THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATION COUNCIL

DIPLOMA IN TECHNICAL EDUCATION EXAMINATION

789 **METAL WORKING AND MECHANICAL PRACTICE**

(SUPPLEMENTARY)

Time: 3 Hours. **ANSWER** **Year: 2008**

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 shaping and its applications.
Shaping is a machining process in which a single-point cutting tool moves linearly across the surface of a stationary workpiece to remove material and produce flat surfaces, slots, grooves, or contoured shapes. It is mostly used for small or medium-sized jobs.

The applications of shaping include machining flat surfaces, forming angular cuts, creating keyways, producing grooves, and cutting slots in various engineering components. Shaping is commonly used in toolrooms and workshops for making prototype components and repair works.

(i) Describe four types of shaping operations with examples.
Horizontal shaping is the most common type where the cutting tool moves in a horizontal stroke to machine flat or angular surfaces. For example, producing a flat face on a mild steel block.

Vertical shaping involves the cutting tool moving vertically rather than horizontally, and it is used for slotting or machining internal surfaces such as keyways inside pulleys.

Tangential shaping is performed by feeding the tool tangentially to the workpiece surface. It is suitable for machining curved surfaces, for example on cams or irregular profiles.

Gear shaping is a specialized operation where shaping machines cut gear teeth profiles using a gear-shaped cutter, widely applied in gear manufacturing industries.

(ii) Explain two safety precautions when using a shaping machine.
Operators must always ensure that loose clothing, gloves, or hair do not come in contact with the moving ram and tool to prevent accidents.

The workpiece should be firmly clamped in the vice or fixture to avoid dislodging during the shaping stroke, which could cause injury or damage to the machine.

2. (a) Explain planing operations and their importance.
Planing is a machining process in which the workpiece is reciprocated against a stationary single-point cutting tool to produce large flat surfaces. Unlike shaping, the tool remains fixed, and the workpiece moves.

The importance of planing lies in its ability to machine very large workpieces such as machine beds, large plates, and structural components with high accuracy and surface finish. It is used in heavy industries where shaping is impractical due to size limitations.

(b) List four advantages of planing over shaping.

Planing allows machining of very large workpieces which cannot be accommodated on a shaper.

It provides better productivity for long surfaces since multiple tools can be mounted and used simultaneously.

Planing achieves higher dimensional accuracy compared to shaping.

It reduces machining time for large parts due to its ability to take heavier cuts per stroke.

(c) Describe three types of planers and their uses.

Open-side planer has only one supporting column on one side, allowing large and wide workpieces to be machined.

Double-housing planer has two columns and a rigid structure, suitable for machining very heavy and large workpieces with high accuracy.

Pit-type planer is constructed in a pit below the floor level, allowing extremely large and heavy workpieces such as ship plates to be machined.

3. (a) (i) Define broaching and its applications.

Broaching is a machining process that uses a toothed tool called a broach to remove material in a single pass. The tool has progressively larger teeth that cut the material step by step.

Applications include machining of keyways, splines, internal gears, holes of irregular shape, and flat surfaces.

(ii) Explain four features of a broach tool.

A broach tool has a series of cutting teeth arranged progressively in size to gradually remove material.

It consists of three zones: the roughing teeth for heavy stock removal, the semi-finishing teeth for improving accuracy, and the finishing teeth for producing the final surface finish.

The tool is long and straight to accommodate a large number of teeth needed for the gradual cutting action.

Broaches are often designed for specific applications, such as internal keyway broaches or surface broaches, making them specialized tools.

(b) List two advantages of broaching.

Broaching provides a very high surface finish and accuracy in a single operation.

It is very fast and economical for mass production of identical components.

4. (a) Explain what soldering is and its applications.

Soldering is a joining process where two metal pieces are bonded using a filler metal (solder) that has a lower melting point than the base metals. The process is performed below 450 °C.

Applications include joining electrical wires, electronic components on circuit boards, plumbing joints, and sheet metal works.

(b) Describe three advantages of soldering over welding.

Soldering requires less heat and simpler equipment compared to welding, making it cheaper and more convenient.

