**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)
                                                                          [6]

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_3) ✓
- 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)
                                                                                                [14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (Specific)

5.1   **Abbreviation:**
        OSU Other ✓ Side Up ✓   (2)

5.2   **Plate girder:**
        Is a combination of plates and angle iron ✓ welded together. ✓   (2)

5.3   **Purpose of supplementary welding symbols:**
        To indicate the additional/supplementary information regarding the weld. ✓   (1)

5.4   **Fusion welds:**
        • Spot welding ✓
        • Projection ✓
        • Seam welding ✓
        • Foil seam welding ✓
        • Flash or resistance butt ✓
        • Gas welding ✓
        • MIG/MAGS Welding ✓
        • Arc welding ✓

                                                                        (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:**

$$\text{Mean diameter} = \text{Outside diameter} - \text{plate thickness} \quad ✓$$
$$= 300 - 20 \quad ✓$$
$$= 280 \text{ mm} \quad ✓$$

$$\text{Mean circumference} = \pi \times \text{mean diameter} \quad ✓$$
$$= \pi \times 280 \quad ✓$$
$$= 879.65 \text{ mm}, ✓ \ ✓ \tag{7}$$

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:**

Scale 1 mm = 5 N

Member	Magnitude	Nature
AD	500 N ✓	STRUT ✓
BD	500 N ✓	STRUT ✓
CD	425 N ✓	TIE ✓
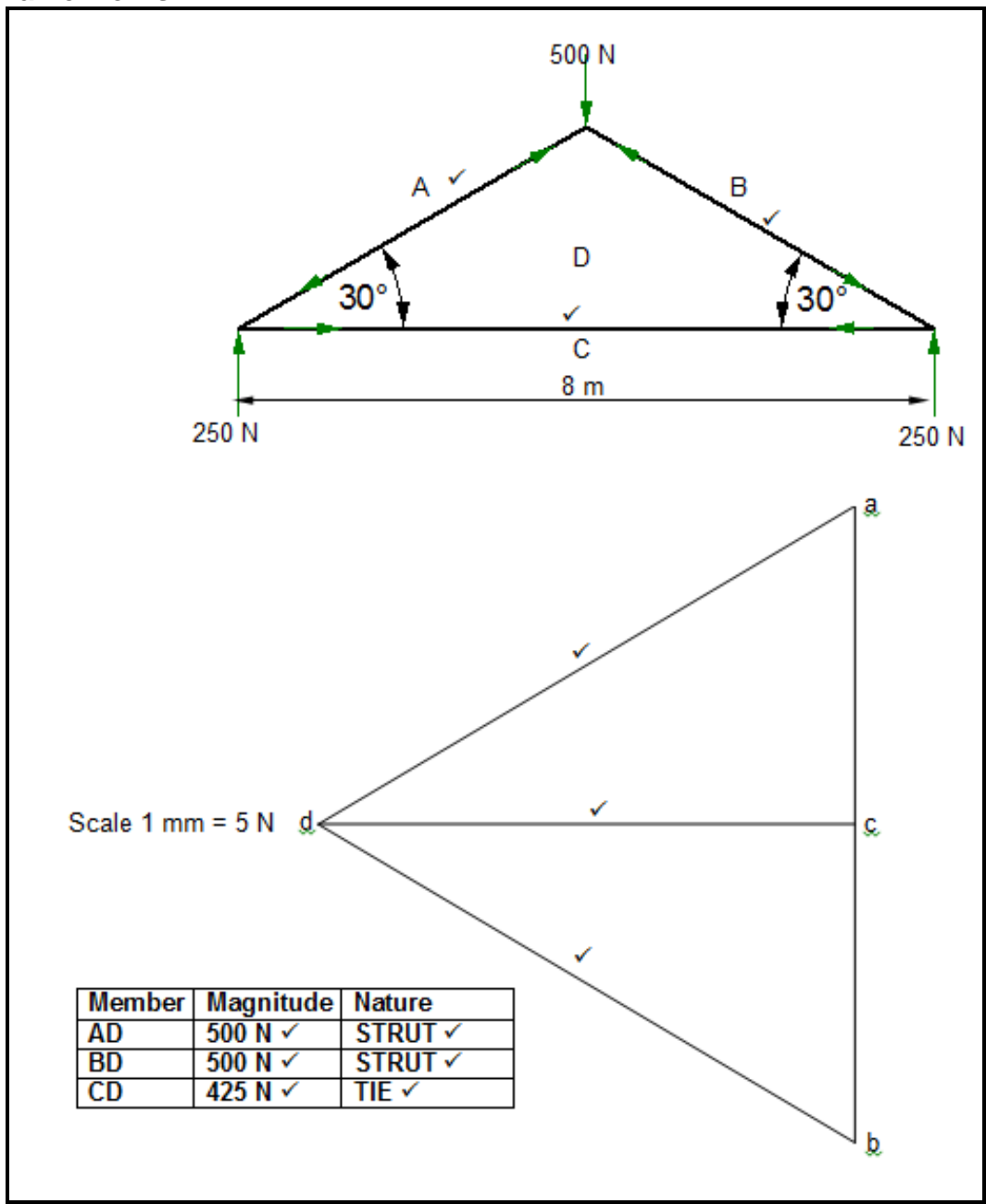
(12)

