

CHAPTER 6: WORKSHOP TECHNOLOGY PRACTICES

6.1 Introduction

This unit describes the competence in applying workshop technology practices. It entails performing masonry, plumbing and carpentry tasks. It also involves performing electrical and mechanical operations.

6.2 Performance Standard

Perform masonry tasks, plumbing tasks, carpentry tasks, electrical operations and mechanical operations as per Manufacturer's specifications and as per SOPs.

6.3 Learning Outcomes


6.3.1 List of Learning Outcomes

- a) Perform masonry tasks
- b) Perform plumbing tasks
- c) Perform carpentry tasks
- d) Perform electrical operations
- e) Perform mechanical operations

easytvvet.com

6.3.2 Learning Outcome No 1: Perform Masonry Tasks

6.3.2.1 Learning Activities

Learning Outcome No 1: Perform Masonry Tasks	
 Learning Activities	Special Instructions
1.1 Identify the safety requirements in the workshop environment. 1.2 Use masonry hand tools appropriately to perform tasks in masonry workshop 1.3 Use masonry machine tools appropriately to perform tasks in masonry workshop 1.4 Maintain Masonry tools used in construction work	<ul style="list-style-type: none"> • Video instruction • Research • Group discussion • Drawings • Direct Instructions

6.3.2.2 Information Sheet No6/LO1: Perform Masonry Tasks



Introduction

This learning outcome covers safety requirements in the learning environment, appropriate use and performance of masonry hand tools, appropriate use of masonry machine tools and maintenance of masonry tools as per manufacturer's specifications.

Definition of key terms

Course: Refers to a horizontal continuous layer of masonry units

Wythe: Refers to the vertical section of masonry, one unit in thickness.

Mortar: Refers to the mixture of cement, aggregate and water used as a binding for material such as blocks and bricks.

Content/Procedures/Methods/Illustrations

1.1 Safety Requirements in the Workshop Environment are identified

- Always check tools against defects before using
- Use the correct and appropriate tools, instruments or equipment as per the task required.
- Always wear personal protective equipment (PPE) e.g. gloves, goggles, hard hat, safety boots and others all the time.
- Follow instructions provided by the authority of the person in charge

- Report any malfunction of tools, equipment or instrument of any incident to the person in charge.
- Provide materials that show no-go zone such as fencing, these no-go zones may include possible collapse zones.
- Provide designs and materials for temporary supports
- Building walls and cross walls at the same time to ensure they support each other
- Avoid stacking material against masonry walls
- Wait for masonry walls to attain the correct strength before backfilling.
- Establishing stop heights to allow the masonry walls to achieve or gain strength.
- Provide temporary supports for walls considering its characteristics
- Designing walls to provide additional stability during the construction phase i.e. adding sequential core filling with reinforcing.

1.2 Masonry Hand Tools are Used Appropriately to Perform Tasks in Masonry Workshop

A hand tool is a device or equipment that does not require electric power and instead relies on human hand energy supply to operate and used to perform a particular intended purpose. The commonly used hand tools include:

- **Floats**

Used for levelling, filling voids and smoothening surfaces before trowelling. Mainly made of aluminium, wood, stainless steel or magnesium. There are two types of floats depending on the scale of use.

- Bull float – used in large areas of concrete
- Hand float – used in small areas of concrete

- **Trowel**

Trowel comes in different sizes and shapes and is made using stainless steel for the purpose of durability and quality. Handles are commonly made of wood or plastic. Larger trowels are used for spreading mortar and also random cutting of soft bricks. Smaller trowels are used for repairing damaged mortar joint. Learning how to hold and load a trowel is a skill to develop over time.

- **Mason's Hammer**

This tool has two ends, square and flat end for hammering nails and the other sharp-chisel like the end for breaking blocks and bricks. To break blocks and bricks, light blows are subjected along and around the required point of split and then a sharp blow using a hammered end will give the required cut. The cut is then cleaned off of burrs, surplus material and straightening edges and surfaces to greater accuracy using the chisel-like side.

- **Blocking Chisel**

A blocking chisel is made of steel and comes in a variety of shapes and sizes/ they are heavier and wider. They are required when more or several blocks or bricks are needed to be split. They are operated by holding the narrow end while striking continuously using a mashing hammer, sledgehammer or mullet against the bricks to give a clean cut.

Levels

Levels are used to ensure, keep and check horizontal surfaces and planes at 180 degrees and vertical planes and surfaces at 90 degrees. To achieve the level surface or the right-angle plane, the bubble inside the tube should line up between two lines at the centre of the tube.

Mason's Line

Mason line is a nylon or Dacron string stretches close to the masonry wall from one end or corner to the other. It is required to make laying blocks or bricks easier and in a straight line i.e. without bulges and hollows.

Steel Square

This tool is used for checking and verifying a 90-degree angle at the corners of a rectangular or a square wall while it is being built.

Plumb Bob

This tool is used for laying blocks/bricks and checking a 90-degree angle on walls while during construction. It consists of a string tied to a weight called bob and straight wood board with uniform edges and a hole for the string at the centre. On a vertical wall, the plumb bob must be in the groove line.

Masonry Hammer

Used to strike chisel while splitting a brick/block

Mixing tools

These are tools required for mixing mortar. They include:

The Shovel; used for scooping and measuring aggregate

Hoe; mixing the mortar sand, cement and water, with two holes for ease of use.

1.3 Masonry machine tools are used appropriately to perform tasks in masonry workshop

Concrete mixer

This is a mechanical device that consists of a rotating drum powered by a mortar that mixes cement, aggregate and water to form concrete at a slightly higher rate.

Masonry saws

This is a powered tool used to cut concrete block/bricks, tiles etc. into precise shapes and sizes.

Process of Using a Mixer

- i. Measure the required amount of material needed for the structure
- ii. Connect the mixer to a power source and start the machine
- iii. Pour the ingredients into the cement mixer starting with a measured amount of water followed with cement and ballast if needed.
- iv. Allow the machine to rotate until the ingredients are mixed evenly and ready for use
- v. Tilt the mixer and pour the mixture into a carrier (wheelbarrow)
- vi. Repeat as needed

Stone Cutting machine

A tile cutter is used in the splitting of tiles to fit uneven flooring. The following are operational principle;

- i. Select the appropriate tile cutter, 2.5 cm longer than the dimensions of the tile
- ii. An experienced professional should conduct the process to avoid wastage and loss of valuable material
- iii. Make a mark where you need to cut. Trace a line using a pencil and a ruler to mark this point. The cuts will correspond with the dimensions of the floor or space.
- iv. Double-check the dimensions to make sure that it's the required size
- v. Side the lever of the cutter towards you until the cutter stops
- vi. Place a tile with the glazed side facing up. Centre the tile beneath the block rails and push it forward until it fits snugly against the end stop.

