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

## **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**MECHANICAL TECHNOLOGY: WELDING AND METALWORK**

**NOVEMBER 2019**

**MARKING GUIDELINES**

**MARKS: 200**

**These marking guidelines consist of 17 pages.**

**QUESTION 1: MULTIPLE-CHOICE (Generic)**

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

**QUESTION 2: SAFETY (Generic)**

- 2.1      **Machine safety rule:**
- Know how to switch the machine off/emergency stop. ✓
  - Wear personal protective equipment (PPE). ✓
  - Know how to use the machine. ✓
  - Ensure that all guards are in place. ✓
  - No tools lying on the machine. ✓
  - Work piece is properly secured. ✓
  - Check the condition of the machine. ✓
  - Follow manufacture's specifications before operating a machine. ✓
  - Operator must have authorization to working on a machine. ✓
  - Make sure the machine is not locked out. ✓
  - Ensure that the machine setup is correct and safe. ✓
  - Ensure that the machine area is clean and safe. ✓
- (Any 1 x 1)      (1)
- 2.2      **Drill press safety precautions:**
- To prevent injuries. ✓
  - To improve accuracy. ✓
  - To prevent work piece rotating/moving. ✓
  - To prevent the drill bit from breaking. ✓
- (Any 1 x 1)      (1)
- 2.3      **Hydraulic press safety rules:**
- Make sure the press is in a good working condition. ✓
  - Take notice of the pre-determined maximum pressure of the hydraulic press. ✓
  - Make sure the area around the press is clean and free of oil, grease and water. ✓
  - Ensure that the platform is rigid and square to the cylinder. ✓
  - Ensure that suitable jigs and prescribed equipment is available. ✓
  - Check hydraulic pipes for leaks or cracks. ✓

- Check supporting pins are not worn out and fitted properly. ✓
- Check fluid levels. ✓
- Compressive force must be applied at 90° to the object. ✓
- Check cable and pulleys on the platform if equipped. ✓
- Correct PPE. ✓
- Pressure gauge must be checked and calibrated. ✓
- Ensure that all guards are in place. ✓

(Any 2 x 1) (2)

2.4 **Reasons for wearing surgical gloves:**

- To prevent HIV/AIDS or any blood related infections being transmitted. ✓
- To prevent contamination of the open wounds. ✓

(2)

2.5 **Safe handling of portable electrical equipment:**

- Ensure the electrical cord and plug, are in a good condition. ✓
- Ensure all safety guards are in place. ✓
- Ensure that the correct attachments (drill bits, blades etc.) are fixed in the correct way. ✓
- Do not force the machine / equipment. ✓
- Operate according to manufacturer instructions. ✓
- Avoid contact with water. ✓
- Keep the cable away from heat, oil, sharp edges and moving parts. ✓
- Make sure that the wires don't wrap around each other. ✓
- Avoid dropping the machine. ✓
- Check the condition of the equipment. ✓

(Any 2 x 1) (2)

2.6 **Responsibility of employer:**

- Provide and maintain working systems, work area, equipment and tools in a safe condition. ✓
- Eliminate or reduce any potential hazard. ✓
- Produce, handle, store and transport goods safely. ✓
- Ensure that every person employed complies with the requirements of this OHS Act. ✓
- Enforce measures if necessary in the interest of health and safety. ✓
- Appoint a person who is trained and who have the authority to ensure that the employee takes precautionary measures. ✓
- Inform employees of the hazards to his health and safety attached to any duty or work situation. ✓
- Provide first aid equipment. ✓

(Any 1 x 1) (1)

**2.7 Responsibility of employee:**

- Pay attention to their own and other people's health and safety. ✓
- Co-operate with the employer regarding the OHS Act. ✓
- Carry out a lawful order given to them. ✓
- Report any situation that is unsafe or unhealthy. ✓
- Report all incidents and accidents. ✓
- Not to interfere with any safety equipment or misuse such equipment. ✓
- Obey all safety rules. ✓

(Any 1 x 1)

(1)  
[10]

**QUESTION 3: MATERIAL (Generic)**

**3.1 Filing test:**

- Use the right ✓ filing skills. ✓
- File on the tip or edge ✓✓ of the metal.
- By applying chalk ✓ to the file surface. ✓

(Any 1 x 2)

(2)

**3.2 Purpose of heat treatment of steel:**

Heat treatment of steel is done to change ✓ the properties/grain structure ✓ of steel.

