SECTION

1

INTRODUCTION TO SAFETY, ENGINES, BUILDING CONSTRUCTION AND MEASUREMENT

UNIT 1

WOODWORK TECHNOLOGY

Tools and Machines in the Woodwork Industry

INTRODUCTION

Staying safe in the workshop is an essential aspect of woodworking practice. Safety is paramount, not just within the workshop, but also in protecting ourselves and others in all environments. In woodworking technology, safety rules are important because of the wide range of potentially hazardous tools and machines involved. However, safety is not only about the tools; it also includes the proper handling of materials to prevent accidents. By mastering these concepts, you will enhance your safety skills, knowledge, and behaviours, laying a solid foundation for responsible woodworking. Let us begin our journey to understand the crucial role of safety in woodwork technology and its wider application in the field of applied technology.

At the end of this unit, you should be able to:

Apply the appropriate safety measures in the workshop.

Key Ideas

Safety is paramount when carrying out activities in the workshop. It is important to follow clear and specific guidelines and instructions to ensure safe working practices at all times and a positive learning experience. This includes:

- Knowing your tools
- Wearing personal protective equipment (PPE)
- Following instructions
- Maintaining a clean workspace
- Assessing, managing, and minimising risks
- Taking your time, seeking assistance when necessary, and
- Reporting any hazards you encounter immediately.

These practices will create a safe and enjoyable environment for everyone involved.

Keywords: apply, appropriate, assess risks, hazards, safety gear, safety, measures, workshop.

WORKSHOP SAFETY

Workshops are dynamic environments where individuals carry out a range of tasks, from constructing and creating to repairing and building. These spaces are equipped with the tools, machinery, and equipment needed to complete specific projects or tasks efficiently. However, in the midst of productivity and creativity, safety remains of utmost importance.

Fig. 1.1.1: Safety first

Prioritising safety—often referred to as "Safety First"—means ensuring that safety takes precedence over all else. This helps to maintain controlled working conditions, preventing injury to yourself, harm to your co-workers, and damage to the workshop, its equipment, and materials. The "Safety First" principle is particularly crucial when handling tools, machinery, and materials.

Workshop safety encompasses the rules and precautions put in place to protect individuals working with tools, materials, and machinery in a woodwork environment. This involves keeping the workspace clean and organised to reduce the risk of hazards such as trips or slips. Additionally, proper storage and handling of tools and equipment are essential to prevent accidents, as shown in Fig. 1.1.2.

Fig. 1.1.2: Clean and organised workspace

Workshop safety also includes regular inspections and maintenance of machinery to ensure it operates properly and does not present any risks to workers.

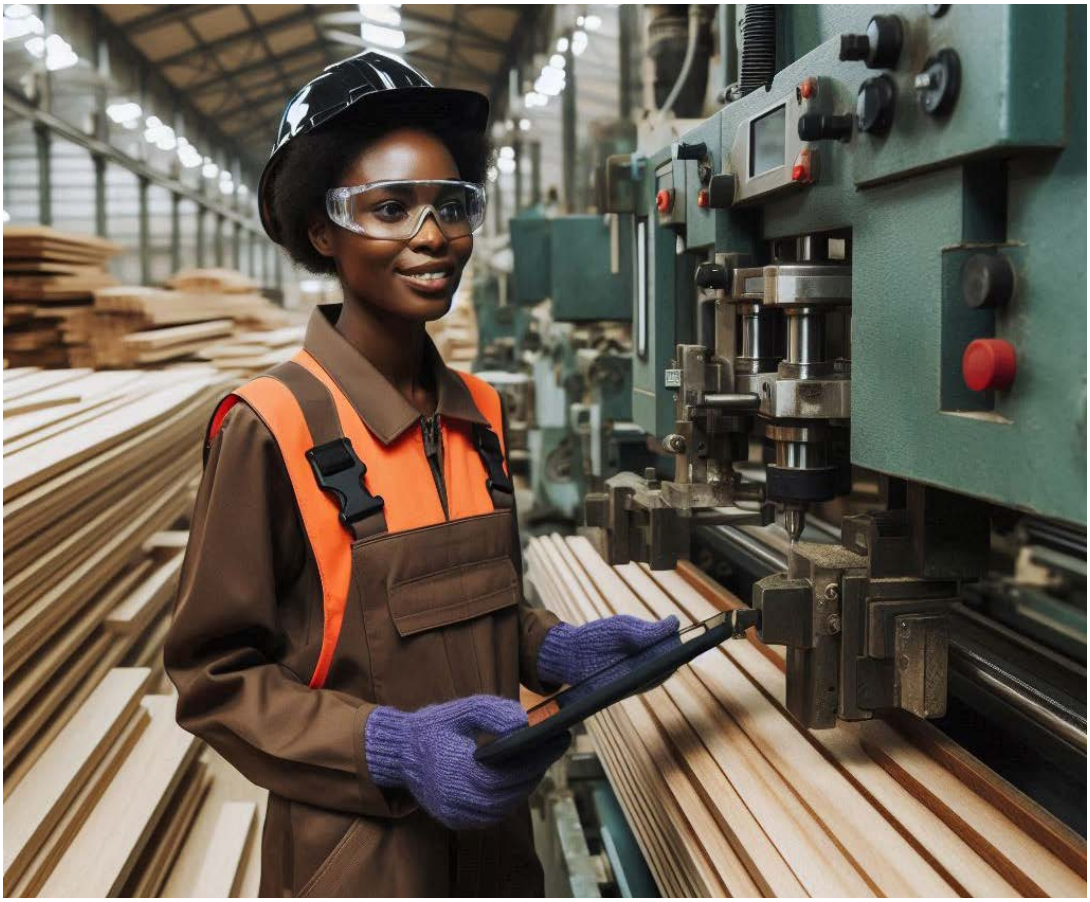


Fig. 1.1.3: A female worker standing in a timber warehouse of a hardwood furniture factory inspecting a production machine.

Additionally, workshop safety should include providing proper training and supervision to workers to ensure they always understand and adhere to safety guidelines.

Fig. 1.1.4: A woodworker adhering to safety guidelines by wearing appropriate PPE to finish a woodwork task.

Activity 1.1.1

Work in pairs to complete all activities under this activity. Perform all the activity tasks under the supervision of your teacher and /or workshop manager or owner.

1 a. With your partner, walk around the school premises with worksheets that include a checklist of common safety hazards. Identify and note down the hazards you observe, discussing each one as you go along. Use the following checklist of common safety hazards:

i. Inadequate use of personal protective equipment (PPE)
ii. Insufficient safety training for staff
iii. Improper handling of machinery and tools
iv. Exposure to wood dust and harmful chemicals
v. Fire hazards from flammable materials
vi. Electrical hazards from faulty wiring
vii. Noise pollution and risk of hearing damage
viii. Lack of adequate ventilation
ix. Poorly maintained equipment
x. Inadequate first aid facilities
xi. Absence of emergency exits
xii. Unsafe storage of materials
xiii. Exposure to bacterial and viral infections
xiv. Physical injuries from sharp tools
xv. Lack of or outdated safety signs
xvi. Machinery left unattended while in operation
xvii. Obstructions of fire exits and safety switches
xviii. Lack of regular safety inspections
xix. Non-compliance with occupational health and safety regulations

b. With your partner, visit a nearby workshop, bringing worksheets and a checklist of common safety hazards. As you observe, note down any hazards you identify and discuss them together.
Note: Follow all safety rules and regulations during your visit. Be sure to comply with any instructions provided by the workshop manager.

2. Each pair will present the top five most critical hazards they found and suggest solutions to mitigate them.

3. a. With your partner, discuss why these hazards pose significant dangers.
b. With your partner, discuss the importance of adhering to safety rules in the workshop.

4. Once completed all the activities above, share your findings with the class for further discussion.

NB: If you are unable to visit a local workshop, use the image below to complete the activities.

Fig. 1.1.5: An untidy workshop image

Safety Practices to Prevent Injury to Oneself and Co-Workers, Damage to Tools and Hand-Operated Power Tools and Machines

Safety in the workshop is essential to protect both individuals and equipment. By following proper safety practices, we can prevent injuries, ensure smooth operations, and maintain the longevity of tools and machines. These practices include using the correct personal protective equipment (PPE), handling tools and machinery responsibly, and maintaining a clean and organised workspace. Adhering to these guidelines helps create a safe and efficient working environment for everyone.

Safety Measures or Precautions

Safety measures or precautions are general rules and regulations given to workers to follow to prevent accidents, such as wearing safety gear clothing, personal protective equipment (PPE), or following safety protocols.

Fig. 1.1.6: A woodworker using a spirit level measure and wearing appropriate PPE in the wood workshop.

Accidents in the workshop can happen for various reasons, such as improper use and handling of hand tools, operating machines and portable tools incorrectly, or tripping over and bumping into obstructions left on floors or benches. Additionally, accidents may occur when lifting, moving, or storing materials and workpieces, dealing with flammable or corrosive liquids and gases, or inhaling toxic vapours or fumes. Ensuring safe practices and awareness of these potential hazards is crucial to maintaining a safe working environment.

Safety measures are essential as they help prevent injuries, ensure proper tool maintenance, improve work efficiency, and promote adherence to rules and regulations, while fostering a sense of responsibility for each other's well-being. By understanding the causes of accidents and following safety guidelines, we can ensure a safer environment for everyone in the workshop.

Safety measures are categorised into personal safety, tool and equipment safety, machine safety, and material safety.

Personal Safety

Personal safety refers to the actions and precautions individuals take to protect themselves from harm or injury while working in the workshop. It involves being aware of potential risks and hazards in the environment and taking proactive steps to minimise those risks. Personal safety also encompasses the physical, emotional, and psychological well-being of the individual, ensuring a holistic approach to safety in the workplace.

Manual handling and lifting are crucial skills to learn to prevent injuries and promote safety. This is essential as it helps avoid musculoskeletal injuries, fosters safety awareness, helps develop useful skills, and promotes physical well-being.

Personal safety focuses on understanding the risks associated with improper manual handling and learning the basic principles of safe lifting. To assess a load, plan the lift, and position yourself correctly, with your feet shoulder-width apart. Proper lifting techniques involve bending the knees, keeping your back straight, using your leg muscles, and holding the load close to your body.

When handling awkwardly shaped or positioned items, it's important to adjust your grip, seek assistance when necessary, and emphasise teamwork for heavy or large items. When moving items over longer distances, ensure you carry them safely, take breaks as needed, and maintain a steady pace. When setting down items, bend your knees and lower the load gradually.

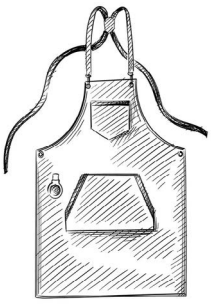
If lifting items to greater heights, use a step stool or ladder and maintain balance and control, especially when lifting above shoulder height.

In summary, equipping yourself with safe manual handling and lifting techniques helps reduce the risk of injury and fosters a culture of safety and health, preparing you for future challenges.

Always wear appropriate safety gear, known as Personal Protective Equipment (PPE), which includes safety glasses or goggles, gloves, safety boots, helmets, aprons, overcoats, overalls, and earplugs. These items protect you from hazards such as fires, falling objects, flying debris, sharp tools, sparks, cuts, eye injuries, and loud noise.

The table below shows the pictures and uses of Personal Protective Equipment (PPE).

Table 1.1.1: Uses of the Safety Gear: Personal Protective Equipment (PPE)

Name	Picture	What to Inspect	Uses
Gloves		**Check for damage:** tears, punctures, cracks. **Fit:** Snug but comfortable. **Cleanliness:** Clean and contaminant-free. **Material suitability:** appropriate for specific hazards.	Protect hands from cuts, burns, abrasions, and chemical exposure. Used in tasks involving handling sharp objects, tools, and chemicals like lacquer, cellulose thinner, etc.
Goggles/safety glasses		**Lens Condition:** No scratches, cracks, or cloudiness. **Frame Integrity:** No damage. **Fit:** Secure and comfortable. **Cleanliness:** Clear lenses. **Coatings:** anti-fog, anti-scratch intact.	Shields the eyes from dust, debris, chemicals, and splashes. Essential for tasks involving drilling, sanding, or handling hazardous materials.
Aprons/ overcoat /overall	 	**Fabric Condition:** No tears, or holes. **Cleanliness:** Clean and contaminant-free. **Seams/Closures:** Functional. **Fit:** Proper fit, unrestricted movement.	Shields clothing from stains, spills, and chemical splashes. Provides an additional layer of protection for the body during tasks involving hazardous materials or a messy woodwork environment.

Strong leather boots		**Sole condition:** No wear, cracks, or separation. **Upper condition:** No cracks, or tears. **Protection:** steel toe intact. **Fit:** comfortable, stable. **Waterproofing:** Effective as required.	Protects the feet from serious injuries, punctures, and electrical hazards. Designed with reinforced toes and soles to withstand heavy objects, sharp objects, and chemicals such as oils and acids.
Face mask		**Filter:** Not expired, unclogged. **Straps**: elastic, secure. **Fit/Seal:** Proper seal, no gaps. **Cleanliness:** Clean, single-use if disposable. **Valves:** Functioning properly.	Helps prevent the inhalation of airborne particles, dust, and contaminants. Used in environments with poor air quality or during tasks such as sanding, painting, or working with chemicals.
Helmet/cap/ beret		**Shell Condition:** No cracks or dents. **Suspension:** Functional, intact. **Chin Strap:** Secure, adjustable. **Fit:** Snug, stable. **Expiry:** Check and replace if necessary.	Guards the head against impacts, falling objects, and overhead hazards.

Ear protector/ earmuff		**Cushions:** No wear, cracks. **Headband:** Not bent, broken. **Fit:** Good seal around ears. **Cleanliness:** Regularly cleaned. Noise Reduction **Rating:** Appropriate for noise levels.	Reduce exposure to loud noises and prevent hearing damage. Worn in noisy environments such as wood workshops, factories, etc.

Safety for Tools and Equipment

Safety for tools and equipment involves implementing measures and practices to prevent accidents, injuries, and damage when using tools and equipment. Essential measures for ensuring the effective and safe use of tools and equipment include:

1. **Proper training**: Ensure that you receive adequate training before using tools and equipment. This includes understanding their correct operation, handling, and maintenance to ensure safety and efficiency.
2. **Inspecting tools**: Regularly inspect tools and equipment for damage, defects, or wear before use. Damaged items should be repaired or replaced to prevent accidents or injuries.
3. **Following the manufacturer's instructions**: Adhere strictly to the manufacturer's guidelines for the safe use of tools and equipment. This includes observing weight limits, voltage ratings, and other specifications such as operational principles and procedures.
4. **Securing workpieces**: Ensure that workpieces are properly secured and stabilised before using tools or equipment to prevent them from slipping or moving, which could cause accidents.
5. **Maintaining a safe work area**: Keep the work area clean, organised, and free from debris to reduce tripping hazards and allow for safe movement while using tools and equipment.
6. **Using tools for their intended purposes**: Only use tools and equipment for their designed purposes. Improvised or improper use can lead to accidents, injuries, and damage to the tools or equipment.
7. **Proper handling and storage**: Handle tools and equipment with care and store them safely when not in use. Sharp edges should be protected, and tools must be stored in designated areas, away from unauthorised access.
8. **Safe operation**: Operate tools and equipment cautiously, being aware of potential hazards. Maintain a firm grip, ensure control, and keep hands and fingers clear of moving parts.

9. **Emergency preparedness**: Be familiar with emergency procedures, such as the location of first aid kits, fire extinguishers, and emergency shut-off switches. Additionally, know how to administer basic first aid if necessary.

Activity 1.1.2

1. In this activity, work in groups of five to identify the correct Personal Protective Equipment (PPE) for different woodworking tasks and understand how to use it safely.

Instructions:

a. **Scenario Assignment**:

   i. Each group will receive a scenario where different types of PPE are needed for specific woodworking tasks.

   ii. Example scenarios:

   - **Building a classroom desk.**
   - **Applying finishes to a classroom desk.**
   - **Handling rough timber.**
   - **Sanding a classroom desk.**
   - **Creating a wooden desk organiser.**

b. **PPE Hunt**: Around the classroom or school compound, various PPE items will be placed. Your task is to find the correct PPE for each scenario given to your group.

c. **Group Discussion**: Once you have identified the appropriate PPE for your scenario, discuss with your group why it is important for that specific task. Explain:

   i. **How the PPE is used.**

   ii. **Why it is important to use the correct PPE.**

   iii. **What could happen if the correct PPE is not used.**

d. **Present Your Findings**:

   i. Each group will present their scenario to the class, showing the PPE they found and explaining its use.

   ii. You will also demonstrate the proper way to wear the PPE for your scenario.

e. **Class Discussion**: As a whole class, led by the class rep or anyone chosen by the teacher, discuss the importance of using the correct PPE for different tasks. How does PPE help prevent injuries, infections, and other hazards?

