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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

NOVEMBER 2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 20 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1	B ✓	(1)
1.2	B ✓	(1)
1.3	C ✓	(1)
1.4	C ✓	(1)
1.5	A ✓	(1)
1.6	B ✓	(1)
		[6]

QUESTION 2: SAFETY (GENERIC)**2.1 Vital functions:**

- Breathing ✓
- Heart rate / pulse ✓
- State of consciousness ✓

(Any 2 x 1) (2)**2.2 Safety glasses during grinding:**

- To prevent any injuries to the operator's eyes. ✓
- To protect eyes from sparks and debris. ✓
- To prevent blindness due to injury. ✓

(Any 1 x 1) (1)**2.3 Type of guards:**

- Fixed guard ✓
- Automatic sweep-away ✓
- Self-adjusting / automatic guard ✓
- Electronic presence sensing device ✓
- Two-hand control device. ✓

(Any 2 x 1) (2)**2.4 Precautions *before* gas welding operations can be undertaken:**

- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment (PPE). ✓
- Ensure that fire equipment is at hand. ✓
- Ensure that the equipment is in a safe working condition. ✓
- Ensure the gas equipment is set-up correctly. ✓
- Ensure the area is well ventilated. ✓
- Ensure that the working area is safe. ✓

(Any 3 x 1) (3)**2.5 TWO disadvantages of the product layout:**

- Lack of flexibility. ✓
- Optimum use of equipment is not possible. ✓

**(2)
[10]**

QUESTION 3: MATERIALS (GENERIC)**3.1 THREE properties:**

- Toughness ✓
- Hardness / Wear resistance ✓
- Softness ✓
- Case hardness ✓
- Ductility ✓
- Malleability ✓
- Elasticity ✓
- Brittleness ✓
- Strength ✓

(Any 3 x 1) (3)**3.2 Heat treatment processes:****3.2.1 Tempering:**

- It consists of heating the hardened steel ✓ to a temperature below its critical temperature (colour chart). ✓
- Soaking it at this temperature for a period of time, ✓
- Quenching/cooling it rapidly in water, brine or oil. ✓

(4)**3.2.2 Hardening:**

- The steel is heated slightly higher than the upper critical temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in water, brine or oil. ✓

(3)**3.3 Examples of case-hardening:**

- Bearing cases ✓
- Bearing ball ✓
- Bearing needles ✓
- Crankshafts ✓
- Gears ✓
- Camshafts ✓
- Cylinder sleeves ✓
- Hammer head ✓
- Jack Hammer drill bits ✓

(Any 2 x 1) (2)**3.4 Why steels are cooled down in still air away from draughts:**

This prevents sudden cooling of localised spots, ✓ which might cause distortion/cracks. ✓

(2)**[14]**

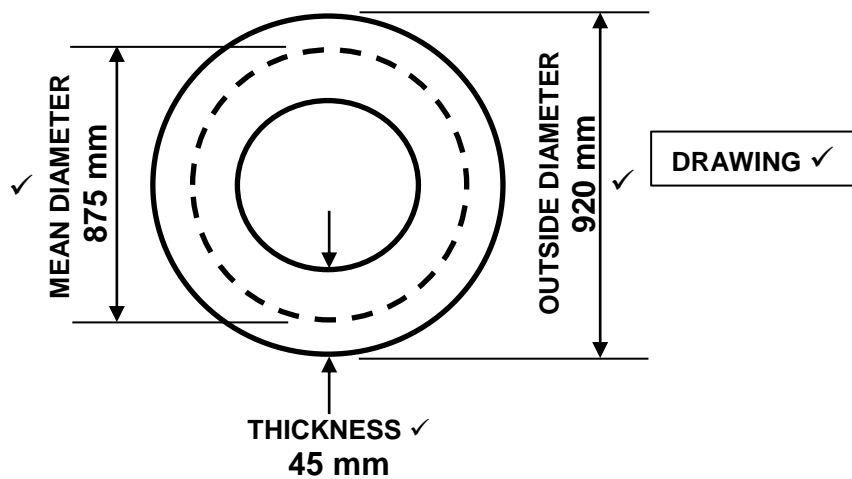
QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