(2)

**3.3 Reasons for tempering hardened steel:**

- To reduce ✓ the brittleness ✓ caused by the hardening process.
- To relieve ✓ strain ✓ caused during hardening process.
- To increase ✓ the toughness ✓ of the steel.
- To give hardened work piece a more ✓ fine-grained structure. ✓

(Any 2 x 2)

(4)

**3.4 Heat treatment processes on steel:**

**3.4.1 Annealing:**

- The steel is heated to the prescribed temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then cooled very slowly to produce maximum softness. ✓

(3)

**3.4.2 Hardening:**

- The steel is heated slightly higher than the upper critical temperature. (AC<sub>3</sub>) ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in rapid cooling medium. ✓

(3)

[14]

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

- |      |     |             |
|------|-----|-------------|
| 4.1  | D ✓ | (1)         |
| 4.2  | A ✓ | (1)         |
| 4.3  | C ✓ | (1)         |
| 4.4  | D ✓ | (1)         |
| 4.5  | B ✓ | (1)         |
| 4.6  | D ✓ | (1)         |
| 4.7  | D ✓ | (1)         |
| 4.8  | C ✓ | (1)         |
| 4.9  | A ✓ | (1)         |
| 4.10 | C ✓ | (1)         |
| 4.11 | A ✓ | (1)         |
| 4.12 | C ✓ | (1)         |
| 4.13 | B ✓ | (1)         |
| 4.14 | D ✓ | (1)         |
|      |     | <b>[14]</b> |

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

- |     |   |     |
|-----|---|-----|
| 5.1 | <b>Abbreviation:</b><br>OSU Other ✓ Side Up ✓   | (2) |
| 5.2 | <b>Plate girder:</b><br>Is a combination of plates and angle iron ✓ welded together. ✓  | (2) |
| 5.3 | <b>Purpose of supplementary welding symbols:</b><br>To indicate the additional/supplementary information regarding the weld. ✓  | (1) |
| 5.4 | <b>Fusion welds:</b> <ul style="list-style-type: none"><li>• Spot welding ✓</li><li>• Projection ✓</li><li>• Seam welding ✓</li><li>• Foil seam welding ✓</li><li>• Flash or resistance butt ✓</li><li>• Gas welding ✓</li><li>• MIG/MAGS Welding ✓</li><li>• Arc welding ✓</li></ul> |     |

**(Any 4 x 1) (4)**

**5.5 Supplementary weld symbols:**

- 5.5.1 Grind ✓ (1)
- 5.5.2 Flame ✓ (1)
- 5.5.3 Machine ✓ (1)
- 5.5.4 Flush ✓ (1)
- 5.5.5 Convex ✓ (1)

**5.6 Material calculations:**

$$\begin{aligned}\text{Mean diameter} &= \text{Outside diameter} - \text{plate thickness} \quad \checkmark \\ &= 300 - 20 \quad \checkmark \\ &= 280 \text{ mm} \quad \checkmark\end{aligned}$$

$$\begin{aligned}\text{Mean circumference} &= \pi \times \text{mean diameter} \quad \checkmark \\ &= \pi \times 280 \quad \checkmark \\ &= 879.65 \text{ mm}, \quad \checkmark \quad \checkmark\end{aligned} \quad (7)$$

**5.7 Weld dimensions:**

- 30°: the included angle in degree ✓
  - 5: root gap or root opening in mm ✓
- (2)  
**[23]**