Activity 1.1.3

1. Imagine your classroom has been transformed into a woodworking workshop. You are a new apprentice, and the workshop manager expects you to demonstrate how to correctly wear various pieces of Personal Protective Equipment (PPE). Around the workshop, PPE discovery zones have been set up, each containing different PPE items. Your task is to step into each zone and try on the PPE.

Tasks:

a. Visit each PPE discovery zone in the classroom, and carefully select the appropriate PPE items. Make sure to try on each item and take note of how it fits and feels when worn correctly.

b. Use a video recording device to capture yourself as you put on each piece of PPE. As you record, explain the importance of each item and how it protects you in the woodworking workshop. For example:

- **Safety glasses** protect your eyes from flying debris.

c. After completing the video, take a moment to reflect on what you learnt about each piece of PPE. Write down your thoughts on the importance of wearing them correctly and how they contribute to your safety in the workshop.

d. Share your recorded video with a classmate and your facilitator. Discuss your experience and the value of wearing PPE in the workshop environment.

2. Your woodworking workshop has received a donation of used tools and equipment. Some of these tools are not in the best condition and need to be examined to determine what repairs or maintenance are needed to ensure they are safe for use. Working in groups of three, you will assess the condition of the tools and perform basic maintenance to make them ready for the workshop.

Tasks:

a. **Tool and Equipment Assessment**: Choose a tool or piece of equipment to assess. Use the checklist below to evaluate its condition:

i. Check for cracks, dents, or broken parts.
ii. Ensure the handles are not worn or damaged.
iii. Test to see if the tool moves smoothly without getting stuck.
iv. Make sure powered tools start and run smoothly.
v. Confirm safety covers and guards are in place and functioning.
vi. Test emergency stop buttons or switches.
vii. Inspect wires for cuts or damage.
viii. Ensure plugs fit properly and are not broken.
ix. Clean off any dust or dirt.
x. Oil parts that need lubrication.

xi. Check if the tool looks good for use and decide if it needs fixing.

b. **Record Your Findings**: Use the table below to document your assessment and identify any work required to make the tools safe.

Tool/Equipment Item	Condition	Work Required to Make Safe

c. **Give reasons why it is important to** perform the necessary maintenance on the tools and equipment. This may include tasks like sharpening blades, tightening screws, or oiling moving parts.

d. Prepare a simple maintenance guide for the tools and equipment you assessed. This guide should outline the type of maintenance needed and how often it should be done to keep the tools in good working order. Use the table below to organise your maintenance schedule:

Tool/Equipment Item	Maintenance Needed	How Often

e. Present your findings to the class, explaining the steps you took to assess and maintain the tools. Include the importance of tool care in ensuring a safe and efficient working environment.

Workshop Machine Safety

Machine safety refers to the practices, measures, and standards established to ensure the well-being of individuals interacting with machines. In the machine shop, it is crucial to follow these rules to maintain safety:

1. Take a safety test before operating any machine.
2. Do not touch machine controls without permission.
3. Always ask for approval before using a machine.
4. Wear the correct and appropriate PPE.
5. Wear goggles when using dusty machines.

6. Follow classroom rules—no running or playing around machines.
7. Ensure there is sufficient space to work safely.
8. Clean up scraps and debris from around the machine.
9. Only use the switches and controls if you are the one operating the machine.
10. Do not distract others while they are working.
11. Keep a safe distance from moving parts and never place your hands near them.
12. Inspect materials for hazards before using the machine.
13. Always remain focused on the task. If you need to speak with someone, turn off the equipment first.
14. Ensure safety guards are properly installed on all moving parts of machines, as shown in Fig. 1.1.7
15. Keep your tools clean and sharp and store them safely when not in use.
16. Turn off machines before attempting any repairs or cleaning.
17. Use clamps to secure workpieces before starting work.
18. Make sure you can easily start and stop the machine.
19. Always switch off a machine and wait for it to come to a complete stop before making any adjustments to avoid injury and prevent damage to the machine, as shown in Fig. 1.1.8.
20. Adhere strictly to the instructions provided for operating the machines.

By following these guidelines, you will ensure a safer environment in the workshop and reduce the risk of accidents.

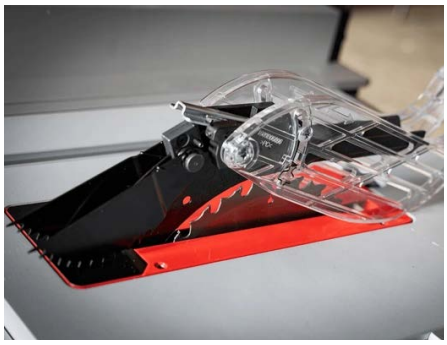


Fig. 1.1.7 (a): Table saw blade with smart guard system

Fig. 1.1.8: Warning Safety Label: Exposed moving parts can cause severe injury.

Materials Safety

Materials safety involves the precautions and measures taken to prevent accidents or injuries associated with handling and using materials in a woodworking workshop. This includes understanding the potential hazards linked to different materials, such as wood, metal, or chemicals, and adopting appropriate steps to mitigate those risks.

For instance, materials safety may involve storing materials correctly to prevent them from falling and causing injuries, as well as using protective gear such as gloves or masks when handling hazardous substances. It also includes the proper disposal of waste materials to minimise environmental impact and reduce the risk of accidents.

Conclusion

Now that you have learnt about safety—covering workshop safety, personal safety, tool and equipment safety, machine safety, and material safety—these measures are vital in any hands-on work environment. It is expected that you follow these safety precautions to prevent accidents and injuries to yourself and others, avoid damage to materials, tools, and equipment, and maintain a safe and productive workspace for everyone.

By adhering to these guidelines, you not only protect yourself but also contribute to a safer, more efficient workshop where tasks can be completed smoothly, and potential hazards are minimised. Remember, safety is everyone's responsibility.

Activity 1.1.4

1. As a new apprentice in the woodworking workshop, you are assigned to research how to safely operate different machines, paying close attention to the importance of safety measures.

   Working in groups of five, each group will be assigned a machine from the workshop, such as a table saw, lathe, sander, drill press, or band saw. Your task is to research your assigned machine, focusing on its safety features and the correct procedures for operating it.

   Your group will then create a "Safety Quest Checklist," which must include all the necessary safety precautions and step-by-step instructions for using the machine safely.

   To complete the activity, follow these tasks:

   a. **Research your machine**: Explore the safety features and proper operating procedures of your assigned machine. You can use workshop materials, manuals, and online resources.

   b. **Create your checklist**: Design a clear and easy-to-follow "Safety Quest Checklist" that highlights key safety precautions and the correct way to operate the machine.

   c. **Discuss and record**: In your group, answer the following questions and record your findings:

      i. What did you learn that could be useful to share with your classmates?

      ii. How will this knowledge change your own personal safety habits when handling machines?

      iii. What are the potential consequences of ignoring safety measures when operating these machines?

   d. **Presentation**: Present your findings and your Safety Quest Checklist to the class. Each group will explain their machine, its safety precautions, and demonstrate the proper operating procedures.

Activity 1.1.5

Imagine you and your classmates are working on a woodworking project in the workshop. While selecting materials, you notice that some wood pieces are cracked and splintered, and there are open containers of stain and varnish without proper lids. To ensure everyone's safety, your group will work together to handle these materials safely and come up with ways to improve safety in the workshop.

You will work in groups of five. Your group will be provided with the following materials: assorted wood pieces (some cracked and splintered) and containers of stain and varnish (some without proper lids). You will also have access to the necessary PPE to use during the activity.

Instructions:

1. **Examine the Materials:**
   a. Inspect the wood pieces for cracks, splinters, and any other defects.
   b. Check the containers of stain and varnish, making sure they have proper lids and look for any signs of leakage.
2. **Answer These Questions:**
   a. What safety hazards can you identify with the materials you have inspected?
   b. What are the potential risks posed by these materials?
   c. How could these hazards cause harm in the workshop?
   d. How should flammable liquids, like the containers of stain and varnish, be stored safely?
   e. What PPE should you wear when handling cracked or splintered wood, and when handling containers of stain and varnish?
   f. Why is it important to follow safe storage practices and wear appropriate PPE when handling materials?
3. **Create a Safety Plan:** Based on your inspection, develop a safety plan to address the identified hazards. This could include guidelines for handling and storing materials safely.
4. **Come Up with Creative Solutions:** Think of innovative ideas to reduce the risks and improve material safety in the workshop. This might involve designing a safe storage area for hazardous materials or creating a safety poster to hang on the workshop wall.
5. **Present Your Findings:** Share your group's findings and ideas with the rest of the class. Explain why your proposed solutions are important for ensuring safety when handling materials in the workshop.

Activity 1.1.6

Read the case studies below and in pairs, answer and discuss the questions.

Case Study 1: The Slippery Floor

Ama is working in a wood shop. After applying a finish to a wooden table, she spills some liquid on the floor but doesn't clean it up. A few minutes later, her classmate Yaw slips on the wet floor and injures his knee.

Questions:

1. What caused Yaw's accident?
2. What safety rule should Ama have followed?
3. How could Ama prevent accidents like this from happening again?

Case Study 2: The Distracted Worker

Kwame is sanding a wooden desk, but he forgets to wear his dust mask. While sanding, dust particles get into his nose and mouth, causing him to cough and feel unwell. Later, he realises he has difficulty breathing.

Questions:

1. What safety rule did Kwame break?
2. Why is it important to wear a dust mask when sanding?
3. What could happen if someone ignores this safety rule over a long period?

Case Study 3: Strain from Heavy Lifting

Kojo tries to lift a heavy toolbox on his own without bending his knees. As he lifts, he feels a sharp pain in his back and has to stop working for the day.

Questions:

1. What mistake did Kojo make when lifting the toolbox?
2. How could he have lifted the toolbox safely?
3. Why is it important to follow proper lifting techniques in the workshop?

Case Study 4: Misusing a Tool

Adwoa is using a hammer to drive nails into a wooden frame, but instead of holding the hammer properly, she swings it too hard and misses the nail, hitting her hand. She ends up with a painful bruise.

Questions:

1. What mistake did Adwoa make while using the hammer?
2. What is the proper way to use a hammer?
3. Why is it important to use tools the right way in the workshop?

Extended Reading

1. Click on the link below to watch a video on how to use a surface planer in Woodworking

https://www.youtube.com/watch?v=vxyQJCMLCsI

2. To read more on Personal Protective Equipment (PPE), click the link below

Walton, J.A. (1974), Woodwork in Theory and Practice (metric edition), pages 1-4.

3. Amoakohene, S. K. & Sackey, J. K. N. (2007). Metalwork Technology (Motivate series), Macmillan Education, pages 1-2.

Review Questions for Section 1, Unit 1

1. Imagine you are starting a new project in the workshop. How would you inspect the area to identify any potential hazards? What steps would you take to address or avoid these dangers before beginning your work?
2. If someone accidentally cuts their finger with a bandsaw, what actions would you take to assist them? How can you ensure that everyone remains safe in this situation?
3. When using a sander to smooth wood, what personal protective equipment (PPE) should you wear? Explain the purpose of each piece of PPE and why it is necessary for your safety.
4. When using a drill to make holes in timber, how can you ensure that you operate it safely? What safety precautions should you follow before, during, and after using the drill?
5. If you need to carry heavy wooden boards across the workshop, what techniques should you use to do so safely? What should you be mindful of to avoid injury?
6. At the end of the day, you are responsible for cleaning up the workshop. Why is it important to keep the workshop tidy? How does maintaining a clean and organised workshop contribute to everyone's safety?
7. As an applied technology student, you need to adopt safe working practices to protect yourself from injuries and keep the tools, equipment, and machines free from damage.

Copy and complete the table below by briefly describing the safety issues and the importance of addressing them:

Safety Issue	Brief description of the safety issue	Importance of addressing the safety issue.
i. Ventilation		
ii. First aid and emergency response		
iii. Training and awareness		
iv. Housekeeping		

REFERENCES

Walton, J.A. (1974), Woodwork in Theory and Practice (metric edition).
Amoakohene, S. K. & Sackey, J. K. N. (2007). Metalwork Technology (Motivate series) Macmillan Education.
Rundmo, T. & Hale, A. R. (2003). Managers' attitudes towards safety and accidents Prevention. Safety Science, 41(7), 557-574. https://doi.org/10.1016/S0925-7535(01)00091-1

UNIT 2

AUTOMOTIVE TECHNOLOGY

Introduction to Engine Technology

INTRODUCTION

In this unit, we will explore the various types of automotive engines and provide detailed descriptions of their main components. Understanding the two primary types of internal combustion engines and the fuels they use will help you make informed decisions about the choice of car you might buy or drive in the future. By examining the main component parts of the engine, you will gain valuable insights into how each element contributes to the engine's overall performance.

At the end of this unit, you should be able to:

Identify types of engines and describe the main component parts of the engine.

Key Ideas

- Many machines used in everyday life rely on engines to perform their tasks.
- The role of an engine is to convert the energy in fuel into another form that enables various parts of the machine to move and perform work.
- For example, an automobile engine transforms chemical energy into mechanical energy, which powers the vehicle.
- This mechanical energy results from a combustion process that generates very high temperatures within the engine's cylinders.
- An automotive engine needs adequate heat to operate effectively.
- The high temperatures we feel when sitting in a car are due to the combustion of fuel in the engine's cylinders.

ENGINES

The engine is the primary source of power in motor vehicles. It transforms chemical energy from the fuel into mechanical energy through an internal combustion process, which produces the power needed to drive the road wheels or any other machinery connected to the engine.

Engines play a crucial role not only in powering vehicles but also in a wide range of applications, from industrial machinery to household equipment. Understanding how engines operate can enhance your appreciation of their design and functionality, as well as inform your decisions on maintenance and repairs.

Purpose of Automotive Engines

The engine is the main source of power for the automobile (or car). It is considered the heart of the vehicle. Its main function is to convert the chemical energy in the fuel into mechanical energy that will propel or move the vehicle. The mechanical energy is achieved through the heat that is generated when the fuel is burnt. The type of fuel used by the engine must possess good combustion characteristics for an efficient result.

Types of Engines

Automotive engines are categorised into two main groups. These are **external combustion** and **internal combustion engines**.

External Combustion (EC) Engine

External combustion engines powered the earliest self-propelled vehicles. In these engines, the burning of fuel occurred outside the engine, typically in a separate container known as a boiler or furnace, which held water or other volatile liquids. Heat was applied to the liquid until it reached its boiling point, generating steam. This steam was then compressed under high pressure and directed into the engine's cylinders, where it exerted pressure on the pistons.

Due to the need for a large container to store both the working fluid and the fuel, external combustion engines were bulky. As a result of their size and inefficiency, they are no longer used in modern automobile applications.

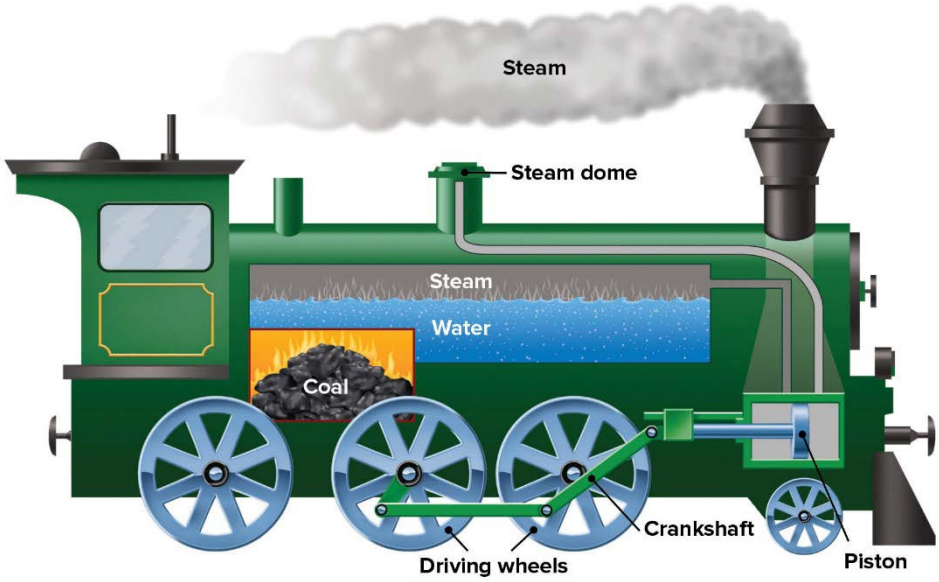


Fig. 1.2.1: An external combustion engine

Activity 1.2.1

1. Watch a video on "Stirling External Combustion Engine", available at the following link:
   https://youtu.be/zTKmCbZnYko?si=nY4okkw1fuuah4da
2. In addition, read relevant documents or books from your school library or online resources to study how external combustion engines work.
3. After completing your research, create a table listing the advantages and disadvantages of external combustion engines.
4. Be prepared to present your findings in class.

