



# basic education

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

**SENIOR CERTIFICATE/  
NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY: WELDING AND METALWORK**

**NOVEMBER 2020**

**MARKING GUIDELINES**

**MARKS: 200**

**These marking guidelines consist of 18 pages.**

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)**

- |     |     |            |
|-----|-----|------------|
| 1.1 | A ✓ | (1)        |
| 1.2 | D ✓ | (1)        |
| 1.3 | A ✓ | (1)        |
| 1.4 | C ✓ | (1)        |
| 1.5 | B ✓ | (1)        |
| 1.6 | B ✓ | (1)        |
|     |     | <b>[6]</b> |

**QUESTION 2: SAFETY (GENERIC)**

- 2.1 **Work procedures on machine:**  
Switch off machine. ✓ (1)
- 2.2 **The horizontal band saw:**
- No adjustments to machine or work piece. ✓
  - Ensure sufficient coolant. ✓
  - Do not leave machine unattended while in operation. ✓
  - Do not lean on machine. ✓
  - Keep hands clear from blade. ✓
- (Any 2 x 1) (2)**
- 2.3 **Surgical gloves:**
- Prevent contamination of wound ✓
  - To prevent transmission of HIV/AIDS or any blood related diseases to the first aid helper. ✓
- (2)**
- 2.4 **Personal protective equipment (PPE) during arc welding:**
- Welding helmet / Helmet ✓
  - Safety goggles / Face shield ✓
  - Leather apron / Apron ✓
  - Leather gloves / Gloves ✓
  - Leather spat / Spats ✓
  - Safety boots / Safety shoes ✓
  - Over-all ✓
  - Skull cap ✓
  - Neck protection ✓
  - Ear plugs / Ear muffs. ✓
  - Respirator ✓
- (Any 2 x 1) (2)**
- 2.5 **Responsibility of the employer regarding the health and safety:**
- Sufficient lighting ✓✓
  - Sufficient ventilation ✓✓
  - Provide first-aid equipment ✓✓
  - Provide a safe / clean working environment ✓✓
  - Provide personal protective equipment (PPE) ✓✓
  - Provide safety training to employees ✓✓
- (Any 1 x 2) (2)**
- 2.6 **Responsible for administering first aid:**  
A qualified / trained first aid person ✓ (1)

**[10]**

### QUESTION 3: MATERIALS (GENERIC)

#### 3.1 Tests to identify various metals:

##### 3.1.1 Sound test:

- Tapping the metal with a hammer (any metal object) ✓ and identify the sound. ✓
- Dropping the metal on the floor ✓ and identify the sound. ✓

(Any 1 x 2) (2)

##### 3.1.2 File test:

File the metal and pay attention to the bite of the file into the metal. ✓ The bigger the bite the softer the metal. **OR** The smaller the bite the harder the metal. ✓

(2)

#### 3.2 Purpose of heat treatment of steel:

- To change ✓ the properties ✓ of steel.
- To change ✓ the grain structure ✓ of steel.

(Any 1 x 2) (2)

#### 3.3 Purpose of case hardening on steel:

To create a hard / wear resistance surface / case ✓ with a tough core. ✓

(2)

#### 3.4 The tempering process for steel:

- Heat the steel to a temperature (temper colour) below the critical temperature. ✓
- Soak it at that temperature for a period. ✓
- Quench / cool in an appropriate quenching agent. ✓ (water, brine, or oil)

(3)

#### 3.5 THREE factors for heat treatment of steel:

- Heating temperature / Carbon content ✓
- Soaking (Time period at temperature) / Work piece size ✓
- Cooling rate / Quenching rate (Quenching medium) ✓

(3)

[14]

**QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)**

- |      |         |     |
|------|---------|-----|
| 4.1  | B / D ✓ | (1) |
| 4.2  | A ✓     | (1) |
| 4.3  | C ✓     | (1) |
| 4.4  | D ✓     | (1) |
| 4.5  | B ✓     | (1) |
| 4.6  | D ✓     | (1) |
| 4.7  | A ✓     | (1) |
| 4.8  | C ✓     | (1) |
| 4.9  | D ✓     | (1) |
| 4.10 | C ✓     | (1) |
| 4.11 | B ✓     | (1) |
| 4.12 | C ✓     | (1) |
| 4.13 | A ✓     | (1) |
| 4.14 | D ✓     | (1) |

**[14]**

**QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)**

**5.1 Advantages of templates:**

- Quicker to use to improve mass production ✓
- Accurate production ✓
- Cheap to manufacture ✓
- Unskilled labour will be able to use it ✓
- Avoid unnecessary wastages / cost effective ✓
- Uniformity in production ✓
- Can be reused. ✓