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

**6.1.1 Power saw/Reciprocating saw:**

- The blade is tensioned in the frame ✓ and cuts in a forward stroke and the blade is lifted in the backward (reciprocating) motion. ✓
  - The blade assembly is raised and lowered ✓ by hydraulic controls to ensure that the cutting pressure is optimum. ✓
- (4)

**6.1.2 Manual guillotine:**

- This guillotine is operated by a foot/hand pedal/lever that activates a pressure plate/blade guard. ✓
  - The blade cuts the material. ✓
  - The cut material is ejected at the back of the machine. ✓
  - Extension bars lengthen the work surface and support longer pieces of material. ✓
- (4)

6.1.3 **Horizontal pyramid rolls:**

- Electrical/Power or hand driven. ✓
- The rollers are arranged so that, when viewed from the side, they give the impression of a pyramid. ✓
- All rollers are mounted in a horizontal position, with the bottom two fixed and rotating in unison. ✓
- The top roller is adjustable (up or down); applying downward pressure on the metal plate being rolled that will cause it to deflect and form the round shape. ✓

(4)

6.2 **Bench Grinder:**

- To sharpen cutting tools and drill bits. ✓
- To removing rough edges. ✓
- To removing excess material. ✓

(3)

6.3 **Materials that can be cut with a plasma cutter:**

- Mild steel ✓
- Alloy steels ✓
- Stainless steels ✓
- Non-ferrous metals ✓

(Any 3 x 1)

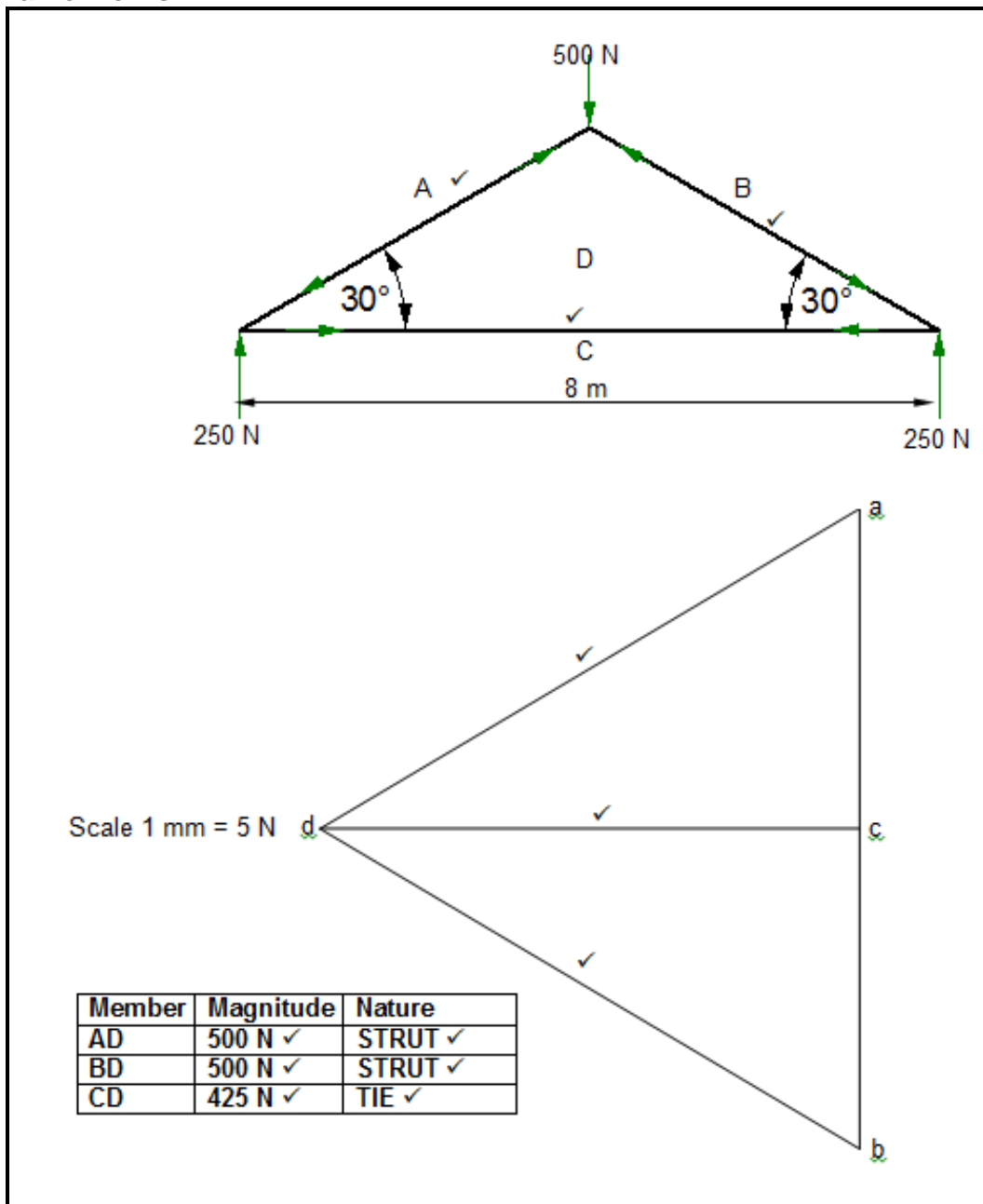
(3)