Internal Combustion Engine

This type of engine uses a volatile fuel, which is ignited within an airtight cylinder to produce the mechanical energy that powers the vehicle. The combustion of the fuel occurs directly inside the engine's cylinders.

Internal combustion engines typically run on fuels such as petrol, diesel, and liquefied petroleum gas (LPG). For efficient combustion, the engine requires an adequate supply of oxygen and a heat source to ignite and burn the fuel. The combustion process causes expansion within the combustion chamber, which forces the piston away, exerting pressure on the crankshaft and causing it to rotate. This rotational force is what propels the vehicle. Any leakage of hot gases during combustion reduces the engine's efficiency and can also lead to accidents.

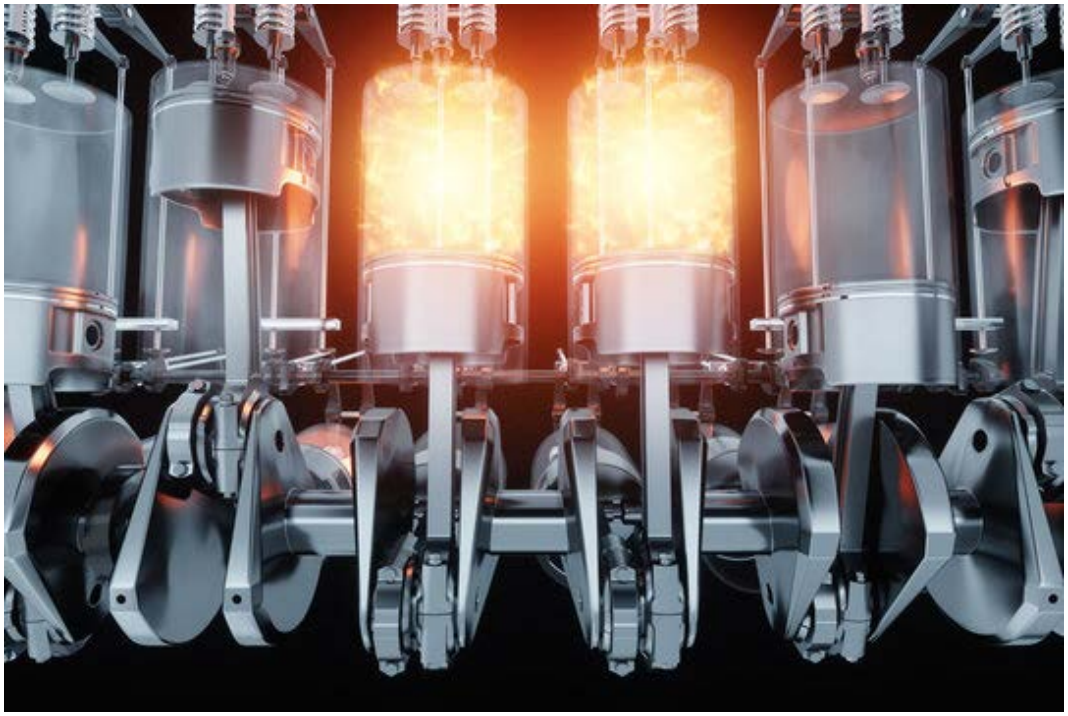


Fig. 1.2.2 Internal combustion engine

Activity 1.2.2

Provide a diagram or illustration displaying the component of a vehicle that uses an internal combustion engine, as commonly seen in everyday life.

Types of Internal Combustion Engineers

There are two main types of internal combustion engines used in modern automobiles: spark ignition (SI) and compression ignition (CI) engines. Both types use reciprocating pistons to generate power and operate on either a two-stroke or four-stroke piston cycle. Regardless of whether it is a two-stroke or four-stroke engine, a reciprocating engine performs the induction, compression, power, and exhaust operations to complete a power cycle. This will be explored further in Unit 2 of Section 2.

Internal combustion engines can also be classified in other ways, including:

1. the number of strokes required to complete a cycle (two-stroke or four-stroke),
2. the number of cylinders (single-cylinder or multi-cylinder),
3. cylinder block design (in-line, vee, flat, or rotary),
4. the medium used to cool the engine (water-cooled or air-cooled), and
5. the method of igniting the fuel in the combustion chamber (spark ignition or compression ignition).

Spark Ignition (SI) Engines

Spark ignition engines are popularly known as petrol engines. The main type of fuel used is gasoline. This type of engine uses a spark, produced by a spark plug, to ignite the fuel inside the combustion chamber. In petrol engines, fuel and air are premixed to form a *charge*. The charge is fed into the combustion chamber and then compressed under high pressure by the piston before it is ignited and burnt.

Compression Ignition (CI) Engines

Compression ignition engines (also called diesel engines) use diesel as their main fuel. In these engines, only air is drawn or pumped into the combustion chamber and then compressed by the piston before the diesel fuel is added. Unlike petrol engines, diesel engines use a fuel injector to spray atomised fuel into the combustion chamber after the air has been compressed to a very high temperature. The already compressed hot air in the combustion chamber ignites the fuel the moment it mixes with it. Compression ignition engines have comparatively heavier parts and are therefore commonly found in heavy-duty vehicles like buses, trucks, and construction machines.

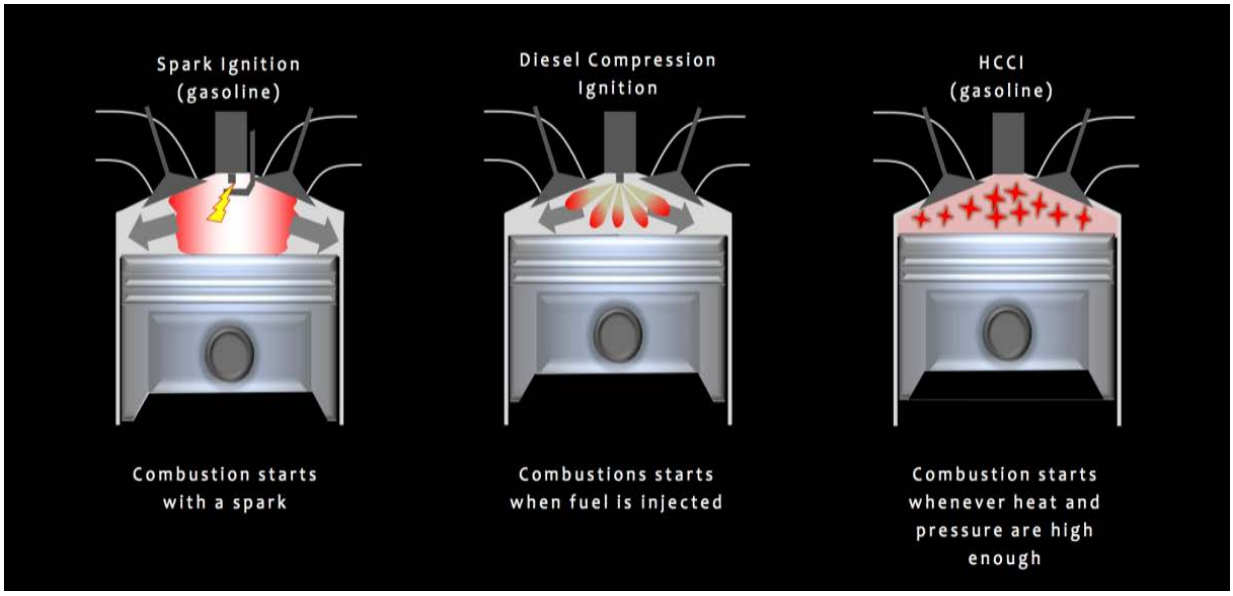


Fig. 1.2.3: Major differences between spark ignition and compression ignition engines

Activity 1.2.3

Comparisons Between Spark Ignition and Compression Ignition Engines

Do this activity in pairs and later discuss the answers you find.

Complete the table below for ten (10) operational differences between spark ignition and compression ignition engines.

One example each has been given to guide you.

Spark ignition engines	Compression ignition engines
e.g., run on petrol as fuel.	e.g., run on diesel as fuel.
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.

Spark ignition engines	Compression ignition engines
8.	8.
9.	9.
10.	10.

Activity 1.2.4

In groups of three, research the reasons why combustion gases must not escape from an internal combustion engine during operation. Prepare a report detailing your findings and present it to the class.

Component Parts of The Internal Combustion Engine

A normal internal combustion engine has numerous parts that ensure its efficient operation. The major component parts are described and illustrated below.

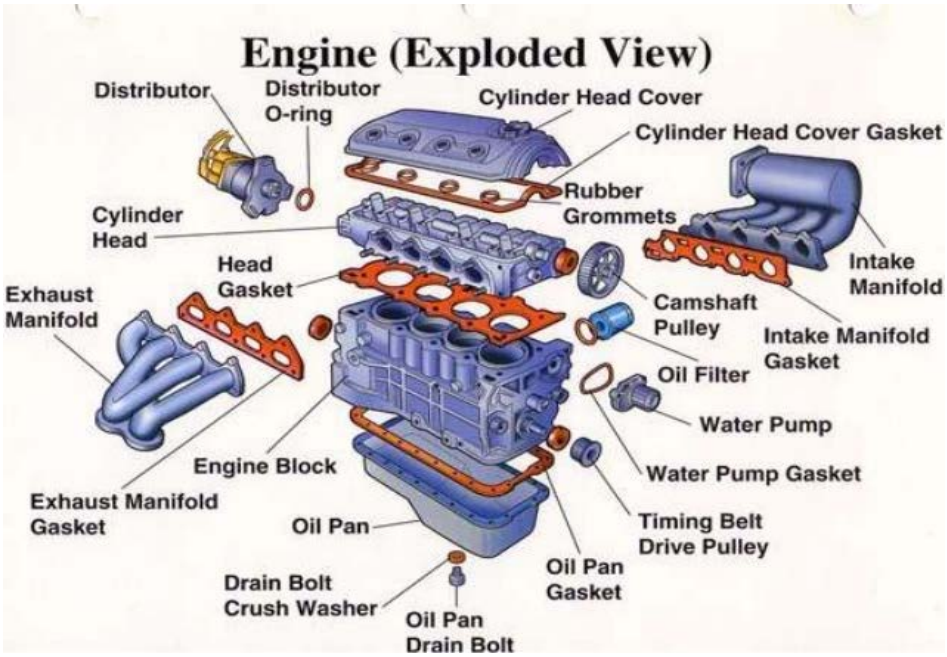


Fig. 1.2.4 Parts of an internal combustion engine

1. Cylinder Block

The cylinder block (also called engine block) serves as the main part of the engine. Combustion of fuel takes place in the cylinder block. All other parts, like the piston, connecting rod, crankshaft, water jackets, and oil galleries, are either mounted on the cylinder block or contained in it.

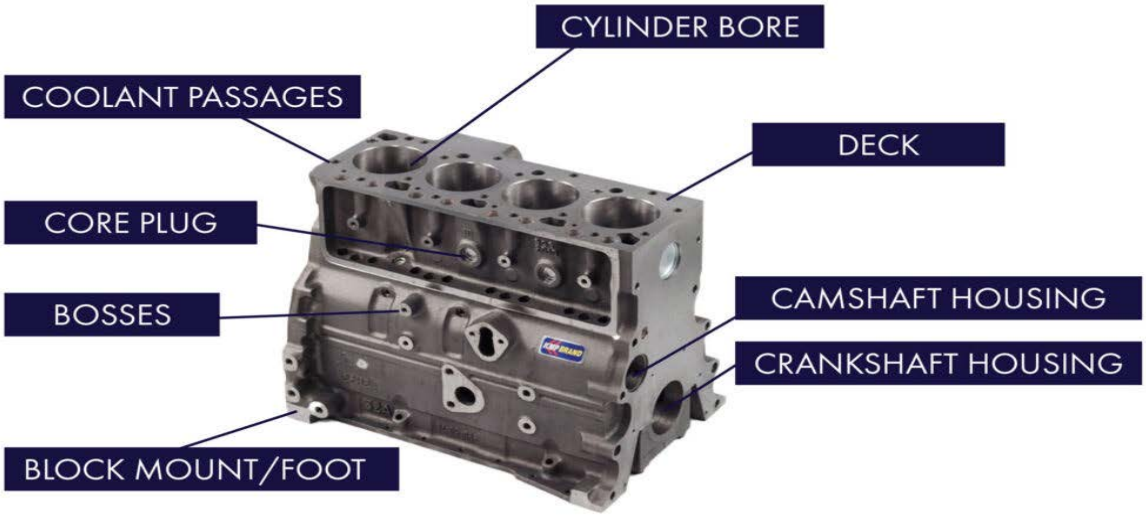


Fig. 1.2.5 Engine Block

Types of Cylinder Arrangements

Multi-cylinder engine blocks come in several forms and shapes. Some of them are in-line, vee, flat, box, and rotary.

a. **In-line engine block**: In this design, the cylinders are arranged in a single row, side-by-side and parallel to one another in the cylinder block.

Fig. 1.2.6: In-line engine block

b. **Vee Engine Block:** In this design, the cylinders are arranged in two rows at an angle to each other to form a 'V' shape. Each row of cylinders is referred to as a ***bank***. Popular Vee block engines are V6 and V8, which are used in high-performance cars.

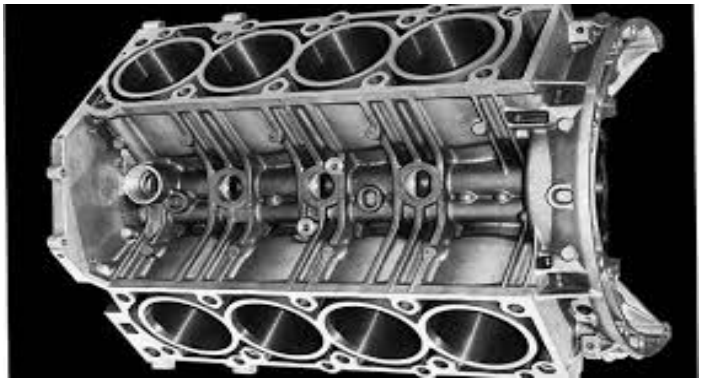


Fig. 1.2.7: Vee engine block

c. **Flat or Box:** This cylinder block design has cylinders arranged in two rows in two banks that lie horizontally or at 180 degrees to each other. Due to its design, it is sometimes called a horizontally opposed cylinder block.

Fig. 1.2.8: Flat engine design (source: www.cars.com)

d. Rotary or Wankel Engine: The rotary engine employs a triangular rotor that revolves around a central shaft within the combustion chamber. However, it is not in popular use today.

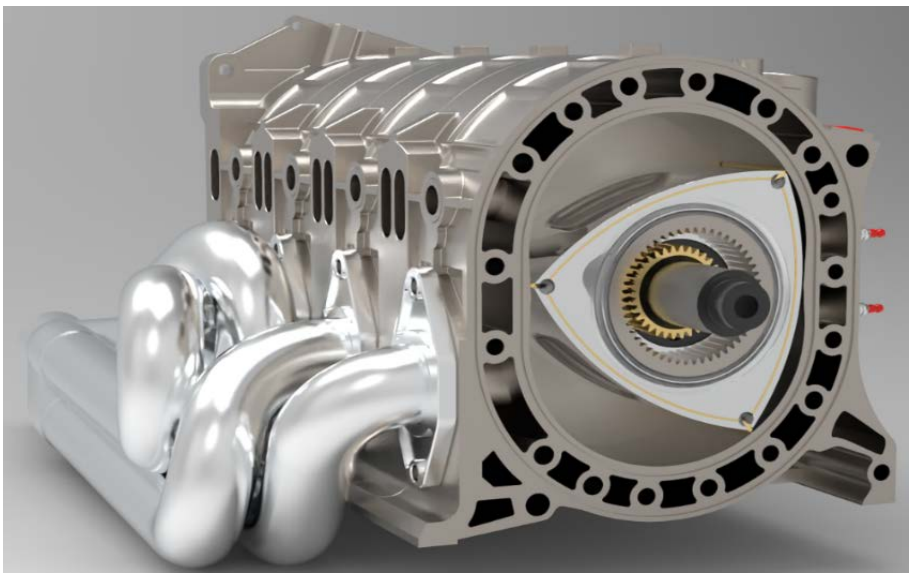


Fig. 1.2.9: Rotary engine block

2. Cylinder Head

The cylinder head is installed on top of the cylinder block to seal the working end of the cylinders, preventing the entry and exit of gases into or from the combustion chamber, except through the designated ports. The cylinder head also houses various components such as the valves, spark plugs, injectors, camshaft, and both the inlet and exhaust manifolds.

Fig. 1.2.10-cylinder head

3. Gasket

The gasket is positioned between the cylinder head and the cylinder block to provide a gas-tight seal, ensuring no loss of pressure from the combustion chamber during the compression and power strokes. It also seals the passages that carry coolant and engine oil, preventing them from entering the combustion chamber.

