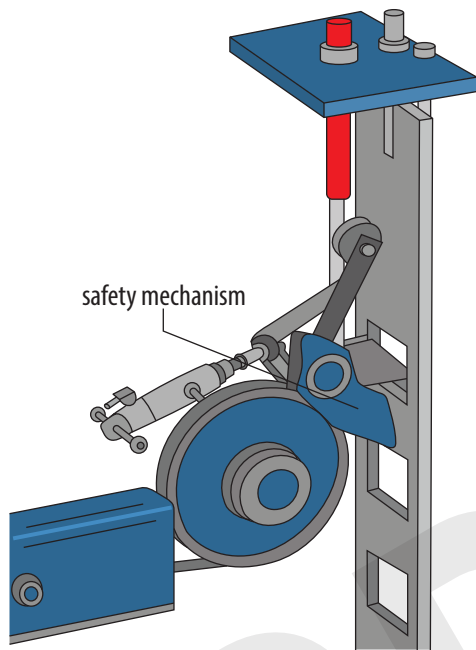


Figure 3.39 An example of a safety locking mechanism

Safety equipment needed when using lifting equipment

The following safety equipment should always be available and used when you are using lifting equipment.

- **Chocks blocks** – are used to prevent the vehicle wheels from rolling when the car is jacked up.



Figure 3.40 Chocks

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- **Trestles** – are used to support a vehicle when it is jacked to prevent the vehicle from falling.



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Figure 3.41 Trestles

Creeper – has a low profile (close to the ground), and a wheeled frame attached to a platform that a user can lie on. Most car creepers are used to gain access to the underside of a vehicle to perform maintenance or inspection. The user does then not need to support themselves with the body of a car.



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Figure 3.42 A creeper

How to safely lift a vehicle

The vehicle jacking points can be found in the manufacturer's manual. The following steps will help to ensure the safe lifting of a vehicle:

- make sure the vehicle is on a flat-level surface
- turn the engine off
- put automatic vehicles in park and manual vehicles in neutral
- engage the handbrake
- chock the wheels that will not be lifted by wedging chock blocks in front of and behind the wheels
- jack the vehicle with the correct capacity on the jacking points
- make sure the vehicle is raised slowly. Check that the vehicle is balanced.
- use trestles to support the weight of the raised vehicle
- lightly knock the vehicle to ensure it is properly supported and will not fall once you start working underneath it
- lay on a creeper when working underneath the vehicle
- remove the trestle before you lower the vehicle.

Activity 12 Vehicle lifting equipment

1. Which hoist is commonly used in an automotive workshop?
2. What are the THREE (3) ways used to operate these hoists?
3. What is the advantage of using the trolley jack in the workshop?
4. When is it necessary to use the following items?
 - a) chocks blocks
 - b) trestles

PRACTICAL APPLICATION

Safely lifting a vehicle to remove and replace a wheel

Work in groups.

Aim: To safely lift a vehicle to remove and replace a wheel.

What to do:

1. Work in a group of 4 or 5.
2. Identify the different tools that you will need to safely lift a vehicle to remove and replace a wheel.
3. Before lifting the vehicle to remove the wheel, make sure all safety considerations have been made.
4. Lift the vehicle and remove the wheel.
5. Secure the replacement wheel before lowering the vehicle.



CHAPTER

4

Entrepreneurship

LEARNING OUTCOMES

By the end of this chapter, learners should be able to explain what entrepreneurship is and describe the qualities that an entrepreneur displays. The following will be covered in this chapter:

- defining entrepreneurship and what an entrepreneur is
- differentiating between different types of entrepreneurships
- learning about advertising on a media platform
- learning about sourcing funds and costing
- defining what a business plan is and learning about how to set up a business plan

What is entrepreneurship?

In Grade 8 we learnt that entrepreneurship is the activity of creating a business (or businesses) while building it up and scaling it to generate a profit. An entrepreneur takes action to make a change in the world.



Figure 4.1 Entrepreneurship is the activity of creating a business from an idea

They see a problem in the world and immediately focus on creating a solution – either by creating jobs or a new product. They constantly take action to ensure progress in our world.



Figure 4.2 Entrepreneurs focus on creating solutions to a problem



Take note

Visit <https://www.iedunote.com/entrepreneurship-definition> to view a definition for entrepreneurship.

Entrepreneurs:

- **create jobs** – thus lowering unemployment rates while helping people feed their families.
- **create change** – as many believe in improving the world with their products, ideas, or businesses.
- **create incubators of innovation** – these provide new ventures, products, technology, markets, quality of goods, etc. to the economy, and these increase the GDP and standard of living.
- **give to society** – they are some of the biggest donors to charities and non-profits.

Some reasons why people become entrepreneurs include:

- wanting to change the world
- wanting to be their own boss
- having flexible working hours
- taking risks
- not being able to find a job in the current economy

- not fitting into the corporate environment
- being curious
- being ambitious.



Figure 4.3 Entrepreneurs take action to make a change in the world

There are four major types of entrepreneurship. These are:

- **small business entrepreneurship**, which makes up 99% of all companies and employs more than half of the non-government workforce.
- **scalable start-up entrepreneurship**, which focuses on finding a scalable business model.
- **large company entrepreneurship**, where large conglomerates work together to remain innovative and create cutting-edge businesses.
- **social entrepreneurship**, which uses an approach in which entrepreneurs develop, fund and implement solutions to solve social, cultural or environmental issues.

Activity 1 Defining entrepreneurship

1. Define the term “entrepreneurship” and list FIVE (5) reasons why someone would choose to become an entrepreneur.
2. There are four major types of entrepreneurship. Explain TWO (2) types and provide examples of companies/businesses in your community that fits into that type.

Factors affecting entrepreneurship

Entrepreneurship is vital for the development of an economy. In South Africa, there has been an increase in entrepreneurial activity from 10,8% (in 2020) to 17,5% (in 2021). Economies that grow attribute this growth to entrepreneurship – and governments all over the world want to encourage this concept.



Figure 4.4 Entrepreneurs contribute to the growth of the economy



Take note

South Africa is best described as a mixed economy.

Let's look at some of the factors that contribute to the growth of entrepreneurship and therefore to the growth of the economy.

Political factors

Political factors play a big role in the development of entrepreneurship. Most of the time, politicians have the responsibility to decide what type of market is in place in a country. Some countries may adopt a **capitalistic** or **communist** economy, while other countries may adopt a **mixed economy**.

Each market has different implications for how entrepreneurs are required to function – capitalism requires innovative entrepreneurs, whereas communism requires well-connected entrepreneurs.

Legal factors

Entrepreneurs are governed by the laws of the country in which they operate. These laws affect entrepreneurship because entrepreneurs need to abide by several legal requirements to operate successfully, for example, courts can enforce contracts that were entered into by an entrepreneur and another contracting party. The provision of declaring bankruptcy has also been positively associated with the development of entrepreneurship because many entrepreneurs fail a few times before they find the right innovation that leads to their success.

Taxation

The government controls the market through provisions of taxation, which is necessary to maintain legal and administrative systems for the entire economy. Where tax regimes are restrictive, many entrepreneurs leave because they want to operate in places where there is minimal interference from the government.

Availability of capital

Entrepreneurs require **capital** to start risky ventures and also require instant capital to scale up the business quickly if the idea is successful. Therefore, countries that have a well-developed system of providing capital at every stage – 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 availability of skilled labour at reasonable prices is an important factor for any entrepreneur. With the advent of **globalisation**, entrepreneurs have the freedom to move their operations to countries where labour markets are more favourable to them.

Raw materials

Raw materials are natural resources that are essential for any industry. Entrepreneurs source raw materials that are affordable so that their business can remain profitable.



Take note

Even business legends like Henry Ford declared bankruptcy in their early days!



Take note

Sometimes seller cartels who have control over natural resources sell raw materials at inflated prices. This causes entrepreneurs' profits to plummet and their businesses to fail.

Advertising on media platforms

Social media is a powerful tool for entrepreneurs and businesses of all sizes. It can make or break a business. Thing that entrepreneurs need to consider before launching their businesses online includes who will manage the **online presence**, and what message they want to put out (that is, their **brand identity**).

Follow these important steps to build your online presence and brand identity:

- make sure that you can stay active on social media – instead of doing everything themselves, it would be best for an entrepreneur to have a social media manager or social media company who can post regular updates
- share your authentic self and your journey by telling subscribers your story. Share your achievements and any important events in which your brand has impacted the lives of others
- tap into social media's lightning-fast way to spread news. Set your brand up to be the solution that someone really needs
- provide regular company updates to the public and potential investors, as well as more targeted updates that you can send to your email list and wider network

Creating a business plan

Every business – no matter how big or small – needs to have a written business plan. This can be used to provide direction or attract investors and is important for the success of a business.



Figure 4.5 A business plan needs to be drawn up before starting a business

A business plan includes the following elements:

- **Executive summary** – a snapshot of your business and its offerings
- **Company description** – a description of what the business does
- **Market analysis** – research on the industry, market and competitors
- **Organisation and management** – your business and management structure
- **Service or product** – the products or services the business offers
- **Marketing and sales** – how the business will handle marketing and your sales strategy
- **Funding request** – how much money you will need for the next three to five years
- **Financial projections** – supply information like balance sheets and income projections
- **Appendix** – an optional section that includes CVs and permits



Take note

Visit <https://www.entrepreneur.com/article/247574> for more information on how to write a business plan.

Activity 2 What affects entrepreneurship

1. Name FOUR (4) factors that influence entrepreneurship and explain each one.
2.
 - a) Explain these terms: online presence and brand identity.
 - b) Find an example of an online brand and write a brief report about their online presence and brand identity.
3. Name the elements that must be included in your business plan.

Here are some steps that you can follow when writing a business plan:

- Research and analyse your product, your market, and your expertise. You need to be aware of what your company does, the products you will offer, your competition, and the market in which you will operate.
- Determine the purpose of your business plan because it serves as a road map for the direction in which direction you want your business to go, and well as a reference point that you can refer to if you run into a bump in your entrepreneurial journey.
- Create a company profile that includes the history of your business, 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.
- Document everything from your expenses, cash flow, financial projections and even minor details.
- Have a marketing plan in place that includes:
 - » the introduction of new products
 - » extending or regaining market for existing products
 - » entering new territories for the company
 - » where new business will come from – be specific



Take note

Visit <https://www.entrepreneur.com/encyclopedia/business-plan> for more information on the importance of a business plan.

**Take note**

Visit <https://www.johnrampton.com/content-marketing-guide> and <https://www.entrepreneur.com/article/43026> for more information on marketing.

- » cross-selling (or bundling) one product with another
- » entering long-term contracts with desirable clients
- » raising prices without cutting into sales figures
- » refining a product
- » enhancing manufacturing/product delivery
- Make your business plan adaptable so that it can be accessible to whoever is reading it. However, keep changes limited from one plan to another – for example, when sharing financial projections, keep that data the same for all plans.
- Show that you're passionate and dedicated, and you care about your business and the plan. List the problems you're hoping to solve, describe your values, and establish what makes you stand out from the competition.

PRACTICAL APPLICATION

Draw up a business plan to present to investors

Work in groups.

Aim: To draw up a business plan that includes all the requirements covered in this chapter that you will present to possible investors

What to do:

1. Conduct research using these links, or use your own research, to start a draft of a business plan.
 - a) <https://www.bplans.com/sample-business-plans/>
 - b) <https://www.entrepreneur.com/article/281416>
 - c) <https://blog.pandadoc.com/write-a-business-plan/>
 - d) <https://www.score.org/resource/business-plan-template-startup-business>
2. Create a full business plan that you will present to possible investors to obtain funding for your business.
3. Your business plan must include all the requirements you have learnt about in this chapter.

The background of the cover features a row of large, shiny metal coils, likely steel, in an industrial setting. A large green circle is positioned on the right side, containing the text 'CHAPTER 5'. A thick green diagonal line runs from the bottom left towards the center. The bottom right corner has a solid orange background with the word 'Materials' in white. There are several small white and orange circles connected by thin white lines, creating a network-like pattern across the green circle and orange background.

CHAPTER

5

Materials

LEARNING OUTCOMES

By the end of this chapter, learners should be able to classify different types of materials and classify metals as ferrous or non-ferrous. The following will be covered in this chapter:

- classifying and describing different types of materials
- differentiating between ferrous alloys, non-ferrous alloys, sheet metals and plastics
- learning about cold rolled sheets, galvanised sheets and expanded metals
- learning about thermoplastics, thermosetting and coding of plastics
- classifying different types of plastics

Revision

In Grade 8 we learnt that everything around us is made up of different materials and that materials are substances that people find useful such that it is produced for economic reasons.

Table 5.1 Different types of materials

Rubber	Metals	Plastic	Wood
			
Ceramic	Glass		Paper
			

Materials are commonly used to produce parts/components and products. They are also used to construct infrastructure (for example, bridges, roads, electrical pylons), buildings (for example, houses or shelters), and processes such as farming, manufacturing, and logistics.

Figure 5.1 shows the different properties of materials.



Figure 5.1 Properties of materials

Classification of ferrous alloys, non-ferrous alloys and sheet metal

In this chapter, we will learn about ferrous alloys, non-ferrous alloys, sheet metals and plastics.

Figure 5.2 Shows ferrous and non-ferrous alloys.

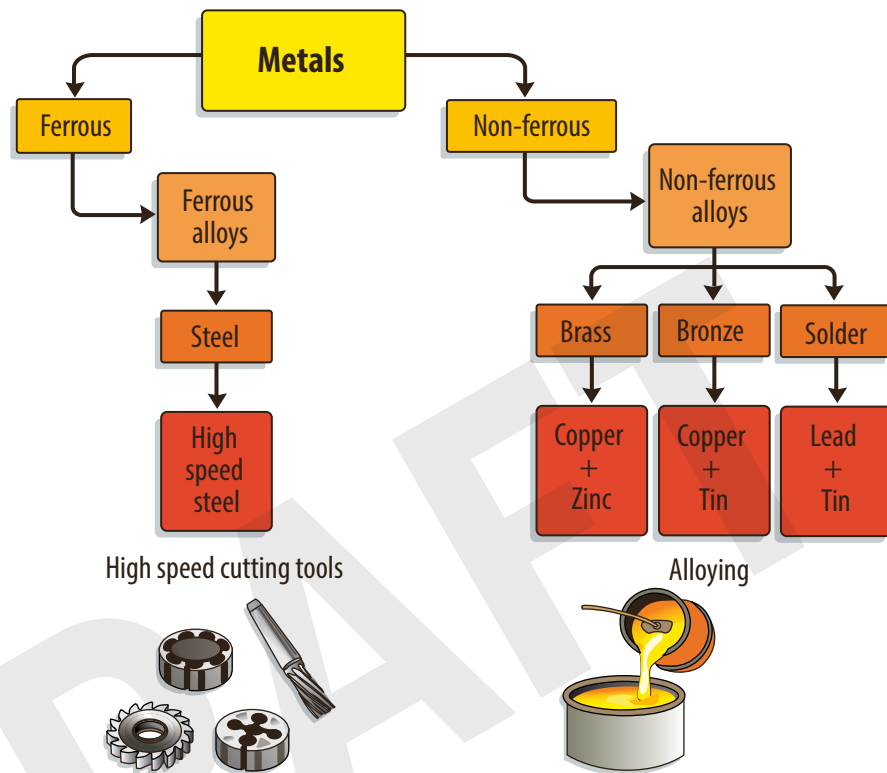


Figure 5.2 Ferrous and non-ferrous alloys

Ferrous alloys (metals)

In Grade 8 we learnt that any form of iron and steel are considered ferrous metals. The iron in ferrous metals tends to make them magnetic, hard, with high tensile strength, durability and ductility. We also learnt that ferrous metals could rust and corrode when exposed to moisture because they have a high carbon content, therefore all ferrous metals must be anodised if they will be used in environments that may expose the metal to elements such as rain, hail and water.

