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: 2004**

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) Layout work refers to the process of transferring dimensions from engineering drawings onto a metal workpiece before machining or fabrication. It is a preliminary step used to mark cut lines, hole centers, and reference points to guide the operator during the actual metalworking process.

(b) Layout work ensures that components are made to the correct dimensions and shapes, reducing errors during fabrication. It helps in visualizing the workpiece before cutting or machining, which prevents material wastage. It provides a clear guide for tools and reduces the risk of misalignment. Lastly, it assists in maintaining consistency and accuracy when producing multiple identical parts.

(c)

(i) A surface gauge is used to scribe lines at a constant height on the workpiece from a surface plate.

(ii) A scriber is a sharp-pointed tool used to scratch fine layout lines on a metal surface coated with layout fluid or chalk.

(iii) A steel rule is used for measuring and marking straight lines with high accuracy.

(iv) A try square is used to mark and check right angles (90 degrees) on metal workpieces to ensure squareness.

(d) Inaccurate layout lines may result from using worn-out or damaged layout tools. If the surface of the workpiece is not properly cleaned or prepared, lines may not adhere or be visible. Errors can also occur if the layout tools are not properly aligned. Lastly, using inappropriate pressure while scribing can lead to either invisible or overly deep lines.

2. (a) A bench grinder is a stationary machine that rotates abrasive wheels at high speed. It is used for sharpening tools, removing burrs, shaping metal parts, and cleaning rust or paint from surfaces. It is an essential machine for maintenance in a mechanical workshop.

(b)
(i) Three types of grinding wheels based on material are: aluminum oxide wheels for steel, silicon carbide wheels for non-ferrous metals, and diamond wheels for hard materials like carbide tools.
(ii) Safety measures include always wearing eye protection to shield against sparks and flying particles, and ensuring that tool rests are adjusted close to the grinding wheel to prevent the workpiece from slipping into gaps.

(c) Dressing a grinding wheel removes embedded metal particles and reshapes the wheel surface to expose fresh abrasive grains. This improves cutting performance, ensures consistent material removal, and prevents overheating due to glazed or clogged wheels.

(d) Improper use of a grinding wheel can cause uneven surfaces on the workpiece. Overheating may lead to burn marks or micro-cracks. Excessive pressure can cause wheel breakage, which is dangerous. Using the side of the wheel may also weaken it and lead to failure.

3. (a) Mechanical measurement is the process of determining physical dimensions such as length, diameter, depth, and angle using tools and instruments. It ensures components meet specified tolerances, which is critical for proper fit and function in mechanical assemblies.

(b)

(i) A micrometer screw gauge measures small dimensions with high precision, typically in the range of 0.01 mm. It is ideal for measuring shaft or rod diameters.

(ii) A steel tape is a flexible measuring tool used for taking larger dimensions such as sheet or plate length and width.

(iii) A dial gauge is used to detect small displacements or deviations in flatness, alignment, or run-out in machine setups.

(iv) A vernier height gauge is used to mark lines or measure vertical dimensions from a surface plate to a specific point on the workpiece.

(c) Inaccuracy may arise from worn or damaged instruments, which give incorrect readings. Improper alignment of the tool with the surface being measured can distort results. Temperature changes may cause expansion or contraction of both the tool and the workpiece, affecting precision.

(d) Precision instruments should be cleaned after each use to remove dust and oil. They should be stored in padded cases to prevent mechanical damage. Calibration should be checked regularly to ensure accuracy. Instruments must not be exposed to moisture or extreme temperatures, which could cause corrosion or dimensional changes.

4. (a) Jigs and fixtures are devices used to hold, locate, and guide the workpiece and tools during machining, drilling, or fitting. They ensure repeatability, accuracy, and efficiency in production operations.

(b)

(i) Jigs provide guidance for the tool, reducing reliance on skilled manual marking and allowing faster, more consistent production. They also improve safety by stabilizing the workpiece during machining.
(ii) Jigs guide the cutting tool and hold the workpiece, whereas fixtures only hold or support the workpiece without guiding the tool.

(c) Operations that require jigs and fixtures include drilling multiple holes in identical locations on several parts, repetitive tapping or reaming, milling with fixed positions, and precision assembly of components with exact alignment.