**(Any 2 x 1) (2)**

**5.2 Use of templates:**

5.2.1 Thin metal is used for profile cutting machines ✓ (1)

5.2.2

- Hardboard templates is used for templates for gussets. ✓
- Hardboard templates are used for checking sizes. ✓
- Hardboard templates is used for marking of holes. ✓

**(Any 1 x 1) (1)**

**5.3 Components of a roof truss:**

- A. Rafter ✓
  - B. Purlin ✓
  - C. Internal bracing members / strut ✓
  - D. Gusset plate ✓
  - E. Main tie / Tie beam / Beam ✓
- (5)**

**5.4 A mild steel ring material:**

**Calculate the dimensions of the required material:**

$$\begin{aligned}\text{Mean } \theta &= \text{Outside } \theta - \text{plate thickness} \\ &= 280 - 12 \quad \checkmark \\ &= 268 \text{ mm} \quad \checkmark\end{aligned}$$

$$\begin{aligned}\text{Mean circumference} &= \pi \times \text{mean } \theta \\ &= \pi \times 268 \quad \checkmark \\ &= 841,95 \text{ mm} \quad \checkmark \\ &\approx 842 \text{ mm} \quad \checkmark\end{aligned}$$

**(5)**

**5.5 Abbreviation 'SANS':**

South African ✓ National Standards ✓ **(2)**

5.6 **Resistance weld:**

5.6.1 Foil seam ✓ (1)

5.6.2 Flash or resistance butt ✓ (1)

5.7 **Weld dimensions:**

- 5 – size (width) of weld ✓
- 25 – length of weld ✓
- 50 – pitch of welds ✓ (3)

5.8 **Position of the weld:**

5.8.1 Weld on the arrow side ✓ (1)

5.8.2 Weld on both sides ✓ (1)

**[23]**

**QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)**

**6.1 Pedestal drill machine:**

**A** = Table / Machine table / Working table / Platform ✓

**B** = Chuck / Drill bit holder ✓

**C** = Motor ✓

**D** = Pillar / Column ✓

(4)

**6.2 Operating principles:**

**6.2.1 Horizontal band saw:**

- The blade is tensioned around two pulleys. ✓
- The machine is driven by an electric motor. ✓
- The blade is fitted so that it cuts in a continuously forward motion. ✓
- The blade assembly is raised and lowered by hand or by hydraulic controls. ✓
- The metal being cut is held firmly in the stock clamp during the cutting process. ✓

**(Any 4 x 1)**

(4)

**6.2.2 Punch and cropper (shear) machine:**

- It is an electrically driven machine. ✓
- It makes use of a flywheel and clutches ✓ to engage various shearing blades or punches. ✓

(3)

**6.3 Primary function of flashback arrestors:**

It prevents ✓ back-feeding/backfiring. ✓✓

(3)

**6.4 Use of taps and dies:**

- Taps are used to cut / clean ✓ internal / nut screw threads ✓
- Dies are used to cut / clean ✓ external / bolt screw threads ✓

(4)

**[18]**





7.1.2 **Magnitude and nature of the members:**

MEMBER	MAGNITUDE (kN)	NATURE
AF	1050 ✓ (1020 – 1080)	STRUT ✓
BG	760 ✓ (730 – 790)	STRUT ✓
CH	760 ✓ (730 – 790)	STRUT ✓
DI	960 ✓ (930 – 990)	STRUT ✓
FG	300 ✓ (270 – 330)	STRUT ✓
HI	200 ✓ (170 – 230)	STRUT ✓
FE	930 ✓ (900 – 960)	TIE ✓
GH	250 ✓ (220 – 280)	TIE ✓
IE	830 ✓ (800 – 860)	TIE ✓
	<b>Minus 2 marks for incorrect conversion (mm to kN)</b>	

(18)