1.4 Masonry tools used in construction works are maintained as per manufacturer's specifications

Maintenance of Masonry Tools

- i. Use the appropriate and right tool for the tasks to prevent tool and user damage.
- ii. Keep all tools in good condition and perform regular checks against defects. Only qualified professionals should install or repair equipment to avoid mechanical failure.
- iii. Clean tools after use and store the dry tools in a dry place.
- iv. Ensure that each tool is free from damage before use to avoid further damage.
- v. Avoid altering tools in ways that reduce the performance and effectiveness of the tool.

- vi. Comply with manufacture's manual guide and instructions most pieces of equipment come with guidelines on procedures of using and maintaining them to ensure machine effectiveness.
- vii. Store all tools in dry places to avoid rust and mechanical damage caused by dampness.

Conclusion

This learning outcome has covered safety requirements in the learning environment, appropriate use and performance of masonry hand tools, appropriate use of masonry machine tools and maintenance of masonry tools as per manufacturer's specifications.

Further Reading



1. Study more on other masonry hand and machine tools and their appropriate use.

5.3.2.3 Self-Assessment



Written Assessment

1. How is mortar cleaned from tools?
 - a) Waiting for the mortar to dry up and then can be easily removed
 - b) Cleaning immediately using water
 - c) Cleaning immediately using linseed oil and kerosene
 - d) Soaking in water and leaving it
2. What is the best way of preventing tools from rusting?
 - a) Oiling the tools
 - b) Clean the tools and immediately store in air-conditioned room
 - c) Keep the tools clean and dry before storage
 - d) Store wet tools in airtight boxes
3. Which of the following tools is used for checking vertical walls?
 - a) Level
 - b) Plumb bob
 - c) Masons line
 - d) Steel square

4. Most moving parts of masonry machine tools are maintained by?
 - a) A cleaning agent provided by the manufacturer
 - b) Clean water
 - c) Oiling
 - d) None of the above
5. The following are safety requirements in the workshop environment except one. Which one is not?
 - a) Provide signs and perimeters to no go zones
 - b) Wear personal protective equipment (PPE) while performing tasks
 - c) Follow instructions from the supervisor
 - d) Construct masonry walls beyond stop heights to finish construction time
6. Identify one way of maintaining masonry tools?
 - a) Storing tools in a dry place
 - b) Cleaning tools before storage
 - c) Oiling moving parts of tools
 - d) All of the above
7. Why are tools such as hammers frequently checked against signs of cracking, chipping or defects?
 - a) To maintain their cost value
 - b) To ensure that they are in good condition
 - c) To ensure that the tools are well-classified
 - d) To ensure that the tools are not missing
8. Propose some of the tools to be used while constructing a brick wall.
9. Examine the components of mortar?
10. Give four personal protective equipment required during masonry instruction
11. Create a list of safety precautions to observe while handling masonry tools.
12. Distinguish hand tools and power tools

Oral Assessment

1. Classify different masonry tools.
2. Summarise the maintenance of the above tools

Practical Assessment

Construct one-meter high wall 3-meter long brick wall under the supervision of the instructor

6.3.2.4 Tools, Equipment, Supplies and Materials

- Spade
- Shovel
- Vibrator
- Pneumatic hammer
- Bench shears
- Anvil
- Pipe wrench
- Pliers
- Bending machine
- Portable power drill
- Saws
- Hammer
- Marking gauges
- Hand drill
- Portable drill machine
- Screwdriver
- Pliers
- Leather gloves
- Hand vices
- Pliers
- Submersible
- Reciprocating pump
- Hand pumps

easytvvet.com

Materials and supplies

- Lumber
- PPR pipes
- PVC pipes
- GI pipes
- Pipe fittings
- Cement
- Sand
- Lime
- Sheet metal
- Steel plates
- Electrical materials
- Electrical appliances
- Plumbing appliances

- Fuel
- Grease
- Oil
- Filters

Personal protective equipment (PPEs)

- Helmets
- Gloves
- Safety goggles
- Safety boots
- Overalls
- Dust masks
- Gas masks
- Dust coats

6.3.2.5 References




Ainsld. (2003). Working with concrete (for pros by pros). Newton. Tanton press.

Gilbera. (2003). Roofing and Siding. California. Sunset books incorporated.

Wolan. (2010) Concrete construction California craftsman Book Company

6.3.3 Learning Outcome No 2: Perform Plumbing Tasks

6.3.3.1 Learning Activities

Learning Outcome No 2: Perform Plumbing Tasks	
 Learning Activities	Special Instructions
2.1 Safety requirements in the workshop environment are identified 2.2 Plumbing hand tools are used appropriately to perform tasks in plumbing workshop 2.3 Plumbing machine tools are used appropriately to perform tasks in plumbing workshop 2.4 Plumbing tools used in construction works are maintained	<ul style="list-style-type: none"> • Practical projects • Demonstration • Oral assessment • Direct instruction

6.3.3.2 Information Sheet No6/LO2: Perform Plumbing Tasks



Introduction

This learning outcome covers plumbing workshop safety requirements, plumbing hand tools, and plumbing machine tools, maintenance of Plumbing tools and use of Plumbing tools.

Definition of key terms

Workshop: It is a fully equipped space containing tools and equipment specific to a particular task. E.g. a plumbing workshop containing plumbing machinery and equipment.

Plumbing hand tools: These any plumbing tools that function using mechanical means only without the use of external power.

Plumbing machine tools: These are plumbing tools that use electric power to run their mortars. They cannot function by mechanical means only.

Content/Procedures/Methods/Illustration

2.1 Safety requirements in the workshop environment are identified

The safety requirements are important to keep both the students and instructor safe and should be observed at all times in workshops.

They include:

- Listening carefully to the instructor and following instructions
- No running in the workshop
- Know where the emergency stop buttons are positioned
- Know where the emergency exits are located.
- Always wear an apron to hold loose clothing
- Put all stools away when attempting practical work
- Do not bring bags to the workshop
- Not use machines that one has not been shown how to use properly.
- Keep hands away from moving machinery
- Use tools carefully
- Report any damaged equipment

The safety procedures are identified by observing the type of machinery in the workshop and by reading instruction manuals of specific machines.

2.2 Plumbing hand tools are used appropriately to perform tasks in plumbing workshop

Plumbing hand tools include pipe fitters, telescopic tube cutter, adjustable spanner, adjustable pipe wrench, slip joint pliers, locking pliers, pipe bender, plunger etc.

