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: 2017**

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 "thread cutting".

Thread cutting is the process of forming helical grooves on the internal or external surface of a cylindrical part to create a screw thread. This operation is commonly performed using tools such as taps for internal threads and dies for external threads, allowing components to be joined or fastened together.

(b) (i) State four types of thread cutting tools used in metal work.

Hand taps are used to cut internal threads in holes manually.

Dies are circular tools used for cutting external threads on cylindrical rods.

Single-point threading tools are used on lathes for precise thread cutting on shafts.

Thread chasers are multi-point tools used to finish or clean up existing threads.

(ii) Describe how external threads are cut using a die.

The die is first fixed securely in a die stock or holder. The rod to be threaded is chamfered slightly at the end. Lubrication is applied to the rod to reduce friction. The die is then aligned squarely to the rod and rotated while applying moderate pressure. After a few turns, the die is reversed slightly to break chips. The process continues until the required length of thread is formed.

(c) Explain the importance of using cutting lubricant during thread cutting.

Lubricants reduce friction between the cutting tool and the metal surface, which prevents excessive heat buildup. This prolongs the life of the tool and improves the quality of the threads. It also helps in chip removal and ensures smoother, cleaner cuts.

(d) State four precautions observed when cutting threads manually.

The workpiece should be clamped firmly to prevent movement during cutting.

Lubrication must be used to ease cutting and protect the die or tap.

The tool must be kept perpendicular to the work surface to ensure correct thread angle.

Avoid excessive force; use reverse turns frequently to clear chips and prevent tool breakage.

2. (a) What is a "lathe machine"?

A lathe machine is a machine tool used primarily for shaping metal or wood. It works by rotating the workpiece about a fixed axis while a cutting tool is moved in one or more axes to perform operations such as cutting, sanding, knurling, drilling, or turning.

(b) (i) Identify four main parts of a lathe and explain their functions.

The bed is the base of the machine which supports all other components and maintains alignment.

The headstock houses the main spindle and motor, and it drives the workpiece.
The tailstock is located opposite the headstock and provides support for the end of the workpiece or tools.
The carriage holds and moves the cutting tool longitudinally and transversely across the workpiece.

(ii) State two types of lathe operations.
Turning is the process of removing material from the external surface of a rotating workpiece.
Facing is the process of cutting a flat surface perpendicular to the axis of rotation.

(c) Describe how facing operation is performed on a lathe.
Mount the workpiece in the chuck securely. Set the cutting tool to the center height of the workpiece. Engage the lathe and move the tool across the end face from the outside towards the center. This creates a flat and smooth surface perpendicular to the workpiece axis.

(d) State four safety rules when operating a lathe.
Always wear safety goggles to protect your eyes from flying chips.
Avoid wearing loose clothing that might get caught in rotating parts.
Ensure the tool is securely clamped and at the correct height before starting.
Never leave the lathe running unattended, and always stop it before making adjustments.

3. (a) Define the term "tempering" in heat treatment.
Tempering is a heat treatment process applied to hardened steel to reduce its brittleness and increase toughness. It involves reheating the metal to a temperature below the critical point and then cooling it at a controlled rate.

(b) (i) Explain the purpose of tempering hardened steel.
The primary purpose of tempering is to relieve internal stresses caused by the initial hardening process. This makes the steel less brittle while maintaining an acceptable level of hardness and strength.

(ii) State the colour range used to control tempering temperature.
The tempering temperature is judged by the colour of the oxide layer that forms on the steel. For example, pale yellow indicates low tempering temperature and higher hardness, while blue indicates higher tempering temperature and greater toughness but reduced hardness.

(c) Describe the procedure of tempering a chisel.
First, harden the chisel by heating it until cherry red and then quenching in oil or water. Clean the tip to

reveal bright metal. Reheat slowly until the desired tempering colour appears at the tip. Once the correct colour is seen, quench the chisel again to lock in the temper.

(d) State four results of overheating during tempering.

The chisel may lose too much hardness and become too soft to hold a cutting edge.

It may cause distortion of the tool shape due to excessive heat.

Oxide scaling may increase, affecting surface quality.

Uneven heating can lead to inconsistent mechanical properties across the tool.

4. (a) What is "riveting" and where is it commonly used?

Riveting is a permanent joining process where metal parts are fastened together using metal pins called rivets. It is commonly used in structural applications such as bridges, ships, and aircraft frames.

(b) (i) State three types of rivet heads.

Pan head rivet has a rounded top and is used where appearance is important.

Flat head rivet has a smooth flat top and is ideal for flush surfaces.

Countersunk rivet is used when the head needs to be embedded into the material.

(ii) Explain the difference between cold riveting and hot riveting.

Cold riveting is done at room temperature and is suitable for small, thin materials.

Hot riveting involves heating the rivet before installation, making it easier to deform and suitable for heavy structural joints.

(c) Describe the procedure of forming a rivet joint.

Drill matching holes in the metal sheets to be joined. Insert the rivet through the holes. Place the rivet head on a hard surface or anvil. Use a hammer or pneumatic riveter to deform the opposite end of the rivet, creating a second head that clamps the sheets together.

(d) State four defects that may occur in riveted joints.

Loose rivets due to improper hammering or undersized rivets.

Cracks in the surrounding metal from excessive force or stress concentration.