Examples of ferrous alloys include:

- stainless steel
- mild steel
- medium carbon steel
- high carbon steel
- cast iron.

Table 5.2 shows how some ferrous alloys are composed and what they can be used for.

Table 5.2 Composition and uses of ferrous alloys

Name	Composition	Uses
stainless steel	iron + carbon + chromium	cutlery, kitchen utensils
mild steel	iron + carbon (0,15 – 0,3%)	butler doors
medium carbon steel	iron + carbon (0,3 – 0,7%)	springs
high carbon steel	iron + carbon (0,7 – 1,5%)	cutting tools
cast iron	iron + carbon + silicon	castings

Non-ferrous alloys (metals)

Non-ferrous metals, however, are metals that do not contain a significant amount of iron but is a mixture of two or more metallic elements that do not contain iron. They are conductive, non-magnetic and light. Non-ferrous metals can be reshaped and re-used, often without losing their valuable properties – that is, they are malleable (they can be pressed or hammered into thin sheets without breaking).

Examples of non-ferrous alloys include:

- silver
- bronze
- brass
- solder.

Table 5.3 shows how some non-ferrous alloys are composed and what they can be used for.

Table 5.3 Composition and uses of non-ferrous alloys

Name	Composition	Uses
silver	copper + lead + zinc	jewellery, silverware
bronze	copper + tin	valves, sculptures
brass	copper + zinc	water fittings, gears
brass	tin + lead	electronic joints, radiators

Activity 1: Materials

1. What is an alloy?
2. Explain the difference between ferrous and non-ferrous alloys.
3. What is the composition of stainless steel?
4. Give TWO (2) examples where stainless steel is used in our daily lives.
5. What is the composition of brass?
6. Name TWO (2) uses of silver.

Sheet metals

Sheet metal is metal formed by an industrial process into thin and flat pieces. Sheet metal is one of the basic materials used in metalworking and it can be cut and bent into a variety of shapes.

Sheet metal thicknesses can differ – extremely thin sheets are considered foil or leaf, and pieces that are thicker than 6 mm are considered plate steel or “structural steel”. Many objects are fabricated using sheet metal every day.

Cold rolled sheets

A cold rolled steel sheet is produced by processing hot rolled steel through a cold rolling process. It is further processed to increase its strength and strength-to-weight ratio. Cold rolled steel sheet metal can hold tighter **tolerances** than hot rolled sheet metal when machined or fabricated and provides a better overall surface finish.

In cold rolling, the steel sheet is cooled to room temperature (after hot rolling) and is then **annealed** and/or **tempered** rolled.



Figure 5.3 Cold rolled sheet metal



Take note

Although cold rolled steel is a specific type of steel, the term is often used to mean all types of carbon steel materials.

Galvanised sheets

Galvanisation or galvanising is the process of applying a protective zinc coating to steel or iron to prevent rusting. The most common method used to do this is hot-dip galvanising in which the sheets are submerged in a bath of **molten** hot zinc.

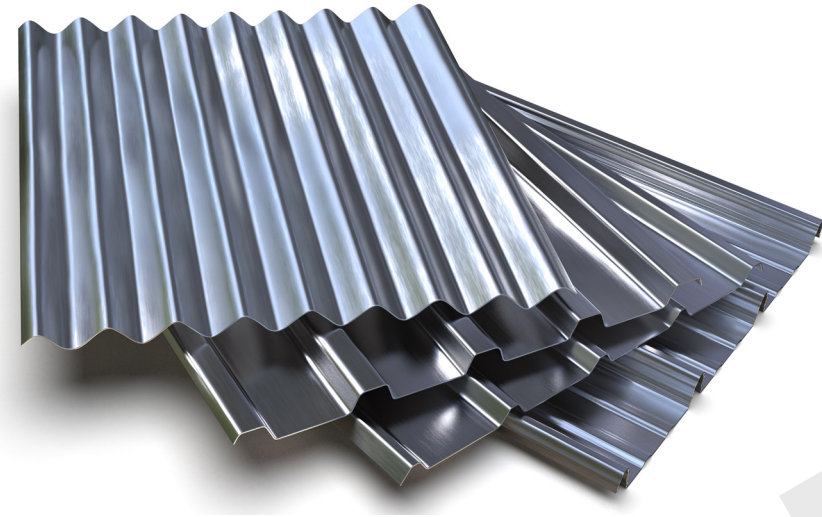


Figure 5.4 Galvanised sheets

Expanded steel metal

Expanded steel metal (mesh) is a sheet product that has been slit and stretched. It can be transformed into diamond-shaped openings, which are lightweight when compared to sheets. They allow for the free passage of light, liquid, sound, and air while providing a decorative or ornamental effect.



Figure 5.5 Expanded steel metal sheets (mesh)



Take note

Our lives are made easier by products such as cell phones, laptops, cars, fridges, and many other products made from plastic. However, single-use plastics are used once, or for a short period of time, before being thrown away. This negatively impacts our environment and our health.

Activity 2: Alloys and sheet metals

1. How does an expanded steel metal differ from ordinary sheet metal?
2. Expanded steel metal offers advantages compared to sheet metal. Mention TWO (2) of these advantages.
3. What is the importance of galvanising?
4. Briefly explain how galvanising is done.

Plastics

What is plastic?

Plastic is used in many items that we see and use daily. These include pens, headphones, plates, bottle caps, and shoes.

In this section, we will learn about two types of plastics – thermoplastics and thermosetting plastics. Table 5.4 compares the properties of the two types of plastics.

Table 5.4 Thermoplastics vs. thermosetting plastics

Thermoplastics	Thermosetting plastics
<ul style="list-style-type: none">• Thermoplastics can soften when heated and harden again when cooled. They are more like candle wax melting when heated and then solidifying when cooled.• They are less rigid and can be moulded.• Examples include Polyvinyl Chloride (PVC), Polystyrene (PS), and Polypropylene (PP),	<ul style="list-style-type: none">• Thermosetting plastic (thermosets) can soften when heated and cooled, and cannot return to its original state when reheated.• They are hard and cannot be softened again.• Examples include epoxy resin, and polyester resin.

Classification of plastics

Table 5.5 shows how plastics can be classified and how they can be used.

Table 5.5 Classification and uses of plastics

Classification	Uses
polyethene terephthate (PETE)	<ul style="list-style-type: none"> commonly used household bottle for food
high-density polyethylene (HDPE)	<ul style="list-style-type: none"> bottles (drinks, shampoo and mouthwash)
polyvinyl chloride	<ul style="list-style-type: none"> pipe and filings, carpet, window frame and gutters
low-density polyethylene (LDPE)	<ul style="list-style-type: none"> refuse sacks, irrigation pipes, flexible bottles, fertiliser bags and films
polypropylene (PP)	<ul style="list-style-type: none"> crates, heavy-duty bags, plants pots and drink straws
polycarbonated polylactide	<ul style="list-style-type: none"> baby bottles, compact discs and medical storage containers
polystyrene (PS)	<ul style="list-style-type: none"> seed trays, fast food trays, egg boxes and hangers

Take note

Visit <https://www.plasticsinfo.co.za/tag/material-identification-codes/> to learn more about the plastic coding system.

Coding of Plastic

The Plastics Industry Association codes plastics for easy classification and recycling purposes. Each plastic product that is manufactured will have a code (1 – 7) that can be used to sort materials for recycling. Figure 5.6 shows the different codes for the types of plastics.

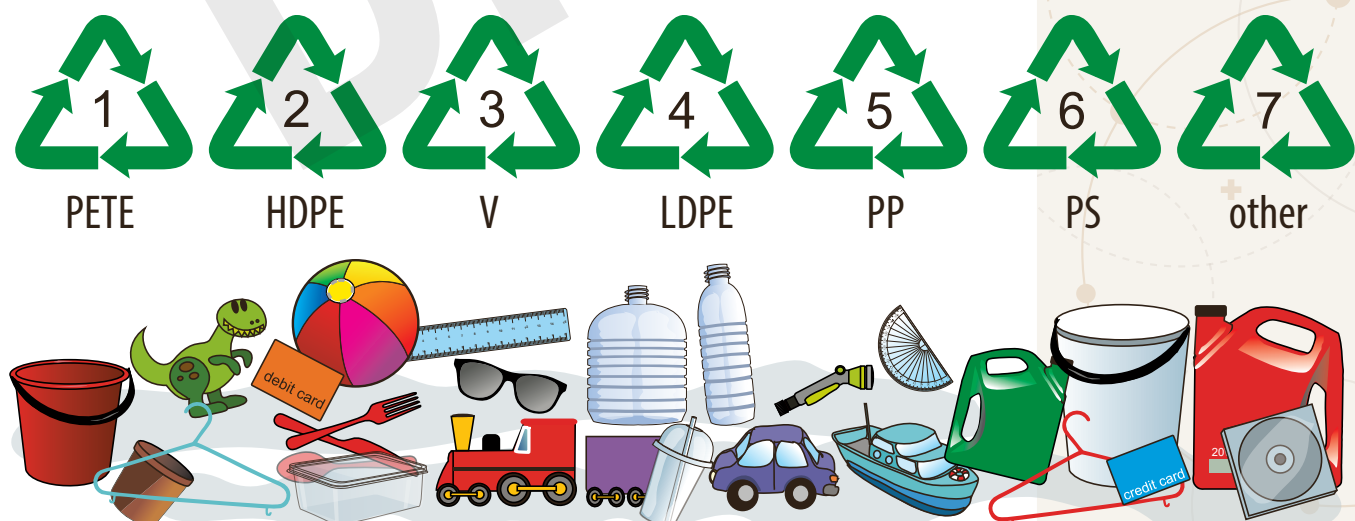


Figure 5.6 Coding plastics

Activity 3 Plastics

1. Explain the differences between thermoplastic plastic and thermosetting plastic?
2. Coding is very important in the usage of plastic.
 - a) What is the importance of this coding?
 - b) Choose TWO (2) plastic codes, then explain what it means and discuss whether they can be recycled or not.

PRACTICAL APPLICATION

Classification And Application Of Plastics

Work in groups.

Aim: To demonstrate an understanding of identifying the different types of plastics and their uses

Resources:

- plastic products
- worksheet
- pen

What to do:

- Work in groups of 4 or 5 learners.
- Write the names of group members.
- Your teacher will provide you with a set of resources.
- Use the plastic codes to sort different plastics.
- Write your results or answers on the worksheet.
- Hand the group results to your teacher for marking and corrections.

A photograph of an industrial welding environment. Two blue robotic arms are positioned over a workpiece, with bright sparks emanating from the welding point. The background shows various industrial components and wiring. The image is overlaid with a large green circle containing the chapter number and a thick green curved line at the bottom.

CHAPTER

6

Joining methods

LEARNING OUTCOMES

By the end of this chapter, learners should be able to explain different joining methods and identify welding joints and symbols. The following will be covered in this chapter:

- applying different joining methods: pop riveting, soldering and arc welding (theory only)
- identifying different components of welding machines
- identifying different welding joints and symbols
- learning about robotic welding
- practically applying soldering methods

Introduction to joining methods

There are five top methods used for the joining of metals: soldering, brazing, bolts and nuts, riveting and welding. This year we will focus on riveting, soldering and arc welding.

Riveting, soldering and arc welding

Riveting

A rivet is a permanent mechanical fastener that has a smooth cylindrical shaft with a head on one end and a tail end opposite the head. We use a rivet gun to install a rivet into a punched or drilled hole.



Figure 6.1 Rivet gun



Figure 6.2 Rivets

When installing a rivet, the tail is bucked (deformed) so that it expands to about one and a half times the original shaft diameter. This pounding creates a new “head” on the other end by smashing the “tail” material flatter and results in a rivet that is roughly a dumbbell shape. This holds the rivet in place.

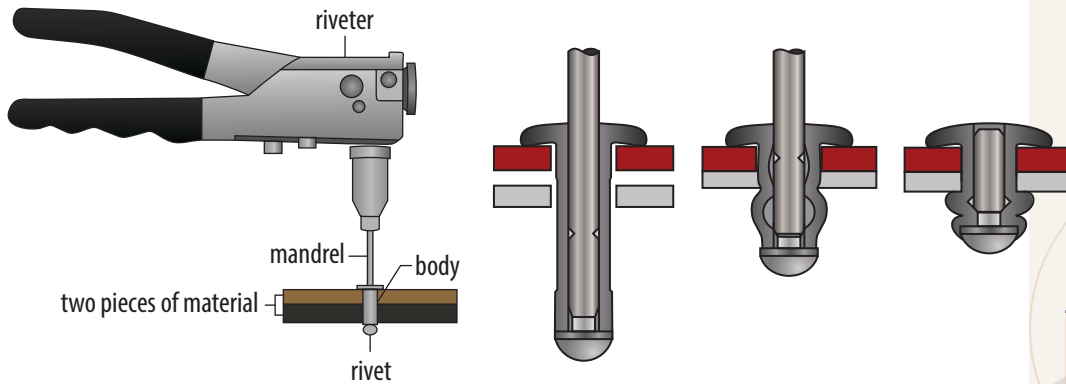


Figure 6.3 Pop riveting process

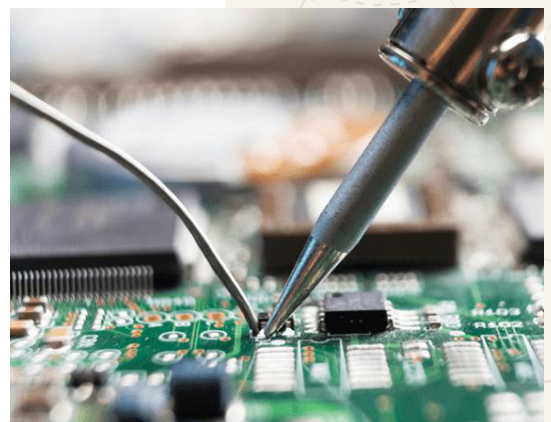
Soldering

Soldering is a joining process wherein **coalescence** is produced by heating below 800 °C, using a non-ferrous filler metal with a melting point below that of the base metal. The metals to be joined dictate the **flux**, solder, and heating methods to be used. Base metals are selected for specific properties such as electrical conductivity, weight, and corrosion resistance.

There are three types of soldering. These are:

- **soft soldering**, which originally used a tin-lead alloy as the filler metal
- **silver soldering**, which uses an alloy containing silver
- **brazing**, which uses a brass alloy for the filler.

The filler metals bond directly with the surfaces of the workpiece and the alloy of the filler metal can be adjusted to modify the melting temperature of the filler.



Take note

To distinguish between the two ends of the rivet, the original head is called the factory head and the deformed end is called the shop head or buck-tail.



Figure 6.4 Soldering, brazing and arc welding



Take note

Soldering is characterised as having a melting point of the filler metal below approximately 400 °C. Filler metals are typically alloys (often containing lead) that have liquidus temperatures below 350 °C.

During the soldering process, heat is applied to the parts that need to be joined. This causes the solder to melt and bond to the workpieces in a surface alloying process called **wetting**. In a stranded wire, the solder is drawn up into the wire between the strands by **capillary action** in a process called **wicking**. Capillary action also takes place when the workpieces are very close together or touching. The resulting tensile strength of the joint will be dependent on the filler metal used.

In electrical soldering, little tensile strength comes from the added solder. It is best to twist or fold the wires together before soldering. This will provide some tensile strength for the joint. A good solder joint produces an electrically conductive, water- and gas-tight join.

Soft solder is so-called because of the soft lead that is its primary ingredient. Table 6.1 lists the advantages and disadvantages of soft soldering.