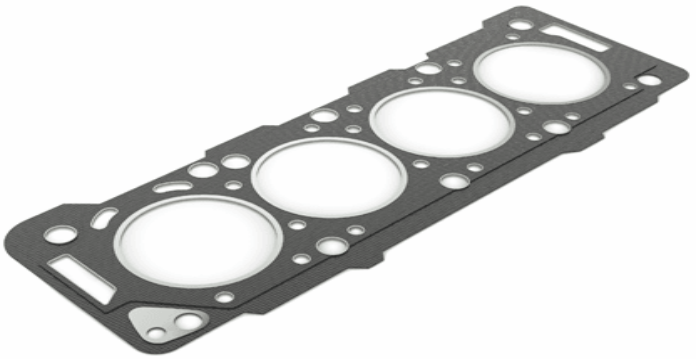


Fig. 1.2.11 Cylinder head gasket

4. Cylinder Liner

The cylinder liner (also called cylinder sleeve) is a cylindrical component that fits inside the bore of the engine block. The liner forms the main cylinder of the engine. It is made from materials such as cast iron or alloy steel, which have good wear-resistant and heat-resistant properties. The liner also provides a smooth surface for the piston rings as the piston moves up and down within the cylinder.

Fig. 1.2.12: Engine cylinder liner

5. Piston

The piston is the main component contained in the cylinder. It is attached to the small end of the connecting rod by means of a **piston pin** (also called a gudgeon pin or wrist pin). The piston performs three basic functions:

a. It transfers the force of combustion to the crankshaft through the connecting rod.
b. It acts together with the piston rings to prevent the escape of compressed air during the compression stroke and combustion gases on the power stroke, and
c. It transfers heat from the combustion chamber to the cylinder walls.

Fig. 1.2.13: Piston

6. Piston Rings

Piston rings are circular metal rings fitted into grooves around the piston. They are split at one point to allow easy installation. These rings prevent gas leakage by sealing the gap between the piston and the cylinder wall.

The top two rings, known as compression rings, prevent high-pressure combustion gases from escaping past the piston and cylinder wall into the combustion chamber. The bottom ring, also referred to as the oil scraper ring or oil control ring, prevents engine oil from entering the combustion chamber. Additionally, the rings help transfer heat from the piston to the cylinder wall, allowing for effective dissipation through the cooling system.

Fig. 1.2.14: Piston rings

7. Connecting Rod

The connecting rod (or conrod) connects the piston to the crankshaft and transmits the motion and force of the piston to the crankshaft. The small end of the connecting rod is attached to the piston, and the big end is attached to the crankshaft by means of a plain bearing.

Fig. 1.2.15: A Connecting Rod

8. Crankshaft

The crankshaft is located at the lower end of the cylinder block *(*referred to as the ***crankcase****)*. It converts the reciprocating motion of the piston into rotational motion. The engine power that drives the car is transmitted from the crankshaft through the transmission system to the road wheels.

Fig.1. 2.16: Crankshaft

9. Camshaft

The camshaft is a long, horizontal shaft equipped with eccentric lobes or cams, typically made from cast iron or hardened steel. It is a crucial engine component responsible for opening the inlet and exhaust valves at the correct timing. Each set of valves has its own lobes; some engines use a single camshaft for both inlet and exhaust valves, while others utilise two camshafts—one for each set of valves. The camshaft is installed parallel to the crankshaft and can be positioned either on the cylinder head or within the cylinder block, near the crankshaft.

Fig. 1.2.17: Camshaft

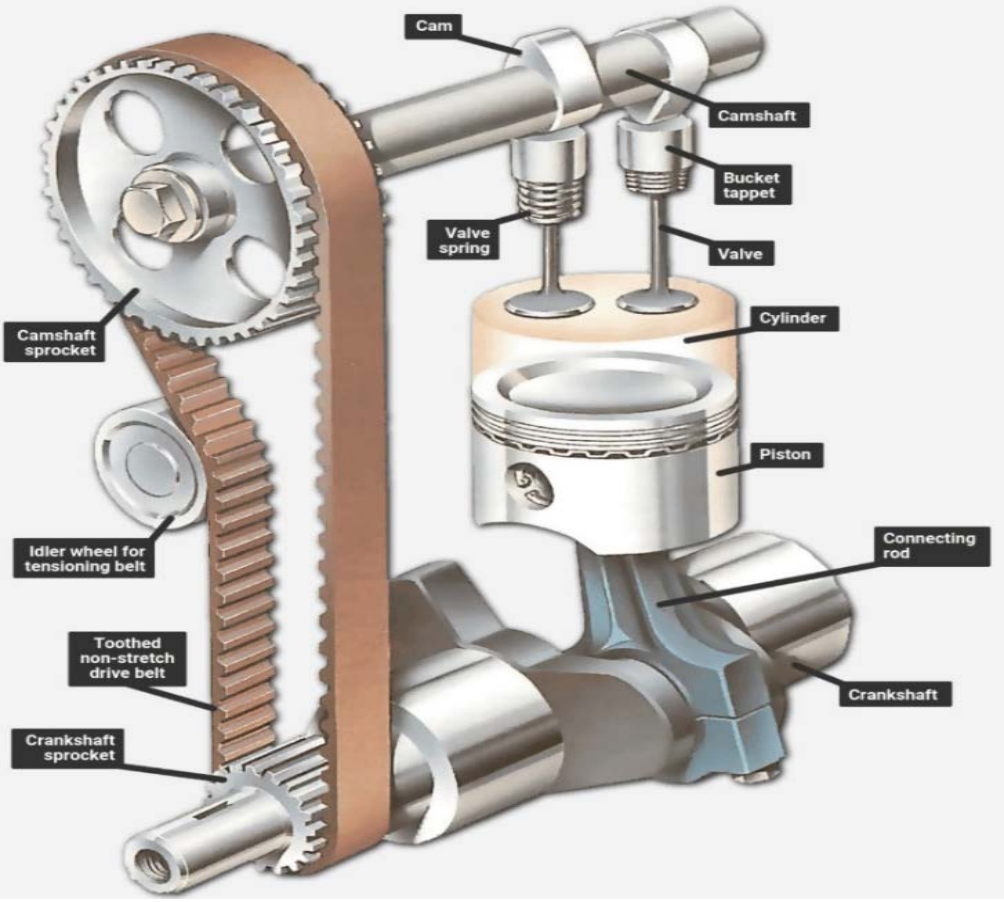


Fig. 1.2.18: Overhead camshaft design (source: www.linkedin.com)

10. Flywheel

The flywheel is a heavy disc with a ring gear at the circumference. It is mounted on the flange (back end) of the crankshaft. The flywheel stores rotational energy and ensures that the crankshaft continues to turn between the first power stroke and the subsequent ones. It also ensures that crankshaft rotation is made more uniform.

Fig. 1.2.19: Flywheel

11. Oil Sump

The oil sump is also called the ***oil pan***. It is bolted to the lower end of the cylinder block. All the oil for lubricating the movable parts is stored in it. There are two types of sumps: ***wet sump*** and ***dry sump***. In a wet sump, all the oil for lubrication is stored in the sump, whereas in the dry system, the lubricating oil is stored in a separate tank.

Fig. 1.2.20 Oil sump

12. Valves

Valves are installed on the cylinder head for the closing and opening of the intake and exhaust ports. Valves regulate the flow of the air-fuel mixture into the cylinder and the expulsion of exhaust gases during the exhaust stroke. The valve is opened using a combination of several components that are operated either directly or indirectly by the camshaft. The closing of the valves is achieved by the valve spring.

Fig. 1.2.21 Valves

13. Cam Follower (valve lifter)

The cam follower or valve lifter is located between the camshaft lobe and the valve. As the camshaft rotates, the movement of the camshaft lobe is transferred to the cam follower, which then operates the valve or a pushrod. Cam followers with flat contact surfaces are commonly referred to as ***tappets***.

Fig. 1.2.22: Tappets

14. Push Rod

The pushrod is a slender, cylindrical metal component that transfers the lifting motion from the cam lobe and tappet to the rocker arms. In engines with overhead valves and 'cam-in-block' camshafts, pushrods are used to operate the rocker arms mounted on the cylinder head.

Fig. 1.2.23: Pushrod

15. Rocker Arm

A rocker arm is installed on the cylinder head, and its function is to transmit the motion of the cam lobe to open the valves. The rocker arms are mounted on a shaft that runs the full length of the cylinder head on overhead camshaft engines.

Fig. 1.2.24: Rocker arm

16. Manifolds

Manifolds are bolted to the cylinder head, with separate manifolds for intake and exhaust. The intake manifold transports and evenly distributes air and fuel into the combustion chambers of a multi-cylinder engine. Conversely, the exhaust manifold allows the burnt gases to exit from all the cylinders. Intake manifolds operate at lower temperatures and are typically made from nylon-reinforced plastic or aluminium. In contrast, exhaust manifolds are constructed from cast iron or steel tubing to withstand the high temperatures of exhaust gases.

Fig. 1.2.25: Intake manifold

Fig. 1.2.26: Exhaust manifold

Activity 1.2.5

1. A local car repair shop has received an old vehicle for servicing. The mechanic identifies it as having a diesel engine. The shop also recently serviced a petrol engine vehicle. Write a short paragraph explaining the key differences between the diesel engine and the petrol engine in terms of their operation and maintenance needs.

2 a. Create a poster detailing three main functions of a motor vehicle engine. Use drawings or diagrams to illustrate each function.

b. Clearly label each part of your diagram and write a brief explanation of how it contributes to the engine's overall operation.

c. If available, use engine models or videos to better understand how the engine functions and include these observations on your poster.

Extended Reading

1. Engine and engine technology in Fundamentals of Motor Vehicle Technology by Hillier, V. A. W. (6th edition), pp. 29-34.
2. Automotive Technology: Principles, Diagnosis, and Service by Haldermanpp, J. D., pp. 280-385.
3. How external combustion engines work: https://www.youtube.com/watch?v=VhT3MN2JXu8&t=193s
4. crankshaft Technology: https://www.tpub.com/engine3/en3-53.htm.tpub.com/engine3/en3-53.htm
5. How to replace engine main bearings: https://www.youtube.com/watch?v=iY-5zbY0uGg&t=14s

Review Questions for Section 1, Unit 2

1. (a) Compile a list of any ten (10) different vehicle models found in Ghana and group them under List A (Spark Ignition engines) and List B (Compression Ignition engines).

   (b) Compare your list with that of your friends and discuss with them how and why the list of vehicles in group A differs from those in group B.

2. Visit this site on the internet: https://spicerparts.com/calculators

   (a) Look for the tab named '*Engine Displacement Calculator*' to discover a software tool that you can use to calculate engine capacity in both cubic centimetres and litres.

   (b) Press the toggle button to discover the equivalent of your answer in litres by computing your figures in inches.

   (c) Ask your partner to solve five engine capacity questions based on the cylinder specifications you will provide them. Your partner will also give you five engine capacity questions to answer. Use the table below to record the answers. Make sure to use both the software tool and the manual calculation.

You	Engine capacity answers	Partner	Engine capacity answers
1.		1.	
2.		2.	
3.		3.	
4.		4.	
5.		5.	

3. Ghana is set to introduce a policy aimed at reducing the importation of cars that run on fossil fuels, to pave the way for the mass introduction of electric vehicles in the future. In your group, discuss three (3) reasons why you agree or disagree with this policy. Present your findings to the class.

4. Auto workshops in Ghana are often cluttered with numerous dysfunctional engine parts. While some are sold as scrap metal, others are repurposed as improvised devices in various applications across homes, workshops, entertainment, and industrial settings. However, many of these parts remain unused. Suggest two ways in which Ghana can manage the increasing volume of auto waste from broken-down engine parts.

UNIT 3

BUILDING CONSTRUCTION

Pre-construction Activities

INTRODUCTION

In building construction, stakeholders play a crucial role in the overall process and are integral to the success of any project. Understanding who stakeholders are and their importance will enhance your knowledge of the various personnel involved in building construction. This builds upon the foundational knowledge of building construction introduced in Career Technology at the junior high school level. This section will enable you to effectively explain the roles of different stakeholders in building construction projects, ensuring their successful completion.

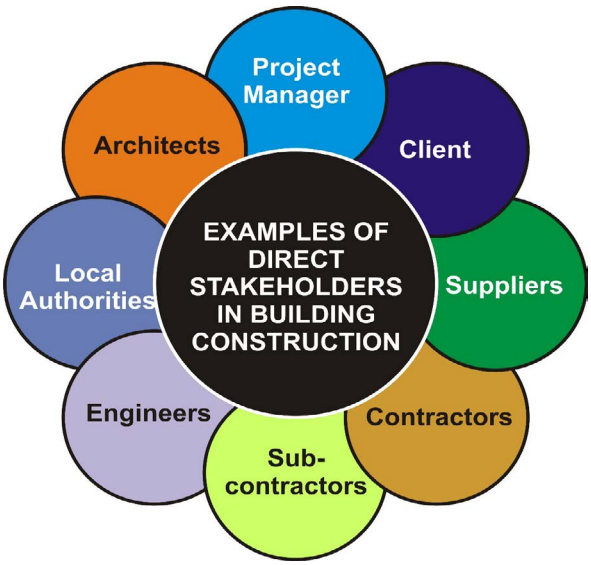


Fig. 1.3.1: Stakeholders in project management

At the end of this unit, you should be able to:

Explain who are the main stakeholders involved in a building construction project.

Key Ideas

- Building construction is a teamwork activity that involves all parties or persons known as stakeholders.
- A stakeholder is a person, group, or organisation with a vested interest, or stake, in the decision-making and activities of a business, organisation, or project.
- The contributions of each stakeholder are necessary and important for the success of every construction project.

CONSTRUCTION STAKEHOLDERS

Building construction involves multiple parties, each playing a vital role at various stages of the project. Understanding who the key stakeholders are is essential, as construction projects are typically completed in phases, with specific individuals or groups responsible for distinct tasks. Effective collaboration and communication between these stakeholders are critical to ensuring the successful and timely completion of the project. Additionally, each stakeholder contributes unique expertise and resources, making their roles indispensable in achieving the project's objectives.

Now, let's take a closer look at the various stakeholders involved in building construction projects, exploring their roles and responsibilities in greater detail.

1. Statutory Authorities

a. District Assembly: The District Assembly is one of the key stakeholders in building construction and serves as a local government institution in Ghana. It is composed of elected and appointed members, including the District Chief Executive and Assembly Members. The assembly functions as the highest political and administrative authority at the district level.

b. Town and Country Planning: The Town and Country Planning Department (TCPD) is a significant stakeholder in building construction projects in Ghana. Established in 1945, its primary responsibility is to plan and manage the growth and development of buildings in cities, towns, and villages across the country. As a key player in construction projects, the TCPD is expected to promote sustainable human settlement development in Ghana.

2. Client Types

The client is a crucial stakeholder in any building construction project. Typically, the client is the owner of the project, as they provide the funding for professional services, materials, labour, and all other associated expenses.

Are you familiar with the different types of clients involved in building construction? They are:

- Private Client
- Commercial Client
- Quasi-governmental Clients

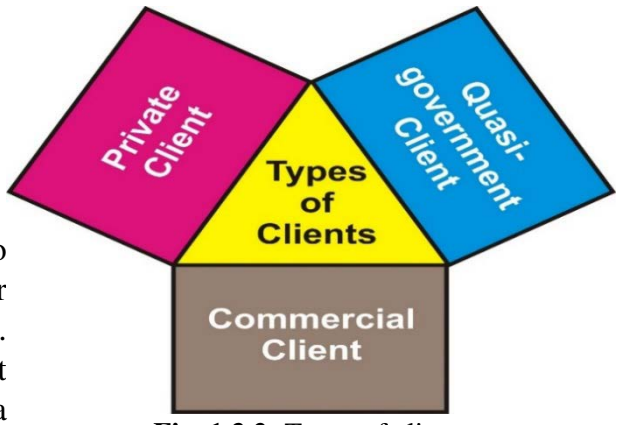


Fig. 1.3.2: Types of clients

a. Private Client

A private client refers to an individual who undertakes the construction of a building for personal occupancy or to rent out to tenants. This category also includes those who want to build, alter, extend, renovate, or maintain a building structure.

b. Commercial Client

Commercial clients are business entities involved in construction projects. This group includes business or legal entities such as private and public limited companies, as well as non-governmental organisations, which initiate and fund construction projects. For instance, a company might construct staff housing or an office block for sale or rent to other businesses.

c. Quasi-governmental Clients

Quasi-governmental clients, or government-quasi agents, are stakeholders in construction projects. These organisations, known as ***parastatals or corporations***, operate within the construction industry to meet the welfare needs of the nation's citizens. Examples of quasi-governmental clients include the National Housing Corporation (NHC), Ghana National Highways Authority (GHANA), State Construction Corporation (SCC), Public Works Department (PWD), and various local government authorities. These clients typically initiate projects based on the needs of citizens and may receive funding subsidies from the central government.

d. The Government

The central government is both a client and a stakeholder in building construction projects. It often initiates and funds construction projects to provide essential services to citizens, such as schools, markets, hospitals, libraries, and roads. Additionally, the government is responsible for the installation, maintenance, and repair of public utilities like water, gas, petroleum, and electricity. Many government projects are initiated through various ministries, with public service officers acting as consultants. In some cases, the government partners with private firms to deliver these projects.