Table 9: Plumbing tools

Tool	Use
Pipe cutter	<ul style="list-style-type: none">• It is used to cut through most piping with ease. They are quicker and produce a designer cut than hacksaws.• They can be used in tight spaces
Telescopic tube cutter	<ul style="list-style-type: none">• It can cut pipes made of copper clearly and neatly• It cuts pipes and tubing with a thickness of 6-35 mm
Adjustable spanner	<ul style="list-style-type: none">• Used to turn nuts and any type of fastening• They are easily adjusted to fit multiple bolt sizes
Adjustable pipe wrench	<ul style="list-style-type: none">• It is one of the most basic and essential tools• It is used to grip onto objects like bolts and surfaces and can be used to remove stuck objects
Slip joint pliers	<ul style="list-style-type: none">• They are also known as water pump pliers• They are used for gripping and holding tops


How to use an adjustable pipe wrench

- i. Select the proper pipe wrench and attach it to the pipe correctly. Adjust the wrench to fit the appropriate size of the bolt.
- ii. One should always make sure to leave some space (about 1.3 cm) between the shank of the hook jaw on the pipe wrench and the pipe itself. This is because the gripping action is better with the gap introduced.
- iii. When the grip is secure make sure the pipe sits in the “V” of the hook and is in contact with either side of the “V” to avoid slipping
- iv. Proceed to turn the wrench in the desired direction over and over again until the bolt is either tightened or loosened depending on the need.

2.3 Plumbing machine tools are used appropriately to perform tasks in plumbing workshop

Plumbing machine tools include a sink auger, drill and laser tape measure.

Table 10: Plumbing machine tools

Machine tool	use
	<ul style="list-style-type: none">• To break up and clear clogs in sinks and tub drain
Drill	<ul style="list-style-type: none">• This is a machine used to drill holes pipes and other materials
Laser tape measure	<ul style="list-style-type: none">• It is used to measure distances such as lengths widths and heights accurately

How to use a sink auger to unclog a drain?

The auger has a corkscrew end attached to a flexible cable that is coiled within a drum canister. It also has a thumbscrew in the collar for locking the cable when the clog is reached.

- First, remove the stopper from the drain.
- Loosen the setscrew at the collar to pull out the cable and then insert it into the drain opening.
- Proceed to push the cable into the opening and when you feel the clog pull out an extra 30 cm and tighten the set screw.
- Press the button to turn the cable or turn the crank in a manual auger.
- Once the cable is pulled back clean the cable and remove the P-trap.
- Clean and maintain the auger.

2.4 Plumbing tools used in construction works are maintained as per manufacturer's specifications

Plumbing tools are prone to contamination of bacteria due to exposure to sewers and other contaminated matter.

How to clean and disinfect

Larger tools and equipment are cleaned using a spray disinfectant between regular clearings.

- Wear appropriate personal protective equipment
- Removes debris
- Wipe or spray all the surfaces with the recommended disinfectant
- Wait for recommended contact time
- Discard all wipes
- As recommended in the instructions follow up with regular cleaning and oiling

Plumbing tools should be maintained by the users or professional maintenance crew for complex machinery.

Conclusion

This learning outcome covered plumbing workshop safety requirements, plumbing hand tools, and plumbing machine tools, maintenance of Plumbing tools and use of Plumbing tools.

Further Reading



1. More tools and equipment used for plumbing
2. Methods of using professional equipment

6.3.3.3 Self-Assessment



Written Assessment

1. Which one of the following cannot be used to tighten a bolt?
 - a) Pipe cutter
 - b) Shovel
 - c) Adjustable pipe wrench
 - d) Masking tape
2. Which tool is the best among the following to be used to make clean fine cutting copper tubes
 - a) Telescope tube cutter
 - b) Slip joint pliers
 - c) Sink auger
 - d) Drill
3. Which one of the following is a plumbing machine tool?
 - a) Hand saw
 - b) Auger
 - c) Telescope tube cutter
 - d) Adjustable spanner
4. Propose some of the safety requirement in a workshop
5. Distinguish between plumbing hand tools and plumbing machine tools.
6. Describe the use of a drill in plumbing.
7. Demonstrate the use of an adjustable pipe wrench.
8. On a given drawing material, illustrate the use of a sink auger.

Oral Assessment

1. Outline the safety measures to be observed while carrying out a plumbing exercise.
2. Compare and contrast the uses of a pipe cutter and a handsaw when cutting a 10 mm pipe?

Project Assessment

Make a well-detailed drawing and analysis of a cold-water system in a simple maisonette. The house is assumed to have 5 bedrooms, 2 of which are unsuited and one extra share bathroom. The ground floor has 1 unsuited room and one toilet and the first floor has 1 unsuited room, 3 extra rooms, one bathroom and one toilet. Use clear illustrations to support your answer.

6.3.3.4 Tools, Equipment, Supplies and Materials

- Spade
- Shovel
- Vibrator
- Pneumatic hammer
- Bench shears
- Anvil
- Pipe wrench
- Pliers
- Bending machine
- Portable power drill
- Saws
- Hammer
- Marking gauges
- Hand drill
- Portable drill machine
- Screwdriver
- Pliers
- Leather gloves
- Hand vices
- Pliers
- Submersible
- Reciprocating pump
- Hand pumps

easytvvet.com

Materials and supplies

- PPR pipes
- PVC pipes
- GI pipes
- Pipe fittings
- Cement
- Plumbing appliances
- Fuel
- Grease
- Oil
- Filters

Personal protective equipment (PPEs)

- Helmets
- Gloves
- Safety goggles
- Safety boots
- Overalls
- Dust masks
- Gas masks
- Dust coats

6.3.3.5 References




Miller, Rex, Mark Richard (2004). Audel Plumbers Pocket Manual (10th Ed), Wiley Publishing

The Copper Development Association (2006). Copper Tube Handbook, New York, USA, The Copper Development Association

easytvvet.com

6.3.4 Learning Outcome No 3: Perform Carpentry Tasks

6.3.4.1 Learning Activities

Learning Outcome No 1: Perform Carpentry Tasks	
 Learning Activities	Special Instructions
3.1 Identify safety requirements in the workshop environment 3.2 Use carpentry hand tools appropriately to perform tasks in carpentry workshop 3.3 Use carpentry machine tools appropriately to perform tasks in carpentry workshop 3.4 Maintain carpentry tools used in construction works	<ul style="list-style-type: none"> • Demonstration • Group work • Practical assessment

6.3.4.2 Information Sheet No6/LO3: Perform Carpentry Tasks



Introduction

This learning outcome covers identification of safety requirements in the workshop environment, appropriate use of carpentry machine tools in the carpentry workshop, appropriate use of carpentry machine tools to perform tasks in the carpentry workshop and maintenance of carpentry tools used in construction work as per the manufacturer's specifications.

Definition of key terms

Welding: This refers to the act of joining together metal or plastic parts by exposing the surface to heat and pressure.