[18]



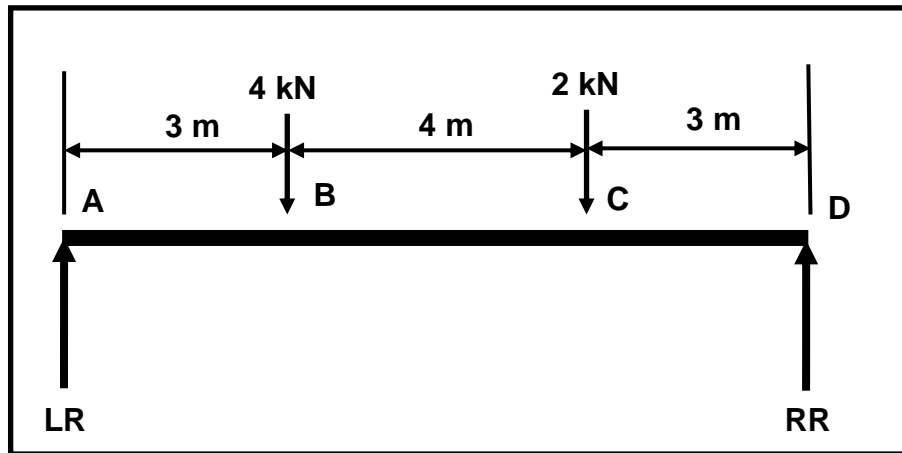
## QUESTION 7: FORCES (Specific)

### 7.1 Frame works:



(12)

7.2



7.2.1 Reactions at supports RL and RR:  
Take moments about RR:

$$\begin{aligned} \text{LR} \times 10 &= (4 \times 7) + (2 \times 3) \\ \text{LR} &= 3,4 \text{ kN} \end{aligned}$$

Take moments about LR:

$$\begin{aligned} \text{RR} \times 10 &= (2 \times 7) + (4 \times 3) \\ \text{RR} &= 2,6 \text{ kN} \end{aligned}$$

(6)

7.2.2 Bending moments:

$$\begin{aligned} \text{BM}_A &= 0 \times 3,4 = 0 \text{ kN.m} \\ \text{BM}_B &= (3 \times 3,4) - (0 \times 4) = 10,2 \text{ kN.m} \\ \text{BM}_C &= (7 \times 3,4) - (4 \times 4) - (0 \times 2) = 7,8 \text{ kN.m} \\ \text{BM}_D &= (10 \times 3,4) - (7 \times 4) - (3 \times 2) + (0 \times 2,6) = 0 \text{ kN.m} \end{aligned}$$

