THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL OF TANZANIA

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

789 **METAL WORKING AND MECHANICAL PRACTICE**

Time: 3 Hour. **ANSWERS** **Year: 2018**

Instructions

1. This paper consists of **eight (8)** questions.
2. Answer any **five (5)** questions.
3. Each question carries **twenty (20)** marks.
4. Non-programmable calculators may be used.
5. Communication devices, programmable calculators and any unauthorized materials are **not** allowed in the examination room.
6. Write your **Examination Number** on every page of your answer booklet(s).

1. (a) Define the term "metal casting".

Metal casting is a manufacturing process where molten metal is poured into a mould cavity and allowed to solidify into the desired shape. Once solidified, the casting is removed from the mould and may be further processed to achieve specific dimensions or surface finish.

(b) (i) List four types of casting processes.

Sand casting, which uses sand as the mould material.

Die casting, which involves forcing molten metal into a steel die under pressure.

Investment casting, which uses wax patterns surrounded by ceramic to form a mould.

Centrifugal casting, where the mould is rotated at high speed during casting to improve density.

(ii) Briefly explain one advantage of sand casting over die casting.

Sand casting is more economical for small production runs and large parts because it requires less expensive tooling and mould preparation compared to die casting, which needs high-cost dies and equipment.

(c) Describe the steps involved in preparing a sand mould.

First, a pattern of the desired part is made and placed in a moulding box. Sand mixed with a binder is packed tightly around the pattern to form the mould. The pattern is then removed to create a cavity. Channels for pouring molten metal, known as runners and gates, are formed. Finally, the mould is closed and ready for pouring the metal.

(d) State four defects that may occur in metal castings.

Blow holes, which are gas pockets formed inside the casting.

Shrinkage cavities due to inadequate feeding of molten metal.

Cold shuts where two streams of metal fail to fuse properly.

Misruns where the metal solidifies before completely filling the mould.

2. (a) What is "gas welding"?

Gas welding is a metal joining process that uses a flame produced by burning a fuel gas with oxygen to melt and fuse the base metals. The most common type is oxy-acetylene welding.

(b) (i) Identify three types of flames used in gas welding and describe one use of each.

Neutral flame is used for welding mild steel and provides balanced heat.

Carburizing flame has excess acetylene and is used for welding high-carbon steels.
Oxidizing flame has excess oxygen and is used for welding brass and bronze.

(ii) State the function of flux in gas welding.

Flux helps to clean the metal surfaces, prevent oxidation, and promote strong bonding by allowing the molten metal to flow smoothly.

(c) Describe the correct procedure of lighting and adjusting a gas welding torch.

First, open the fuel gas slightly and ignite it with a spark lighter. Then slowly open the oxygen valve until the desired flame type is achieved. Adjust both valves to obtain a neutral flame for most welding operations.

(d) State four safety precautions to observe when using a gas welding set.

Always check for gas leaks before use.
Wear protective goggles and flame-resistant clothing.
Do not use oil or grease on gas fittings.
Keep cylinders upright and secured to avoid tipping.

3. (a) Define the term "metal shearing".

Metal shearing is a cutting process that uses a pair of straight-edged blades to slice through sheet metal. It is commonly used for cutting large sheets into smaller sizes without forming chips.

(b) (i) Explain the difference between straight shearing and slitting.

Straight shearing involves a single cut across the entire width of the sheet, while slitting is a continuous cutting process along the length of the sheet to produce strips.

(ii) State three factors affecting shearing quality.

Blade sharpness determines the cleanliness of the cut.
Clearance between blades affects edge finish and deformation.
Material thickness influences the force required and cutting results.

(c) Describe how a guillotine shear is operated manually.

The metal sheet is placed on the shear bed and aligned with the cutting edge. A hold-down bar secures the sheet. The operator then pulls the lever or handle to bring down the upper blade, cutting through the sheet with a shearing action.

(d) State four causes of burrs when shearing sheet metal.

Dull blades may tear the sheet rather than cut it cleanly.

Improper blade clearance can cause excessive deformation.

Excessive material thickness for the machine can increase edge roughness.

Misalignment of the sheet during cutting can produce uneven edges.

4. (a) What is meant by "bench vice" in metalwork?

A bench vice is a mechanical device fixed to a workbench, used to hold a workpiece securely in place during operations like sawing, filing, or drilling.

(b) (i) Mention three parts of a bench vice and state their functions.

The jaws grip the workpiece tightly during operations.

The screw mechanism moves the movable jaw forward or backward.

The base is attached to the bench and supports the entire vice.

(ii) Explain how to maintain a bench vice for long service life.

Clean the jaws regularly to remove metal filings.

Lubricate the screw and movable parts to prevent rust and ease movement.

Avoid overtightening to prevent damage to the threads and jaw faces.

(c) Describe how to clamp and file a metal bar using a bench vice.

Place the metal bar between the jaws and tighten the handle until the bar is held securely. Ensure the bar is level and does not project too far. Use a suitable file and apply pressure on the forward stroke only, maintaining a consistent filing angle.

(d) State four safety measures to follow when using a bench vice.