Improper alignment of holes leading to poor clamping.

Inconsistent rivet head shape reducing joint strength and appearance.

5. (a) Define “die” as used in metal shaping.

A die is a specialized tool used in manufacturing to shape or cut material, usually metal, by pressing or stamping it into a desired form. Dies are commonly used in operations like blanking, punching, drawing, and forming to produce uniform parts.

(b) (i) State two differences between blanking and punching dies.

In blanking, the part removed from the sheet is the desired product, while the remaining sheet is scrap.
In punching, the hole left in the sheet is the desired result, and the removed portion is waste.

(ii) List three materials used to manufacture dies.

High-speed steel is used for its durability and heat resistance.
Carbide is used for high-volume production due to its hardness.
Tool steel is commonly used for general-purpose dies due to its toughness and wear resistance.

(c) Explain the working principle of a compound die.

A compound die performs two or more operations, such as blanking and piercing, in a single stroke at the same station. This setup increases production efficiency and ensures better alignment between cuts, reducing handling and setup time.

(d) State four maintenance practices of die sets.

Regularly clean the die to remove debris and prevent scoring.
Lubricate moving parts to reduce wear and friction.
Inspect the die for cracks or wear and replace worn components.
Store dies in dry, protected environments to prevent rusting or accidental damage.

6. (a) What is “hand tapping”?

Hand tapping is the process of manually cutting internal threads into a previously drilled hole using a tool called a tap. It is often performed using a tap wrench and a set of taps in sequence to form a complete thread.

(b) (i) Mention the three taps used in internal threading.

Taper tap is used to start the thread due to its gradual cutting action.
Second tap continues the cutting with a reduced taper.
Plug or bottoming tap finishes the thread to the bottom of the hole.

(ii) Describe the tapping procedure for making an internal thread.

Drill a hole slightly smaller than the tap's thread size. Fix the taper tap in a tap wrench and align it vertically with the hole. Turn the wrench clockwise with gentle pressure while ensuring it remains straight. Rotate back slightly after every full turn to break chips. Follow with the second and plug taps to complete the thread.

(c) Explain how to determine the correct tap drill size.

The tap drill size is found by subtracting the thread pitch from the nominal diameter. For example, for an M8 x 1.25 tap, the drill size is 8 – 1.25 = 6.75 mm. Standard tap drill charts are also available for reference.

(d) State four common problems encountered during tapping and their solutions.

Tap breakage due to misalignment can be prevented by maintaining vertical alignment.
Thread distortion occurs from using the wrong tap size; always use the correct sequence.
Chipped threads may result from dry tapping; apply cutting oil for smoother operation.
Jamming happens if chips are not cleared; use back-turning regularly to break chips.

7. (a) Define the term "soldering".

Soldering is a joining process where two or more metal parts are connected by melting and flowing a filler metal (solder) into the joint, typically below 450°C, without melting the base metals.

(b) (i) Differentiate between soft soldering and hard soldering.

Soft soldering uses a low-melting-point solder such as tin-lead alloy, suitable for electronics and light metalwork.
Hard soldering uses higher-melting-point solders like silver or brass, requiring more heat and is used for stronger mechanical joints.

(ii) State three tools used in soldering operations.

Soldering iron provides the heat to melt the solder.
Solder wire acts as the filler material that joins the metals.
Flux cleans the surfaces and promotes better bonding by preventing oxidation.

(c) Describe the steps involved in making a soldered joint.

Clean the surfaces to be joined thoroughly. Apply flux to remove oxidation and enhance bonding. Heat the

joint area using the soldering iron until it reaches the solder's melting point. Feed solder wire into the joint and allow it to flow evenly. Remove the heat and let the joint cool undisturbed for a strong bond.

(d) State four precautions to observe when soldering metal parts.

Avoid inhaling fumes by working in a well-ventilated area.

Use heat-resistant gloves and goggles for protection.

Do not touch the heated tip of the soldering iron.

Ensure surfaces are clean and dry before soldering to avoid weak joints.

8. (a) What is "metal fatigue"?

Metal fatigue is the weakening or failure of a metal material caused by repeated cyclic loading or stress over time. It occurs below the metal's ultimate tensile strength and leads to the development of cracks and eventual fracture.

(b) (i) Explain how cyclic loading contributes to fatigue failure.

Cyclic loading subjects the metal to alternating tension and compression forces. Over time, microscopic cracks develop at stress concentration points. As these cracks grow with continued loading, the material becomes more brittle and eventually breaks.

(ii) Give two examples of parts affected by metal fatigue.

Aircraft wings are exposed to continuous stress during flight cycles and are highly prone to fatigue.

Crankshafts in engines endure repeated rotation and load cycles, making them vulnerable to fatigue failure.

(c) Describe methods used to reduce fatigue failure in mechanical components.

Fillets and rounded corners reduce stress concentration.

Surface treatments like shot peening increase resistance to crack initiation.

Proper lubrication reduces friction and vibration.

Using materials with higher fatigue strength improves life span.

(d) State four signs indicating that a metal part is experiencing fatigue.

Visible cracks, especially at corners or welds, may appear.

Unusual noise or vibrations during operation can signal weakening.

Increased wear on the surface may be noticed.

Sudden failure without prior overloading suggests fatigue-related damage.