3. Design Team

The design team is another key stakeholder in building construction projects, comprising professionals responsible for planning, designing, estimating, and overseeing construction. The core members of the design team are shown in the diagram below:

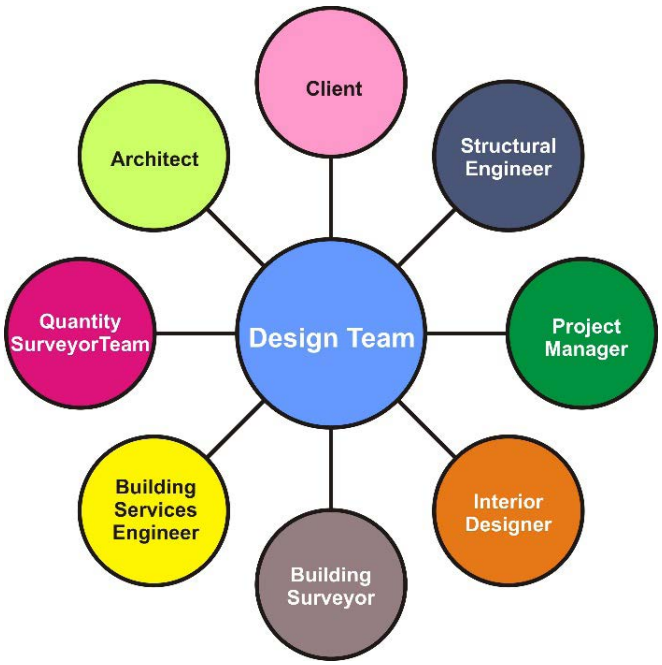


Fig. 1.3.3: Design team in building construction

More Stakeholders

Stakeholder	Description
Clients	They are usually the owner of the project and initiate the project, provide requirements for the project execution, and agree to design decisions.
Architect	Leads and guides the design process, develops architectural drawings, and ensures designs meet aesthetic and functional requirements to be agreed on by the client.
Structural Engineer	Designs the structural framework of the building to ensure its stability and safety for the entire project.
Quantity Surveyor	Ensures the correct estimates of project costs, manages budgets, and procures appropriate materials.
Building Services Engineer	Ensures effective designs are undertaken for the mechanical, electrical, and plumbing systems within the building project.
Building Surveyor	Visualises and assesses existing buildings on the land, advises on land development regulations, and provides technical guidance for building construction projects.
Interior Designer	Ensures the effective use of the designed interior spaces, selects appropriate finishes, and their application, and coordinates the efficient furnishing of the room space.
Project Manager	Oversees the entire project, coordinates the design team, and ensures project objectives are met.

4. Building Team

a. **Clerk of Works**: The Clerk of Works (COW) plays a critical role in building construction, ensuring that quality standards are consistently upheld throughout the construction process. They act as the on-site representative for the client, architect, or project manager, overseeing the works to ensure they meet the required specifications.

b. **Works superintendent**: The works superintendent, also known as the construction superintendent, is responsible for managing the day-to-day operations on construction sites. They coordinate various aspects of the project to ensure its successful and timely completion.

c. **Foreman**: The construction foreman holds a key position, coordinating and supervising a team of workers on-site. The foreman oversees, directs, and guides the activities of skilled workers, commonly referred to as artisans, ensuring that tasks are carried out efficiently and to a high standard.

d. **Headmen of works**: The Headmen are typically the most senior of the non-skilled workers or labourers. Appointed due to their extensive experience as labourers, they lead their peers in all activities on the construction site. Headmen take directives from the foremen and report to them on all non-skilled tasks.

e. **Non-skilled workers or labourers**: Non-skilled workers, often referred to as labourers, play a vital role in supporting construction projects. They assist artisans on-site by performing tasks such as site preparation, material handling, demolition, clean-up, and general support work.

f. **Artisans as stakeholders**: Artisans in building construction are skilled craftsmen who specialise in various trades. They are responsible for carrying out specific tasks related to the construction of buildings and infrastructure, ensuring high standards of craftsmanship in their respective areas of expertise.

Table 1.3.1: Artisans and their descriptions

Artisan	Description
Masons	Specialise in building structures using materials such as bricks, blocks, and stones. They are responsible for laying the foundation and constructing walls, columns, and other structural elements. Artisans who work with blocks to erect a wall are called block layers. Those who use bricks to erect a wall are called brick layers. The artisans who use stones to erect walls are called masons or stone masons.
Carpenters	Work with wood, crafting and installing structural frameworks, doors, windows, roofs, and finishes like trim and moulding. They play a crucial role in shaping the interior and exterior of buildings.
Plumbers	Specialise in installing and maintaining plumbing systems, including pipes, fixtures, and fittings for water supply, heating, and sanitation. They ensure the proper functioning of water and waste management systems.
Electricians	Install and maintain electrical systems, including wiring, fixtures, and appliances, to provide power and lighting within buildings. They ensure electrical safety and comply with regulations.
Painters	Apply paint, varnish, and other finishes to surfaces, enhancing the appearance and protecting structures from corrosion and weathering. They contribute to the aesthetic appearance and longevity of buildings.
Tilers	Apply tiles as a finish to wall and floor surfaces. Apart from tile application to the walls and floor surface finishes, tilers are usually the skilled experts that are required to apply the tile finishes to the washrooms, especially the lavatories, i.e., the urinals and the toilet.

Activity 1.3.1

1. Visit a building construction site and observe the various personnel, noting their specific activities. Ensure that you adhere to all safety protocols and be vigilant about safety issues at all times. Pay attention to all warning signs and listen carefully to the instructions given by the site foreman.
2. Firstly, locate the site foreman and request permission to speak with some of the workers. Approach the personnel and enquire about their specific roles and

activities on the construction site. Compile a profile album report detailing the various stakeholders in building construction. Include as many photographs as possible to illustrate the diverse range of people involved.

3. After your site visit, in groups of five, outline seven stakeholders in construction projects and explain their duties.

   If you are unable to visit a building site, you may use the YouTube showing artisans and other construction personnel at work to give you the ideas of stakeholders in building construction projects.

Fig. 1.3.5: A carpenter framing a roof.

Fig. 1.3.4: Mason at work at a construction site.

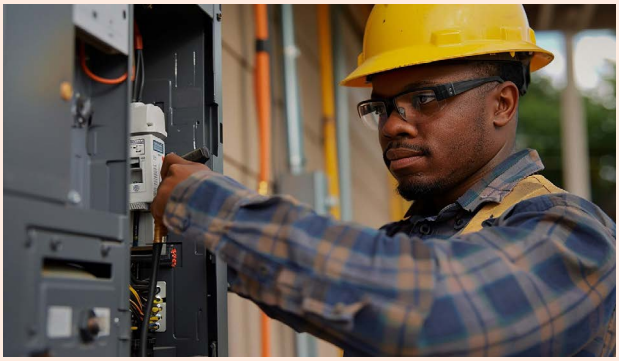


Fig. 1.3.6: Electrician at work.

Fig. 1.3.7: Plumber at work

Extended Reading

1. Chinyio, E. A., & Olomolaiye, P. (Eds.). (2010). Construction stakeholder management. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
2. Naoum, S. (2016). People and Organisational Management in Construction. ICE Publishing, 40 Marsh Wall, London E14 9TP.

Review Questions for Section 1, Unit 3

1. a. Outline the various stakeholders involved in building construction.
   b. Describe the specific activities each stakeholder performs.
2. Explain, in your own words, what you know about the different stakeholders involved in building construction projects.

UNIT 4

STRAND: ELECTRICAL AND ELECTRONIC TECHNOLOGY

Electrical systems design

INTRODUCTION

Safety practices are necessary; it is essential for you to know basic safety rules and procedures and be aware when getting into a situation that might be hazardous. The most common hazards of electricity are electrical shock, death from electric shock or electrocution, fires, burns, explosion, and injuries.

At the end of this unit, you should be able to:

Discuss safety in the use of electricity.

Key idea

Electrical safety is about having effective organisational measures and technical means in place to prevent harmful and dangerous effects on consumers of electricity and remedial measures to resuscitate victims.

SAFETY IN THE USE OF ELECTRICITY

Safety is one of the prime considerations in the usage of electricity. Avoiding hazards of electricity such as shock, burns, injuries and death from electric shock or electrocution are a matter of applying common sense and making sure that equipment is properly connected, and safety procedures are followed.

In the home, laboratory, or workshop safety features employed include:

1. Hand tools that have insulated handles.

Fig 1.4.1: Tools with insulated handles

2. Not working on electricity with wet hands.
3. Damaged wires should not be used for electrical connection.
4. not touch any wire that may appear to be live.
5. not leaving objects, tools and equipment, anywhere to obstruct walkways.
6. Unplugging all unused appliances / equipment from the outlets.
7. Keeping electrical equipment / devices and outlets away from water.
8. Never putting fingers or other objects/metals in an outlet.
9. Never pulling a plug out by its cord.
10. Always disconnecting the faulty apparatus/equipment from the supply.
11. Using dry powder extinguishers to put out small electrical or electronic fires.

ELECTRIC SHOCK

Electric shock sometimes causes a fright and some pain, but it can be severe enough to make someone unconscious and stop the heart. *Electric shock occurs when any part of the body gets in contact with live parts of an electrical supply while at the same time, touching ground, neutral or another live causing a current flow through the tissues of the body.* Electric shock kills by temporally paralyzing the heart muscles, and the greatest danger occurs when electric current flows from one arm to the other or an arm through to the legs. Typical effects of electric shock are unconsciousness, difficulties in breathing or no breathing at all, weak, erratic pulse or no pulse at all, burns and cardiac arrest.

Fig 1.4.2: Sign for indicating electrical danger.

NOTE: Electrocution is death caused by electric shock. Depending on how severe the electric shock is other injuries may occur such as burns on the skin and burn injuries affecting internal tissues and organs.

Causes of electric shock

Some of the causes of electric shock may include:

1. Faulty appliances
2. Damaged extension leads
3. Electrical appliances, in contact with water
4. Incorrect, damaged or deteriorated household wiring
5. Downed power lines
6. Lightning strikes

Effects of Electric shock

Depending on the length and severity of the electric shock the victim may suffer a number of consequences

These include:

1. Burns to the skin and internal tissues
2. Amnesia (blankness or forgetfulness)
3. Seizure or respiratory arrest
4. Interference or inconsistent working of the heart
5. Psychiatric disorders
6. Electrocution

What to do for a victim of electric shock

1. Get the victim away from contact with the electricity by switching off the power.
2. If power cannot be switched off, drag or push the victim away from contact with the supply using a piece of dry wood, or a broom handle as shown in Fig.1.4.3 or hook a rope around the victim's arm or leg and pull him.

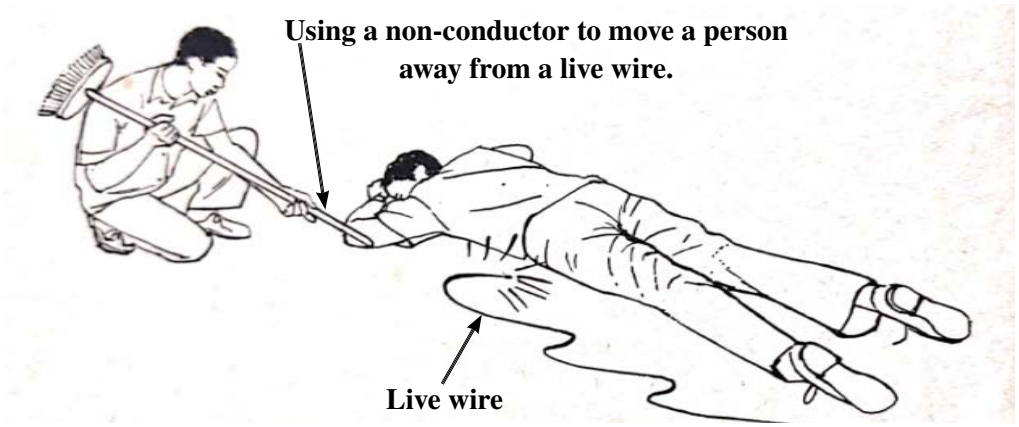


Fig 1.4.3: Victim lying face down with head apparently on the folded arms.

Once the victim is away from the electricity supply, if due to the shock, the victim becomes unconscious, stops breathing, no heartbeat, then, start the artificial respiration but only if properly trained and qualified to do so. This is often referred to as the Cardio-pulmonary resuscitation (CPR) as detailed in a manner below.

a. Kneel next to the victim
b. Lie the victim on his back and tip his head back.
c. Pull the victim's jaw forward to move the tongue away from the airway.
d. Place the heel of one hand (the first aider) in the middle of the chest of the victim.
e. Place the other hand on top of the first hand and interlace the fingers and push the chest reasonably down.
f. Wait for the chest to come back completely and check if the victim is breathing before repeating the process
g. Take a deep breath from the chest (first aider).

h. Pinch the victim's nostrils together.

i. Put your mouth over the victim's lips as shown in Fig. 1.4.4

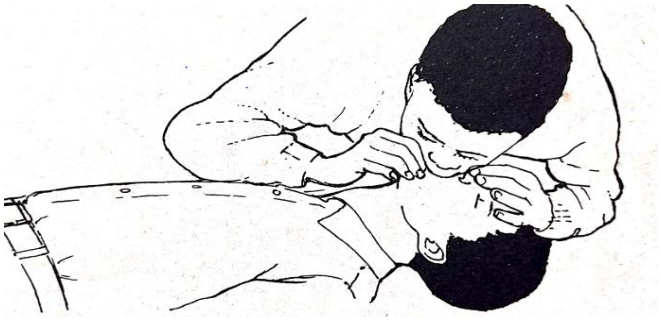


Fig. 1.4.4: Illustration of mouth-to-mouth during CPR.

j. Making an airtight seal as possible, blow air into the victim's lungs two times.

k. Repeat 30 chest compressions followed by two breaths and then check for normal breathing.

l. Don't give up until trained help comes.

If the victim is unconscious but breathing on his own and has not sustained any serious injuries than the shock, put him in the recovery position shown in Fig 1.4.5. to enable him breath easily.

Roll the victim onto his side, and move the uppermost arm for it to make a right angle with his body. Move the uppermost leg so that it makes a right angle with body. Turn the head to the side, and tilt back, push the chin forwards.

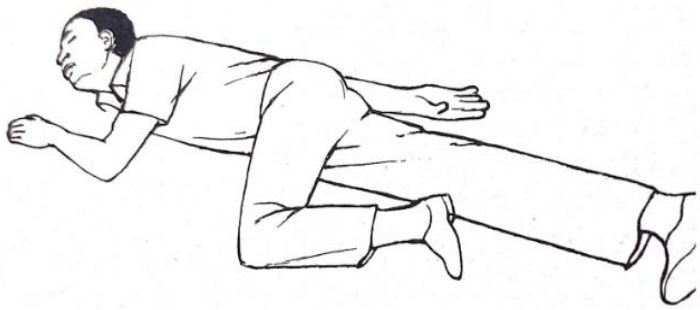


Fig 1.4.5: Recovery position after CPR.

Burns

The most common shock-related non-fatal injury is burns. Electrical burns sometimes cause mild skin damage, Pain, swellings, redness, blisters on the surface of the skin and severe internal organ tissue damage. **Treatment for burns** Put the burnt area under running water for at least 20 minutes and cover it with a sterilized gauze bandage or a clean cloth.

NOTE: To prevent electric shocks the points raised under " safety in the use of electricity" topic should be followed.

See Annex 1 for further reading on dealing with high voltage electricity and working with domestic electricity.