Carpentry: This is the act of shaping, cutting, joining and sculpting of wood or timber

Content/Procedures/Methods/Illustrations

3.1 Safety requirements in the workshop environment are identified

Safety requirements in a workshop

All persons using workshops should apply good housekeeping practices which are;

- Removal of rings and loose jewellery before operating machinery.
- Always keep a tidy workplace which makes it easier to spot and avoid hazards.
- Always wear appropriate footwear and clothing such as gloves, overalls and safety glasses.
- Only use the workshop for its intended purpose.
- Do not operate electrical machinery using wet hands.

- Long hair should be tied up and nails kept neat and short
- The workshop should be well lit.
- The workshop should have adequate sanitary and hygienic washing facilities.
- The workshop should be equipped with adequate fire-fighting equipment.

3.2 Carpentry hand tools are used appropriately to perform tasks in carpentry workshop

Carpentry hand tools

All carpentry hand tools should be used and stored appropriately to perform tasks in a carpentry workshop. Some of the carpentry hand tools used in the making of a quality end product are listed below:

- Claw hammer
- Tape measure
- Utility knife and blades
- Moisture meter
- Chisel
- Level
- Screwdriver
- Nail set
- Sliding level
- Layout square
- Pliers
- Anvil

- The claw hammer:** This is a tool primarily used for driving nails or pulling them out from an object
- Tape measure:** This is a tool primarily used to measure the distance from one point to another. It consists of metal, ribbon, plastic or fibreglass with linear measurements markings.
- Utility knife and blades:** This is a tool used for general cutting consisting of a blade usually 4-7 inches.
- Moisture meter:** This is a digital instrument used to detect the level or amount of moisture content in materials.
- Chisel:** This refers to a tool shaped cutting edge of a blade on its end used for carving, sculpting or cutting materials such as wood.
- Level:** This is a tool consisting of a small glass tube containing alcohol or a similar liquid and an air bubble used to indicate the horizontal plane of a material or a surface.

How to use a level?

Place the level on a flat surface and mark at the end of the level. Make another mark along the side of the level under the flacon in the Centre. Take the reading of the position of the bubble.

3.3 Carpentry machine tools are used appropriately to perform tasks in carpentry workshop

Carpentry machine tools

Carpentry machines are usually powered by electric motors intended to process wood. Some of these machines are listed below;

Table 11: List of Tools

Drill press	Wood lathe
Bench grinder	Panel saw
Mortiser	Pin router
Band saw	Nail gun
Combination machine	Chain saw
Drum sander	Electric drill
Jointer	Thicknesses

- **Drill press**



Figure 80: Drill press

Source: <https://gistgear.com>

Also known as pedestal drill, pillar drill or bench drill is a machine mounted on a stand or bolted on the floor used for producing holes in hard materials.

How to use a drill press?

Open the chuck, slide in a bit, snug the chuck by hand around the bit's shaft, then tighten the chuck's three jaws with the key. Make sure to remove the chuck. When drilling large holes, drill a smaller pilot hole first. Set the table to the desired height for the operation you have to perform. Secure the workpiece to be drilled. Make sure the drill is operational and introduce it to the bit of the workpiece. Once you have finished drilling, release pressure on the level and it would return to its original position.

- **Bench grinder**

This is a benchtop or worktop type of machine used to drive abrasive wheels for grinding materials.

- **Mortiser**



Figure 81: Mortiser

Source: <https://www.gdmlindex.co.uk>

This is a machine used to cut square or rectangular holes in a piece of timber. Some types of mortises include; square chisel, horizontal or slot mortise and chain mortiser.

- **band saw**



Figure 82: Band saw

Source: <https://www.toolnut.com>

This is a machine consisting of a long, sharp blade with a continuous band of toothed metal stretched between two wheels used in cutting materials.

- **Combination machine**

This is a machine that combines the functionality of two or more separate machines into a single unit used for woodworking and customized craftsmanship.

- **Drum sander**

This is a powerful machine with replaceable abrasive sheets which sand wooden surfaces to a shiny smooth finish.

- **Jointer**

This is a machine used to merge two edges or surfaces in order to produce a wider board by producing flat edges on boards.

3.4 Carpentry tools used in construction works are maintained as per manufacturer's specifications

Maintenance of carpentry tools

After performing woodworking activities and processes, the tools and equipment should be properly cleaned and stored to prevent damage to the tools and promote their life cycle through;

- Proper storage of tools through hanging them on pegboards, putting them in boxes or drawers or chests
- Clean, inspect and care for tools through wiping using a rag so as to be sure they are free of residual debris.
- Inspect tools for wear and damage in order to prevent additional costs for the purchase of new equipment.

- iv. Lubricate moving machine parts so as to prevent rusting, wear and tear.
- v. Keep batteries, plugs and wipes in shape so as to prevent them from intertwining causing breakages and acid leakage from batteries.

Conclusion

This learning outcome covered identification of safety requirements in the workshop environment, appropriate use of carpentry machine tools in the carpentry workshop, appropriate use of carpentry machine tools to perform tasks in the carpentry workshop and maintenance of carpentry tools used in construction work as per the manufacturer's specifications.

Further Reading



From the internet, research more on the safety requirements in a workshop, examples and use of carpentry hand tools and machinery.

6.3.4.3 Self-Assessment



Written Assessment

1. Which one of the following mortises is false?
 - a) Signature chisel mortiser
 - b) Circular chisel mortiser
 - c) Horizontal mortiser
 - d) Chain mortiser
2. Which one of the following is not an example of a carpentry hand tool?
 - a) Claw hammer
 - b) Mallet
 - c) Tape measure
 - d) Level
3. Which one of the following is a machine used to cut square or rectangular holes in a piece of timber?
 - a) Square chisel
 - b) Horizontal mortise
 - c) Slot mortiser
 - d) Chain mortise

4. Among the following; which one is not a carpentry machine use in a workshop?
 - a) Jointer
 - b) Drum sander
 - c) All of the above
 - d) None of the above
5. In a level, a specific liquid is usually placed in the air bubble to identify the liquid among the following choices
 - a) Alcohol
 - b) Spirit
 - c) Water
 - d) Oil
6. Which of the following is not an example of a carpentry hand tool?
 - a) Claw hammer
 - b) Level
 - c) Mortise
 - d) Combined machine
7. Which of the following materials is not used when marking the linear measurements in a tape measure?
 - a) Ribbon
 - b) Metal
 - c) Wood
 - d) Plastic
8. Outline the uses and function of a mortise.
9. Compare and contrast the types of mortise.
10. Develop a plan to carry out machinery maintenance in a simple workshop.
11. Investigate the function of a combination machine
12. Develop a safety guide for a workshop.

Oral Assessment

1. Propose hand tools to use when building a wooden bench
2. Classify the different machine tools.

Practical Assessment

Among the methods and procedures of maintenance of hand tools, carry out one of the methods of tool maintenance and take sufficient photographs showing how you carried out the task in a systematic order.