QUESTION 5: TERMINOLOGY(TEMPLATES) (SPECIFIC)**5.1 Steel ring calculations:**

5.1.1 Mean \varnothing = Outside \varnothing - plate thickness
 = 920 - 45 ✓
 = 875 mm ✓ (2)

5.1.2 Mean circumference = $\pi \times$ Mean \varnothing
 = $\pi \times 875$ ✓
 = 2748,89 ✓
 = 2749 mm ✓ (3)

5.1.3 Steel ring drawing:**5.2 Weld symbols:**

5.2.1 Weld all around ✓ (1)

5.2.2 Flush ✓ (1)

5.2.3 Convex ✓ (1)

5.2.4 Grind ✓ (1)

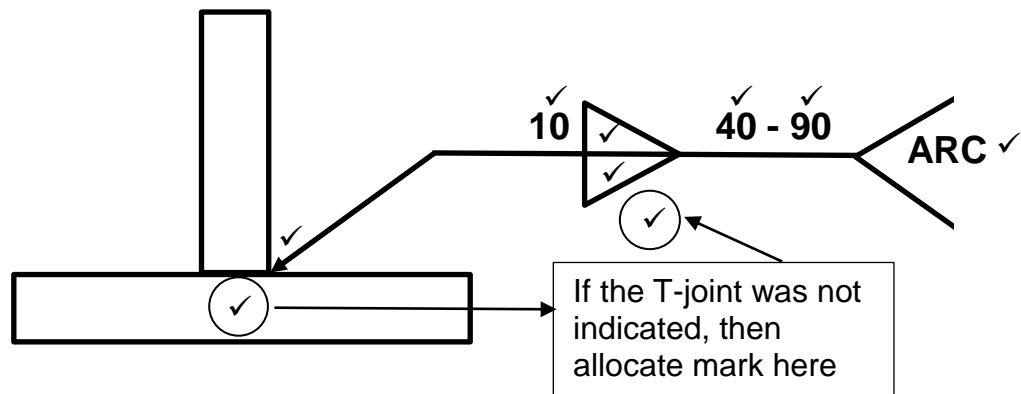
5.3 Template makers tools:

- Hand saws ✓
- Chisels ✓
- Plane ✓
- Hand drill and drill bits ✓
- Steel tape ✓
- Straight edge ✓
- Compass ✓
- Trammel pins ✓
- Carpenter's square ✓
- Protractor ✓
- Chalk line ✓
- Or any appropriate hand tool ✓

(Any 2 x 1)

(2)

5.4 Fillet weld on T joint:



(8)
[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)**6.1 Punch and shear machine:**

- Cutting steel profiles. ✓
- Punching holes in a steel plate. ✓ (2)

6.2 Inert gas:

- Stabilizers arc roots on the material surface. ✓
- Ensures a smooth transfer of molten droplets from the wire to the weld pool. ✓
- Prevents atmospheric contamination of the weld pool. ✓
- Prevents defects (Any other applicable defect). ✓

(Any 2 x 1) (2)**6.3 Advantages of MIGS/MAGS welding:**

- Less distortion. ✓
- MIG/MAGS welding quality is better. ✓
- Fewer stops and starts. ✓
- MIG/MAGS works with many metals or alloys. ✓
- Greater deposition rates. ✓
- Less post welding cleaning (no slag to chip off weld). ✓
- Better weld pool visibility. ✓
- No stub end losses or wasted man hours caused by changing electrodes. ✓
- Low skill factor required to operate MIG/MAGS welding torch. ✓
- Can weld in any position. ✓
- The process is easily automated. ✓
- No fluxes required in most cases. ✓