Activity

1. Identify four dangerous situations and behaviours likely to cause electric shocks. Refer to the causes of electric shock.
2. List the procedures involved when treating an electrocuted victim.
   i. What type of injury is sustained by the victim?
   ii Select the procedure based on the injury.
3. Why do we have insulation around electrical workshop tools?
   i. State the effect of touching a live electric wire.
   ii. State what role the insulation plays in the scheme of things.
4. Explain how electrical wiring issues in buildings can cause electric shocks?
   i. State the colour code of electrical wires.
   ii. If the switch is off, is power available at the switch terminal?
   iii. What happens when a live and neutral wire touch?
   iv. What is the result of an accidental contact of these wires.
5. Describe the safety precautions to be taken to prevent electric shocks in a workplace.
   i. What safety dress do you wear in an electrical workshop?
   ii. State the type of tools recommended for use in an electrical workshop.
6. How can a severe electric shock cause damage to internal organs and tissues?
   i. State what makes an electric shock severe.
   ii. State the type of injuries a victim can suffer in an electric shock.
   iii. List the organs that can be severely affected in the body.
   iv. List what can contribute to a severe electric shock.
7. What role does the current intensity play in determining the severity of an electric shock?
8. How can safety be ensured while providing first aid to an electric-shock victim?
   i. State the very first precaution to observe before coming in contact with a victim of electric shock.

EXTENDED READING

Click on the link below to read an article on electrical burns. https://www.emedicinehealth.com/what_are_the_three_types_of_electrical_burns/article_em.htm

Review Questions Section 1 Unit 4

1. State the colours used in signs to communicate safety and give examples of what they represent.
2. A short-circuit fault occurred in a domestic electrical appliance, some components were overloaded, and the appliance exploded, and then the attendant fell unconscious. Outline the procedures appropriate to rescue the victim.
3. Explain in detail why electrical equipment should not be operated with wet hands. You can draw a picture of pictures to support your answer.
4. A short-circuit fault occurred in a domestic electrical appliance, the appliance exploded and started burning, suggest the type and class of fire extinguisher suitable to put out the fire.
5. Electrical connections in a network were made with damaged wires, what kind of dangers it poses to the electricity consumers in the network.
6. An electrical appliance burst into flames when connected to the power source. Identify the type of faults that could have resulted in the fire outbreak.

ANNEX 1-FURTHER READING

Dealing with high voltage electricity

High voltage electricity refers to electrical potential large enough to cause injury or damage. In certain industries, high voltage refers to voltage above a certain threshold. Equipment and conductors that carry high voltage warrant special safety requirements and procedures.

1. When working on high voltages, be sure that the floor is not conductive, such as a concrete floor.
2. Disconnect the mains to prevent any possible feedback, verify the absence of voltage, ground short-circuit signal and delimit /cordon off the working area with barricades and warning whips.
3. Wear personal protective equipment.
4. Avoid contact with power lines. De-energize or guard power lines when working on them.
5. Work at a safe distance.
6. Wear rubber gloves with leather protection, insulating sleeve and flameproof clothing before working on power lines
7. Use extreme caution around trees
8. Always use wooden or fiberglass ladders outdoors.
9. Switch off the main supply before working on an electrical fault or equipment.
10. Do not work on electricity in places where your head is likely to touch live mains before making it dead.
11. Use carbon dioxide extinguishers to put off large electrical fires at power sub-stations.
12. If someone is in contact with a high voltage sub-station transformer, do not attempt a rescue; get immediate specialist help!
13. Observe high voltage and other safety signs as they are messages that communicate the need to keep a safe distance from a dangerous situation.

Working with domestic electricity

Mains electricity or utility power, grid power, domestic power, and wall power is a general-purpose alternating-current electric power supply. It is the form of electrical power that is delivered to homes and businesses.

A domestic electricity supply involves three wires, the live, neutral and earth wires. The live wire is dangerous in normal circumstances, and it is live with respect to earth. This means that the mains voltage will flow from the live wire through any conducting medium or person that is connected to and standing on the ground with or without wearing a footwear. This can cause serious injury or death to occur.

UNIT 5

METAL TECHNOLOGY

Engineering Materials, Tools, and Machines

INTRODUCTION

In the exciting world of metalwork technology, we will begin by learning about Occupational Safety and Health (OSH), a critical aspect of working in a metal workshop. Metalworking involves handling sharp and heavy materials, which can pose risks ranging from small cuts to serious injuries. Prioritising safety not only protects you and your classmates but also enhances productivity by reducing accidents and keeping everyone healthy. You will learn about important health and safety measures, including the proper use of personal protective equipment (PPE) like gloves and protective eyewear, ensuring that the workshop is clean, well-lit, ventilated, and equipped with fire safety tools.

At the end of this unit, you should be able to:

- Explain health and safety related to workshop, tools, materials, and machines
- Explain the uses of various types of measuring, marking, holding, striking, and cutting tools.

Key Ideas

- The incorrect use of tools and equipment in the workshop can cause serious accidents.
- An accident could change your life by causing permanent injury, damage, or death.
- To avoid accidents, personal protective equipment (PPE) must be identified and used appropriately.
- The study of health and safety issues in the metal workshop is crucial to ensuring the well-being of oneself, others, and the overall functioning of tools, equipment, and machines. Regular inspections, training, and a strong commitment to safety policies are essential to maintaining a healthy and safe metal workshop in schools. It is important to comply with the local and international regulations and standards related to workplace safety.
- In any skill acquisition, a thorough understanding of measuring, marking out, holding, striking, and cutting tools and equipment is essential. This knowledge enhances work efficiency and supports the design and production of artefacts in the metal workshop. Additionally, having an in-depth grasp of these tools and equipment will improve your comprehension of the learning indicators, as you can use real-world tools and equipment that replicate those used in the metal workshop and other professional settings.

Keywords

Measuring, marking out, holding, striking, cutting, health, safety, workshop, tools, materials, machines, PPE, guarding, electrical, welding, fire, chemical, handling, noise, control, ventilation, first aid, emergency, response, training, awareness, housekeeping, noise, control.

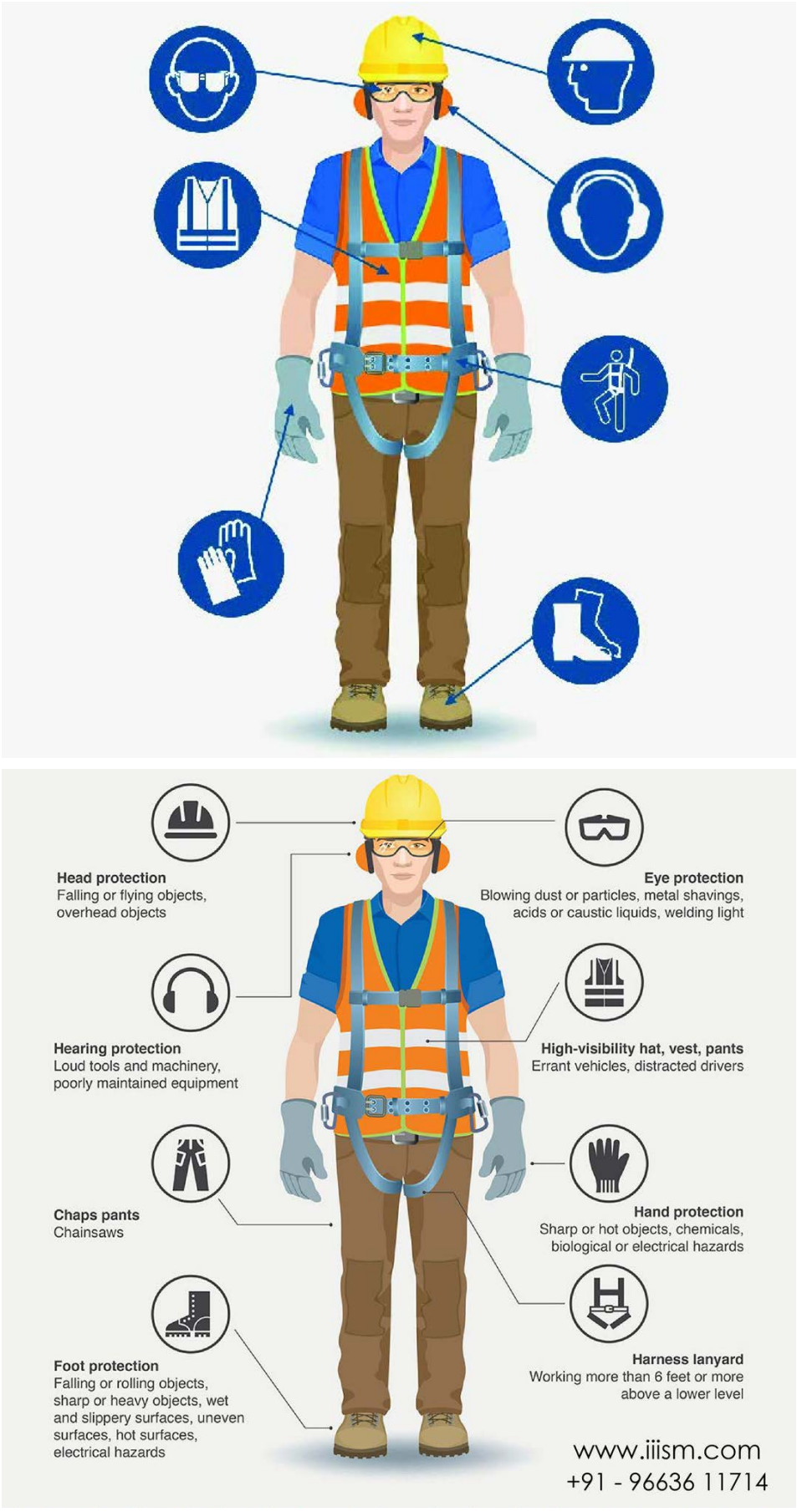
Additionally, precision, skill, and safety are key to success. Understanding the use of measuring, marking out, holding, striking, and cutting tools is not just about knowing how to use them—it's about unlocking your potential to create remarkable pieces with efficiency and creativity. In this unit, you will explore how different tools and equipment play a vital role in shaping, assembling, and creating metal products, opening doors to a world of innovation in applied technology. Essential tools like the steel rule, callipers, engineer's vice, hammers, hacksaws, and shears. These tools come in various shapes and sizes, each designed for specific purposes, whether it's measuring accurately, marking out plans, holding metal securely, or cutting and shaping it. Mastering these tools is the foundation for becoming proficient in metalwork, helping you achieve precision, save time, reduce waste, and avoid unnecessary costs.

By the end of this unit, you will not only have a deep understanding of the tools used in metalwork but also be aware of the safety standards that will allow you to work confidently, efficiently, and safely. The skills and knowledge you gain here will be essential as you explore the endless possibilities of metalwork in future projects.

SAFE USE OF HAND TOOLS IN METAL WORK

Review of health and safety issues in a metal workshop are crucial to address to ensure the well-being of learners, teachers and the overall functioning of tools, equipment, and machines. Regular inspections, training of teachers and learners, and a strong commitment to safety policies are essential to maintaining a healthy and safe mechanical workshop in schools. It is important to comply with local regulations and standards related to workplace safety. Some basic health and safety issues that should be considered:

1. **Personal Protective Equipment (PPE)**: Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that can cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. PPE, such as safety glasses, gloves, hearing protection, and steel-toed boots, to protect against potential hazards.



Fig, 1.5.1: Personal Protective Equipment and Demonstration of How to Use Them

The Table below shows types of Protection, PPE to use and Protections offered.

Types of Protection	Types of PPE	Protections offered
Eye Protection	Glasses, Goggles, face shields	Impact, foreign objects, splashes, and burns.
Ear Protection	Ear plugs, Earmuffs	Impact, foreign objects.
Head Protection	Class A, B or C hard hats	Impact, overhead penetration, electrical hazards.
Personal Fall Protection Systems	Harnesses, restraints	Impact, foreign objects.
Body Protection	Fire resistant clothing, HAZMAT suits, steel toe boots, latex gloves	Impact, splashes, extreme temperatures, flames, cuts, hazardous chemicals.

2. **Machine safety:** Machines are an integral part of our modern world, powering industries and making our lives more efficient. However, their power and complexity also pose potential risks to the people working with or around them. Developing and enforcing strict safety procedures for using machinery, including lockout/tagout procedures during practical sessions and maintenance work are essential.

Fig.1.5.2: Ways of Observing Machine Safety.

3. **Machine guarding**: Guards are materials and equipment that keep you from having direct contact with moving parts and other dangerous areas of a machine. Some guards also protect you from shavings, flying shards or metal sparks created by working machines. Machines should have proper guards in place to prevent accidental contact with moving parts. Regular maintenance and inspection of these guards is essential.

There are several different types of machine guards. The most common types of machine guards are:

a. Fixed guards
b. Interlocking guards
c. Adjustable guards
d. Self-adjusting guards

Fig 1.5.3: Examples of Machines with Guards.

4. **Material safety:** A material safety data sheet is a technical document that contains information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with materials.

   Importance of Material Safety Data Sheet

   Material safety data sheets are very important because they alert you and other end users to the potential hazards posed by a particular product. They also provide essential information on how to store, handle and dispose of hazardous substances correctly, as well as first aid measures in case of exposure.

5. **Tool safety:** A **hand tool** is any tool that is not a power tool, that is, one powered by hand (manual labour) rather than by an engine. Some examples of hand tools are garden forks, secateurs (scissors), rakes, hammers, spanners, pliers, screwdrivers and chisels. Hand tools are generally less dangerous than power tools. You have to regularly inspect tools and equipment for damage or wear. Using improper tools can lead to accidents and damage to both tools and workpieces. Ensure that tools are stored properly when not in use to prevent tripping hazards and to maintain a clean and organised workspace.
6. **Electrical and welding safety**: It is the safety to be observed when using electrical appliance and machines, especially during welding. Always keep the hands and the body dry during a welding operation. Avoid standing in water, on wet surfaces, or working with wet hands or wearing sweaty garments. Do not dip energized (hot) electrode holders in water. Avoid direct contact with the live parts of welding equipment and the workpiece. Always wear long sleeves and appropriate protective clothing, eye protection, gloves, and footwear to protect skin from burns due to ultraviolet light, sparks, and molten metal.

   Ten (10) Welding Safety Precautions

   a. Conduct welding in a designated safe location.
   b. Protect yourself from fire hazards.
   c. Consider the risks.
   d. Maintain your equipment.
   e. Always wear appropriate PPE.
   f. Ventilate the welding area.
   g. Protect yourself from fumes and gases.
   h. Provide warnings for other workers.

i. Read warning labels and relevant documents and keep training.
j. Enforce safety procedures.

Fig. 1.5.4: Observing Electrical and Welding Safety

6. **Manual handling**:

Manual handling means transporting or supporting a load by hand or bodily force. It includes lifting, putting down, pushing, pulling, carrying or moving loads. Manual handling is any activity where you lower, push, pull, hold or restrain an item.

Importance of Manual Handling training:

a. Increases your awareness.
b. Fosters safe workplaces.
c. Saves costs.
d. Follows compliance.
e. Gains competitive advantage.

Demonstrating the proper lifting techniques to prevent injuries Always use mechanical aids, when possible, to reduce the risk of manual handling injuries.

Fig 1.5.5: Proper Manual Lifting Techniques

7. **Fire safety:** Fire safety is the set of practices intended to reduce destruction caused by fire. Fire safety measures include those that are intended to prevent the ignition of an uncontrolled fire and those that are used to limit the spread and impact of a fire. Have adequate fire prevention and control measures in place, including fire extinguishers, emergency exits, and proper storage of flammable materials.

Fig 1.5.6: Some firefighting signs and equipment.

8. **Chemical handling:** Proper storage, labelling, and handling of hazardous chemicals.

What to do when working with chemicals:

a. Remove and use only the amount of chemicals needed for the immediate job at hand.
b. Properly seal, label, and store chemicals in appropriate containers. Check stored chemicals for deterioration and broken containers.

Basic Principles for the Safe Use of Chemicals:

a. Follow all basic safety precautions to minimize risks when working with hazardous chemicals.
b. Pay attention to the health and physical hazards of the materials you use.
c. Never work alone when hazardous chemicals are involved.

How to Ensure Safe Handling of Chemicals

a. Store chemicals and medicines in a safe way.
b. Store chemicals where children cannot reach them or open them.
c. Add clear labels to packages of chemicals.
d. Avoid storing chemicals in drinking bottles.
e. Dispose of chemicals and medicines in a safe way.

9. **Noise control:** Noise control or noise mitigation is a set of strategies to reduce noise pollution or to reduce the impact of that noise, whether outdoors or indoors. Implement measures to control noise levels in the workshop, such as providing hearing protection and isolating noisy machinery.