6.3.4.4 Tools, Equipment, Supplies and Materials

- Spade
- Shovel
- Vibrator
- Pneumatic hammer
- Bench shears
- Anvil
- Pipe wrench
- Pliers
- Bending machine
- Portable power drill
- Saws
- Hammer
- Marking gauges
- Hand drill
- Portable drill machine
- Screwdriver
- Pliers
- Leather gloves
- Hand vices
- Pliers
- Submersible
- Reciprocating pump
- Hand pumps

easytvvet.com

Personal protective equipment (PPEs)

- Helmets
- Safety goggles
- Safety boots
- Overalls
- Dust masks
- Gas masks
- Dust coats

6.3.4.5 References




- Alban J. Lynch. (2005). The history of grinding. New York: Springer
Black & Decker. (2018). Carpentry made simple. Minneapolis: Cool springs.
Brian Porter. (2013). Carpentry and joinery, vol.2. London: Routledge.

easytvvet.com

6.3.5 Learning Outcome No 4: Perform Electrical Operations

6.3.5.1 Learning Activities

Learning Outcome No 4: Perform electrical operations	
 Learning Activities	Special Instructions
4.1 Safety requirements in the workshop environment are identified	<ul style="list-style-type: none">• Demonstration• Practical assessment• Oral assessments
4.2 Conventional tools used in the electrical workshop are identified	
4.3 Power supply sources are identified	
4.4 Basic electrical circuits are installed and maintained	

6.3.5.2 Information Sheet No6/LO4: Perform Electrical Operations



Introduction

This learning outcome covers identification of safety requirements in the workshop environment, identification of conventional tools as per SOPs, identification of power supply sources as per SOPs, installation and maintenance of basic electrical circuits as per IEE regulations.

Definition of key terms

IEE wiring regulations.

Are based on the British standards (7671) which set the standards for all domestic and industrial installations and wiring.

Side cutter

This is a tool used to cut the wire and the leads of components in electrical devices as well as in stripping the insulation from wires.

Content/Procedures/Methods/Illustrations

4.1 Safety requirements in the workshop environment are identified as per SOPs

When working in an electrical workshop, safety and caution must be observed to avoid injury or in extreme cases death. Safety requirements can be identified and given form verbal instructions from the supervisor, written instructions from the manuals obtained from some equipment in the workshops, general and careful observations of students and common knowledge.

The basic safety requirements for an electrical workshop include;

- a) Avoid working with both hands since it increases the likelihood of current passing through the chest cavity.
- b) Assume all electrical devices to be live to avoid ignorant accidents or incidents.
- c) Disconnect devices from the power source before doing any repair works.
- d) Do not use tools with conducting handles when working with electrical devices to avoid cases of electrocution.
- e) Wear nonconductive protective clothes to handle plugged in equipment and devices.
- f) In case of spillage, do not move live equipment or devices away from the source but instead shut off power at the main switch or circuit breaker.
- g) Ensure all conductors and contacts are properly enclosed to avoid injuries and accidents.
- h) Do not handle equipment with wet hands, feet or body when standing on a wet floor to avoid electrocution.
- i) Highly flammable fluids should not be stored near electrical equipment to avoid any accidents arising.
- j) Avoid equipment with damaged insulation or broken plugs.
- k) Drain capacitors before removing them from a circuit to avoid electric shock.
- l) Wear goggles and avoid fumes when soldering circuit boards.
- m) Do not overload electric outlets.
- n) Use non-metallic drawing equipment like pencils and rulers as well as non-metallic watchbands and jewellery to avoid electrical shock.

4.2 Conventional tools used in the electrical workshop are identified as per SOPs

Electrical tools are essential for carrying out electrical operations effectively. These tools have been proven over the years to meet the demands of the current generation but there remain tools that every electrical personnel require. They can be further be classified into hand tools and machine tools.

a) Hand tools

These are tools that are operated without the use of external power sources and can be operated by hand and are usually portable.

Examples of hand tools

- **Multimeter**

It is a flexible instrument as it is able to measure voltage, current resistance and capacitance among others. They can either be analogue or digital depending on preference.



Figure 83: Multimeter

Source: <https://www.uline.com>

How to use a digital multimeter

A multimeter has 3 main parts: Display, selection knob and ports.

On measuring voltage,

- i. Plug the black test lead into the terminal labelled “COM” for voltage to measure both AC and DC voltage.
- ii. Move the dial to V- for AC voltage (voltage in a socket) or V- for DC voltage (power sources directly i.e. batteries)
- iii. Turn the dial to a higher voltage than the one expected or if unsure set it in a generally high region before lowering it to get a better reading.
- iv. Connect the black probe to the batteries ground/’-and the red probe to power or ‘+’ to measure the DC voltage.
- v. Put probes in corresponding wall socket slots to measure AC voltage but avoid probes from contacting each other. Additional caution is required when dealing with AC current as it can be dangerous. Thus, a noncontact tester is preferred than a digital multimeter.
- vi. Observe the multimeter to acquire the reading needed to show whether the voltage is appropriate.

NOTE: If you encounter a negative reading on the multimeter, it simply means the red and black probes are switched.

Wire stripper

It is a handheld tool used to strip or cut off wire insulation and is designed with various sized cutting teeth to accommodate different sizes of wires. It also includes cutting jaws for trimming wire ends. There are some types that combine the use of crimping wires and stripping the vinyl insulation from wires.



Figure 84: Wire Stripper

Source: <https://saudi.souq.com>

Fish tape

This is a tool used to pull wires through electrical and PVC conduits by creating a new route for wiring.

This is done by pulling the tape out of the wheel by pressing a button or pulling a lever then feeding the tape into the conduit until it emerges from the other end where the wires are attached to the fish tape in order to pull them through the conduit.



Figure 85: Fish tape

Source: <https://www.homedepot.com>

Pliers

There are various types of pliers required for electrical operations with the main ones including side cutting pliers specially designed for trimming wires and cutting small wires. Longnose pliers are used for cutting and holding of fine wires in tight spaces. Other types of pliers include slip joint pliers, retainer ring pliers and snap ring pliers.

Screwdrivers

They are essential to most crafts and technical disciplines including electrical operations. They are used to loosen or tighten screws with slotted heads.

The different types of screwdrivers include electronic screwdrivers, multi-tip screwdrivers, precision screwdriver sets and many more.

b) Machine tools.

i. electric drill.

It is a motor-driven power drill with a replaceable drill bit used to make holes in wood, metal, plastic. It is especially useful with larger products.



Figure 86: Electric drill

Source: <https://haiwangtool.en.made-in-china.com>

ii. Power saw

Power saw varies with the type and scope of the work being done with examples of saws used for electrical work including hole saws, cut off saws and portable band saws. They are especially useful to ensure clean cuts at optimum speed and high performance.



Figure 87 power saw; source copia.co.ke

4.3 Power supply sources are identified as per SOPs

A power supply source is an electrical device used to provide electrical supply to electrical and electronic equipment.