Table 6.1 Advantages and disadvantages of soft soldering

Advantages	Disadvantages
Soft soldering uses the lowest temperatures	Soft soldering does not make a strong joint and is unsuitable for mechanical load-bearing applications
It thermally stresses components the least	It is unsuitable for high-temperature applications as it loses strength and eventually melts

To achieve a sound soldered joint, the following should be considered:

- **joint design:** should be designed bearing in mind the requirements of solders and their limitations.
- **pre-cleaning:** the surfaces must be thoroughly cleaned to allow the solder to wet the base metal.
- **fluxing:** must be provided to remove traces of surface film or oxides and to prevent the formation of oxides during the soldering operation. Flux should promote the wetting of the surface by the solder.
- **application of heat:** heating the joints evenly or uniformly is very important to ensure a sound joint.

Follow these two steps to apply the solder:

1. wet the metal surfaces
2. fill the gap between the wetted surfaces with solder.

Depending on the conditions dictated by the application, each step can be done separately. This allows for more easily controlled conditions. To cool the joint, use a water spray or air blast as soon as possible after soldering the joint. Slow cooling could cause excessive alloying, and result in a brittle joint.

Silver soldering and brazing use higher temperatures. They typically require a flame or carbon arc torch to melt the filler. Table 6.2 lists the advantages and disadvantages of silver soldering.

Table 6.2 Advantages and disadvantages of silver soldering

Advantages	Disadvantages
Silver soldering is used by jewellers, machinists and in some plumbing applications	Silver soldering requires the use of a torch or other high-temperature source
It is much stronger than soft soldering	

Brazing is often used to repair cast-iron objects, wrought-iron furniture, etc. Table 6.3 lists the advantages and disadvantages of brazing.

Table 6.3 Advantages and disadvantages of brazing

Advantages	Disadvantages
Brazing provides the strongest of the non-welded joints	Brazing requires the hottest temperatures to melt the filler metal, requiring a torch or other high-temperature source and darkened goggles to protect the eyes from the bright light produced by the white-hot work

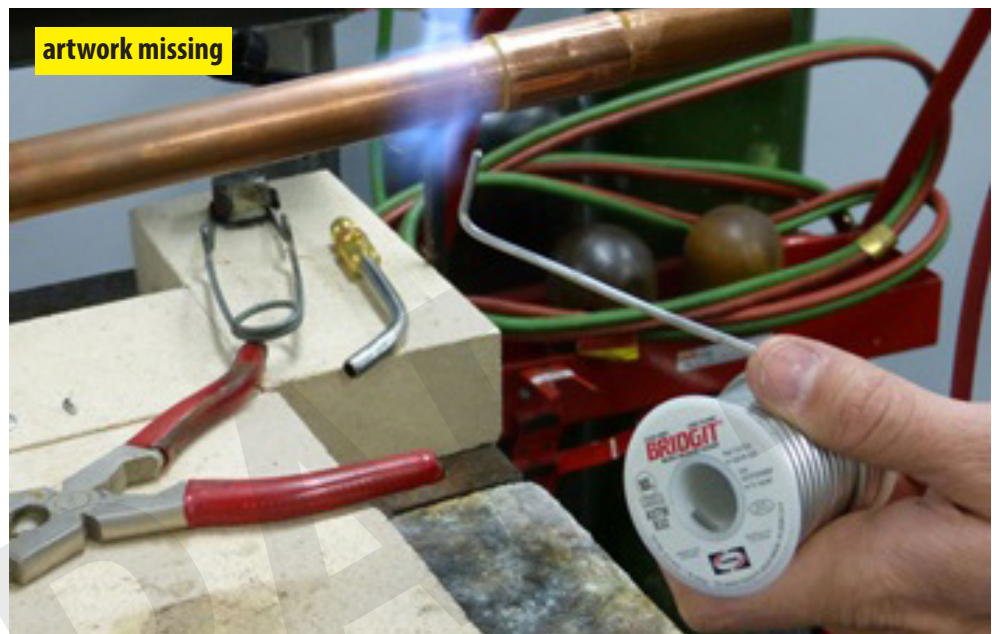


Figure 6.5 Brazing

ACTIVITY 6.1 Soldering

1. Name THREE (3) examples of permanent joints.
2. Explain what a rivet joint is.
3. Draw a neat simple sketch of a lapped riveted joint.
4. Give THREE (3) forms of soldering and explain each one.
5. List ONE (1) advantage and ONE (1) disadvantage of soft solder.
6. List ONE (1) advantage and ONE (1) disadvantage of brazing.
7. Define the following terms:
 - a) joint design
 - b) pre-cleaning
 - c) fluxing
 - d) proper fixtures or alignment of parts
 - e) heating of the base metal.

Arc welding

Welding is a process of joining two or more parts using heat or pressure or both. It is used on metals, thermoplastics and sometimes wood.

Arc welding is a type of welding process that uses an electric arc to create heat to melt and join metals. A power supply creates an electric arc between a **consumable** or **non-consumable electrode** and the base material using either **direct current (DC)** or **alternating current (AC)**. The welding area is usually protected by some type of shielding gas, vapour, or slag.

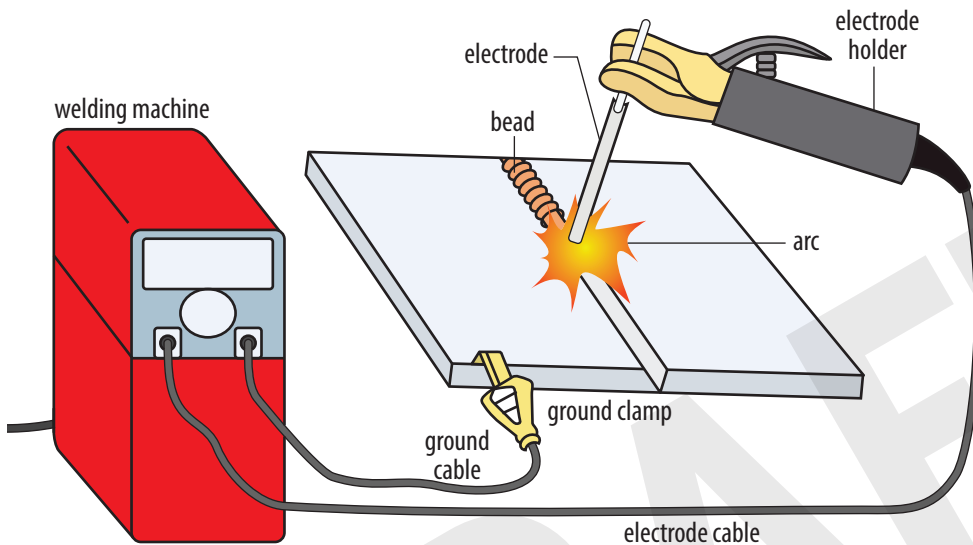


Figure 6.6 Welding machine components

Safety precautions for arc welding

You should be aware of the danger of electric shocks, burns, ultraviolet rays and bits of welding slag. Always guard yourself against these dangers by using the correct PPE when working. Spectacles, goggles or other appropriate eye protection must always be worn.

When arc cutting and arc welding with an open arc, the OSHA requires operators to use welding helmets or hand shields with filter lenses and cover plates.

Weld preparation

Before workpieces can be welded together the weld edges must be cleaned. Oil, wax layers, paint or scale must be removed, and the welding points must be metallurgically clean. Without this preparation, the welds will not last.



Take note

Anyone viewing arc welding should wear the appropriate PPE.

The following tools and equipment are essential in welding:

- **electrode lead and electrode holder:** which needs to be the correct size and attached to the positive terminal of the welding machine. It holds the electrode.



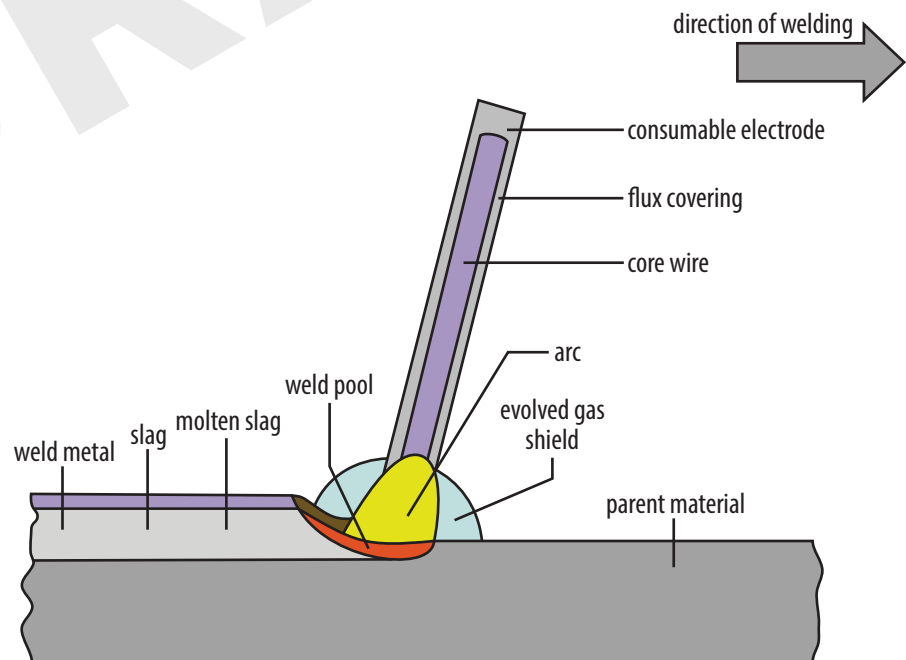
Figure 6.7 Electrode lead and holder

- **work lead/earth clamp:** is attached on the negative side and will be attached to the parent metal using a clamp



Figure 6.8 Work lead/earth clamp

- **parent metal:** refers to the metal that will be welded – it is also called the workpiece. To get the correct fusion, it is important to select the correct size rod, which will be dependent on the metal that will be welded.



- AC or DC machine
- chipping hammer
- wire brush
- electrodes/welding rods.

Different types of joints

In Grade 8 we learnt that individual parts meet at the joints, where the forces generated during the use of the component are distributed. Here are examples of different types of joints.

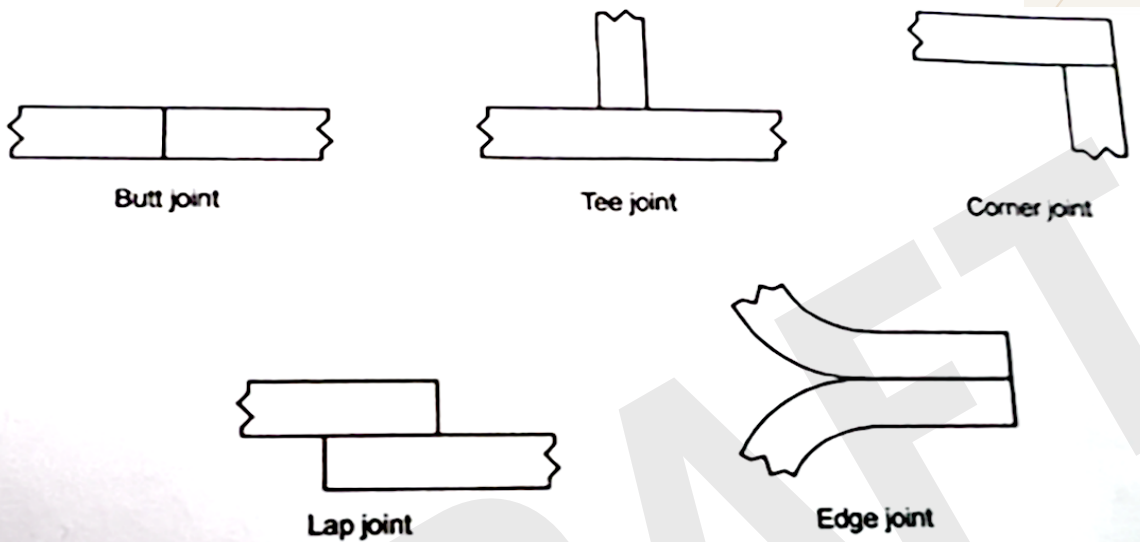


Figure 6.9 Types of joints

This year we will learn about two types of joints: butt joint and lap joint.

Butt joint: this is a technique in which two pieces of material are joined by simply placing their ends together. The butt joint is the simplest joint to make since it merely involves cutting the material to the appropriate length and welding them together.

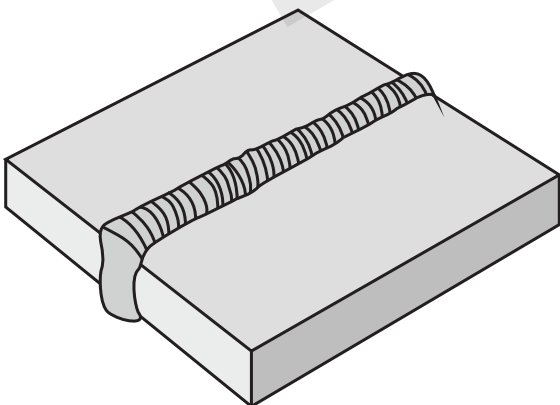


Figure 6.10 Butt joint

Lap joint: this is a joint between two pieces of metal in which the edges or ends are overlapped (placed on top of each other) and welded together to produce a continuous or flush surface.

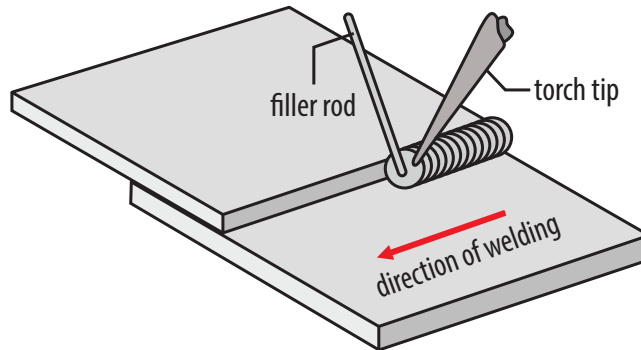


Figure 6.11 Lap joint



Take note

If the weld symbol is below the reference line, the weld should be made on the same side as the arrow.

Welding symbols

Welding symbols as a communication tool between a designer and a welder. The arrow and leader line point to the joint tells a welder what type of weld to do.

Table 6.4 shows the basic welding symbols.

Table 6.4 Basic welding symbols

Name	Weld	Symbol
square butt		
square V butt		
square V butt with broad root face		
single bevel butt		
single bevel butt with broad root face		
single U butt		
single J butt		

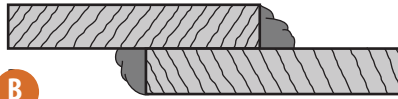
these 2 artworks are missing

Activity 6.2 Arc welding

1. Name the welding joints shown in A and B:

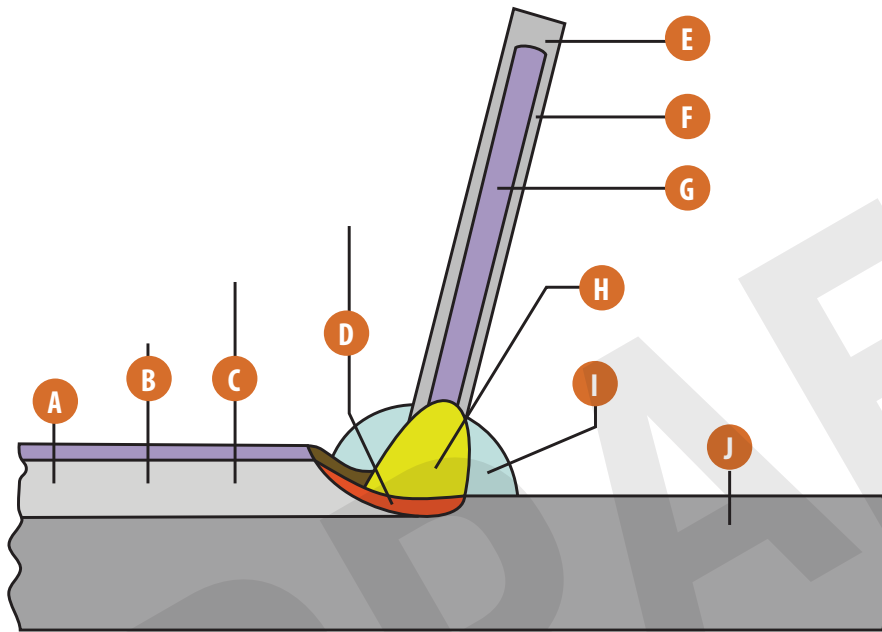


A



B

2. Explain the term arc welding.
3. Give SIX (6) tools and equipment that are essential in welding.
4. State FIVE (5) personal protective equipment for welding.
5. Redraw and label the sketch below.