7.2 **BEAMS:**

7.2.1 **Bending moments:**

$$BM_B = (3,4 \times 3) \quad \checkmark$$

$$= 10,2 \text{ kN.m} \quad \checkmark$$

$$BM_C = (3,4 \times 7) - (4 \times 4) \quad \checkmark \quad \checkmark$$

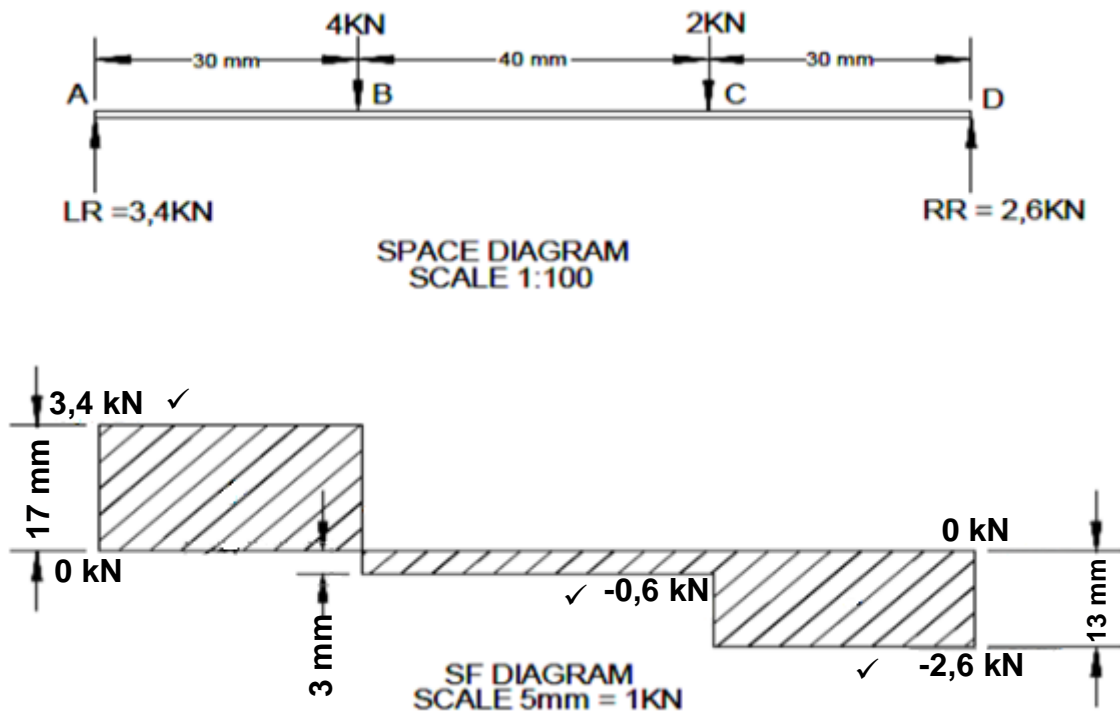
$$= 23,8 - 16$$

$$= 7,8 \text{ kN.m} \quad \checkmark$$

$$BM_D = 0 \text{ kN.m} \quad \checkmark$$

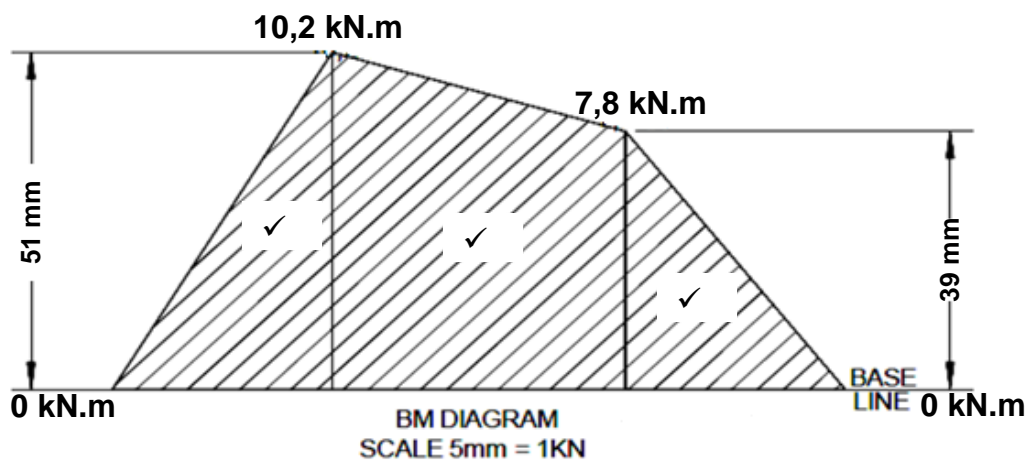
(6)

7.2.2 Shear force diagram:



(3)

7.2.3 Bending moment diagram:



Markers need to draw to scale at marking centre  
 SCALE 5mm =1kN.m

(3)

7.3 **Stress and Strain:**

7.3.1 **Maximum stress:**

$$\begin{aligned}\text{Maximum Stress} &= \frac{\text{Maximum Load}}{\text{Area}} \\ &= \frac{8 \times 10^3}{0,08 \times 10^{-3}} \quad \checkmark \\ &= 100 \times 10^6 \text{ Pa} \quad \checkmark \\ &= 100 \text{ MPa} \quad \checkmark\end{aligned}$$