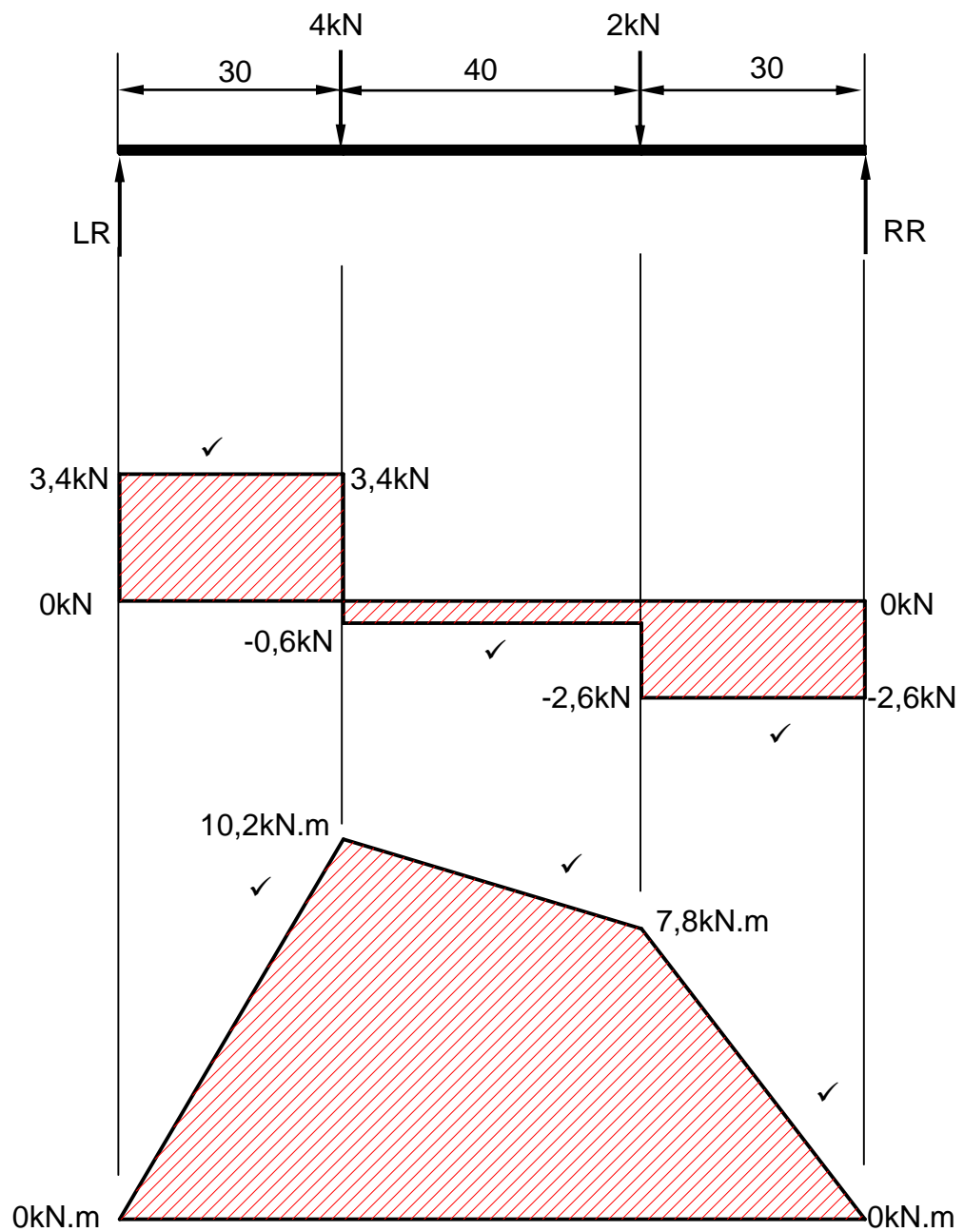
(4)

7.2.3 Shear forces:

$$\begin{aligned} \text{SF}_A &= 0 \text{ kN} \quad \text{OR} \quad \text{UF}_A = 3,4 \text{ kN} \\ \text{SF}_B &= 3,4 - 4 = -0,6 \text{ kN} \\ \text{SF}_C &= 3,4 - (4 + 2) = -2,6 \text{ kN} \\ \text{SF}_D &= 0 \text{ kN} \quad \text{OR} \quad \text{UF}_D = 2,6 \text{ kN} \end{aligned}$$