Take note

Robot welding is a relatively new application of robotics that became popular in the 1980s when the automotive industry began using robots extensively for spot welding. Since then, both the number of robots used in industry and the number of their applications has grown.

An introduction to robotic welding

Robotic welding uses robots, which are mechanised programmable tools, to completely automate the welding and handling of parts. It is commonly used for resistance spot welding and arc welding in high-production applications, such as the automotive industry. A human operator still sometimes prepares the materials to be welded.



Figure 6.12 Robotic welding



CHAPTER

7

Terminology

LEARNING OUTCOMES

By the end of this chapter, learners will be introduced to the lathe machine, milling machine and heat engines. The following will be covered in this chapter:

- identifying machines and their components
- learning about the function or purpose of machines
- learning about the function or purpose of different components of machines.

Introduction to the centre lathe, milling machines and heat engines

What is a centre lathe?

In Grade 8 we learnt that a centre lathe is used to produce cylindrical shapes from materials including steel and plastic. It produces a cutting action by rotating a workpiece against the cutting edge of the tool while it holds and rotates the workpiece. The cutting tool can be moved in many directions to do many operations.

A centre lathe is shown in Figure 7.1. When you open the headstock you will find an arrangement of gears. These gears can be replaced to alter the speed of rotation of the chuck.

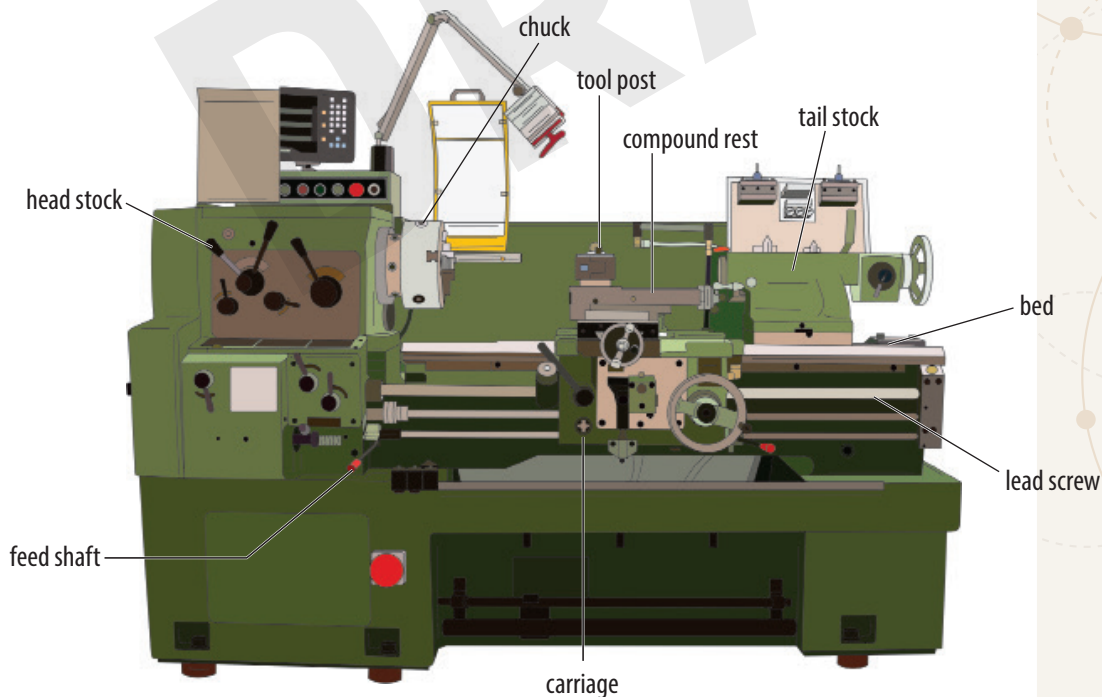


Figure 7.1 A Centre lathe machine

Components of a centre lathe

The following are the main parts of the lathe machine:

- headstock
- chuck
- lathe bed
- tailstock
- tool post
- cross-slide
- compound slide
- lead screw
- lead shaft
- saddle.
- carriage.

Uses of each lathe component

Headstock

The headstock is found on the end of the bed. It provides the rotational power for the lathe's operations. It contains the gearbox and the spindle where the chuck is mounted to rotate the workplace against the cutting tool.



Figure 7.2(a) Different headstock components

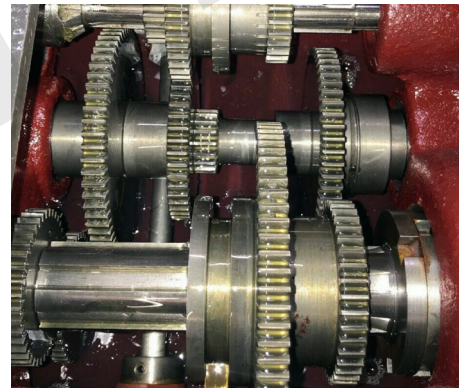


Figure 7.2(b) Interior of a headstock

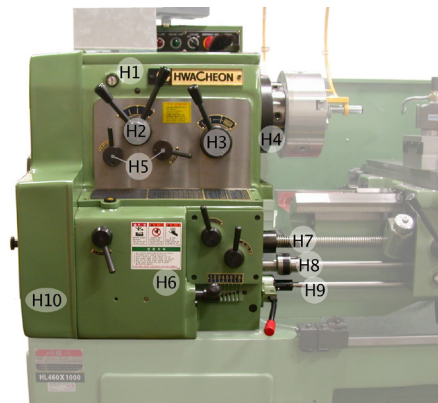


Figure 7.2(c) Exterior of a headstock

The chuck

The chuck (also known as the self-centering chuck) is mounted on the spindle and holds the workpiece firmly while it is worked on. It grips the workpiece with the three jaws moving to the centre at the same time. A chuck key moves all three jaws simultaneously.



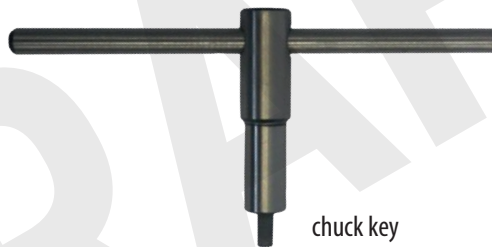
Figure 7.3 (a) A three jaw chuck



Figure 7.3 (b) A four jaw chuck

Chuck key

The chuck key is a wrench that is used for tightening or loosening the jaws of a chuck.



Lathe bed

The lathe bed is a base that connects to the headstock and permits the carriage and tailstock to be moved lengthwise because of the V-ways formed on them.

Three major units mounted on the bed are the:

- headstock
- tailstock
- carriage.

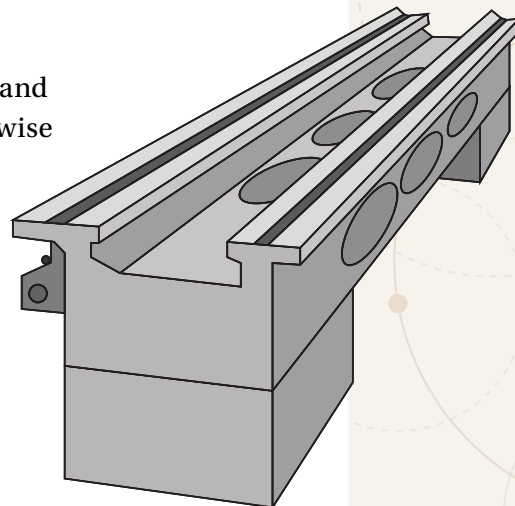


Figure 7.4 A lathe bed

Tailstock

The tailstock supports the free end of the work. It is also used in drilling, reaming, and taper-turning operations. It can be moved longitudinally or be locked in any position on the lathe bed.

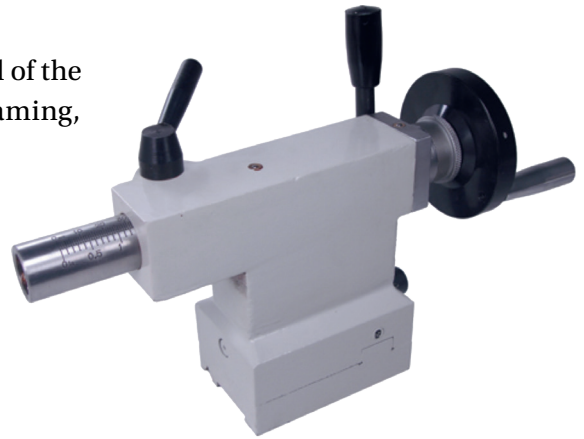


Figure7.5 An example of a tailstock

Tool post

A cutting tool is held on the tool holder that is secured in the tool post of the lathe, which is securely clamped on the compound slide.



Figure7.6 (a) A quick change tool post



Figure7.6 (b) A four holder tool post

Cross slide

The cross-feed lever can move the saddle in and out perpendicular to the centre of the lathe. The cross slide supports the compound slide.

Compound slide

The compound slide is located on top of the cross slide and can be rotated in a full circle and locked in any position. The base has a protractor to set up the compound slide at the required angle.

The lead screw

The lead screw is used to transmit power from the headstock to the carriage for screw thread-cutting operations.

Lead shaft

The lead shaft is a power transmission mechanism that provides precise longitudinal movement of the carriage for turning operation movements.

Saddle

The saddle is an H-shaped casting that fits over the bed and slides along with from the headstock to the tailstock.

Carriage

The carriage is attached to the lathe bed and consists of the saddle, cross slide, compound slide, and tool post. The carriage can be traversed along the bed by hand control (manually) or by power feed (automatic).

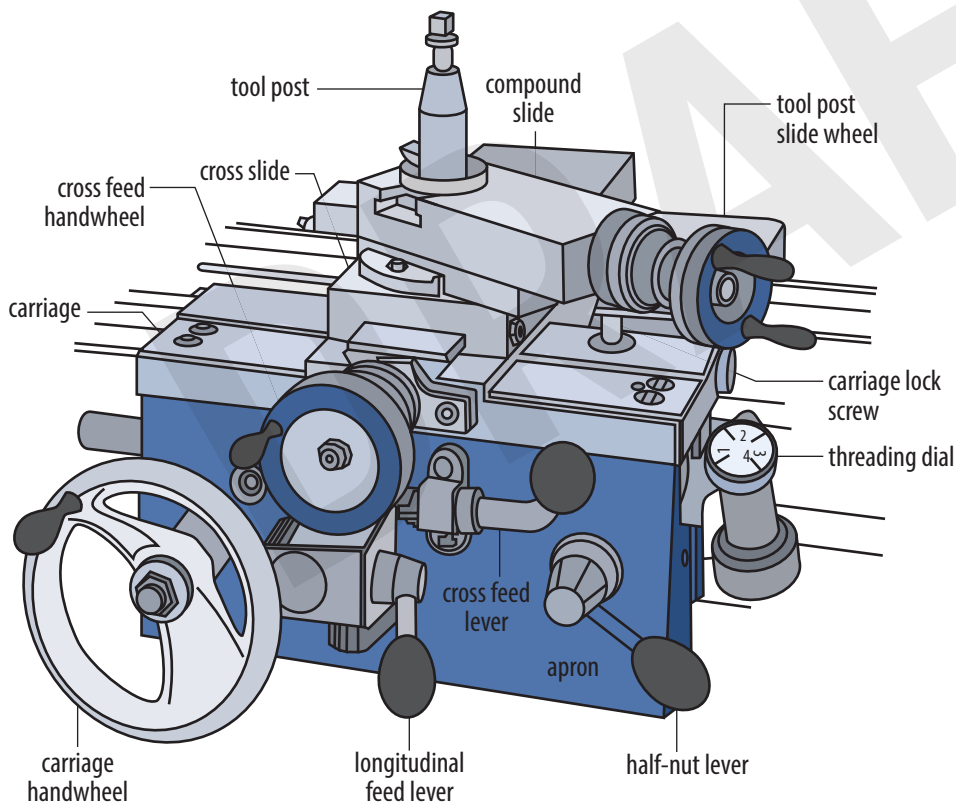


Figure 7.7 The carriage

Coolants

The coolant is the liquid that is used on the lathe for to:

- cool down the cutting tool and the workpiece
- prolong the cutting tool life
- lubricate the cutting tool face.
- safeguard the operator from extra-fine cuttings (small debris).

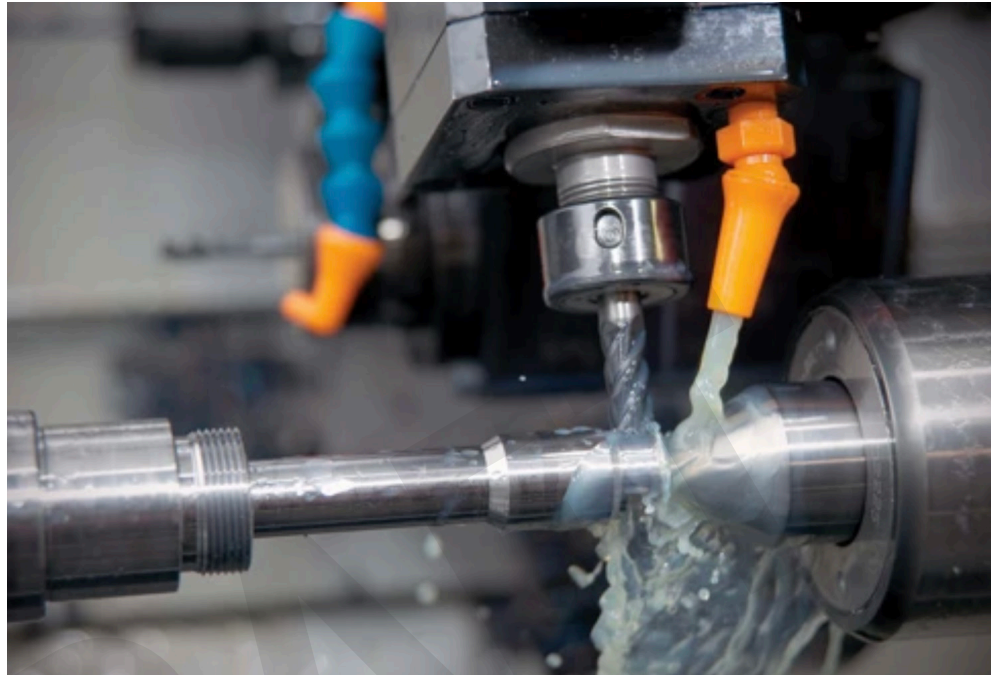


Figure 7.8 A coolant

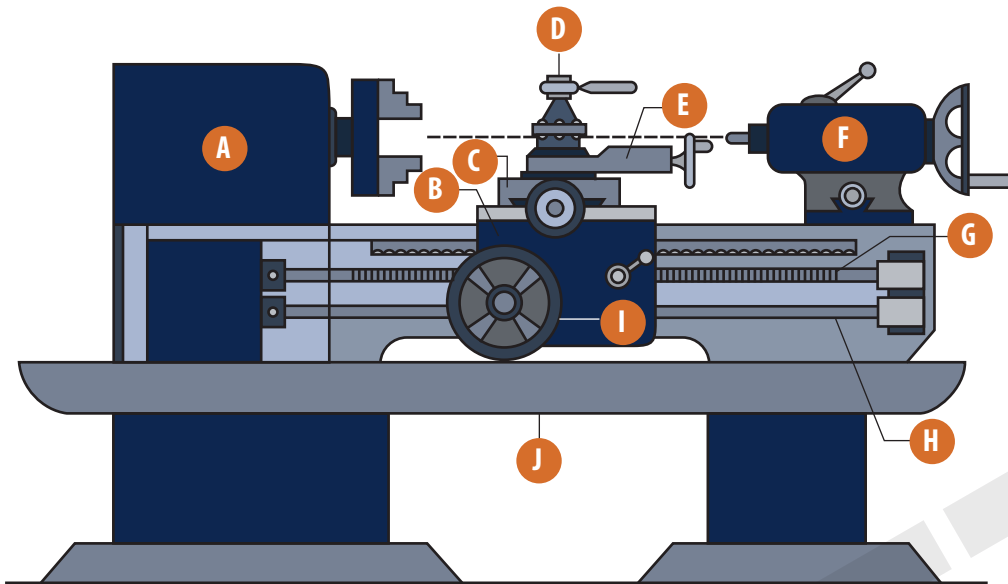
Safety precautions

To safely operate the lathe machine, always adhere to the following precautions:

- never leave the chuck key on the chuck
- never adjust the cutting tool while the lathe is in motion
- always wear safety goggles
- never wear loose clothing
- switch the lathe machine off after use.

