Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2022

MECHANICAL TECHNOLOGY: (WELDING AND METALWORK) MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 11 pages.

SECTION A: COMPULSORY

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 D ✓
1.2 B ✓
1.3 A ✓
1.4 C ✓
1.5 C ✓
1.6 B ✓

(6 x 1) **[6]**

QUESTION 2: SAFETY (GENERIC)

2.1 **Personal protective equipment**

- Welding helmet ✓
- Leather apron ✓
- Leather hand gloves ✓
- Overall/work suit ✓
- Safety boot ✓ (Any 3 x 1) (3)

2.2 **Arc welding safety precautions**

- Wear correct PPE ✓
- The welding cables and electrode holder must be well insulated ✓
- Your eyes must be protected with a welding helmet before attempting any strike ✓
- Ensure there is no water in the environment ✓
- Keep combustible materials away from the welding area ✓ (Any 3 x 1) (3)

2.3 **Reason why you must not force a drill bit into the workpiece**

- It can cause a broken drill bit and possible injuries. ✓ (1)

2.4 **Reason for clamping a small workpiece before drilling**

- To avoid slipping ✓
- Prevent drill bit from breaking ✓
- To ensure smooth and straight drilling ✓ (Any 1 x 1) (1).

2.5 **Safety precautions to be observed when handling gas cylinders**

- Store or transport cylinders in an upright position ✓
- Avoid oil or grease from coming in contact with oxygen fittings ✓
- Never stack cylinders on top of one another ✓
- Do not bang or work on cylinders ✓
- Never allow cylinders to fall ✓ (Any 2 x 1) (2)

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QUESTION 3: MATERIALS (GENERIC)

3.1 3.1.1 **Test required to determine the carbon content of a metal**
- Sound test ✓
- Spark test ✓ (Any 1 x 1) (1)

3.1.2 **Test required to determine the ductility of metal**
- Bending test ✓ (1)

3.2 **Cutting colour coded metals from unmarked end**
- In order to keep its identity ✓ (1)

3.3 **Types of case-hardening**
- Carburising ✓
- Nitriding ✓
- Cyaniding ✓ (3)

3.4 **Effect of medium or high carbon steel on case-hardening**
- The hardness will penetrate the core of the steel ✓ (1)

3.5 **Heat treatment process of metal**
It has to do with heating metal to the required temperature, ✓ allow to soak in that temperature for a given period of time, ✓ then cool in the appropriate medium. ✓ (3)

3.6 **Factors that determine the hardness of steel during heat treatment**
- Work size ✓
- Quenching rate ✓
- Carbon content ✓ (3)

3.7 **Properties achieved from an annealed steel**
- Softness ✓
- Ductility ✓ (Any 1 x 1) (1)

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QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

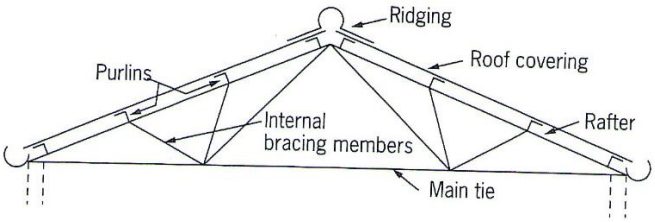
4.1 B ✓
4.2 B ✓
4.3 C ✓
4.4 D ✓
4.5 A ✓
4.6 C ✓
4.7 D ✓
4.8 D ✓
4.9 A ✓
4.10 C ✓
4.11 C ✓
4.12 D ✓
4.13 D ✓
4.14 B ✓ (14 x 1) **[14]**

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 **Tools required in the template loft:**

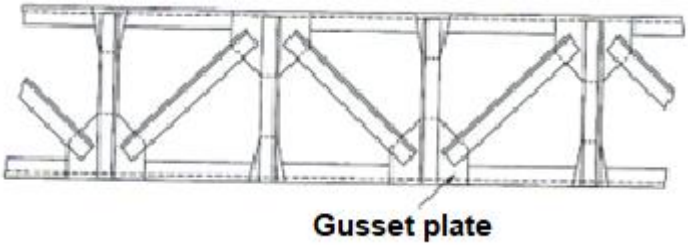
- Circular saw ✓
- Planer ✓
- Drilling machine ✓
- Steel tape
- Straight edge (Any 3 x 1) (3)

5.2 **Roof truss sketch:**



✓✓✓✓✓ (5)

5.3 **Rectangular lattice girder sketch:**



✓✓✓✓ (4)