(4)

7.2.4 SF and BM diagrams:



(6)

### 7.3 Stress and Strain:

#### 7.3.1 Stress:

$$A = \frac{\pi d^2}{4} \quad \checkmark$$

$$= \frac{\pi \times 0,01^2}{4}$$

$$A = 7,85 \times 10^{-5} \text{ m}^2 \quad \checkmark$$

$$\text{Stress} = \frac{\text{Load}}{\text{Area}} \quad \checkmark$$

$$= \frac{50 \times 10^3}{7,85 \times 10^{-5}} \quad \checkmark$$

$$= 6369426752 \text{ Pa} \quad \checkmark$$

$$= 636,94 \text{ MPa} \quad \checkmark \quad (5)$$

#### 7.3.2 Strain:

$$\text{Strain} = \frac{\Delta L}{OL} \quad \checkmark$$

$$= \frac{0,6 \times 10^{-3}}{20} \quad \checkmark$$

$$= 3 \times 10^{-5} \quad \checkmark \quad (3)$$

#### 7.3.3 Final length:

$$\text{Final length} = OL + \Delta L \quad \checkmark$$

$$= 20 + 0,6 \times 10^{-3}$$

$$= 20,0006 \text{ m} \quad \checkmark \quad (2)$$

#### 7.3.4 Young's modulus:

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

$$E = \frac{636,94 \times 10^6}{3 \times 10^{-5}} \quad \checkmark$$

$$E = 2,1231 \times 10^{13} \text{ Pa}$$

$$E = 21231,33 \text{ GPa} \quad \checkmark \quad (3)$$

[45]

## QUESTION 8: JOINING METHODS (Inspection of weld) (Specific)

### 8.1 Causes of arc-welding defects:

#### 8.1.1 Undercutting:

- To high welding current ✓
- Electrode at incorrect angle ✓
- Excessive weaving ✓
- Arc length too long ✓
- Travel speed too high ✓

(Any 2 x 1) (2)

#### 8.1.2 Causes of slag inclusion:

- Defective consumables. ✓
- Inadequate shielding gas. ✓
- Joint contamination. ✓
- Too low current. ✓
- Improper slag removal from previous weld. ✓
- Excessive weaving ✓
- Electrode at incorrect angle ✓

(Any 2 x 1) (2)

### 8.2 Factors determining gas pressure for oxy acetylene welding:

- The nozzle size. ✓
- Thickness of material. ✓

(2)

### 8.3 Factors determining current setting for welding:

- Base metal type. ✓
- Base metal thickness. ✓
- Electrode diameter. ✓
- Position of the weld. ✓

(Any 2 x 1) (2)

### 8.4 Preventative measures for weld defects:

#### 8.4.1 Porosity:

- Cleaning the welding surface. ✓
- Use dry electrodes. ✓
- Avoid rust on electrode. ✓
- Ensure that supply of shielding gas is not interrupted. ✓
- Avoid welding in windy conditions. ✓
- Use correct arc length. ✓

(Any 2 x 1) (2)

8.4.2 **Incomplete penetration:**

- Set to correct current setting. ✓
- Apply the correct electrode angle. ✓
- Increase the travel speed. ✓
- Use the correct root gap. ✓
- Ensure the correct joint preparation. ✓

(Any 2 x 1) (2)

8.5 **Guided bend test:**

- Lack of fusion. ✓
- Incomplete penetration. ✓
- Cracks in the weld metal. ✓
- Quality of the weld at the face and root of the weld. ✓

(Any 2 x 1) (2)

8.6 **Visual inspection process:**

- Shape of profile. ✓
- Uniformity of the surface. ✓
- Overlap. ✓
- Undercutting. ✓
- Penetration bead. ✓
- Root groove. ✓
- Slag inclusion. ✓
- Spatter. ✓
- Cracks. ✓