Activity 1 The lathe machine

1. Study the following machine and supply the labels



2. State the function of the following lathe parts:
 - a) tailstock
 - b) tool post
 - c) chuck
 - d) chuck key
 - e) headstock.
3. Give THREE (3) reasons why a coolant is used on the lathe.
4. State whether the following rules are True or False:
 - a) The chuck key must be always in the chuck.
 - b) The cutting is adjusted only when the lathe is in motion.
 - c) Always wear safety goggles.
 - d) Never wear loose clothing.
 - e) Switch it off after use.

What is a milling machine?

In Grade 8 we learnt that a milling machine shapes a workpiece that is clamped on the table vice by feeding it (workpiece) onto the revolving cutting tool (cutters). They are used to machine flat and irregularly shaped surfaces. They can also be used to drill, bore, and cut gears, threads, and slots.

The milling machine is a **versatile** machine and is used to machine plain surfaces, keyways, dovetails, and gears. The most common types are universal, vertical, and horizontal milling machines

Vertical milling machine

The vertical milling machine includes the quill – which moves vertically in the head and contains the spindle and cutting tools. The knee moves up and down by sliding parallel to the column. The column holds the turret, which allows the milling head to be positioned anywhere above the table. Handles move the table to the left and right (X axis), in and out (Y axis), in addition to moving the knee, saddle, and table up and down (Z axis).

It is used for assorted light work such as the milling of bevels, keyways, slides, chamfers, other angles, grooves, dies, jigs recesses, slots, tees and dovetail slots.

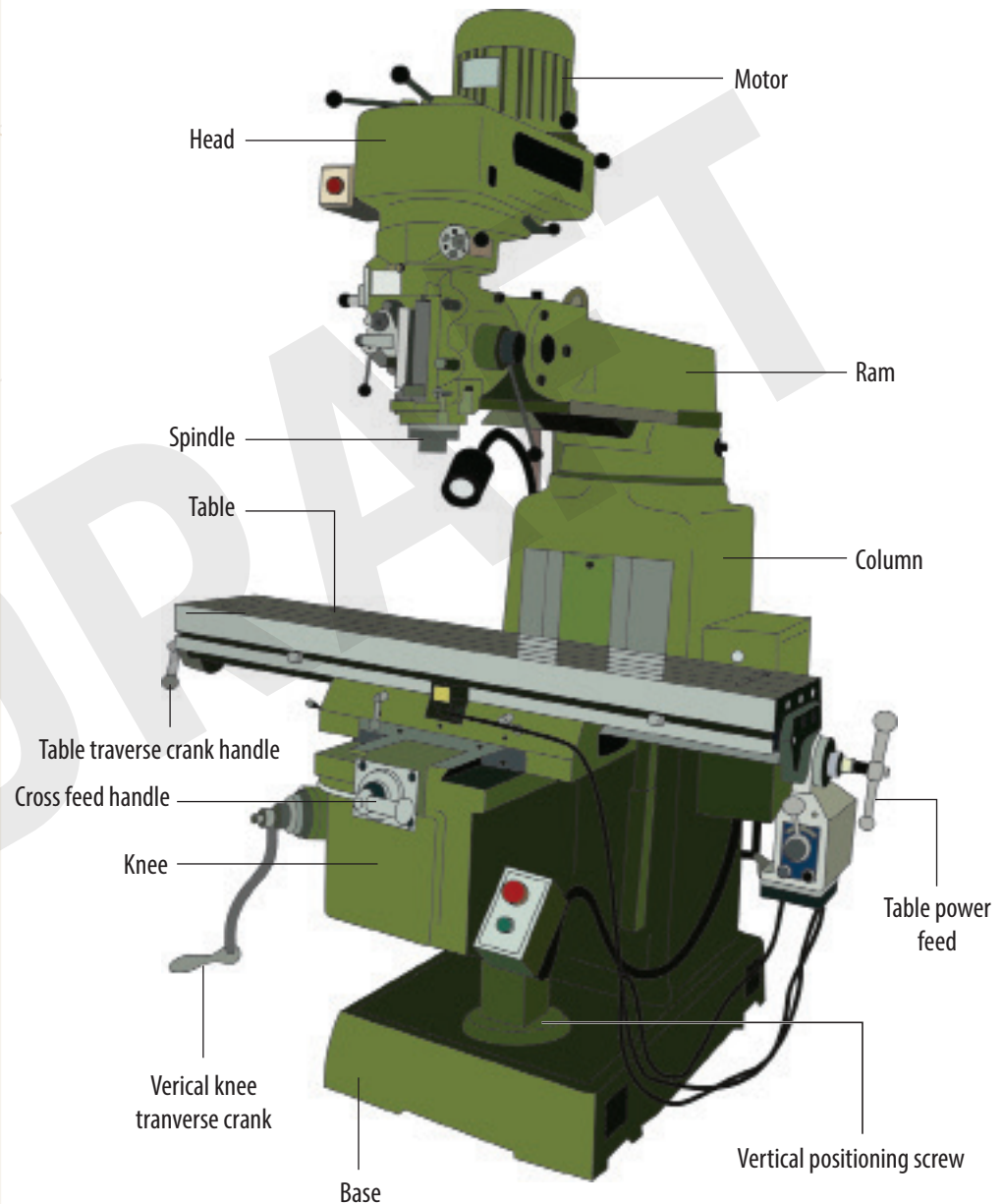


Figure 7.9 A vertical milling machine

Horizontal milling machine

The horizontal milling machine is mainly used for cutting gears. It is used together with a diving head.

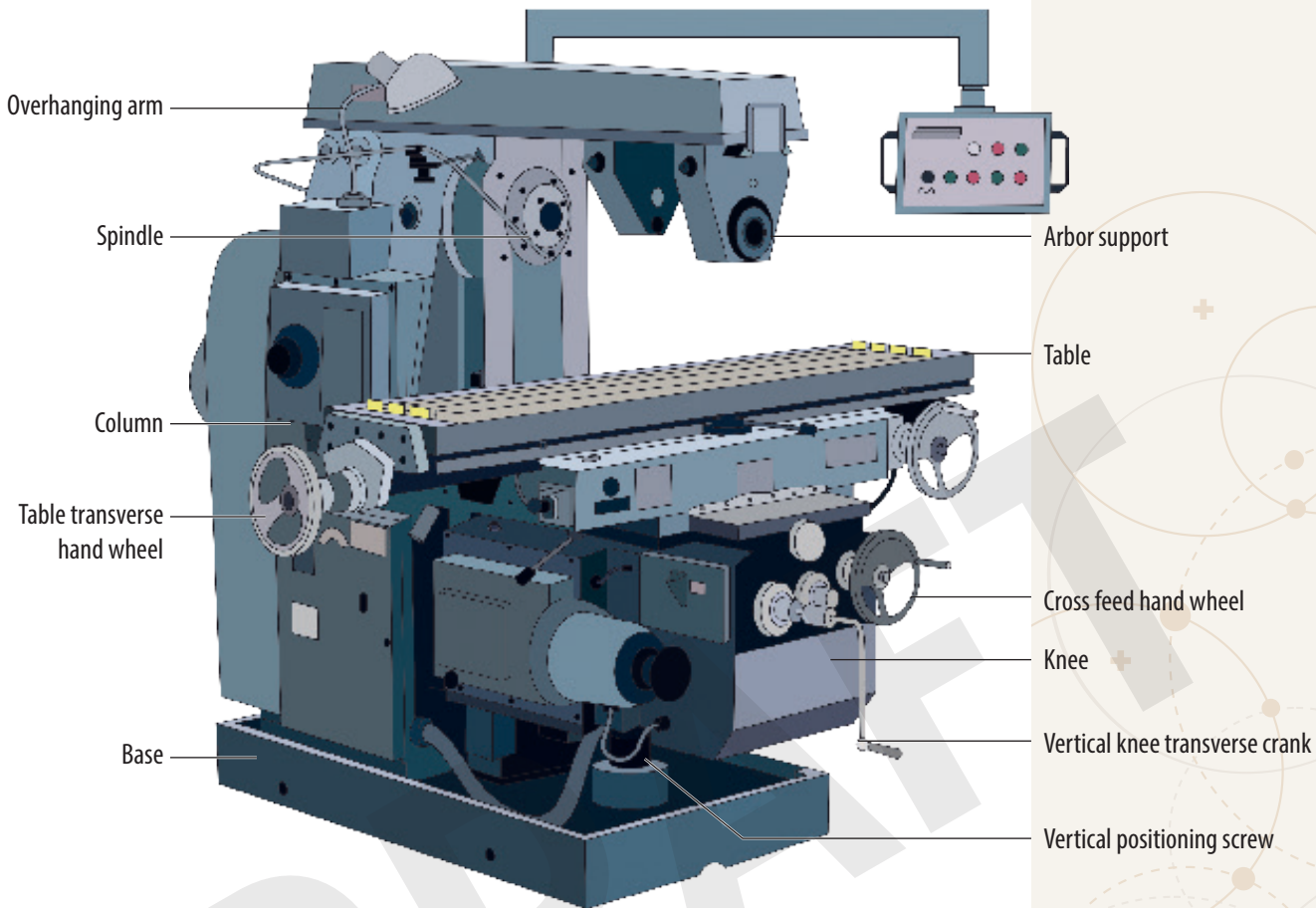


Figure7.10 A horizontal milling machine

Components of a milling machine

Spindle

The spindle is used to hold and drive the milling machine's cutting tool. The spindle is driven by an electric motor via a gear train, and it is perpendicular to the table.

Table

The milling machine table is where different attachments are mounted for milling operations to be performed. The milling machine table can be moved (manually and automatically) up and down, backward and forward.

Base and column

The base and column support the other parts of the milling machine. There is an oil reservoir and pump in the column to lubricate the spindle. The column rests on the base and it has a coolant reservoir and a pump to provide coolant in the machining operations.

Switches

A milling machine switch is an electric device that is used to switch the machine on and off. The milling machine can move the table sideways, upward and downward, and forward and backward using a transverse crank wheel, vertical knee crank, and cross-feed handle.

Activity 2 The milling machine

1. What is the purpose of a milling machine?
2. Give TWO (2) types of milling machines.
3. What is the function of the following milling machine components?
 - a) spindle
 - b) table
 - c) switches

Engines

An engine is a machine with moving parts that converts heat power into motion, that is, it converts heat energy (thermal energy) into mechanical energy.

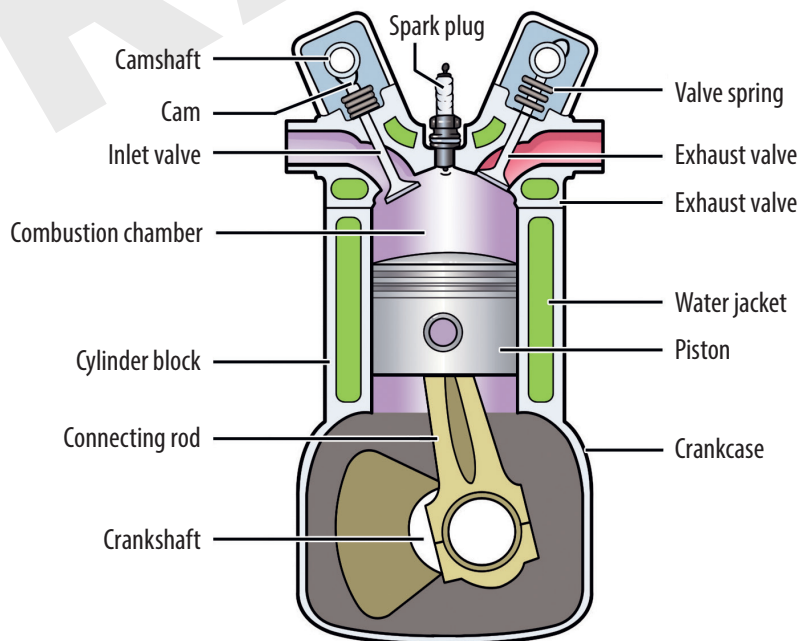


Figure 7.11 A cross-sectional view of a four-stroke engine

In Grade 8 you learnt about the different components of an engine. Let's revise what we have learnt.

Table 7.2 Components of an engine and their functions

Component	Function
crankshaft	The crankshaft changes the linear movement of the piston to a rotary motion.
connecting rod	The connecting rod connects the piston to the crankshaft.
cylinder block	The cylinder block houses the cylinders.
combustion chamber	The combustion chamber is the space where the burning of gases happens.
intake valve	The intake valve controls the entry of fresh air: fuel.
cam	The cam controls the opening and closing of the valves at different intervals.
camshaft	The cams are machined on the camshaft which controls the valve opening and closing.
spark plug	Spark plugs ignite the air-fuel mixture in the combustion chamber
valve spring	The valve spring keeps the valve closed on its seat
exhaust valve	The exhaust valve controls the exit of burnt exhaust gases.
cylinder head	The cylinder head covers the cylinders in the cylinder block.
water jacket	The water jacket is the path where the engine coolant flows.
piston	The piston moves down creating in the inlet. it compresses the mixture. It pushes out the burnt exhaust gases.
crankcase	The crankcase contains oil.

We can use the following engine terms when working with heat engines:

- **TDC** (top dead centre): the highest point the piston can reach is the cylinder.
- **BDC** (bottom dead centre): the lowest point the piston can reach is the cylinder.
- **stroke**: the distance moved by the piston between the top dead centre and bottom dead centre in the cylinder.
- **bore**: a bore is the diameter of each cylinder.
- **engine cycle**: the complete operation of the engine in the cylinder from the inlet/intake stroke to the exhaust/outlet stroke.

The operation of a four-stroke petrol engine

An engine is a machine (for example, in a vehicle) that consists of moving parts. The engine converts heat power/energy into mechanical motion/energy by burning a fuel-air mixture under pressure inside the engine's cylinder. This heat power/energy is then converted into movement by the pistons, connecting rods and crankshaft.