There are two main types of power supply;

a. AC power supply

An AC power source such as AC mains used to supply power to homes acquires voltage from the mains supply and uses a step up or step down the voltage.

AC power supply is further classified into:

- Single-phase systems.
- Three phased systems

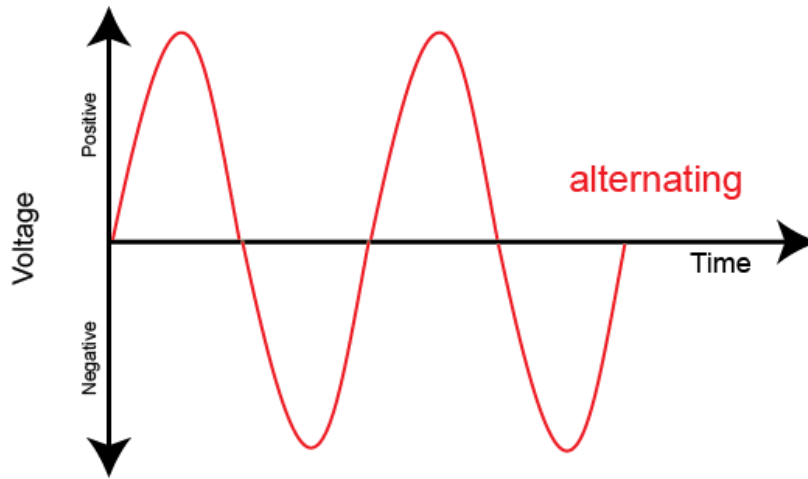


Figure 88: AC Graph

c. DC power supply

These are power sources that produce DC currents as the output basic DC is built with 4 circuits each with a core function.

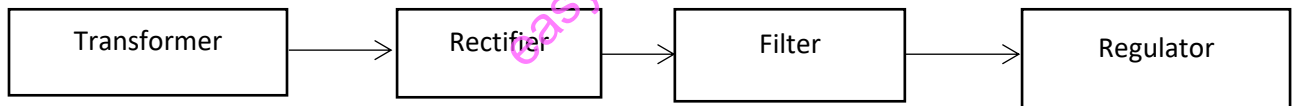


Figure 89: Transformer.
Step-up/step down voltage.

Rectifier

Provides a pulsating DC signal.

Filter

Change/convert DC signal to non-pulsating DC signal.

Regulator

- Smooth DC signal.
- Provides constant voltage at the output.

There are other types of the power supply based on AC and DC current including linear power supply, switched power supply, uninterrupted power supply, regulated power supply, programmable power supply, computer power supply and linear power supply.

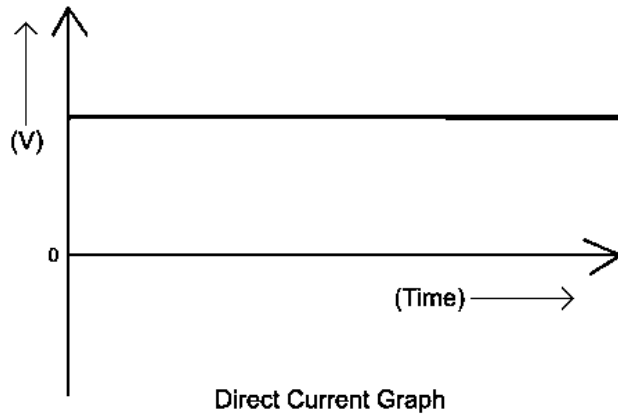


Figure 90: DC Graph

4.4 Basic electrical circuits are installed and maintained as per IEE regulations

An electrical circuit is a continuous path or loop that allows electrical current to flow from the power source through the wiring to the electrical device and back to the power source.

Electrical circuits essentially convert electrical energy to another source of energy at the load (electrical device) such as a bulb.

There are generally two types of circuits; AC and DC-based on the power supply but there are other types such as series circuit, short circuit, open circuit and closed circuit based on the construction of the circuit.

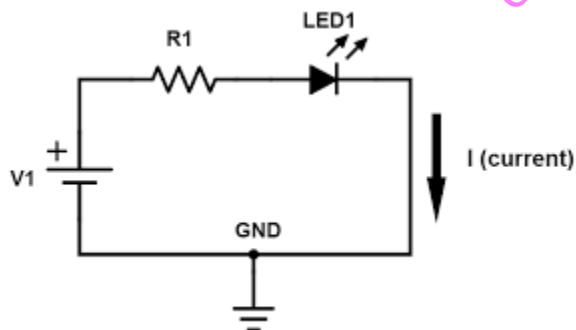


Figure 91: Basic electric circuit

Installation of basic circuits

Installation procedure described as per IEE regulations of a switched socket which in this case is a 15A switched socket outlet for 50Hz, 240V AC power supply.

Material requirement.

- PVC box for 15A switched socket outlet.
- 1 switched outlet.
- 1 MCB 16A from an already installed Distribution Board (DB).

Preparation

- i. Install socket outlet box at the required position.
- ii. Lay 13mm PVC conduit from the Distribution Board to the receptacle position.
- iii. Colour code wires correctly.

Procedure

- i. Ensure power is isolated (shut down).
- ii. Connect the phase (live wire) to the outgoing side of a 16A MCB from Distribution Board.
- iii. Connect the neutral wire to the neutral link provided in the DB and draw 15A receptacle and connect to the terminal marked N.
- iv. Connect the earth wire to the earth link provided in the DB.
- v. It is advisable to number the phase and neutral wires at the DB for easy identification.

Maintenance of electrical circuits

Lubricate rollers and bearing surfaces in the operating mechanism to avoid drying out which slows down the operating speed of the circuit breaker.

Conclusion

This learning outcome covered identification of safety requirements in the workshop environment, identification of conventional tools as per SOPs, identification of power supply sources as per SOPs, installation and maintenance of basic electrical circuits as per IEE regulations.

Further Reading



1. Specifications required for power supply.
2. Features of AC and DC power supplies.
3. IEE wiring regulations.
4. Single-phase systems.
5. Three-phase systems.

6.3.5.3 Self-Assessment



Written Assessment

1. Which measuring tool is used to measure more than one function?
 - a) Voltmeter.
 - b) Multimeter.
 - c) Fish tape.
 - d) Tape measure.
2. What is the function of a filter in a DC power supply?
 - a) Convert DC signal to AC signal.
 - b) Convert AC signal to DC signal.
 - c) Convert DC signal to non-pulsating DC signal.
 - d) Convert AC signal to non-pulsating DC signal.
3. Which tool is used to strip or cut off the insulation from wires?
 - a) Pliers.
 - b) Wire stripper.
 - c) Screwdriver.
 - d) Electric drill.
4. Which one is not an example of a hand tool?
 - a) Screws.
 - b) Power saw
 - c) Fish tape.
 - d) Pliers.
5. How many circuits are found within a basic DC supply?
 - a) 2.
 - b) 6.
 - c) 1
 - d) 4
6. Which one is not a type of electrical circuit?
 - a) Series circuit.
 - b) AC circuit.
 - c) Parallel circuit.
 - d) Conduct circuit.
7. What does SOPs stand for?
 - a) Standard operating procedure.
 - b) Standard occupational procedure.
 - c) Short operating procedure.
 - d) Specific operating procedure.