(Any 2 x 1) (2)**6.4 Bending test:**

- To determine the materials ductility. ✓
- To determine the materials bend strength. ✓
- To determine the materials resistance to fracture. ✓
- To identify a weak point on the beam. ✓

(Any 2 x 1) (2)**6.5 Power-driven guillotine:**

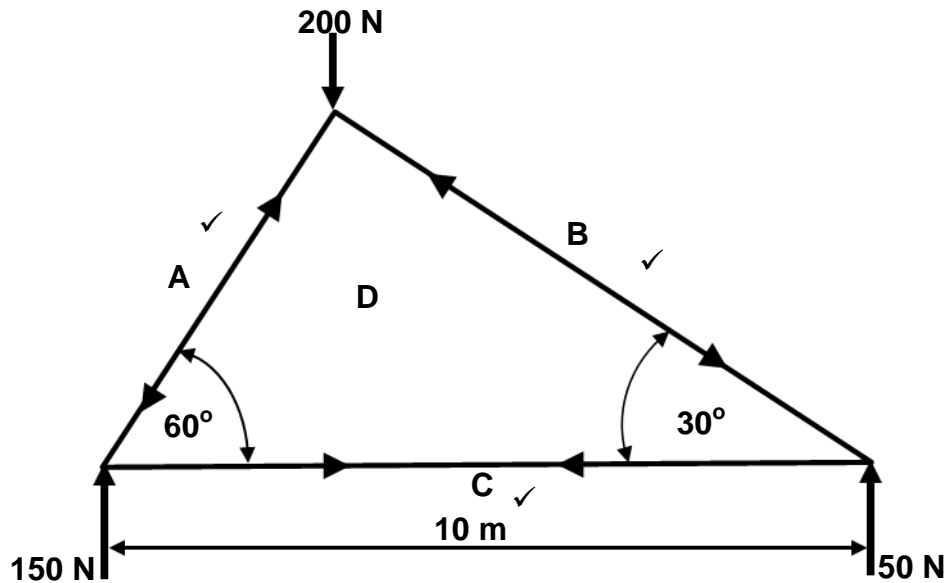
- A bottom cutting blade is fixed horizontally. ✓
- A top cutting blade moves downwards. ✓
- It is driven by an electric motor activated by a foot pedal. ✓
- It is driven by a flywheel, gearbox and axle. ✓
- It lowers the blade by eccentric motion or action. ✓

(Any 4 x 1) (4)

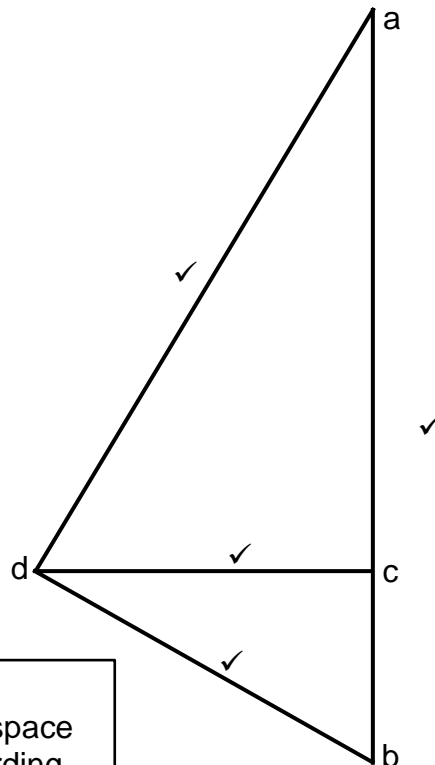
- 6.6 **Hydraulic press labels:**
- A – Adjustment hole ✓
 - B – Pressure gauge / Gauge ✓
 - C – Platform / Rest / Table ✓
 - D – Cylinder / Piston / Plunger ✓
 - E – Handle / Lever ✓
 - F – Base / Stand / Legs ✓

(6)

[18]

QUESTION 7: FORCES (SPECIFIC)**7.1 Simple Frames:****7.1.1 Space diagram:**

(3)

7.1.2 Force diagram:**Note to marker:**

Marker must redraw the space and force diagrams according to given scales for marking purposes.