Let's take a closer look at how a four-stroke petrol engine works:

Intake stroke

- The piston moves from the top dead centre to the bottom dead centre.
- The inlet valve opens, allowing the air-fuel mixture into the cylinder.
- The exhaust valve is closed.
- Before the piston reaches the bottom dead centre, the inlet valve starts closing.

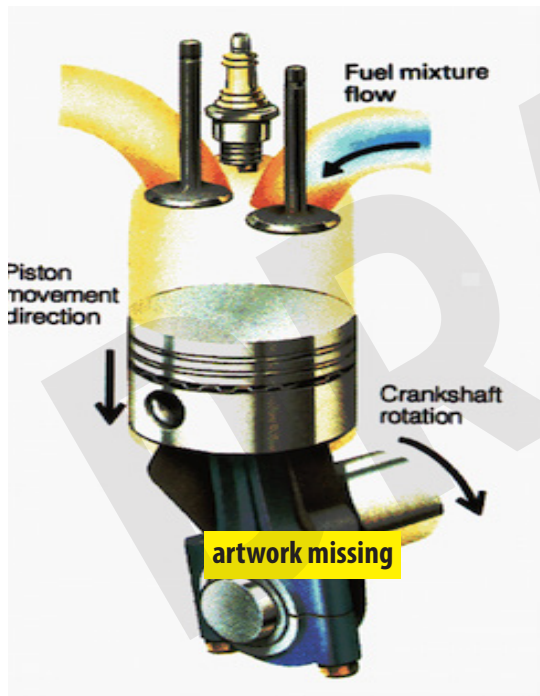


Figure 7.5 Intake stroke

Compression stroke

- The piston moves from the bottom dead centre to the top dead centre.
- Both inlet and exhaust valves remain closed.
- The air-fuel mixture is compressed in the small combustion chamber.



Figure 7.6 Compression stroke

Power stroke

- Both the inlet valve and exhaust valve remain closed.
- Just before the piston reaches the top dead centre, the spark plug provides a spark to ignite the air-fuel mixture.

Exhaust stroke

- As the piston reaches the bottom dead centre, the exhaust valve opens, and the inlet valves remain closed.
- The piston moves from the bottom dead centre to the top dead centre.

- Combustion of the air-fuel mixture causes the gasses to expand, forcing the piston to move to the bottom dead centre.

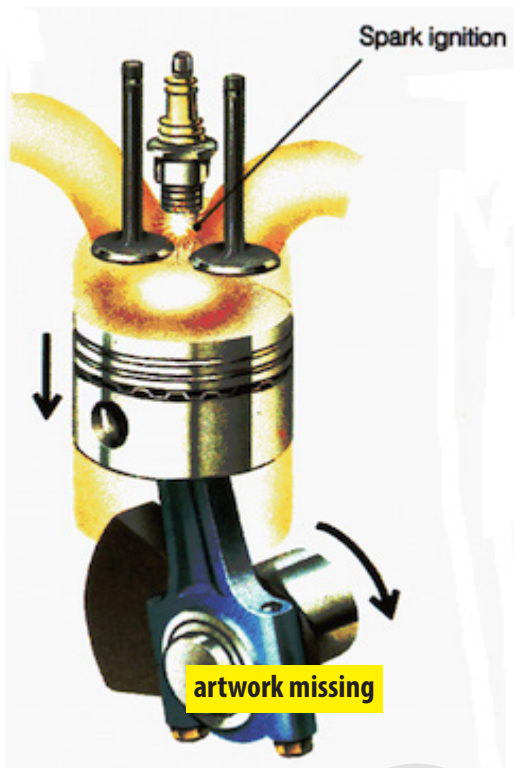


Figure 7.7 Power stroke

- The upward movement of the piston forces the burnt gases out through the opened exhaust valve.

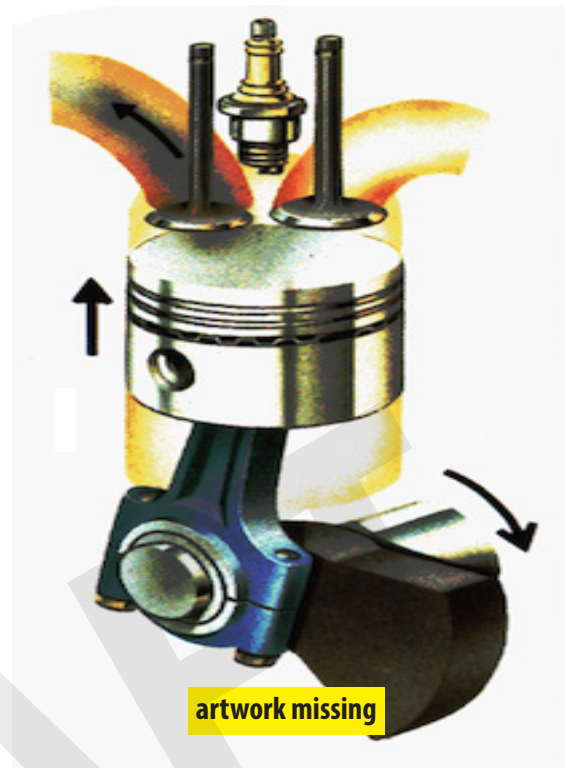
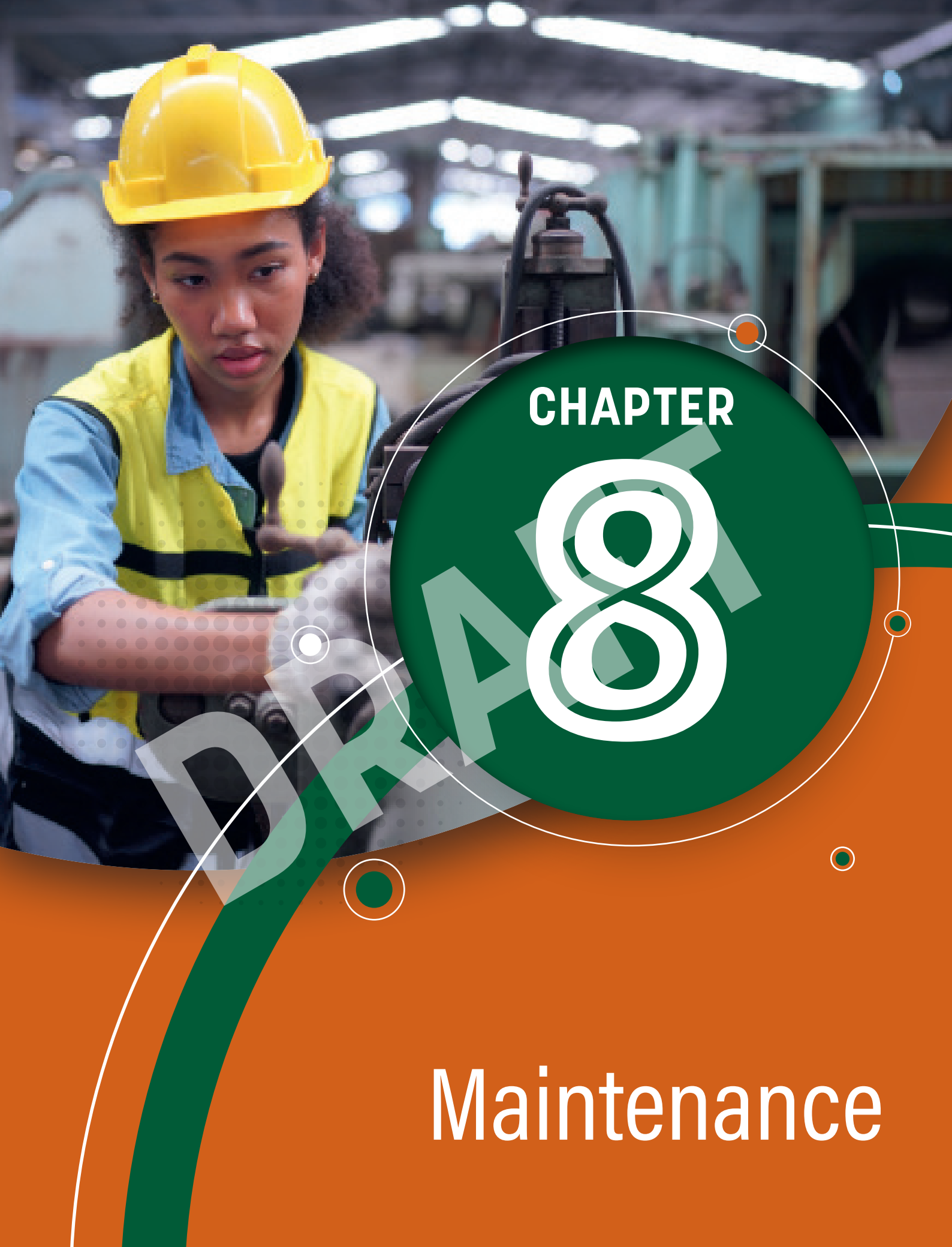


Figure 7.8 Exhaust stroke

Activity 3 Engines

1. Explain the following terms:
 - a) bore
 - b) bottom dead centre
 - c) stroke
 - d) top dead centre.
2. What are the functions of the following parts:
 - a) crankshaft
 - b) intake valve
 - c) spark plug
 - d) cam
 - e) combustion chamber?
3. Describe the operation of all four strokes of a petrol engine.



CHAPTER

8

Maintenance

LEARNING OUTCOMES

By the end of this chapter, learners should be able to explain what maintenance is and define engine maintenance. The following will be covered in this chapter:

- defining maintenance and lubrication
- learning about the purpose of lubrication
- learning about different types of maintenance
- inspecting liquid levels and top ups
- inspecting motor vehicle defects
- learning about the importance of regular maintenance
- differentiating between replaceable components during a service
- learning about the learning and care of automotive batteries
- identifying the correct size and type of automotive batteries

Revision of the meaning of maintenance

In Grade 8 we learnt that maintenance can be just a simple cleaning or lubrication process, or it may involve all the maintenance tasks (the work being done) on machinery and mechanical equipment to keep them functional. Maintenance involves functional checks, servicing, repairing, or replacing devices, equipment and machinery over a certain period. It aims to keep downtime to a minimum, keep employees safe from malfunctioning machinery, and minimise the costs of fixing a machine when it does break down due to unplanned failure.

Maintenance can include the following:

- regularly scheduled services
- routine checks
- emergency repairs
- the replacement or realignment of worn, damaged, or misaligned parts.



Figure 8.1 Maintenance

There are different inspection or service intervals or frequencies for maintaining smooth and continuous operation. The inspection frequency for maintenance depends on:

- the level of the oil/lubricant before operating the machines/equipment
- the conditions a machine or the equipment is subjected to.

This year we will learn about three types of maintenance:

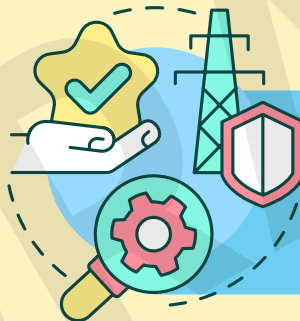


Preventative maintenance:

maintenance that is regularly performed on equipment to lessen the likelihood of it failing.

Predictive maintenance:

maintenance that monitors the performance and condition of equipment during normal operation to reduce the likelihood of failures.



Reliability-centered maintenance:

maintenance that is performed after every operation has been completed to ensure that the machinery will be ready and functional during the next operation.

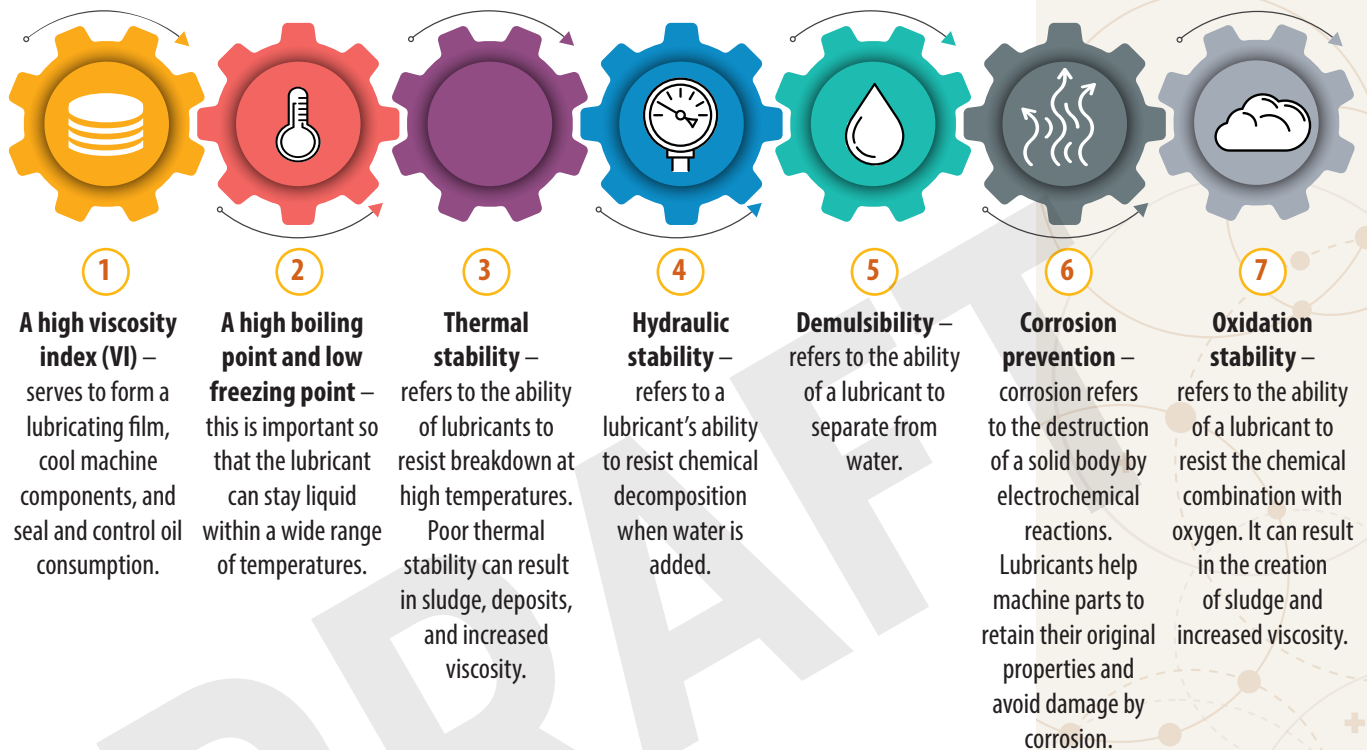
Activity 1 Maintenance

1. Define maintenance.
2. Name and explain THREE (3) types of maintenance that can be carried out in the Mechanical Technology workshop.
3. True or False: There are different inspection or service intervals or frequencies for maintaining smooth and continuous operation.
4. List THREE (3) things maintenance can include.

Lubrication

In Grade 8 we learnt that lubrication keeps friction (that is metal-to-metal contact) to a minimum by forming a film over moving parts and allowing them to slide smoothly past one another. The application of lubricants such as oil or grease in an engine or moving machine parts helps to reduce premature parts failure and ensures maximum life and endurance of a machine.

A good lubricant generally possesses the following characteristics:



Lubrication of machines and equipment

Lubrication of machines or equipment will prolong the lifespan of the machine and prevent unnecessary breakdowns and expensive repairs. It:

- prolongs the life of the machines/equipment.
- enhances the performance of machines/equipment
- reduces friction
- reduces wear
- lowers temperature
- prevents corrosion of the material surface
- cleans the flushing point
- acts as a sealing effect in different machine/equipment parts
- prevents dust from settling on machines/equipment.