7.2
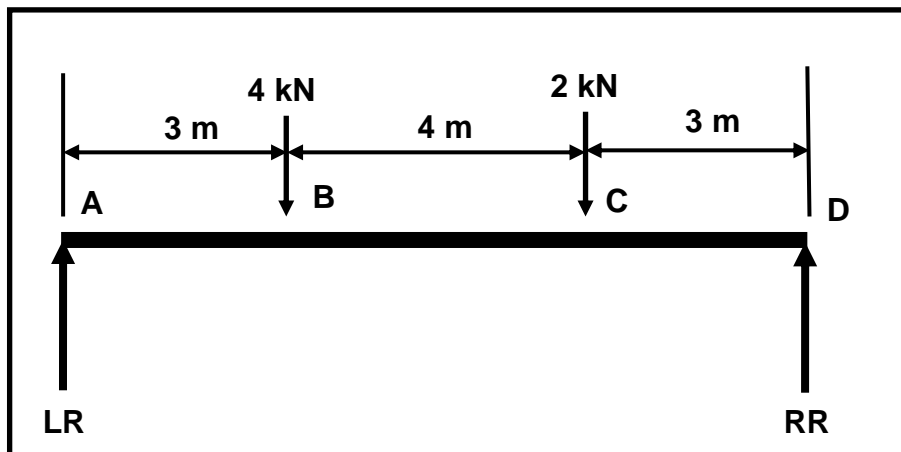
7.2.1 Reactions at supports RL and RR:
Take moments about RR:

$$LR \times 10 = (4 \times 7) + (2 \times 3)$$
$$LR = 3,4 \text{ kN} \checkmark$$

Take moments about LR:

$$RR \times 10 = (2 \times 7) + (4 \times 3)$$
$$RR = 2,6 \text{ kN} \checkmark$$

(6)

7.2.2 **Bending moments:**
$$BM_A = 0 \times 3,4 = 0 \text{ kN.m} \checkmark$$
$$BM_B = (3 \times 3,4) - (0 \times 4) = 10,2 \text{ kN.m} \checkmark$$
$$BM_C = (7 \times 3,4) - (4 \times 4) - (0 \times 2) = 7,8 \text{ kN.m} \checkmark$$
$$BM_D = (10 \times 3,4) - (7 \times 4) - (3 \times 2) + (0 \times 2,6) = 0 \text{ kN.m} \checkmark$$

(4)

7.2.3 **Shear forces:**
$$SF_A = 0 \text{ kN} \quad \textbf{OR} \quad UF_A = 3,4 \text{ kN} \checkmark$$
$$SF_B = 3,4 - 4 = -0,6 \text{ kN} \checkmark$$
$$SF_C = 3,4 - (4 + 2) = -2,6 \text{ kN} \checkmark$$
$$SF_D = 0 \text{ kN} \quad \textbf{OR} \quad UF_D = 2,6 \text{ kN} \checkmark$$

(4)