(4)

7.1.3 **Magnitude:**

Member	Magnitude (N)
AD	174 ✓
BD	100 ✓
CD	86 ✓

Note to marker: Tolerance ± 2 mm
--

(3)

7.1.4 **Nature of members:**

Member	Nature
AD	Strut ✓
BD	Strut ✓
CD	Tie ✓

(3)

7.2 **Shear forces and bending moments:**7.2.1 **The magnitude of the UDL/Point Load:**

$$\begin{aligned} \text{UDL} &= 6 \text{ N/m} \times 5 \text{ m} \\ &= 30 \text{ N} \checkmark \end{aligned}$$

(1)

7.2.2 **The magnitude RL:**

$$\begin{aligned} \text{RL} \times 10 &= (40 \times 2) + (30 \times 4,5) + (20 \times 9) \\ &= 80 + 135 + 180 \\ \text{RL} &= \frac{395}{10} \checkmark \\ &= 39,5 \text{ N} \checkmark \end{aligned}$$

(5)

7.2.3 **The magnitude RR:**

$$\begin{aligned} \text{RR} \times 10 &= (20 \times 1) + (30 \times 5,5) + (40 \times 8) \\ &= 20 + 165 + 320 \\ \text{RR} &= \frac{505}{10} \checkmark \\ &= 50,5 \text{ N} \checkmark \end{aligned}$$

(5)

7.2.4 **The shear force at points A, UDL and B:**

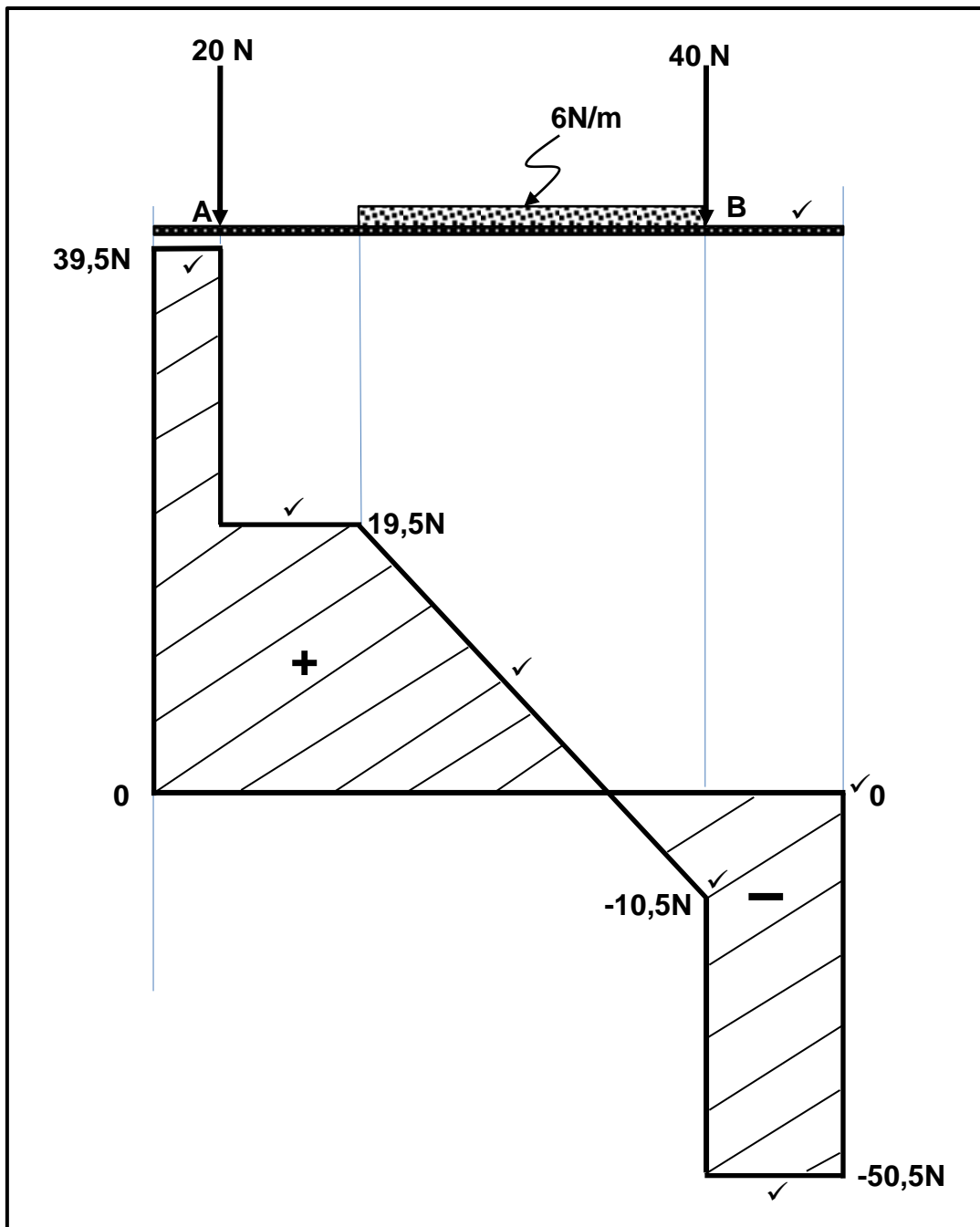
$$\begin{aligned} \text{SF}_A &= 39,5 - 20 \checkmark \\ &= 19,5 \text{ N} \checkmark \\ \text{SF}_{\text{UDL}} &= 39,5 - 20 - 30 \checkmark \\ &= -10,5 \text{ N} \checkmark \\ \text{SF}_B &= 39,5 - 20 - 30 - 40 \checkmark \\ &= -50,5 \text{ N} \checkmark \end{aligned}$$