8. Sketch a simple electric circuit using a cell and two bulbs
9. Outline safety requirements for an electric workshop.
10. Develop a safety requirement plan for a busy workshop.
11. Compare and contrast direct current and alternating current
12. Why is it important to avoid using both hands in the workshop? Explain

Oral Assessment

1. Demonstrate the use of a multimeter.
2. Given electrical drawings, derive the materials required to perform the electrical tasks.

Practical Assessment

Design an electric layout plan for a simple 2-bedroom bungalow and thereafter create a simple electric circuit for wiring a fluorescent lamp using 1 36W 4ft fluorescent lamp, 1 starter and base, 2 fluorescent lamp holders, 1 MCB of 6A from an already installed Distribution Board, 1, 2.5 microfarad correction capacitor.

6.3.5.4 Tools, Equipment, Supplies and Materials

- Pliers
- Portable power drill
- Saws
- Hand drill
- Screwdrivers
- Close-cut saw
- Portable drill machine
- Long nose
- Side cutter
- Draw in wire
- Electrical knife
- Electrical hammer

Materials and supplies

- Electrical materials
- Electrical appliances

Personal protective equipment (PPEs)

- Helmets
- Gloves
- Safety goggles
- Safety boots

- Overalls
- Dust masks
- Dust coats

6.3.5.5 References



Grant, Casey C. (2013) interoperable electronic safety equipment; performance requirements for compatible and interoperable electronic equipment for emergency first responders. New York: Springer science and business media.


Lenk, Ron. (2005). The practical design of power supplies. New York. Wiley/IEEE.

Mark, Raymond A. (2005) demystifying switching power supplies, Oxford: Newness

easytvvet.com

6.3.6 Learning Outcome No 5: Perform Mechanical Operations

6.3.6.1 Learning Activities

Learning Outcome No 5: Perform mechanical operations	
 Learning Activities	Special Instructions
5.1 Identify Safety requirements in the workshop environment 5.2 Use Mechanical hand tools appropriately to perform tasks in the mechanical workshop 5.3 Identify diesel and petrol engine components 5.4 Operate diesel and petrol engines 5.5 Perform simple engine maintenance 5.6 Identify water pumps based on the working principle 5.7 Perform basic maintenance on water pumps	<ul style="list-style-type: none">• Practical tests• Direct instruction• Oral assessment

6.3.6.2 Information Sheet No6/LO5: Perform Mechanical Operations



Introduction

This learning outcome covers identification of safety requirements in the workshop environment, appropriate use of mechanical hand tools to perform tasks in the mechanical workshop, identification of diesel and petrol engine components, operation of diesel and petrol engines, maintenance of the simple engine, identification of water pumps and performance of basic maintenance on water pumps.

Definition of key terms

Tinsnips: Also known as shears they are designed to cut and trim sheet metals and other tough materials.

Centrifugal: This is moving or directed away from the axis or centre. A centrifuge is an equipment that applies a centrifugal force that puts an object in rotation around a fixed centre.

Reciprocating pump: This is a class of positive displacement pumps where a volume of liquid is collected in an enclosed space and discharged using pressure.

Content/Procedures/Methods/Illustrations

5.1 Safety requirements in the workshop environment are identified as per sops

Before using any machine or equipment in the workshop all persons should read the following carefully and understand the safety requirements which include;

- Always listen carefully and follow the teacher's instructions
- No running in the workshop, it could cause an accident
- Locate the position of all the emergency exits and stop buttons in the workshop.
- Always wear overall, dust coat or apron to protect your clothes and the safety of the eyeglasses to protect your eyes.
- Wear heavy-duty boots when coming to the workshop.
- Always wear reflective jackets and helmet when operating machinery.
- Put all stools away when working on practical.
- Do not operate a machine without supervision unless you have been shown how to operate it safely.
- Report any damages to tools, machines or equipment immediately

Safety procedures in a workshop can be identified through;

- i. Completely reading the instruction manuals for machinery and equipment.
- ii. Observing the type of machinery and equipment in the workshop
- iii. Careful listening to the instructions given by the teacher or instructor

5.2 Mechanical hand tools are used appropriately to perform tasks in mechanical workshop

Mechanical hand tools are tools which are driven by hand and not powered by electricity or a motor. These tools are categorized by;

- a) **Wrenches**- it is used to loosen or tighten, bolts, screws, nuts, mechanical caps and casing. They are classified into
 - **Key**: They look like old fashioned keys without teeth and are specialized i.e. bottle openers, window cranks and Allen wrenches
 - **Socket**: It can either be a handle that is attached to a cylindrical socket or a single piece
 - **Spanners**: It has pins or hooks and is used to turn spanner handle i.e. adjustable wrenches
- b) **Pliers**: It is used to firmly hold objects, bend and compress materials. The different types of pliers include;
 - Hose clamp pliers; it compresses hose and spring clamps.
 - Snap ring pliers; used for gears on mountain bikes and similar vehicles
 - Battery pliers; maintain bolts on car batteries and jumper cables.

- c) **Snips**; used for cutting and trimming sheet metal and other tough materials. They are categorized as:
- Tinnier snips: Straight pattern
 - Compound action snips: Cut down aluminium in the construction of aircrafts
 - Configuration snips: Snips that are different in configuration.
- d) **Screwdrivers**: Used for removing or installing screws. It is classified by its tip i.e.
- Slotted drivers; it has a single slot on the head of the screw and is driven by a flat-bladed screwdriver.
 - Cruciform drivers; the head of the fastener has cross shape i.e. reason screwdriver

Procedure on how to use a wrench

- i. Identify the item to be tightened or loosened is it a bolt, nut, screw, mechanical cap or casing
- ii. Turn the screw mechanism to open the adjustable wrench to fit the size of the screw
- iii. Slip the open jaw over the screw then turn the screw mechanism to clamp tightly
- iv. Turn the wrench clockwise or anticlockwise to tighten or loosen respectively
- v. Loosen the screw mechanism on the adjustable wrench to remove it

5.3 Diesel and petrol engine components are identified based on their functions and engine system

A diesel engine is any internal combustion engine which air is compressed to a sufficiently high temperature in the cylinder to ignite diesel fuel through mechanical compression.