5.4 **Calculations of a basketball ring:**

Mean ~~Θ~~ = Outside ~~Θ~~ – plate thickness ✓

OR

Inside ~~Θ~~ + plate thickness

Mean ~~Θ~~ = 320 – 30 ✓

= 290 mm ✓

Mean Circumference = π x mean ~~Θ~~

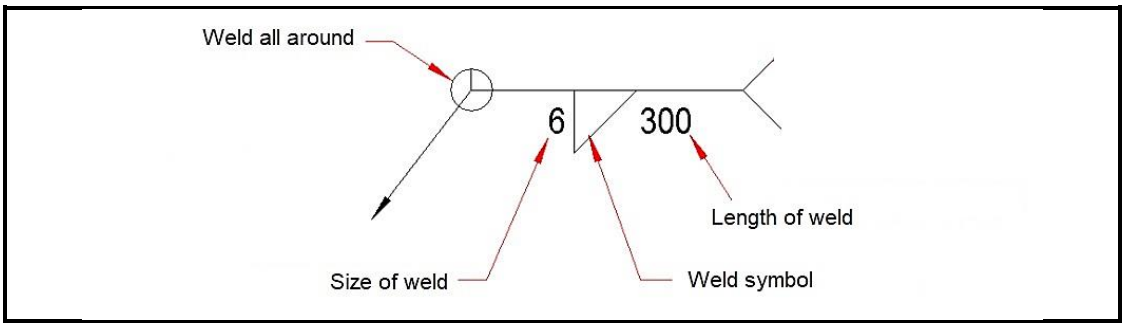
= π x 290 ✓

= 911,18 ✓

Rounded of to 911 for one ring. ✓

911 x 2 = 1 822 mm for the set of two rings. ✓ (7)

5.5 **T-joint sketch:**



(4)

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QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Consequences of aluminum on a grinding wheel:**
The soft material lodges in the pores of the wheel and expands. ✓
Pieces can dislodge when the wheel is revolving at a high-speed causing injury. ✓ (2)

6.2 **Function of the following:**

6.2.1 **Angle grinder:** ✓
To cut, grind or polish material. ✓ (2)

6.2.2 **Guillotine:**
To cut ✓ sheet metal. ✓ (2)

6.3 **Types of press machines:**
Manual press machine. ✓
Hydraulic press machine. ✓ (2)

6.4 **Principles of arc welding equipment (inverters):**
- Inverters use electronic circuits ✓ to convert AC to DC ✓ by inverting the sine wave signal. ✓
- The steady arc that is produced by the DC power source ✓ ensures a neater weld bead with less spatter. ✓ (5)

6.5 **Types of rolling machines:**
A – Pyramid rolls ✓
B – Off-set pinch rolls ✓
C – Vertical rolls ✓ (3)

6.6 **Purpose of plasma cutter:**
Plasma cutting is a process that cuts through electrically conductive materials ✓ by means of an accelerated jet of hot plasma e.g., steel, aluminium, brass and copper. ✓ (2)
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QUESTION 7: FORCES (SPECIFIC)

7.1 STRESS AND STRAIN

7.1.1 Stress

$$\text{Area} = \frac{\pi d^2}{4} \quad ✓✓$$

$$= \frac{\pi \times (0{,}024)^2}{4} \quad ✓$$

$$= 4{,}525 \times 10^{-4}\ m^2 \quad ✓$$

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{60 \times 10^3}{4{,}525 \times 10^{-4}} \quad ✓$$

$$= 132{,}579 \times 10^6\ Pa$$

$$= 132{,}58\ MPa \quad (6)$$

7.1.2 Strain

$$\text{Strain} = \frac{\text{Change in length}}{\text{Original length}} \quad ✓✓$$

$$= \frac{0{,}22 \times 10^{-3}}{212 \times 10^{-3}} \quad ✓$$

$$= 1{,}038 \times 10^{-3}$$

$$= 1{,}04 \times 10^{-3} \quad ✓ \quad (4)$$

7.1.3 Young's modules

$$\text{Young's modulus of Elasticity (E)} = \frac{\text{Stress}}{\text{Strain}} \quad ✓✓$$

$$= \frac{132{,}58 \times 10^6}{1{,}04 \times 10^{-3}} \quad ✓$$

$$= 127{,}48 \times 10^9 \quad ✓$$

$$= 127{,}48\ GPa \quad ✓ \quad (6)$$

7.1.4 Youngs' modulus on softer materials will decrease ✓✓
or be lower than harder materials. ✓✓ (4)

7.2 Reactions

Take reactions **A** and **B**

A x 6 = (600 x 4) + (400 x 3) + (500 x 2) ✓
= 2 400 + 1 200 + 1 000
= 4 600/6 ✓
A = 766,67 N ✓