7.2.4   **SF and BM diagrams:**
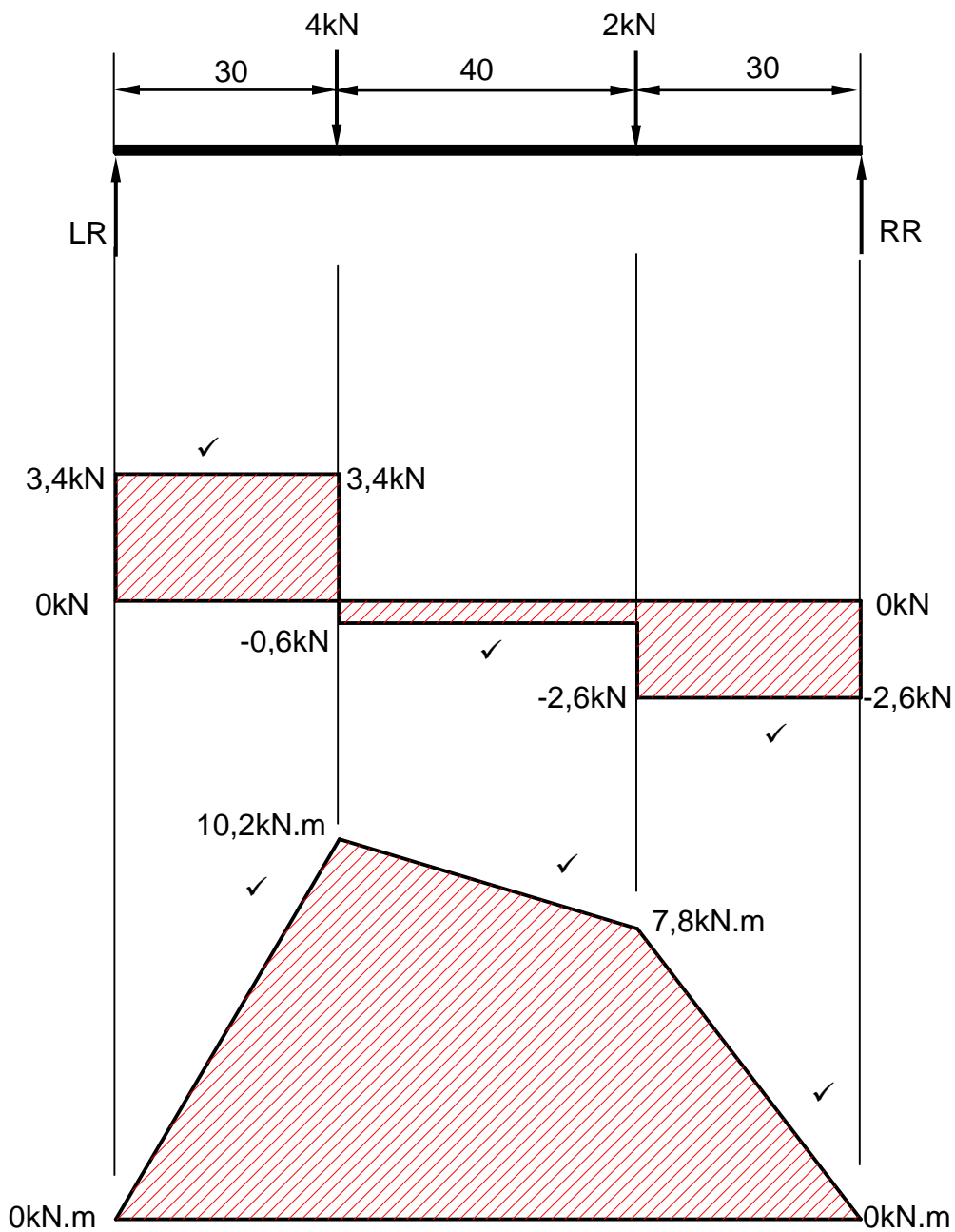
(6)

7.3   **Stress and Strain:**

7.3.1   **Stress:**

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

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

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

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

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

$$= 636942675{,}2 \, Pa$$

$$= 636{,}94 \, MPa \qquad \checkmark$$

(5)