Components of a diesel engine

- Cylinder block: Solid casting including cylinder and water jackets
- Cylinder holes: Found in the cylinder block and contain the piston
- Pistons: Movable plugs open at one end which transfer explosion force to the connecting rod.
- Connecting rod; a link between the piston and crankshaft
- Crankshaft; changes the reciprocating motion of the piston to the rotary motion in the power train.
- Crankshaft gear drivers- idle gear/camshaft
- Camshaft; have cam lobes which operate the valves
- Timing gear; drives the camshaft
- Cam lobes; eccentrics on the camshaft which operate valves
- Timing rods; rod links that transfer motion from the lifter to the rocker arm
- Rocker arm; transfer motion from pushrod to a valve
- Valve lifter; rides on the camshaft so that the cam lobe raises it to operate the valve.

- Cooling passageways; hollow spaces in the block through which coolant circulates.
- Wrist pin; floating connecting piece for piston and connecting rod.
- Oil pump; minimizes friction by providing pressure to circulate oil to rotate engine parts
- Oil pan; a reservoir for engine oil
- Intake valve; allows air to enter the cylinder.
- Exhaust valve; allows exhaust gases to be expelled from the engine
- Flywheel; attached to the end of the camshaft and provides inertia to carry the crankshaft from one firing impulse to the other
- Pushrods; links that transfer motion from the lifter to the rocker arm.
- Valves; open and close the cylinder to allow air to enter or gases to leave.

These parts or components of an engine can be identified through instructions by a teacher or instructor through illustrations from a model of an engine. The petrol engine is an internal combustion engine with sparks, ignition or spark plugs and the air and fuel are mixed after compression to ignite the air-fuel mixture. It comprises of

- Spark plugs; supply the plugs that ignite the air-fuel mixtures
- Valves; intake and exhaust valves open and close to let in air and fuel and expel exhaust respectively
- Piston; a cylindrical piece of metal that moves up and down inside the cylinder
- Piston rings; provides a sliding ring between the outer edge of the piston and the inner edge of the cylinder to prevent air-fuel mixtures and exhaust from leaking into the sump and prevent oil from the sump from leaking into the combustion area
- Connection rod; connects the piston from the crankshaft
- Crankshaft; turns pistons up and down in a circular motion
- Sumps; contains oil/ reservoir (oil pan)

5.4 Diesel and petrol engines are operated based on the manufacturer's manual

Operating a diesel engine

- i. When the piston begins to move down, the inlet valve opens and the air is sucked in
- ii. Then the inlet valve closes at the bottom of the stroke and the piston rises to compress air
- iii. At the top of the stroke fuel is squirted in which then ignites and forces the piston down
- iv. When the piston is travelling upwards the exhaust valve opens and the burnt gas/ exhaust is expelled.

5.5 Simple engine maintenance is performed as per manufacturer's specifications

- Perform regular oil changes to prevent the accumulation of black sludge
- Regular checking of the engine coolant and the cooling system to prevent the engine from overheating
- Regular changing of oil filters to ensure that the air entering the engine is clean free from debris.

Simple engine maintenance could be done through checking the engine oil, coolant and air filters in an existing engine and determining if they are up to standard or functioning.

5.6 Water pumps are identified based on the working principle

A water pump is a machine that moves water from one point to another through mechanical action. They are categorized as;

- Direct lift
- Displacements
- Gravity pumps

Types of water pumps

- **Gravity pumps:** Water is lifted by gravity and gravitational force.
- **Impulse pumps:** It uses the pressure created by gas where the gas trapped in the liquid is released and accumulated in the pump which creates pressure which creates pressure which pushes the liquid upwards.
- **Centrifugal pumps:** It uses centrifugal force to pump water and is mostly operated by an electric motor. Water pumps can be identified by reading the instruction manual to understand how it functions in order to determine the type.

5.7 Basic maintenance is performed on water pumps as per sops

- Double-check to ensure that speed of water pumps corresponds with the output of horsepower
- Examine for any damages, leakages, or wear and tear
- Check and clean seals and oiling bearings

Performing basic maintenance could be done through checking of the:

- Functioning
- Output
- Sound

Conclusion

This learning outcome covered identification of safety requirements in the workshop environment, appropriate use of mechanical hand tools to perform tasks in the mechanical workshop, identification of diesel and petrol engine components, operation of diesel and petrol engines, maintenance of simple engines, identification of water pumps and performance of basic maintenance on water pumps as per sops.

Further Reading



From the internet, read more on:

1. Parts of pliers
2. Parts of screwdriver
3. Operating a petrol engine
4. Borewell compressor
5. Shallow good pumps
6. Pressure booster pumps

6.3.6.3 Self-Assessment



Written Assessment

1. In a diesel engine, the fuel is injected by
 - a) Igniter
 - b) Heat resulting from compression
 - c) Spark
 - d) Injected fuel
2. A diesel engine has
 - a) One valve
 - b) Two valves
 - c) Three valves
 - d) Four valves
3. All are safety wears expect
 - a) Overall
 - b) Training boots
 - c) Helmet
 - d) Reflector jackets

easytvvet.com

4. All the following are mechanical hand tools except
 - a) Allen wrench
 - b) Battery pliers
 - c) Tinsnips
 - d) Power saw
5. The moving part of a centrifugal pump is called a
 - a) Impeller
 - b) Volute
 - c) Diffuser
 - d) Suction nozzle
6. In a centrifugal pump, the liquid enters the pump
 - a) At the centre
 - b) At the bottom
 - c) At the top
 - d) From sides
7. To carry out engine maintenance you do the following except
 - a) Regular oil changes
 - b) Changing of oil filters check and mend seals
 - c) Checking engine coolant
8. Analyse five parts of a diesel engine
9. Evaluate on cooling passageways
10. Compare and contrast between the diesel engine and petrol engine.
11. Evaluate two basic maintenance of a water pump
12. Develop a safety plan to be carried out in a workshop in case of emergency

Oral Assessment

1. Simulate how a diesel engine work?
2. Analyse a cooling passage?

Case Study Assessment

Mr Karanja who is an architect was going for a site visit discovered that his car was expelling black smoke from its exhaust. As a mechanical operations consultant explain to Mr. Karanja what he should do to avoid polluting the environment

6.3.6.4 Tools, Equipment, Supplies and Materials

- Centrifugal
- Submersible
- Reciprocating pump
- Hand pumps
- Hand grinder

Materials and supplies

- Fuel
- Grease
- Oil
- Filters

Personal protective equipment (PPEs)

- Helmets
- Gloves
- Safety goggles
- Safety boots
- Overalls

6.3.6.5 References



- Edgan T. West bury (2007) Model Petrol Engines Maharashtra; Knowledge publications
- James Rishel (2001) Water pumps and Pumping Systems. New York; M.C. Grow Hill Education
- Klaus Mollenhaver, Helmut Tschoke (2010), Handbook of Diesel Engines. New York; Springer Science and Business Media