(Any 3 x 1) (3)

8.7 **X-ray test:**

- The X-ray or gamma ray source is placed in front of the object being tested. ✓
- The film is put behind the object being tested. ✓
- The source is activated and the X-rays/gamma penetrate the test piece. ✓
- As they pass through the areas of lower density (air pockets, cracks or inclusions) ✓ the rays expose the film as lighter on the negative, indicating a welding defect. ✓
- Film or picture need to be analyzed. ✓

(6)  
[23]

**QUESTION 9: JOINING METHODS (Stresses and Distortion) (Specific)**

**9.1 Distortion:**

Weld distortion is the warping of the base plate ✓ caused by heat from the welding arc/flame. ✓

(2)

**9.2 Effect of cold working on steel:**

- To break down the crystal structure elongating the grains. ✓
- It gives the metal greater hardness and tensile strength. ✓
- It reduces ductility. ✓
- Steel can be made to recrystallize under the action of heat. ✓

(4)

**9.3 Factors that affect distortion and residual stress:**

- If the expansion that occurs when metal is heated is resisted ✓ then deformation will occur. ✓
- When contraction that occurs on cooling is resisted ✓ then a stress will be applied. ✓
- If this stress causes movement ✓ then distortion occurs. ✓
- If this stress does not cause movement ✓ then there will be residual stress in the welded joint. ✓

(Any 2 x 2)

(4)

**9.4 Rate of cooling:**

- The size of the work piece. ✓
- Weld thickness. ✓
- Thermal conductive properties of parent metal. (Type of material) ✓

(3)

**9.5 The iron-carbon equilibrium diagram:**

- A. Ferrite and pearlite ✓
- B. Ferrite and austenite ✓
- C. Austenite ✓
- D. Cementite and austenite ✓
- E. Pearlite and cementite ✓

(5)

[18]