7.3.2   **Strain:**

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

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

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

(3)

7.3.3   **Final length:**

$$Final \, length = OL + \Delta L \qquad \checkmark$$

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

$$= 20,0006 \, m \qquad \checkmark$$

(2)

7.3.4   **Young's modulus:**

$$E = \frac{Stress}{Strain} \qquad \checkmark$$

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

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

$$E = 21231,33 \, GPa \quad \checkmark$$

(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 to 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:**
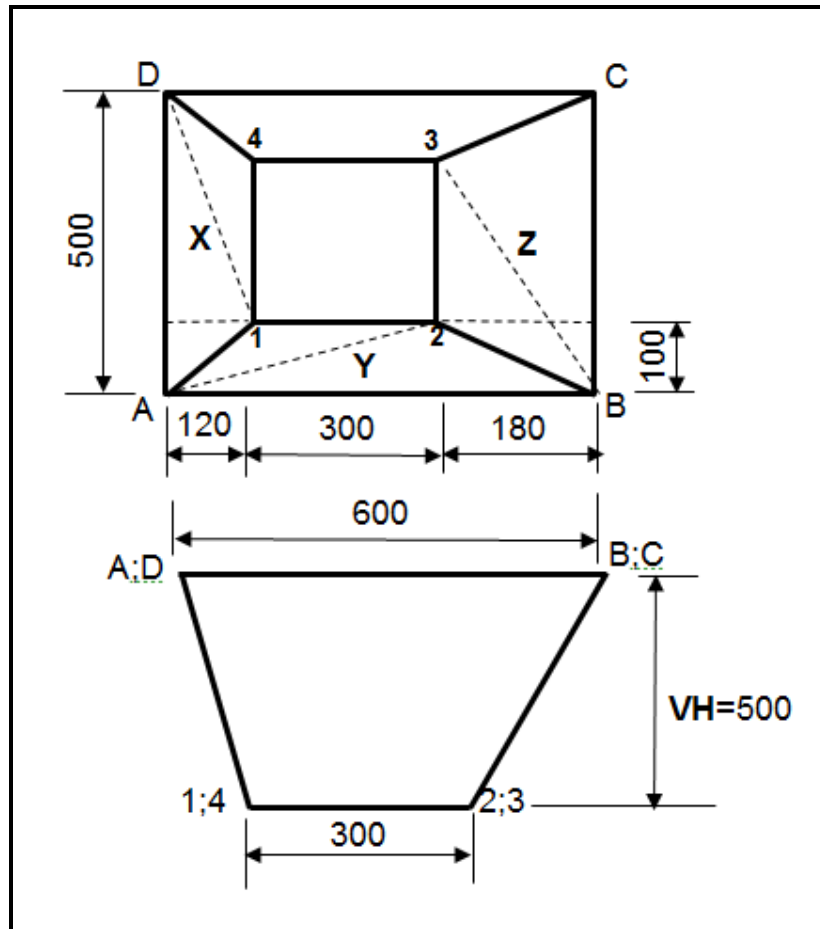
    11.1.1   **True lengths of A-1:**

          Vertical height = 500 mm

          True length (A-1):

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

(4)

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

          Vertical height = 500 mm

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

(4)

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

Vertical height = 500 mm

$$B - 2 = \sqrt{100^2 + 180^2 + 500^2} \quad \checkmark$$
$$= \sqrt{10000 + 32400 + 250000} \quad \checkmark$$
$$= 540{,}74 \, mm \quad \checkmark \quad \checkmark$$

(4)

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

Vertical height = 500 mm

$$B - 3 = \sqrt{180^2 + 400^2 + 500^2} \quad \checkmark$$
$$= \sqrt{32400 + 160000 + 250000} \quad \checkmark$$
$$= 665{,}13 \, mm \quad \checkmark \quad \checkmark$$

(4)

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

Vertical height = 500 mm

$$D - 1 = \sqrt{120^2 + 400^2 + 500^2} \quad \checkmark$$
$$= \sqrt{14400 + 160000 + 250000} \quad \checkmark$$
$$= 651{,}46 \, mm \quad \checkmark \quad \checkmark$$

(4)
[20]
[200]