Activity 2 Lubrication

1. List and explain FOUR (4) characteristics a good lubricant possesses.
2. Fill in the missing words:
Lubrication keeps _____ (that is metal-to-metal contact) to a minimum by forming a _____ over _____ and allowing them to slide smoothly past one another. The application of _____ such as oil or grease in an engine or moving machine parts helps to reduce premature parts _____ and ensure _____ life and endurance of a machine.
3. State whether the following statements are True or False: Lubrication of machines or equipment:
 - a) reduces the life of the machines/equipment
 - b) reduces wear
 - c) acts as a sealing effect in different machine/equipment parts prevents dust from settling on machines/equipment.
enhances the sealing effect of machines/equipment

Liquids

Inspection of levels and top-up fluids

There are six fluids in a motor vehicle that needs to be checked on the monthly basis. This will ensure that they are at the right level and that they are clean. These are:

- **engine oil** – most cars need an engine oil change every 15 000 km or according to the manufacturer's specification. Before you check it, make sure the vehicle is not idling and that the engine has cooled down. Pull out the dipstick and check the marks for low or full.
- **gearbox** (differential or transmission) – this is normally done by mechanics because some cars do not have a dipstick (automatic), and the car needs to be hoisted.
- **coolant** – ensure that the car is not idling and that the engine has cooled down before checking the coolant. It can either be in the radiator or the expansion bottle. Usually the bottle has mark levels on the side to show the level of fluid inside the radiator.
- **brake fluid** – the brake master reservoir has a translucent bottle with a line indicating minimum or maximum.
- **power steering reservoir** – it is located next to the engine and its cap also serves as the dipstick. It also has marks to indicate the levels.
- **windshield wiper reservoir** – towards the back of the side of the engine, the windshield wiper reservoir contains water to clean the windscreen if it is dirty. You can wash your windscreen while driving to have clear visibility of the road.

Inspection for defects (motor vehicle)

To check for defects in a motor vehicle, check the:

- **radiator cap** – so that it does not leak and the pressure relief valve is closed.
- **wiper blades** – to make sure they are not torn or cracked.
- **fan belt** – to make sure it is not worn or loose.
- **pipes** – to make sure they are not leaking and are properly clamped.
- **hand brake** – and adjust to to a maximum of 5 clicks (if necessary)
- **brake pads** – to make sure they should not be less than 3 mm.
- **battery terminals** – to ensure that there is no deposit on terminals. Also to check that the terminals are securely fastened.

Engine maintenance

Importance of regular maintenance

Regular vehicle maintenance should not be neglected. Having the basic knowledge of the red flags you need to look out for, will help you to diagnose a problem early. Regular maintenance:

- reduces the risk of an unexpected breakdown
- improves driving quality
- improves vehicle performance
- saves expensive repair costs
- improves safety.

Different replaceable components during minor service include:

- engine oil
- oil filter
- sump plug washer
- top-ups.

Automotive batteries (lead, acid storage and gel type batteries)

The main purpose of an automotive (car) battery is to supply electric current that feeds the starter and starts the engine. Once the engine is running, power is supplied by the alternator.



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Figure 8.2 An example of lead-acid batteries

Handling

When working with a battery, follow these safety precautions:

- wear protective clothing
- mount the battery on its stand
- clamp the battery in the vehicle
- if it is not in use, do not place the battery on the ground

Care

To care for a battery:

- check the electrode levels regularly
- always keep the terminals clean and dry
- inspect the battery case for leaks
- check the battery hold down and stand
- avoid battery terminal contact with metal
- clean the terminals and the top

Identifying the correct size and type of battery for a vehicle

Choosing the correct size of a battery is important. It should fit in the tray and start the vehicle with ease. The battery size and specifications are determined by the manufacturer, who will specify which size and type of battery to use in the vehicle. Always check the manufacturer's specifications – if you use a battery that is too big, it will negatively impact the electrical system in a vehicle; if you use a battery that is too small, it will not last long.

When choosing a battery:

- check the labelling on the current battery
- check in the owner's manual in the car
- ask the dealership for the correct type of battery size
- ask the consultant at the battery shop to check the size of your current battery if you are unsure of the battery size.

Activity 2 Maintenance

1. Which SIX (6) fluids should be checked during routine maintenance?
2. Identify FIVE (5) defects that need to be checked when servicing a vehicle.
3. What are the TWO (2) colours of the battery terminals?
4. State FOUR (4) ways to identify the correct size and type of battery for the vehicle.
5. Which parts must be changed when conducting the minor service in a car engine?

PRACTICAL APPLICATION

Identify the vehicle's replaceable components and fluids and check if they need maintenance/replacement/top-up

Work in groups.

Aim: To identify the vehicle's replaceable components and fluids and check if they need maintenance/replacement/top-up

Resources:

- worksheet
- pen

What to do:

- Work in groups of 3 or 4 learners.
- Use the template to identify the vehicle's replaceable components and fluids (listed below):
 - engine oil level
 - oil filter
 - radiator cap
 - battery terminals
 - hand brake
 - water pipes
 - wiper blades.
- Check if the components and/or fluids need maintenance/replacement/top-up.
- Use the worksheet provided and fill in the condition or maintenance report based on your findings.

Maintenance	
Component	
Condition report	
Action to be taken	
Action taken	
Checked by:	
Signature:	
Date	

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CHAPTER

9

Body works and
spray painting

LEARNING OUTCOMES

By the end of this chapter, learners should be able to perform surface preparation on a body panel grind and feather edging operations. The following will be covered in this chapter:

- identifying the type of panel and name the material it is made from
- identifying and assessing the body panel to be repaired
- performing different tasks in accordance with the workshop procedures
- learning about different tools and materials
- identifying and explaining the use of primer
- performing and demonstrating different task in accordance with the manufacturer's manuals
- cleaning and storing tools, equipment and materials in accordance with workshop procedure
- identifying the various types of primers

Bodywork

Auto bodywork includes both maintenance and repair work – which is not limited to post-accident repairs – and includes both mechanical and structural assessments and repairs. Auto bodywork is highly specialised. In Grade 8 we learnt that modern-day vehicles require special techniques, skills, and tools for body repair work and fixing damaged parts. Auto body and related repair workers or collision repair technicians straighten metal panels, remove dents, and replace parts that cannot be fixed. Even though they repair all types of vehicles, most work primarily on cars, sport utility vehicles, and small trucks.

Specialised tools made of high-carbon tool steel have been designed for this purpose. These tools have been forged and heat-treated to ensure a long service history when used correctly. Without the correct tools, body repair work could not be done successfully. A skilled body repair worker knows how to use the basic tools in a body repair toolkit efficiently. These tools include the hammer and dolly. Other tools have been developed around these tools – and in this chapter, we will learn about these specialised tools and their uses. We will also focus on how to use these tools in coordination with one another so that repair jobs can be successfully carried out.

Power tools

Disc sanders

A disc sander is a must-have tool for auto body repair. This versatile power tool can be used for basic sanding and body filler shaping, as a heavy-duty grinder, or even as a file substitute.



Figure 9.1 An example of a disc sander

The disc sander is used to grind off paint or excess material. It is also used to finish off repaired panels, for example, after welding.

Follow these safety procedures with working with a disc sander:

- do not apply too much pressure while sanding
- use the correct sanding disc
- hold the sanding disc with two hands
- always wear safety goggles when working with a sander
- always ensure that electric grinders are properly earthed
- before plugging in the machine, ensure that the wall plug and machine are turned off.

To care for a disc sander, follow these instructions:

- clean the external and internal surfaces of the angle grinder after use
- ensure that it is properly greased
- store the disc sander in the storeroom once you have completed your work.

Sanding blocks

In Grade 8 we learnt that if you must sand a vehicle by hand, it is best to use an automotive sanding block. When you sand by hand, pressure is unevenly placed on the piece of sandpaper. The tiny variations in pressure can cause the surface of the vehicle to become wavy and uneven. When you use a sanding block, wrap the sandpaper around the block to create a flat and even sanding surface.

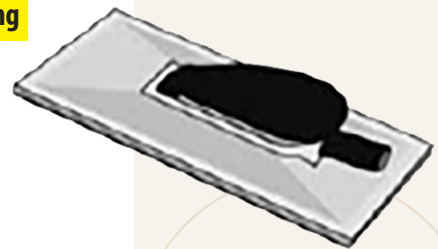
The block spreads out the pressure of your hand, resulting in a more even result. The difference may be slight, but once the paint goes on, the difference in the quality will be obvious.



Figure 9.2 Different sanding blocks



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Body filler

Auto body filler (otherwise known as putty or mud) is used by auto body technicians to fill in spaces on a vehicle's exterior after dents have been corrected.

Abrasives

Automotive repair and body shops rely on abrasive products to complete many tasks efficiently and effectively. Abrasives play a role in paint removal, cutting, polishing, and surface preparation before painting. Body shops need to find suppliers they trust to provide high-quality automotive abrasive products at competitive prices. When you use abrasives as part of every project, you will want to find products that perform as expected and produce excellent results.



Figure 9.4 P80 sandpaper

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Figure 9.5 P180 sandpaper



Figure 9.3 Example of body filler

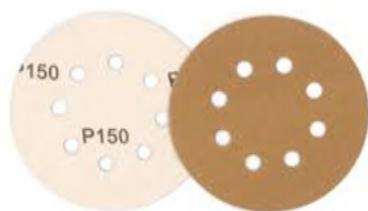


Figure 9.6 P150 Hookit disc

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Figure 9.7 P320 Hookit disc

Surface preparation on a body panel grind and feather edging operations

To perform surface preparation on a body panel grind and feather edging operations, The follow these steps to identify and assess the body panel that needs to be repaired:

- before working on a vehicle:
 - » identify the component materials involved in the construction of the vehicle in the areas that will be worked on during repair
 - » identify the component materials of the vehicle in the areas that you will work on during the repair
- select suitable PPE to wear and use vehicle coverings throughout all vehicle body panel repair activities
- before use of different tools and equipment, inspect, prepare, and use the tools and equipment following the manufacturers' instructions
- ensure your methods of preparation leave sub-structure body panels clean, free from materials likely to hinder repair, and free of surface finishes when required
- prepare and reinstate vehicle body panels using the equipment recommended and following the equipment manufacturer's methods/ instructions, recognised researched repair methods, workshop procedure, and health, safety and legal requirements.



Take note

The closer you can get the repair area to perfection before priming, the less priming and blocking you'll need.

Once the bodywork has been sanded and finished with 80 grit, the edges must be sanded smooth using 150 to 320 grit sandpaper. Paint edges left behind from grinding or sanding are rough, which may result in a lot of priming and blocking. Using a disc sander to layer each layer of coating at least 0,5 cm will eliminate the hard edges that may show up after painting and make the priming and blocking much faster.

Follow the following procedure once the surface has been prepared:

- Properly clean the surface.



Figure 9.8 Cleaning preparation of the surface

- Grind or sand the area (newer thin metal should have the coating removed using a disc sander with 80 grit sandpaper). This will reduce the amount of metal removed throughout the repair process.

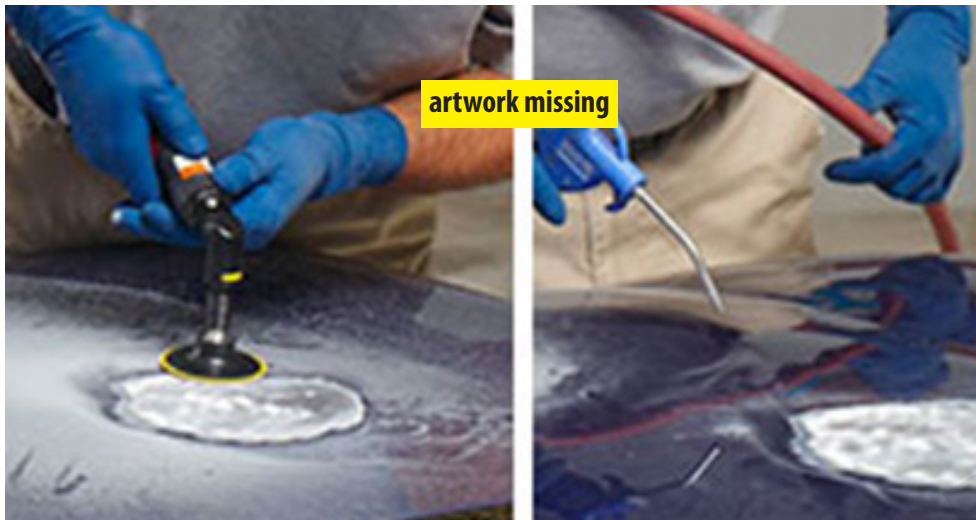


Figure 9.9 Grinding process

- Properly mix the body filler using a spreader and a mixing board.
- Blow the repair area off with compressed air and apply the body filler to the metal. Do not allow your body filler to overlap with the painted surface.
- Use a block sander to sand the filler before completely drying it using a cheese grater or 80 grit sandpaper. This will reduce the amount of sanding. Once completely hardened, shape the surface with 80 grit sandpaper and leave the surface slightly higher than the substrate. This will allow additional sanding using a finer grit to remove the 80 grit scratches.

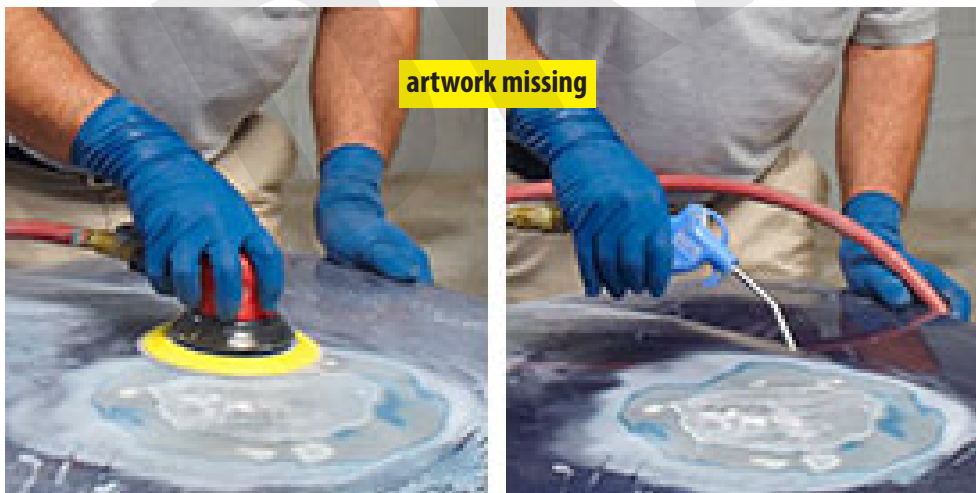


Figure 9.10 Sanding process

- Apply a guide coat to the repair area to help identify low areas.
- Sand the repair area using 120 grit sandpaper to remove the rough 80 scratches.

- Now the surface is ready to feather edge the surrounding paint edges. You can use 150 – 320 grit sandpaper on a disc sander to level or layer the surrounding paint edges and scratches.
- Next, apply a finish glaze and have the repair ready to prime and block.

PRACTICAL APPLICATION

Perform surface preparation on a body panel grind and feather edging operations

Work in groups.

Aim: To perform surface preparation on a body panel grind and feather edging operations

Resources:

- disc sander
- body panel
- different grits of sandpaper

What to do:

1. Work in groups of 3 or 4 learners.
2. Wash the panel following the workshop procedures.
3. Answer the following questions:
 - a) State the safety precautions while using the disk sanders.
 - b) Identify the following tools:



artwork missing



b.

- c) List FOUR (4) different types of grit for sandpaper.
 - d) List the steps that should be taken to identify and assess the body panel to be repaired.
4. Conduct grinding, sanding and feather edging operations on the scratched panel.