B x 6 = (500 x 4) + (400 x 3) + (600 x 2) ✓
= 2 000 + 1 200 + 1 200
= 4 400/6 ✓
B = 733,33 N ✓ (6)

7.3 7.3.1 **STRAIN**

$$\text{Strain} = \frac{\text{Change in length}}{\text{Original length}} \quad \checkmark$$

$$\text{Strain} = \frac{14{,}4 \times 10^{-3}}{80} \quad \checkmark$$

$$= 1{,}8 \times 10^{-4} \quad \checkmark \quad (3)$$

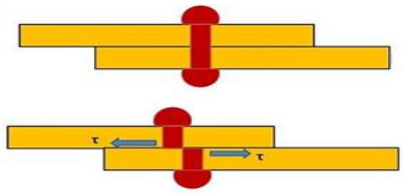
7.3.2 **Young's modulus:**

$$E = \frac{\text{Stress}}{\text{Strain}} \quad \checkmark$$

$$E = \frac{16 \times 10^{6}}{1{,}8 \times 10^{-4}} \quad \checkmark$$

$$= 88{,}9 \text{ GPa} \quad \checkmark \quad (3)$$

7.4 7.4.1 **Sketch of shearing stress**



✓✓✓ (3)

7.4.2 **Sketch of tensile stress**

✓✓✓ (3)

7.5 **Purpose of tensile test:**
It is used to determine ✓ the tensile strength of material. ✓ (2)

7.6 7.6.1 **Hooke's law:**
Strain is directly proportional ✓ to the stress its deformation causes, ✓ provided the limit of proportionality is not exceeded. ✓ (3)

7.6.2 **Safety factor:**
It is the maximum number of times ✓ with which the maximum stress is decreased, to obtain a safe stress. ✓ (2)

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QUESTION 8: JOINING METHODS (INSPECTION OF WELDS) (SPECIFIC)

8.1 **Welding processes for inspection:**

- Is there fusion between the weld metal and the parent metal? ✓
- Is there an indentation, denoting undercutting along the line where the weld joins the parent metal (lines of fusion)? ✓
- Has penetration been obtained right through the joint, indicated by the weld metal appearing through the bottom of the V or U on a single V or U-joint? ✓
- Has the joint been built up on its upper side or has the weld a concave side on its face, denoting lack of metal and thus weakness? ✓ (4)

8.2 **Uses of weld gauges:**

- To check the angle of preparation. ✓
- To check the misalignment. ✓
- To check the fillet leg/excess weld metal. ✓
- To check the fillet throat.
- To check for undercutting. (Any 3 x 1) (3)

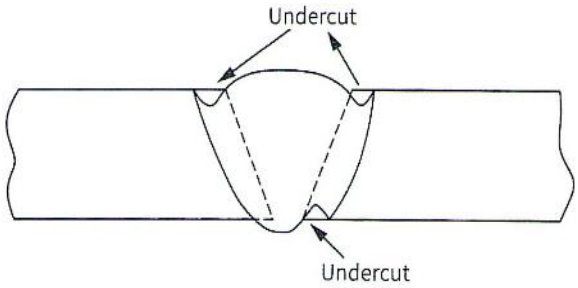
8.3 **Incomplete penetration:**

- When the weld bead does not penetrate the full depth of the weld or into the root of the weld. ✓
- When two opposing weld beads do not inter-penetrate. ✓
- When the weld bead does not penetrate to the toe of a fillet weld, but only bridges across it. ✓ (3)

8.4 **'Presence of pits':**

Porosity ✓ (1)

8.5 **Sketch of undercutting:**



✓✓ (2)

8.6 **Welding spatter:**

It is little droplets of molten material, ✓ that are generated at or near the welding arc. ✓ (2)

8.7 **Three welding flames:**

- Neutral flame ✓
- Carburising flame ✓
- Oxidising flame ✓ (3 x 1) (3)

8.8 **Types of cracks:**

- Heat affected zone (HAZ) ✓
- Centre line cracks ✓
- Crater cracks ✓
- Transverse cracks (Any 3 x 1) (3)

8.9 **Types of destructive tests:**

- Nick break test ✓
- Guided bend test ✓
- Free-bend test
- Machinability test (Any 2 x 1) (2)

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QUESTION 9: JOINING METHODS (STRESSES AND DISTORTION) (SPECIFIC)

9.1 **Weld distortion:**

Weld distortion is the warping of the base metal ✓ caused by the heat from the welding arc/flame. ✓ (2)