(d) Using worn-out jigs may lead to imprecise machining, causing errors in hole position or size. Damaged jigs may fail to hold the workpiece securely, increasing the risk of tool breakage or injury.

5. (a) Lathe accessories are additional tools or attachments used to enhance the capabilities of a lathe machine during turning, threading, drilling, or facing operations. They help in securing workpieces and guiding cutting tools accurately.

(b)

(i) A chuck is used to hold and rotate the workpiece securely during machining. It may be a three-jaw or four-jaw type depending on the shape of the workpiece.

(ii) A faceplate is used to mount irregularly shaped workpieces that cannot be held in a chuck.

(iii) Centres support long workpieces at both ends, allowing them to rotate smoothly and without deflection.

(iv) The tool post holds the cutting tool and allows adjustment of its position for accurate machining.

(c) Before mounting, ensure that the workpiece is properly centered and securely clamped to avoid imbalance. The machine should be turned off during setup. The cutting tool must be adjusted to the correct height and securely fastened to avoid chatter or tool slippage.

(d) Inaccuracies may occur due to poor alignment between the workpiece and lathe axis. Dull or improperly set tools can cause irregular surface finish. Excessive spindle speed or feed may deform the material. Loose work holding devices may allow vibration or slipping during machining.

6. (a) Drilling is the process of creating a round hole using a rotating drill bit. Boring, on the other hand, is used to enlarge an existing hole and improve its accuracy or finish using a single-point cutting tool, often done on a lathe or boring machine.

(b)

(i) Twist drills are used for general hole drilling in metals and plastics. Flat drills are used for shallow holes in sheet metal. Step drills are used for creating holes of different diameters in thin materials.
(ii) A counterbore tool enlarges the upper portion of a hole to accommodate the head of a bolt or screw, allowing it to sit flush or recessed into the material.

(c) Centre punching marks the exact location where the drill bit should enter. This prevents the drill from wandering off-center during the initial stage of drilling and improves accuracy.

(d) Drill speed depends on the material hardness, drill bit diameter, type of drilling machine, and desired surface finish. Harder materials require slower speeds, while larger drill bits rotate more slowly to avoid overheating. Operator experience also influences speed settings.

7. (a) Heat treatment is a controlled process of heating and cooling metals to alter their physical and mechanical properties. It is used to increase hardness, improve ductility, relieve internal stresses, or refine grain structure for better performance.

(b)

(i) Annealing softens the metal by heating it to a specific temperature and then slowly cooling it, improving machinability and reducing brittleness.

(ii) Hardening involves heating the metal above its critical temperature and then rapidly quenching it in water or oil, increasing hardness and wear resistance.

(iii) Tempering is done after hardening to reduce brittleness and improve toughness by reheating to a lower temperature followed by slow cooling.

(iv) Normalizing involves heating the metal to a temperature above its critical point, followed by air cooling. It produces a uniform grain structure and improves mechanical properties.

(c) Hardening makes the metal very hard and brittle, while tempering reduces that brittleness and restores ductility and toughness. Tempered materials are better suited for dynamic loading.

(d) Improper heat treatment may lead to warping or distortion of components. Overheating can cause grain growth, reducing strength. Insufficient quenching may result in soft spots that compromise performance or safety.

8. (a) Work hardening is the process by which a metal becomes harder and stronger due to plastic deformation. It occurs when a metal is cold worked through operations like bending, drawing, or hammering.

(b)

(i) Work hardening increases tensile strength, improves wear resistance, and raises yield strength. However, it also reduces ductility, making the metal more brittle.

(ii) Annealing is used to relieve work hardening by softening the metal through controlled heating and cooling. Stress relieving is another method where the metal is heated below its transformation temperature to reduce internal stresses.

(c) Safety measures include using protective gloves and eye protection due to sharp edges and flying particles. Ensure proper ventilation if heat is applied. Tools and workpieces should be securely clamped to avoid slippage during shaping.

(d) Work hardening improves surface durability and increases the strength of formed components, which is beneficial in cold-formed parts. However, it reduces ductility, making further forming operations more difficult. It may also lead to cracking if the metal is excessively worked without relief processes.