Always clamp the workpiece securely to prevent slipping.

Do not hammer directly on the vice to avoid cracking it.

Keep hands clear of the jaws while tightening.

Avoid using the vice as an anvil to prevent damage.

5. (a) Define "drilling jig" and explain its importance in production.

A drilling jig is a work-holding device used in machining operations to guide the drill bit into the correct location on the workpiece. It ensures accuracy and repeatability in hole placement, especially in mass production, by eliminating the need to mark or measure each part individually.

(b) (i) Differentiate between a jig and a fixture.

A jig not only holds the workpiece but also guides the cutting tool, such as a drill. A fixture, on the other hand, only holds the workpiece in a fixed position but does not guide the tool.

(ii) State two types of jigs used in drilling.

A plate jig is a flat jig with holes that guide the drill bit.

A channel jig holds the workpiece in a channel-shaped body and guides the drill using bushings.

(c) Describe how a plate jig is used to drill holes in a metal component.

The metal component is placed under the plate jig, aligning its surface with the guide holes. The drill is inserted through the jig's guide bushings and into the workpiece. The jig ensures the drill follows the correct path without deviating, producing uniform hole placement across multiple components.

(d) State four advantages of using jigs in mass production.

Jigs reduce setup time and improve drilling speed.

They eliminate the need for repeated marking, increasing accuracy.

They reduce operator error by guiding the tool.

They allow unskilled workers to produce consistent results.

6. (a) What is "tool wear"?

Tool wear refers to the gradual loss of material from the cutting edge or surface of a tool due to contact with the workpiece during machining operations. This wear affects tool performance and dimensional accuracy of the workpiece.

(b) (i) State three types of tool wear that occur during machining.

Crater wear occurs on the tool face due to high temperatures and chip flow.

Flank wear happens along the side of the tool, causing poor surface finish.

Built-up edge forms when material sticks to the tool, altering its cutting geometry.

(ii) Explain how tool wear affects the machining process.

As tool wear increases, cutting forces rise, leading to higher power consumption. Surface finish of the workpiece deteriorates, and dimensional accuracy is reduced. Tool wear may also cause chatter and tool breakage if not addressed in time.

(c) Describe how tool wear can be reduced in lathe operations.

Using appropriate cutting speeds and feeds for the material reduces friction.

Applying coolants helps in heat dissipation, lowering thermal damage.

Selecting the correct tool material and geometry extends tool life.

Sharpening tools regularly ensures consistent cutting performance.

(d) State four signs indicating that a cutting tool is worn out.

The tool produces excessive noise or vibration during operation.

Surface finish of the workpiece becomes rough or inconsistent.

Increased cutting force is required, straining the machine.

Visible dullness or deformation is noticed on the tool edge.

7. (a) Define "forging" in metal working.

Forging is a metal forming process where a metal workpiece is shaped using compressive forces, typically with the help of a hammer or press. The metal is often heated to make it more malleable before shaping.

(b) (i) Mention two types of forging and give one example where each is applied.

Open-die forging is used for large parts like shafts and cylinders.

Closed-die forging is used for precision parts like connecting rods in engines.

(ii) State the function of an anvil in forging.

An anvil provides a hard and stable surface against which the heated metal is placed and struck during forging. It supports and shapes the metal during hammering.

(c) Describe the procedure for forging a round bar into a square section.

Heat the round bar in a forge until it reaches forging temperature. Place it on the anvil and strike it evenly on opposite sides with a hammer to create flat surfaces. Rotate the bar 90 degrees and repeat the process to form the other sides. Continue shaping until all sides are of equal dimension and the square cross-section is achieved.

(d) State four disadvantages of forging compared to casting.

Forging requires more energy and effort due to manual operations.

It is difficult to produce complex shapes compared to casting.

Tooling and equipment for forging are often more expensive.

There is a limit to the size and thickness of parts that can be forged manually.

8. (a) What is meant by "coolant" in machining operations?

A coolant is a fluid used in machining to remove heat generated by cutting and reduce friction between the tool and the workpiece. It helps extend tool life, improve surface finish, and maintain dimensional accuracy.

(b) (i) State three types of coolants used in metalworking.

Soluble oil emulsions provide lubrication and cooling.

Synthetic coolants are chemical-based and used for high-speed machining.

Straight oils offer excellent lubrication for low-speed, heavy-duty operations.

(ii) Explain two main purposes of using coolant during machining.

Coolants absorb and dissipate heat from the cutting zone, preventing thermal damage to the tool and workpiece.

They also lubricate the cutting area, reducing friction and wear on the tool.

(c) Describe how coolant is applied during lathe operations.

Coolant is directed onto the cutting area using a nozzle or pipe. It flows continuously over the tool and workpiece during the cutting process, either by gravity feed, pump, or flood system, depending on the machine setup.

(d) State four risks of not using coolant in heavy machining.

Excessive heat may deform the workpiece or reduce dimensional accuracy.

Tool life is significantly shortened due to overheating and wear.

Surface finish becomes poor due to increased friction and tool marks.

Chips may weld to the cutting edge, causing built-up edge and tool damage.