(3)

7.3.2 **Safe working stress:**

$$\begin{aligned}\text{Safe Stress} &= \frac{\text{Maximum Stress}}{\text{Safety Factor}} \\ &= \frac{100 \times 10^6}{4} \quad \checkmark \\ &= 25 \times 10^6 \text{ Pa} \quad \checkmark \\ &= 25 \text{ MPa}\end{aligned}$$

(2)  
**[45]**

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

- 8.1 **Welding spatter:**
- Too high current / Amperage too high ✓
  - Too long arc / Arc blow ✓
  - Not using anti-spatter spray ✓
  - Electrode angle too small ✓
  - Welding speed too fast ✓
  - Wet electrodes ✓
  - Gas-flow too high (gas welding) ✓
  - Incorrect polarity for electrode type ✓
- (Any 4 x 1) (4)**
- 8.2 **Gas cutting:**
- 8.2.1 **Nozzle too high from surface:**
- Excessive melting of the top edge. ✓
  - Undercut at the top of the cut face with lower part square and sharp bottom corner. ✓
- (2)**
- 8.2.2 **Nozzle too close to the surface:**
- Top edge slightly rounded and heavily beaded. ✓
  - Cut face usually square with fairly sharp bottom corner. ✓
- (2)**
- 8.3 **Causes of weld defects:**
- 8.3.1 **Porosity:**
- Dirty weld surface ✓
  - Wet welding electrodes ✓
  - Rust in the MIG wire electrode ✓
  - Interruption of shielding gas supply ✓
  - Welding in windy conditions where effectiveness of shielding gas is compromised ✓
  - Wrong gas used on the specific metal ✓
  - Weld ability of parent metal not good ✓
  - Wrong electrode used on the specific metal ✓
  - Too high temperature ✓
- (Any 2 x 1) (2)**
- 8.3.2 **Poor penetration:**
- Welding current is too low ✓
  - Travel speed is too fast ✓
  - Incorrect electrode angle ✓
  - Poor edge preparation ✓
  - Insufficient root gap ✓
  - Gas flow too low (gas welding) ✓
- (Any 2 x 1) (2)**

- 8.4 **Heat Affected Zone (HAZ) Cracks:**
- Excessive hydrogen ✓
  - High residual stress levels (work piece cooled too fast) ✓
  - High carbon content on the base metal ✓
- (Any 2 x 1) (2)**
- 8.5 **Visual inspection:**
- Shape of the profile ✓
  - Uniformity of the surface ✓
  - Overlap ✓
  - Undercutting ✓
  - Penetration bead ✓
  - Root groove ✓
  - Surface cracks ✓
- (Any 3 x 1) (3)**
- 8.6 **Ultrasonic test:**
- Gel should be put on the surface of the work piece. ✓
  - The sender/receiver is moved in a zigzag motion across the weld to broaden its detection range. ✓
  - A high frequency sound wave is send into the metal. ✓
  - When the wave is stopped, the sender serves then as a receiver. ✓
  - The receiver monitors the waves as it is reflected through the metal. ✓
  - Each wave is visually represented on an oscilloscope. ✓
  - The calibrated oscilloscope will then indicate the deviations in the waves which represents the defects in the metal. ✓
- (Any 6 x 1) (6)**
- [23]**

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

- 9.1 **Residual stress:**  
Residual stresses are stresses that exist in a metal ✓ after cooling. ✓ (2)
- 9.2 **Effect of hot working on steel:**
- In hot working, deformation and recrystallization occur simultaneously so that the rate of softening is greater than work hardening. ✓
  - Hot-working should be finished at a temperature just above the recrystallization temperature. ✓
  - To obtain a fine grain structure. ✓
  - If the finishing temperature is too high, grain growth will occur while the metal is cooling above the recrystallization temperature and inferior properties will develop. ✓ (4)
- 9.3 **Iron-carbon diagram:**
- 9.3.1 Iron-carbon equilibrium diagram ✓ (1)
- 9.3.2 A. Temperature / Degrees Celsius ✓  
B. Austenite ✓  
C. Austenite and Cementite ✓  
D. Ferrite and Pearlite ✓  
E. Carbon content ✓ (5)
- 9.4 **Result when metal is cooled rapidly:**
- The metal sets up internal and external stresses. ✓
  - Causes cracks on the surface of the metal. ✓
  - Causes deformation. ✓
  - Hardness increases. ✓
  - Martensite forms. ✓
- (Any 2 x 1) (2)
- 9.5 **Quenching media:**
- Water ✓
  - Brine ✓
  - Oil ✓
  - Air ✓
  - Metal / Molten salts ✓
  - Lime ✓
  - Sand ✓
  - Ash ✓
- (Any 4 x 1) (4)
- [18]**