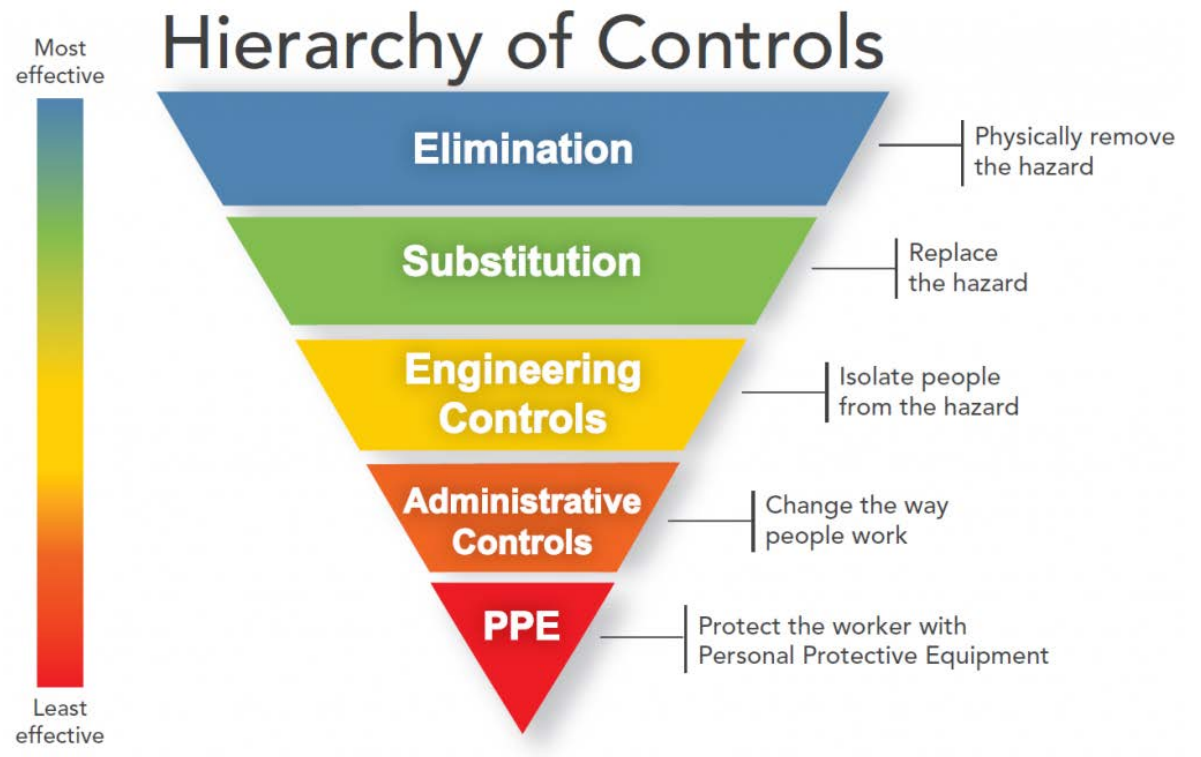


Fig 1.5.7: Noise protection sign, some noise isolating equipment.

10. **Ventilation:** Ventilation is the process by which 'clean' air (normally outdoor air) is intentionally provided to a space and stale air is removed. This may be accomplished by either natural or mechanical means. Ensure adequate ventilation to prevent the build-up of harmful fumes and dust. Install effective exhaust systems where necessary.

    a. **Methods of Ventilation**

    There are **three methods** that may be used to ventilate a building: natural, mechanical and hybrid (mixed-mode) ventilations**.**

i. *What is natural ventilation:* Natural forces (e.g. winds and thermal buoyancy force due to indoor and outdoor air density differences) drive outdoor air through purpose-built, building envelope openings. Purpose-built openings include windows, doors, solar chimneys, wind towers and trickle ventilators. This natural ventilation of buildings depends on climate, building design and human behaviour**.**

ii. *What is mechanical ventilation:* Mechanical fans drive mechanical ventilation. Fans can either be installed directly in windows or walls, or installed in air ducts for supplying air into, or exhausting air from, a room.

iii. *What is hybrid or mixed-mode ventilation:* Hybrid (mixed-mode) ventilation relies on natural driving forces to provide the desired (design) flow rate. It uses mechanical ventilation when the natural ventilation flow rate is too low

b. **Why ventilation is important in the workshop?**

i. Helps in controlling moisture
ii. Maintains good health of you and your colleagues
iii. Improves Air Quality
iv. Increases Comfort level
v. Better Air Regulation
vi. Reduces Temperature

11. **First aid and emergency response:** First aid refers to the emergency or immediate care you should provide when a person is injured or ill until full medical treatment is available. For minor conditions, first aid care may be enough. For serious problems, first aid care should be continued until more advanced care becomes available.

Have well-equipped first aid kits readily available and ensure that learners are trained in basic first aid. Establish emergency response protocols and conduct regular drills.

Types of Basic First Aid

a. Cardiopulmonary Resuscitation. Those trained in cardiopulmonary resuscitation (CPR) can help a victim of cardiac arrest to start breathing again. ...
b. Bleeding. It is important to stop a wound from bleeding to prevent the loss of too much blood.
c. Burns.
d. Choking.
e. Broken Bones.

Fig 1.5.8: Some items in a first aid box.

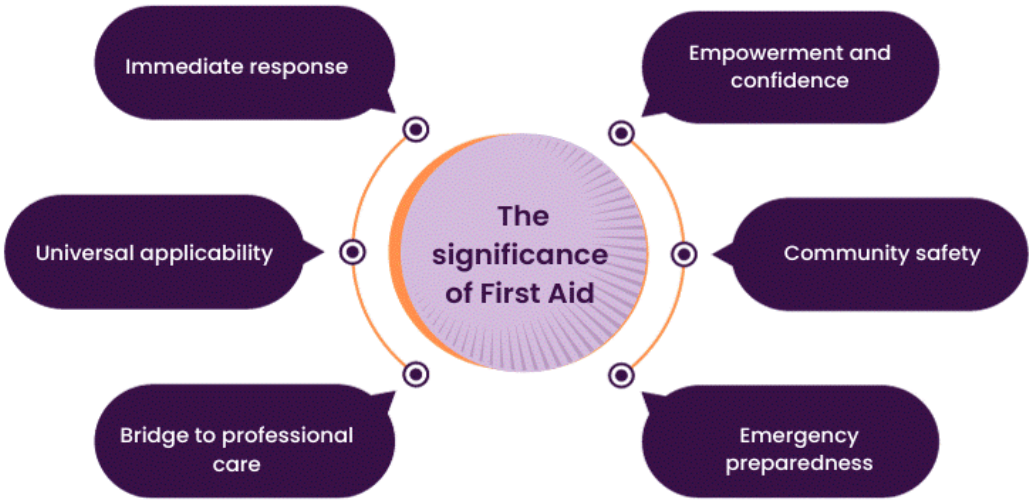


Fig 1.5.9: Significance of First Aid

12. **Training and awareness:** Regular safety training must be provided for all users of the workshop to keep them informed about potential hazards and the proper procedures for maintaining a safe working environment.
13. **Housekeeping:** Housekeeping may also be defined as "a provision of clean, comfortable and safe environment", and one who does so is often known as a Housekeeper. Housekeeping is the management and routine support activities of running and maintaining an organized physical institution occupied or used by people, like a school, house, ship, hospital or factory, such as cleaning, tidying/organizing, cooking, shopping, and bill payment. Keep the workshop clean and organised to minimise tripping hazards and ensure a safe working environment.

Fig 1.5.10: Basic tools and equipment used for housekeeping

Activity 1.5.1

1. As an Applied Technology learner, adequate knowledge and understanding of how to use the Personal Protective Equipment is paramount.

   a. Using the table below as a guide, prepare a chart for learning the topic '**Reasons for Using Personal Protective Equipment (PPE):**

Name of PPE	Part of the body PPE will Protect	One Reason for Using the PPE
i. Overall		
ii. Shield		
iii. Helmet		
iv. Gloves		
v. Strong boots		

b. i. Display your chart for appraisal in class in groups.

   ii. Prepare an appraisal report indicating strengths, weaknesses and recommendations and discuss in class.

Activity 1.5.2

Accidents sometimes occur in the workshop when people are careless and do not pay attention to simple instructions and procedures for using sharp tools and equipment. Safe working rules have been made available for you to follow in order to prevent accidents.

Prepare a chart for learning the topic '**Importance of observing safety in the workshop**'. Use the table below as a guide:

Type of safety	Brief description of type of safety	One importance of observing the safety
i. Machine safety		
ii. Material safety		
iii. Tool safety		
iv. Electrical and welding safety		
v. Fire safety		

Activity 1.5.3

1. a. Using ICT tools, prepare brief notes on the following safety issues and discuss in class in groups:
   i. Machine guarding
   ii. Manual handling
   iii. Chemical handling
   iv. Noise control
   v. Ventilation

   b. i. Prepare short notes on (a i-iii) and share with your classmates.

   ii. Write down all the websites you visited to gather the information on (a i-iii) and share with your colleagues in class.

HAND TOOLS IN METAL WORK

Hand tools are fundamental to the craft of metalworking, offering precision and control in the creation and manipulation of metal components. These tools are designed to handle various tasks involved in shaping, joining, and finishing metal, each tailored for specific functions to enhance accuracy and efficiency. Whether you're measuring, cutting, striking, or holding metal, understanding the proper use and maintenance of hand tools is crucial for achieving high-quality results and ensuring safety in the workshop. This topic explores the essential hand tools used in metalwork, their functions, and best practices for effective use.

Measuring Tools

Measuring tools are essential for obtaining precise measurements of items. Mastering their use ensures accuracy and quality in metalworking projects, from basic measurements to ultra-precise dimensional checks. These tools form the foundation of successful fabrication processes, contributing to efficiency and excellence in metalwork.

In metalwork, a variety of measuring tools are essential for precision and accuracy in fabrication. Let's explore the uses of some of these tools:

1. **Steel Rule**: A basic but indispensable tool for straightforward linear measurements. It is ideal for gauging the lengths, widths, and thicknesses of metal components with reasonable accuracy.
2. **Pocket Rule**: Designed for portability and convenience, this compact tool is perfect for quick measurements in the field or workshop.
3. **Locking Measuring Tape**: Essential for measuring longer distances, this versatile tool is used for the lengths of metal pipes, beams, or other large components with ease.

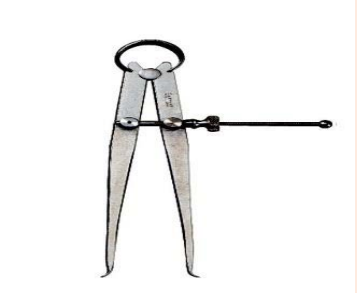
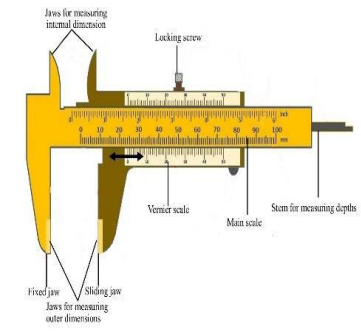
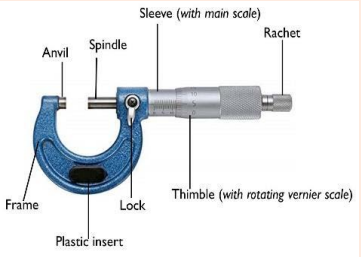
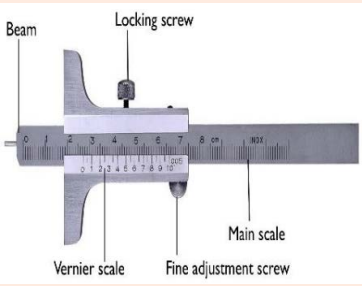
4. **Vernier Callipers**: These are crucial for precise measurements down to fractions of a millimetre or inch. With a main scale and a vernier scale, they provide accurate readings for thicknesses, diameters, and depths of metal parts.
5. **Micrometres**: Offering ultra-precise measurements to thousandths of a millimetre or inch, micrometres are essential for measuring tiny components, machining tolerances, and material thicknesses with extreme accuracy.
6. **Vernier Height Gauge**: Used for measuring vertical distances or heights, this tool allows for precise measurements of workpiece heights, flatness checks, and hole depths in metalworking applications.
7. **Vernier Protractor**: For setting and measuring angles accurately, the vernier protractor provides precise angular measurements for layout work, machining tasks, and assembling alignments.
8. **Dial Gauge**: Also known as a dial indicator or test indicator, this tool is used for checking flatness, alignment, and runout in machined surfaces and components, offering sensitivity and fine adjustments.
9. **Inside and Outside Callipers**: These are essential for measuring the internal and external dimensions of cylindrical objects. They are invaluable for marking out, layout work, and dimension checks during machining operations.
10. **Dividers**: Offering versatility for marking out or transferring measurements, dividers have two sharp-pointed legs and a pivot point. They are perfect for scribing arcs, circles, or parallel lines on metal surfaces during layout work and pattern marking.

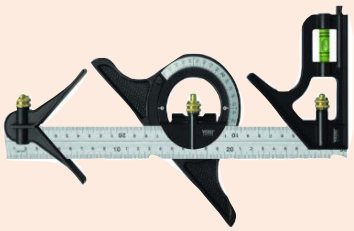
Activity 1.5.4

The table below lists examples of measuring tools. Complete the table by adding their descriptions, uses, and care and maintenance details.

Table 1.5.1: Measuring Tools and their Uses

Name of Tool	Pictorial sketch of the Tool	Description and Uses	Care and Maintenance of Tools
1. Outside calliper			

Name of Tool	Pictorial sketch of the Tool	Description and Uses	Care and Maintenance of Tools
2. Inside calliper			
Spring divider			
3. Vernier calliper			
4. Micrometre			
5. Depth Gauge			

Name of Tool	Pictorial sketch of the Tool	Description and Uses	Care and Maintenance of Tools
6. Measuring tape			
7. Steel rule			
8. Combination set			
9. Dial gauge and indicator			

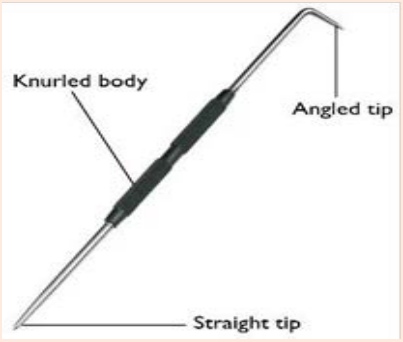
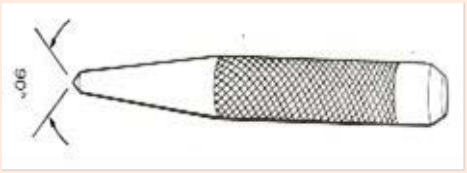
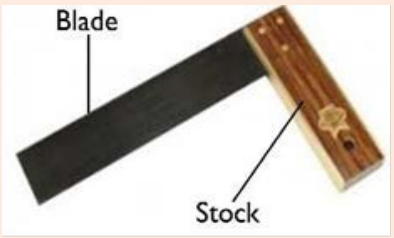
Marking Out Tools

Before you can shape or form workpieces, mark them to the required dimensions. Marking out tools are indispensable in metalworking, providing the precision needed to transfer measurements and layout designs onto metal surfaces. These tools help ensure that cuts, drills, and other modifications are executed with accuracy, aligning closely with the project's specifications. By clearly marking lines, angles, and reference points, these tools guide metalworkers in creating accurate and well-aligned components. Understanding the various types of marking-out tools and their applications is essential for achieving high-quality results and maintaining efficiency in the metalworking process.

Activity 1.5.5

The table below shows some examples of marking out tools. Add their descriptions, uses, care, and maintenance to the table.

Table 1.5.2: Marking out tools

Name of tool	Pictorial sketch of the tool	Descriptions and uses of tools	Care and maintenance of tools
1. Scriber			
2. Dot punch			
3. Centre punch			
4. Engineer's try square			
5. Vee block			

6. Scribing block or surface gauge			
7. Surface plate			
8. Angle plate			

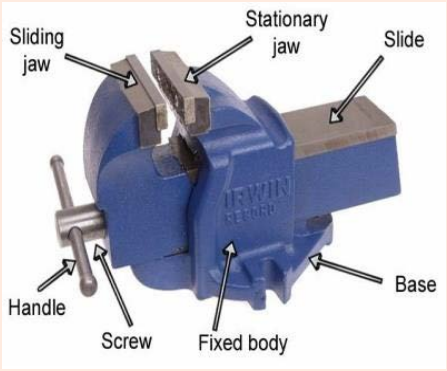
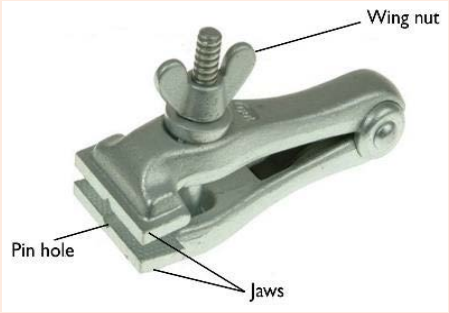
Holding Tools

Holding tools are essential in metalwork, providing the stability and support needed to work on metal pieces with precision and safety. These tools firmly grip or secure the material in place during tasks such as cutting, filing, or drilling, allowing for more accurate and controlled work. Proper use of holding tools ensures that metal components remain steady, reducing the risk of accidents and enhancing the overall quality of the finished product.