Spray painting

Primers

There are many different types of primers and fillers that are all 100% liquid. This ensures that every bit of material sprayed onto the panel, dries on the panel without any evaporation. Before using primer/fillers, make sure you read Technical Data Sheet to ensure that you are using the correct product.

Let's look at different primers that you will use in the Mechanical Technology workshop.

- **etch primer/filler:** a light green primer that must be mixed with an activator. Mixing ratios are nominally 2:1, but will depend on what paint product will be used. Always read Technical Data Sheet before mixing etch primers. They are suitable for priming normally difficult substrates, for example, aluminium, galvanised steel, fibreglass, and a variety of alloys.



Figure 9.11 Using etch primer

- **plastic primers:** designed for application to bare plastic surfaces such as polypropylene, fibreglass, and vinyl plastics (such as vehicle bumpers). Coating these substrates with plastic primer will render them overcoat tables with a range of products.



Figure 9.12 Example of plastic primer being applied

New words

etch to cut, bite, or corrode with an acid or the like; engrave with an acid or the like, as to form a design in furrows that when charged with ink will give

- **medium solid spray filler:** a yellow or grey primer that has a normal mixing ratio of 4:1 with a normal hardener for covering body filler. No thinner is added to any of the products before spraying – the TECHNICAL DATA SHEETS should always be referred to.

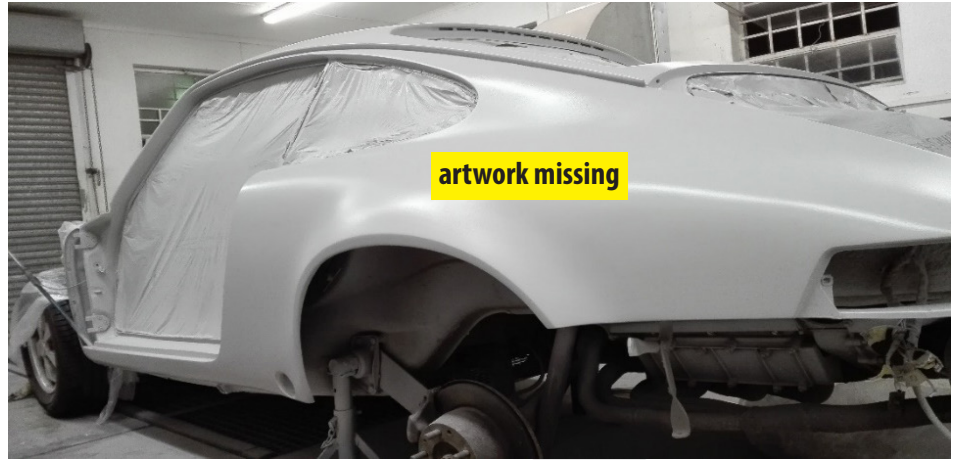


Figure 9.13 Medium Solid filler

The following precautions must be taken after applying primers:

- the spray gun should always be cleaned well using thinners after each use
- under no circumstances must the material be left in the gun for longer than 20 minutes – it will harden, and after 2 hours, will render the gun useless
- primers contain isocyanides that are poisonous and a derivative of cyanide gas. Ensure that you wear the correct breathing apparatus, and work in a spray booth to protect those working around you.
- apply 3 – 4 light cross-coats
- primer/filler dries hard so do not overspray other vehicles or panels
- allow two and a half hours for air drying, or force dry in 20 minutes at 40 °C before flattening
- do not mix more primer/filler than is necessary
- read technical data sheet for mixing ratio and drying times.
- **1K primers:** grey primer is a single-pack product that can be used to prevent overnight rust or short-term deterioration. It is not a filler so spot putty must be used to fill scratches otherwise you run the risk of sinkage in the topcoats because of the solvent evaporation. Black etch primer is the same and is only good enough as a primer.

Dry guide coats

A dry guide coat reveals surface imperfections such as pinholes and scratches. Dry consistency requires no masking and requires no drying time. The product may be used in both wet and dry sanding. It contains no added solvents and is ideal to highlight body lines.



Figure 9.14 Dry coats

Before flattening primer/filler, spray a guide coat (as shown in Figure 9.14) over the panel to indicate high and low spots as you flat. The black spots are the low spots that you need to flat away from the black guide coat. Once the black has been sanded evenly off, you are ready to move on to the next step.

A guide coat is mixed using one-part black air-drying paint and nine parts thinners. This gives a thin watery coat of black paint to thinly cover the yellow or grey primer.

Use these masking procedures when applying a guide coat:

- to achieve a good finish, the masking procedure must be good – and for the masking procedure to be good, the operator needs plenty of practice at masking. The sooner you learn to mask well, the sooner you can mask quickly and efficiently.

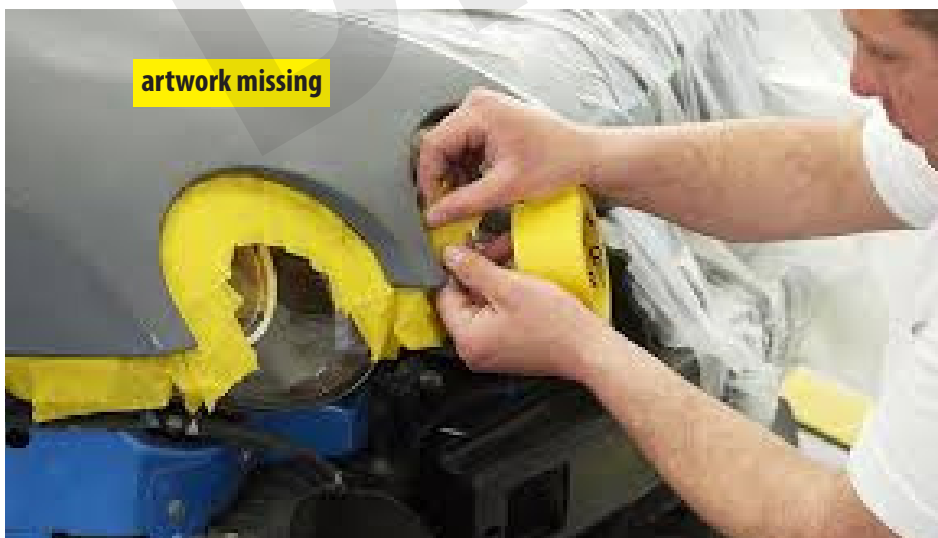


Figure 9.15 Masking



Take note

Remember to use large pieces of paper instead of lots of little ones.

- visualise what you will do and plan where you will start and end, and whether you will use the paper long way or sideways. Prepare one edge of the paper by folding it over and applying masking tape starting at a corner or long section. Make sure that there is no masking touching the paint when you have finished masking. This will cause some of the paint to be removed when you pull off masking, and you will have to touch up those places with a small touch-up brush afterward.
- not masking the entire vehicle properly will result having to remove paint from rubbers, plastic, etc. – which is not an easy task once the paint is dry.
- make sure that all masking has been firmly pressed down and stuck to prevent overspray from going in under the paper or masking tape. Make sure also that you have used the correct thickness of tape. If masking stripes or lines, use plastic tape as it is thinner and does not leave such a higher edge. It can also be bent around corners or shapes. Figure 9.16 shows a picture of a masking cart that helps us to stick the masking tape and paper together before applying them to the panel.

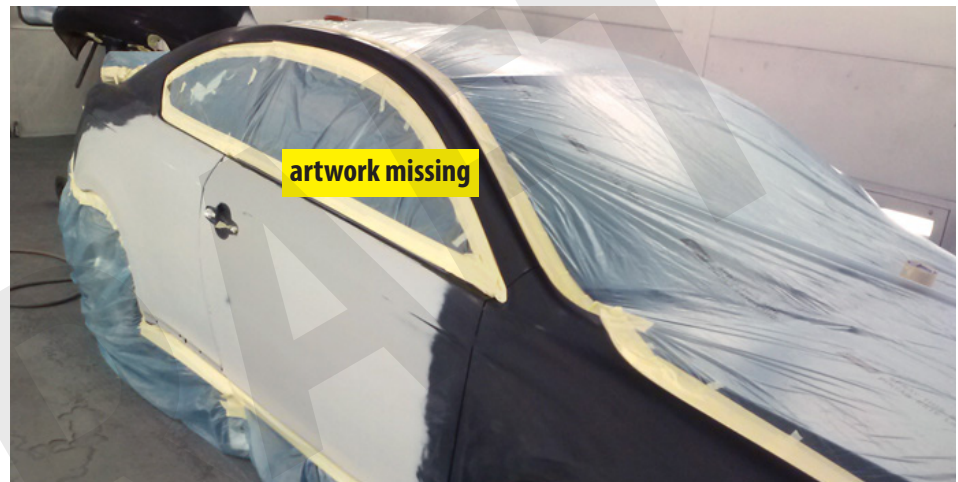


Figure 9.16 Make sure masking is firmly applied

Activity 1 Spraypainting

1. Define etch primer.
2. What is a plastic primer designed for?
3. State the precautions that must be taken after applying primers.
4. Describe how you would conduct masking on a panel that needed to be sprayed with primer.

PRACTICAL APPLICATION

Preparing a panel for primer

Work in groups.

Aim: To prepare a panel for primer

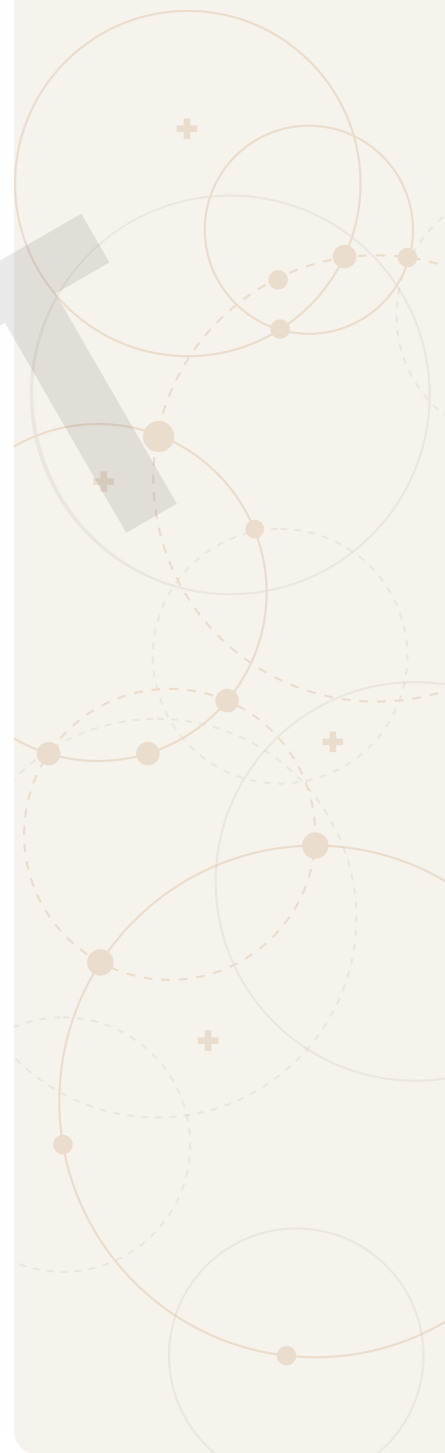
Resources:

- primer
- spray gun
- masking tape
- paper (to be used for masking)

What to do:

1. Work in groups of 3 or 4 learners.
2. Prepare a panel for primer by applying masking.
3. Demonstrate the correct use of primers following the manufacturer's manuals.

DRAFT



Glossary

- alloy** a metal made by combining two or more metallic elements, especially to give greater strength or resistance to corrosion
- annealing** a heat treatment process that changes the physical properties of a material to increase ductility and reduce hardness to make it more workable
- arson** the criminal act of deliberately setting fire to property
- circlip** a metal ring sprung into a slot or groove in a bar to hold something in place
- clutter** cover or fill (something) with an untidy collection of things
- co2** carbon dioxide (co2) is an odourless, colourless gas
- composites** a thing made up of several parts or elements
- conglomerates** a large corporation formed by the merging of separate and diverse firms
- coupling** a device for connecting parts of machinery
- deterioration** the process of becoming progressively worse
- disequilibria** a loss or lack of equilibrium or stability, especially concerning supply, demand, and prices
- ductility** is the ability of a material to be drawn and deformed into thin wire without fracture
- elevations** height above a given level, especially sea level
- employees** a person employed for wages or salary, especially at a non-executive level
- employers** a person or organization that employs people
- ferrule** a ring or cap, typically a metal one, which strengthens the end of a handle, stick, or tube and prevents it from splitting or wearing
- hazard** a danger or risk
- illegal substances** illegal drugs are those that are not prescribed by a doctor or bought at a pharmacy
- incidents** an instance of something happening; an event or an occurrence
- inoperative** not working or taking effect
- l2 and m28 powder** the l2 powder and m28 powder fire extinguishers (special powder extinguishers) are designed specifically to fight combustible metal fires (class d), such as sodium, lithium, magnesium, and aluminium
- negligence** failure to take proper care of something
- octagonal** shape with eight sides

osh act occupational health and safety act, act 85 of 1993

osteoporosis a medical condition in which the bones become brittle and fragile from loss of tissue, typically because of hormonal changes, or deficiency of calcium or vitamin d

precautionary measures carried out as a precaution, preventive

prohibition the action of forbidding something, especially by law

recesses a hollow space inside something

regulations a rule or directive made and maintained by an authority

respirators an apparatus worn over the mouth and nose or the entire face to prevent the inhalation of dust, smoke, or other noxious substances

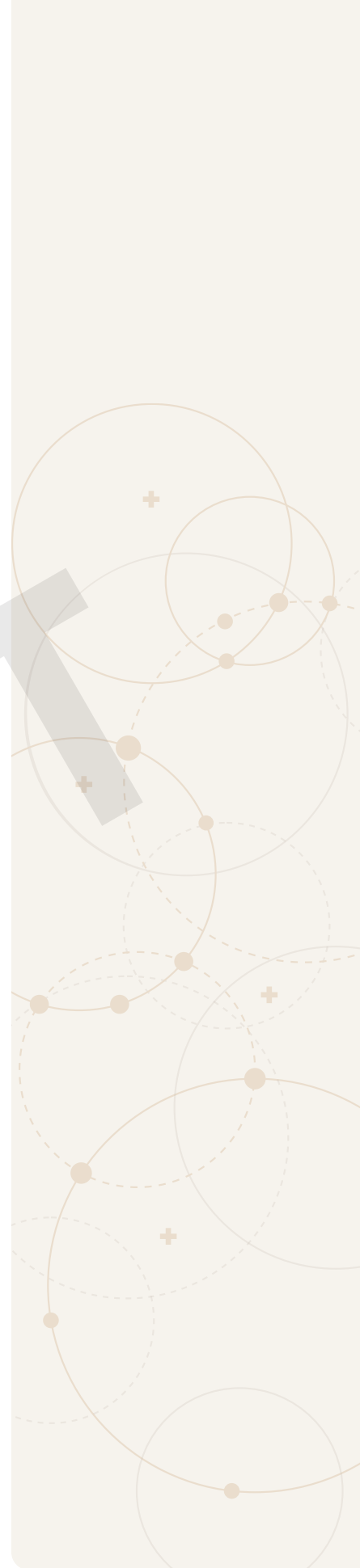
revenues income, especially when of an organization and substantial nature

spindle a rod or pin serving as an axis that revolves or on which something revolves

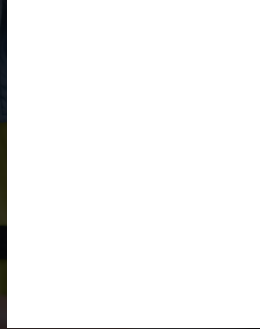
tempered improve the hardness and elasticity of (steel or other metal) by reheating and then cooling it

workshop a room or building in which goods are manufactured or repaired

DRAFT



Other books in the series



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