## QUESTION 10: MAINTENANCE (SPECIFIC)

### 10.1 Types of maintenance:

- Preventative ✓
- Reliable centred ✓
- Predictive ✓
- Routine ✓
- Corrective ✓
- Condition based ✓
- Reactive maintenance ✓

(Any 2 x 1) (2)

### 10.2 Lockout on machines:

To ensure that nobody can turn on ✓ the machine while maintenance is being carried out. ✓

(2)

### 10.3 Rules to be observed before machine start up:

- Check if there is lock out tag ✓
- Confirm that the machine is safe and operational. ✓
- Check that all guards and safety devices are in position and operative. ✓
- Inform workers that the machine is being brought back into service. ✓
- Check that the area surrounding the machine is clear and that turning it on will not endanger anyone. ✓
- Check that all relevant fasteners have been properly tightened. ✓
- Check that all lockout devices have been removed. ✓
- Turn on the machine's power supply. ✓
- Know where the stop switch or emergency switch is located. ✓

(Any 2 x 1) (2)

### 10.4 Factors to be observed when selecting the cutting speed of a drilling machine:

- Type of material ✓
- Diameter of drill bit ✓
- Material of which the drill bit is made ✓
- Type of drill bit ✓
- Firmness with which the work is clamped ✓
- Condition of the machine ✓
- Use of cutting fluids ✓
- Rate of feed ✓

(Any 3 x 1) (3)

[9]



### QUESTION 11: DEVELOPMENT (SPECIFIC)

#### Square-to-round transition:

##### 11.1 The true length FG:

$$IK = 300(2\text{units})$$

$$IH = 150(1\text{unit})$$

$$HK = 1\sqrt{3} (1\text{unit} \times \sqrt{3})$$

The true length FG:

$$\begin{aligned} \text{Plan length FG} &= FK - GK \quad \checkmark \\ &= 400 - 300 \\ &= 100 \text{ mm} \quad \checkmark \end{aligned}$$

The true FG is equal to H'F

$$\begin{aligned} CG^2 &= C'F^2 + FG^2 \\ &= 400^2 + 100^2 \quad \checkmark \end{aligned}$$

$$C'G = \sqrt{170000} \quad \checkmark$$

$$CG = 412,31 \text{ mm} \quad \checkmark$$

$$\begin{aligned} \text{True length C'G} &= \sqrt{412,31^2 + 800^2} \quad \checkmark \\ &= 900 \text{ mm} \quad \checkmark \end{aligned}$$

(7)

11.2 Length CI, the sides CE and EI of triangle CEI must be calculated:

$$\begin{aligned}CE &= CF - EF \\ &= 400 - 150 \quad \checkmark \\ &= 250 \text{ mm} \quad \checkmark\end{aligned}$$

But EI = FH

$$\begin{aligned}HK &= 1 \text{ unit} \times \sqrt{3} \\ &= 150\sqrt{3} \quad \checkmark \\ &= 259,81 \text{ mm} \quad \checkmark\end{aligned}$$

$$\begin{aligned}FH &= FK - HK \\ &= 400 - 259,81 \quad \checkmark \\ &= 140,19 \text{ mm} \quad \checkmark\end{aligned}$$

$$\begin{aligned}CI^2 &= CE^2 + EI^2 \\ &= 250^2 + 140,19^2 \quad \checkmark \\ &= \sqrt{82153,24} \\ CI &= 286,62 \text{ mm} \quad \checkmark\end{aligned}$$

$$\begin{aligned}\text{True length } CI^2 &= CI^2 + (\text{Perpendicular Height})^2 \\ &= 286,62^2 + 800^2 \quad \checkmark \\ &= \sqrt{722151,02} \\ &= 849,79 \text{ mm} \quad \checkmark\end{aligned} \tag{10}$$

11.3 JI is one-twelfth of the circumference:

$$\begin{aligned}\text{True Length of JI (Circumference)} &= \pi \times \frac{MD}{12} \quad \checkmark \\ \frac{1}{12} \text{ Circumference} &= \frac{1884,9}{12} \quad \checkmark \\ &= 157,08 \text{ mm} \quad \checkmark\end{aligned}$$

(3)  
**[20]**  
**GRAND TOTAL: 200**