It produces less thermal distortion since the temperatures are much lower.

Soldered joints can be easily dismantled for repair or replacement, unlike welded joints.

(c) Outline two factors affecting soldering quality.

Cleanliness of the metal surfaces is essential; dirt or oxide layers prevent proper bonding.

Proper selection of flux and solder material is necessary to ensure good wetting and strong joints.

5. (a) Describe the purpose of angle plates and V-blocks in marking out.

Angle plates are used to hold workpieces at 90° during marking out and machining to ensure accuracy of right-angled surfaces.

V-blocks are used to hold cylindrical workpieces securely so that accurate lines and centers can be marked.

(b) Explain the steps for marking out a cylindrical workpiece.

The surface of the cylinder should first be cleaned and coated with marking blue.

The workpiece is then placed in a V-block to hold it firmly in place.

A surface gauge or height gauge is used to scribe lines along the cylinder according to the required dimensions.

Finally, the center can be marked by rotating the workpiece in the V-block and intersecting lines drawn to locate the axis.

(c) Discuss the use of a surface gauge in marking out.

A surface gauge is used to scribe accurate parallel lines on a workpiece. It consists of a base, upright spindle, and adjustable scriber.

It ensures precision by sliding over a flat surface plate while holding the scriber at a set height to mark the workpiece consistently.

6. (a) Explain power hacksaw operation.

A power hacksaw operates by using a motor to drive a reciprocating saw blade that cuts metal stock automatically. During the forward stroke, the blade cuts, while in the return stroke it is lifted slightly to avoid rubbing.

(b) List advantages of power hacksaws over hand hacksaws.

They cut faster and with less manual effort compared to hand hacksaws.

They can handle larger and tougher materials with greater efficiency.

(c) Identify two materials used for hacksaw blades and why they are preferred.

High-speed steel (HSS) is commonly used because it retains hardness at high temperatures and resists wear.

Bimetal blades, made of HSS teeth bonded to a flexible steel back, are preferred for their toughness and ability to withstand breakage.

7. (a) A rectangular metal block of 100 mm × 50 mm × 25 mm is to be planed. Calculate:

i) Material removal rate if depth of cut is 2 mm, feed is 0.3 mm/rev, and speed is 100 rev/min.

MRR = Feed × Depth of cut × Speed × Width of cut

MRR = 0.3 mm/rev × 2 mm × 100 rev/min × 50 mm

MRR = 3000 mm^3/min

ii) Power required if cutting force is 500 N.

Power = Force × Cutting speed

Cutting speed = Stroke length × Speed = 100 mm × 100 rev/min = 10,000 mm/min = 10 m/min = 0.167 m/s

Power = 500 N × 0.167 m/s = 83.5 W

(b) Determine the time required to remove 10 mm along the 100 mm length.

Time = Distance / Feed per stroke

Feed = 0.3 mm/stroke, Distance = 10 mm

Time = 10 / 0.3 = 33.3 strokes

At 100 strokes/min, Time = 33.3 / 100 = 0.33 min = 20 seconds

(c) Calculate cutting speed in m/min.

Cutting speed = Stroke length × Strokes per min ÷ 1000

= (100 mm × 100) ÷ 1000 = 10 m/min

8. (a) A 20 mm thick steel plate is to be drilled and tapped with M12 × 1.75 thread. Calculate:

i) Drill diameter required for tapping.

Drill diameter = Nominal diameter – Pitch = 12 – 1.75 = 10.25 mm

ii) Time required if feed per revolution is 0.15 mm and depth of thread is 12 mm.

Number of revolutions = Depth ÷ Feed = 12 ÷ 0.15 = 80 rev

If spindle speed = N (not given), time = 80 ÷ N. Assuming 300 rev/min, time = 80 ÷ 300 = 0.27 min = 16 seconds

(b) Determine the torque required if the cutting force is 350 N at radius 6 mm.

Torque = Force × Radius = 350 × 0.006 = 2.1 Nm

(c) Calculate reaming allowance if the tapped hole is to final size 12 mm and drilled hole is 11.8 mm.

Reaming allowance = 12 – 11.8 = 0.2 mm