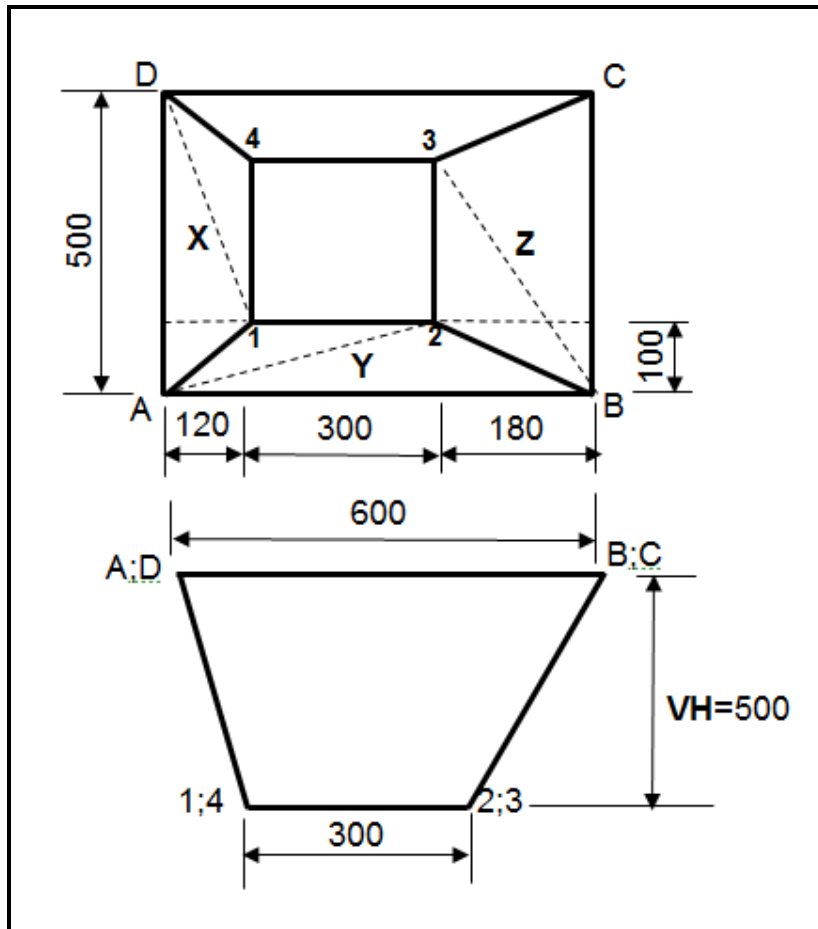
**QUESTION 10: MAINTENANCE (Specific)**

- 10.1 **Lockout on machines:**  
To ensure that nobody can turn on the machine ✓ while maintenance is being carried out. ✓ (2)
- 10.2 **Tagging plates:**  
It has multiple holes, so that more than one technician can lock out the machine simultaneously. ✓ (1)
- 10.3 **Aspects of plant and equipment maintenance:**
- Do not ignore maintenance. ✓
  - Do not ignore reports of damaged or unsafe equipment. ✓
  - Do not ignore faulty or damaged equipment. ✓
  - Do not ignore inspection. ✓
- (Any 2 x 1) (2)
- 10.4 **Maintenance guidelines of the horizontal band saw:**
- Check electrical wiring and isolation. ✓
  - Change the band saw blade as required. ✓
  - Check band wheels at every blade change. ✓
  - Monitor band wheel bearings. ✓
  - Inspect band guides. ✓
  - Inspect the condition of the guards. ✓
  - Check blade tension and alignment. ✓
  - Inspect the hydraulic system and oil level. ✓
  - Check vice for wear on both stationary and movable parts. ✓
  - Align vice with the blade. ✓
  - Inspect the chip removal system daily. ✓
- (Any 2 x 1) (2)
- 10.5 **Effect of overloading of the rolling machine:**  
It limits the lifespan ✓ of bearings, gearbox and motor components. ✓ (2)
- [09]**



### QUESTION 11: DEVELOPMENT (Specific)

#### 11.1 Square to rectangular hopper off centre:



##### 11.1.1 True lengths of A-1:

Vertical height = 500 mm

##### True length (A-1):

$$\begin{aligned} A-1 &= \sqrt{120^2 + 100^2 + 500^2} \quad \checkmark \\ &= \sqrt{14400 + 10000 + 250000} \quad \checkmark \\ &= 523,83 \text{ mm} \quad \checkmark \checkmark \end{aligned}$$

(4)

##### 11.1.2 True length (A-2):

Vertical height = 500 mm

$$\begin{aligned} A-2 &= \sqrt{100^2 + 420^2 + 500^2} \quad \checkmark \\ &= \sqrt{10000 + 176400 + 250000} \quad \checkmark \\ &= 660,61 \text{ mm} \quad \checkmark \checkmark \end{aligned}$$

(4)

**11.1.3 True length (B-2):**

Vertical height = 500 mm

$$\begin{aligned} B-2 &= \sqrt{100^2 + 180^2 + 500^2} \quad \checkmark \\ &= \sqrt{10000 + 32400 + 250000} \quad \checkmark \\ &= 540,74 \text{ mm} \quad \checkmark \quad \checkmark \end{aligned} \quad (4)$$

**11.1.4 True length (B-3):**

Vertical height = 500 mm

$$\begin{aligned} B-3 &= \sqrt{180^2 + 400^2 + 500^2} \quad \checkmark \\ &= \sqrt{32400 + 160000 + 250000} \quad \checkmark \\ &= 665,13 \text{ mm} \quad \checkmark \quad \checkmark \end{aligned} \quad (4)$$

**11.1.5 True length(D-1):**

Vertical height = 500 mm

$$\begin{aligned} D-1 &= \sqrt{120^2 + 400^2 + 500^2} \quad \checkmark \\ &= \sqrt{14400 + 160000 + 250000} \quad \checkmark \\ &= 651,46 \text{ mm} \quad \checkmark \quad \checkmark \end{aligned} \quad (4)$$

**[20]**  
**[200]**