9.2 **Methods to reduce distortion:**

- Do not overweld. ✓
- Apply intermittent welding. ✓
- Place welds near the neutral axis. ✓
- Use as few passes as possible.
- Use back-step welding.
- Anticipate the shrinking forces.
- Plan the welding sequence.
- Use strong backs. (Any 3 x 1) (3)

9.3 **Difference between hot working and cold working:**

Hot working is when deformation of steel ✓ takes place above the recrystallisation temperature of the steel. ✓

Cold working is when deformation of steel ✓ takes place below the recrystallisation temperature of the steel. ✓ (4)

9.4 **Effect of electrode size:**

The larger the welding electrode diameter, ✓ the higher the current ✓ that is required to weld and therefore the higher the welding temperature. ✓ (3)

9.5 **Factors for setting up residual stress:**

- Heat present in the weld. ✓
- Qualities of parent metal, filler rod or electrode. ✓
- Shape and size of weld. ✓
- Number of successive welds runs.
- Comparative weight of weld metal and parent metal.
- Type of welding joint. (Any 3 x 1) (3)

9.6 **Examples of distortion:**

- Pre-bending. ✓
- Pre-setting the parts to be welded. ✓
- Pre-springing the parts to be welded. ✓ (3)

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QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 **Responsibility of employer-maintenance:**

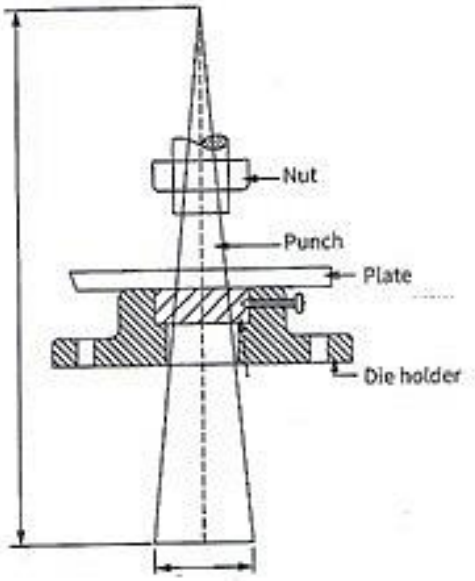
Employer should think about the hazards which can occur if:

- The tools break during use. ✓
- Machines starts up unexpectedly. ✓
- Contact is made with materials that are normally enclosed within the machine. (Any 2 x 1) (2)

10.2 **Possible causes of malfunction:**

- Lack of lubrication or incorrect lubrication. ✓
- Overloading ✓
- Friction (Any 2 x 1) (2)

10.3 **Labels on punching and shearing machine:**



✓✓✓✓ (4)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT)

11.1 11.1.1 Vertical height CE:

In triangle CED: $\text{Tan } \Theta = \frac{\text{Opposite (CE)}}{\text{Adjacent (ED)}}$ ✓

$CE = \text{Tan } 75° \times ED\ (205)$ ✓

$= 765{,}07 \text{ mm}$ ✓ (3)

11.1.2 Main radius AD: $\text{Cos } \Theta = \frac{\text{Adjacent (BD)}}{\text{Hypotoneuse (AD)}}$ ✓

$AD = \frac{450}{Cos\ 75°}$ ✓

$= 1\ 738{,}67 \text{ mm}$ ✓ (3)

11.1.3 Small radius AC:

In triangle CED: $\text{Cos } 75° = \frac{\text{Adjacent (205)}}{\text{Hypotoneuse (CD)}}$ ✓

$CD = \frac{205}{Cos\ 75°}$ ✓

$= 792{,}06 \text{ mm}$ ✓

BUT, AC = AD – CD

$= 1\ 738{,}67 – 792{,}069$ ✓

$= 946{,}601 \text{ mm}$ ✓ (5)

11.1.4 Circumference = $\pi\ x\ Diameter$

$= \pi\ x\ 900$ ✓

$= 2\ 827{,}8 \text{ mm}$ ✓ (2)

11.2 11.2.1 $CD^2 = \sqrt{60^2} + 120^2$ ✓

$= \sqrt{18\ 000}$

$CD = 134{,}16$ ✓ (2)

11.2.2 $AD^2 = \sqrt{60^2} + 60^2 + 120^2$ ✓

$= 21\ 600$ ✓

$AD = 146{,}97$ ✓ (3)

11.2.3 $DB^2 = \sqrt{60^2} + 240^2 + 120^2$ ✓

$= 75\ 600$ ✓

$DB = 274{,}95$ ✓ (3)

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TOTAL: 200