Activity 1.5.6

Holding tools are support devices used to securely position a tool or a workpiece in a specific spot or orientation. Add their descriptions, uses, care, and maintenance to the table.

Table 1.5.3: Holding tools and their uses.

Name of tool	Pictorial sketch of the tool	Description and uses of the tool	Care and maintenance of tools
1. Engineer's vice			
2. Hand Vice			
3. Leg Vice			
4. Machine vice			

Striking Tools

Striking tools are essential in metalwork for shaping, assembling, and manipulating metal materials through controlled impact. These tools, which include hammers, mallets, and other striking instruments, are designed to deliver force with precision, allowing for tasks such as bending, riveting, and driving metal components into place. Proper use of striking tools ensures efficient work, while understanding the specific functions of each tool helps prevent damage to both the workpiece and the tool itself.

Activity 1.5.7

Striking tools are tools used for delivering an impact or blow to a workpiece. The table below shows some examples of striking tools used in metal workshops. Add their descriptions, uses, care, and maintenance to the table.

Table 1.5.4: Striking tools, their description, and their uses.

Name of tool	Pictorial sketch of tool	Description and uses of the tool	Care and maintenance of tools
1. Sledgehammer			
2. Ball pein hammer			
3. Straight pein hammer			

4. Cross-pein hammer			
5. Raw hide mallet			

Cutting Tools

Cutting tools are essential in metalwork for shaping and separating metal pieces with precision and efficiency. These tools are specifically designed to trim, slice, or cut through various types of metals, making them fundamental to fabrication and manufacturing processes. Whether performing rough cuts or fine detailing, understanding the appropriate cutting tools for each task ensures accuracy, reduces waste, and enhances overall productivity.

Cutting tools are wedge-shaped, sharp-edged devices used to remove excess layers of material from workpieces, ensuring the desired shape, size, and accuracy are achieved.

Cold chisels are made from tool steel with the appropriate strength, shape, and temper, suited for chipping or cutting cold metals. They can be used for cutting metals in both cold and hot conditions. Cold chisels typically have a point angle of 60 degrees, while hot set chisels have a point angle of 30 degrees.

Note: It is important to grind off the mushroomed head formed by hammering. Failure to do so may result in pieces snapping off, posing a serious safety hazard.

Activity 1.5.8

Examples of cold chisels (flat chisel, crosscut chisel, round-nosed chisel, diamond point chisel) are found in the table below. You are to add their descriptions, uses, and care and maintenance to the table.

Table 1.5.5: Cutting tools, description, uses, and care and maintenance.

Name of tool	Pictorial sketch of the tool	Descriptions and uses of tools	Care and maintenance of tools
Flat chisel			
Round nose chisel			
Diamond point chisel.			
Crosscut chisel			

Saws Used in The Metal Workshop

In the metal workshop, metals are cut into shape before filing. The types of saws used for cutting purposes in the school workshop include the hacksaw.

The Hacksaw

The hacksaw is a cutting tool used in metal/plastic workshops. It has a frame, a handle, and a blade. There are two types of hacksaws: the adjustable/standard hacksaw and the junior hacksaw.

The hacksaw has a frame that can be turned at right angles for cutting deep into the material. The blade is secured in the rigid frame, and the teeth point forward to enable the blade to cut on the forward stroke.

Hacksaw teeth used for cutting different materials:

Teeth/25mm Materials to be cut

14 for solid sections of soft materials

18 suitable for general use.

24 for solid sections, between 3 and 9 mm (e.g., heavy tubing and sheets).

32 for sections less than 3 mm thick

NOTE: At least three consecutive teeth of the hacksaw blade should be in contact with the material.

If the material is soft and has a large section, use a blade with few teeth per 25mm (14 or 18 teeth per 25mm). Use a fine-tooth blade when cutting a fairly thin section.

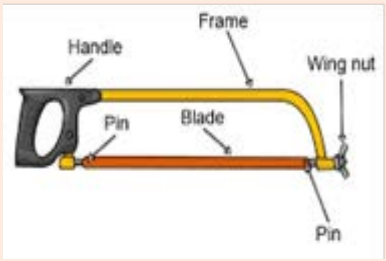
Points to Watch When Using the Hacksaw Are as Follows:

1. Hold the work securely on the vice.
2. Grip the hacksaw firmly, using both hands (Figure 4.9).
3. Use the same stance as in filing.
4. Use the full length of the blade.
5. Move the blade in a straight line to avoid breaking it.
6. Do not exert too much pressure on the blade.
7. Make sure the blade is held tightly in the frame; if it is loose, it is likely to break.

Activity 1.5.9

Sketches in the table below show types of saws. Add their descriptions, uses, care, and maintenance to the table.

Table 1.5.6: Descriptions, uses, care and maintenance

Name of tool	Pictorial sketch of the tool	Descriptions and uses of tools	Care and maintenance of tools
1. Adjustable/ Standard hacksaw			
2. Junior hacksaw			

Hand shears/snips

Hand shears (also known as Tinman's snips) are made of tool steel. They are used for cutting light-gauge materials such as tin plates. They come in different sizes and shapes.

The common shapes are straight, curved, and universal patterns. You are to add their descriptions, uses, and care and maintenance to the table.

Activity 1.5.10

Images in the table below show types of hand shears/snips. Add their descriptions, uses, care, and maintenance to the table.

Table 1.5.7: Descriptions, uses, care and maintenance

Name of tool	Pictorial sketch of hand shear/ snips	Descriptions and uses of tools	Care and maintenance of tools
3. Straight hand shears or snips			
Curved hand shears or snips			
Universal hand shears or snips			

Files

Filing is a method of removing surplus metal, and the file, which is the most widely used hand tool in the school workshop, is used for this cutting operation. It is made of carbon tool steel, containing about 1.3 percent carbon.

The major parts of a file are:

a. The handle, made of either wood or plastic: the wooden handle is fitted with a metal ferrule to avoid splitting when fitting tang:
b. The blade, has a tang that fits into the handle.
c. The teeth are shown on the blade, which are either single or double-cut

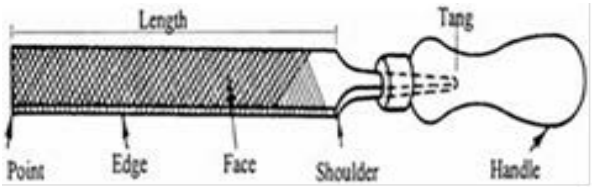


Fig. 1.5.2: Showing parts of a file

NOTE: Use the single-cut file on softer materials such as brass and aluminium and the double-cut for general filing, especially on iron and steel.

Grades of File Cuts

The coarseness of file cuts/grades is described in the table below:

Cut/grade	Specific use
Rough	Filing soft metals and plastics
Bastard	Shaping steel and iron castings
Second	Generally used for harder metals and or for good finishing
Smooth	Draw filing and finishing hard metals
Dead smooth	Accurate filing with a high finish

Types of Sections of File

Files are essential tools used in metalworking, woodworking, and other trades for smoothing and shaping materials. Files are categorised based on their sections, or the cross-sectional shape of the file, which determines the type of work they are best suited for. Each type of file section is designed for specific tasks, allowing craftsmen to choose the most suitable tool for shaping and finishing their work accurately.

Activity 1.5.11

The commonly used types of files are identified in the table below. Add their descriptions, uses, and care and maintenance to the table.

Table 1.5.9: descriptions, uses, care and maintenance

Name of tool	Pictorial sketch of the tool	Descriptions and uses of tools	Care and maintenance of tools
1. Flat file			
2. Hand file			
3. Square file			
4. Rectangular file			
5. File card			

General Care and Maintenance of Files

To extend the lifespan of files, it is essential to handle them with care. The following tips will help you prolong the effective life of your files:

1. Store files separately in a rack, ensuring they do not rub against each other.
2. Avoid using files on hardened steel.

3. Never use a file as a hammer.
4. Keep files away from acids to prevent corrosion.
5. Use a file card regularly to prevent pinning.

Pinning: Pinning occurs when filings become tightly packed in the teeth or cuts of the file, reducing its effectiveness and causing deep scratches on the work surface. To remove pinning, use a brush or file card. To further reduce pinning, rub the file's surface with chalk before use.

Conclusions/Summary

Measuring and marking out tools are crucial in the production industry. As a career technologist, it is essential to competently use appropriate tools, equipment, and processes for measuring, marking out, holding, cutting/shaping, and joining/assembling artefacts and products.

Having knowledge of these tools and understanding their correct usage will enhance your efficiency and accuracy at work. This will also help you avoid wastage of materials, money, and time, ensuring the desired results are achieved.

You have also learnt the importance of caring for and maintaining measuring, marking out, holding, cutting/shaping, striking, and joining/assembling tools. Proper maintenance will prolong the life of these tools and equipment, ensuring they remain effective for future use.

Activity 1.5.12

In this activity, you will work with your group to create colourful and interactive charts that explain the uses of various types of measuring, marking out, holding, striking, and cutting tools. Get started with the following instructions:

1. Form groups of three and assign each member a tool category to research (e.g., measuring tools, marking out tools, etc.).
2. Use creative ideas to design your charts, making sure they're eye-catching and easy to understand. Include pictures, descriptions, and examples for each tool.
3. Display your charts for your classmates to see. Make your presentation as interactive as possible. You can ask questions or give small demonstrations to engage your audience.
4. After the presentations, gather feedback from your classmates and facilitator.
5. As a group, write down any suggestions for improving your charts based on the feedback. Make necessary adjustments to ensure your charts are even better!

Activity 1.5.13

In groups of five, under the supervision of your facilitator or workshop manager, visit a nearby mechanical workshop to observe various tools in action. Follow the following instructions to complete the activity.

1. Before the visit, ensure you are familiar with the health and safety guidelines. This is crucial to keep everyone safe during the trip.
2. As a group, head to the workshop and take the opportunity to observe the measuring, marking out, holding, and cutting tools used to create artefacts and products.
3. Bring along your sketchbook or camera. Take pictures or make detailed sketches of the tools and equipment you see. Pay attention to their features and how they are used!
4. **Group Project**: Once back in class, work with your group to compile your findings into a sketchbook or photo album. Include your pictures or sketches, along with descriptions of each tool and its purpose.
5. **Display and Appraisal**: Share your sketchbooks or photo albums with the class. Set up a display for everyone to appreciate your hard work and creativity. Engage with your classmates by asking questions and discussing what you learnt.

Activity 1.5.14

Reporting is a vital skill that enhances your learning experience during educational visits. To help you develop this skill, follow these steps:

1. **Seek Guidance**: Approach your facilitator or an expert in report writing for assistance in creating a template. This template will serve as a guide for structuring your report effectively.
2. **Template Development**: Collaborate with your facilitator to outline key sections that should be included in your report. Common sections might include:
    a. The name of the visit and the date.
    b. The purpose of the visit.
    c. A brief description of what you did and observed.
    d. Details about the measuring, marking out, holding, and cutting tools you encountered.
    e. Your thoughts on the visit, what you learnt, and how it relates to your studies.
    f. A summary of your overall experience.

3. **Prepare Your Report**: Using the template, write your individual visit report. Be sure to include clear descriptions, observations, and personal reflections. Aim for a well-organised and engaging document.
4. **Share with Classmates**: Once your report is complete, share it with your classmates. This can be done through a presentation or by distributing printed copies. Encourage discussions and feedback to enhance learning.

Activity 1.5.15

Your Applied Technology facilitator has tasked your group with an exciting mission: to discover more about caring for and maintaining the tools you've been studying in class. Follow the steps below to complete the activity

Steps:

1. **In groups of five,** decide who will research which type of tool:
   a. Measuring Tools
   b. Marking Out Tools
   c. Holding Tools
   d. Cutting Tools
2. **Do Your Research**: Look for information on how to care for and maintain your assigned tools. You can use:
   a. Books
   b. Articles
   c. Websites
3. **Take Notes**: Write down the names of the tools and some important care tips. Make sure to note where you found your information.
4. **Share Your Findings**: Come together as a group and share what you learnt. You can create a simple poster or slide presentation to display your information.
5. **Present to the Class**: Share your group's findings with the class. This is a great way to teach each other about tool care.

Activity 1.5.16

As a Career Technology student, adequate knowledge and understanding of how to use personal protective equipment is paramount.

1. a. Using the table below as a guide, prepare a chart for learning the topic '**Reasons for Using Personal Protective Equipment (PPE):**

Name of PPE	Part of the body PPE will protect	One Reason for Using the PPE
i. Overall		
ii. Shield		
iii. Helmet		
iv. Gloves		
v. Strong boots		

   b. Display your chart for appraisal in class in groups.

2. Prepare an appraisal report indicating strengths, weaknesses, and recommendations and discuss them in class.

Activity 1.5.17

Accidents sometimes occur in the workshop when people are careless and do not pay attention to simple instructions and procedures for using sharp tools and equipment. Safe working rules have been made available for you to follow to prevent accidents.

1. Prepare a chart to learn the topic '**Importance of observing safety in the workshop**'. Use the table below as a guide:

Type of safety	Brief description of the type of safety	One importance of observing the safety
i. Machine safety		
ii. Material safety		
iii. Tool safety		
iv. Electrical and welding safety		
v. Fire safety		

Extended Reading

1. Visit the sites or click the links below for additional information on the tools discussed.

https://youtu.be/PPFp_KprTuw

https://www.scribd.com/document/339371538/Work-Holding-Devices-Keith

https://www.slideshare.net/DavidKamwendo/metal-holding-tools

Review Questions for Section 1, Unit 5

The following questions will help you learn more about the areas we have covered.

1. Accidents sometimes occur when tools and equipment are used in the metal workshop. Safe working rules have therefore been made to follow, to prevent accidents. Briefly describe the following safety issues:
   a. Personal Protective Equipment (PPE)
   b. Machine safety
   c. Machine guarding
   d. Material safety.
   e. Tool safety
   f. Electrical and welding safety.
2. In order that accidents will be prevented in the metal workshop, rules have been set for learners to follow.
   a. Using the table below as a guide, briefly explain the safety issues and describe ways of addressing them:

Safety Issue	Brief explanation of each of safety Issue	One way each for addressing the Safety Issue
i. Manual handling		
ii. Fire safety		
iii. Chemical handling		
iv. Noise control		

   b. Display your work for appraisal in class in groups.
3. Explain the reasons for measuring and marking out artefacts before production
4. Make freehand pictorial sketches of the following metalwork tools:
   a. Try-square
   b. Scriber
   c. Hand vice
   d. Hand file
   e. Hacksaw
5. Label any two parts of each of the tools sketched above.
6. Describe how the hacksaw blade is fixed to the frame and why.
7. Describe how pinning occurs in a file and how that can be prevented.

References

Applied Technology Facilitating Learning Materials (2024). NaCCA, Ministry of Education, Accra, Ghana.

J.K.N. Sackey and S.K. Amoakohene (1996). Metalwork Technology, Motivate Series. MacMillan Education Ltd., London and Basingstoke.

Image link: https://www.shutterstock.com/image-photo/scissors-cutting-metal-sheets-isolated-on-2193519257?irclickid=WaLyxz0BLxyKUm0UFpxj9xLfUkHTpXyAJVLGws0&irgwc=1&pl=4869764-1906897&utm_campaign=Freepik%20Company&utm_content=1906897&utm_medium=Affiliate&utm_source=4869764&utm_term=www.freepik.com

Imagelink:https://www.shutterstock.com/image-photo/tree-branch-shears-has-pair-blades-2125194005

Image link: https://www.shutterstock.com/image-photo/man-holding-pair-kitchen-scissors-isolated-1395229646

Image link: https://m.indiamart.com/proddetail/leg-vice-19724678548.html

V-block (Source: bgi.privateiti.com)

Surface plate (Source : eleymet.com)

Angle plate (Source : www.ubuy.com.gh)

PPEs : https://www.who.int/teams/health-product-policy-and-standards/assistive-and-medical-technology/medical-devices/ppe

Machine Safety: https://www.conro.com/what-is-machine-safety/

Preventing workplace injury: https://safetyskills.com/machine-guarding/#:~:text=There%20are%20several%20different%20types,sparks%20created%20by%20working%20machines.

Machine guarding: https://www.rit.edu/ehs/machine-guarding#:~:text=The%20purpose%20of%20machine%20guarding,%2For%20flying%20chips%20%26%20sparks

John Watson (1989), Introductory Electricity and Electronics, Macmillan Publishers. Evans C. Sraha (2021) Applied Electricity and Electronics for SHTS, Books Galore Ventures, Koforidua -Ghana.

Acknowledgements

Ghana Education Service (GES)

List of Contributors

Name	Institution
Philip Kwesi Incoom	Metro Education Office, Cape Coast
Micheal Kobla Tsorgali	AAMUSTED, Kumasi
Tetteh Bruce	Koforidua SHTS
Frank Fabian Aidoo	Ga North M.E.O, Ofankor
Evans Charles Sraha	Ghana National College, Cape Coast