OR

$$\begin{aligned} \text{SF}_A &= 39,5 - 20 \checkmark \\ &= 19,5 \text{ N} \checkmark \\ \text{SF}_{\text{UDL}} &= 19,5 - 30 \checkmark \\ &= -10,5 \text{ N} \checkmark \\ \text{SF}_B &= -10,5 - 40 \checkmark \\ &= -50,5 \text{ N} \checkmark \end{aligned}$$

(6)

7.2.5 Shear force moment diagram:



(7)

Note to marker:

Marker must redraw the shear force diagram according to given scales for marking purposes.

- ONLY if ALL components indicated are correct but incorrect scale used, then a 2-mark penalty is applied for incorrect scale.
- ONLY if the diagram is correct according to scale but no values are indicated, then a 2-mark penalty is applied.

7.3 Stress:**7.3.1 Maximum stress in MPa:**

$$\begin{aligned}
 \text{Stress} &= \frac{\text{Load}}{\text{Area}} \\
 &= \frac{45000}{0,8 \times 10^{-5}} \quad \checkmark \\
 &= 56,25 \times 10^8 \text{ Pa} \\
 &= 5625 \text{ MPa} \quad \checkmark
 \end{aligned}$$

(2)

7.3.2 Safe working stress MPa:

$$\begin{aligned}
 \text{Safety factor} &= \frac{\text{Maximum Stress}}{\text{Safe working Stress}} \\
 \text{Safe working stress} &= \frac{\text{Maximum Stress}}{\text{Safety factor}} \quad \checkmark \\
 &= \frac{56,25 \times 10^8 \text{ Pa}}{4} \quad \checkmark \\
 &= 14,06 \times 10^8 \text{ Pa} \\
 &= 1406,25 \text{ MPa} \quad \checkmark
 \end{aligned}$$

(3)

7.3.3 Diameter:

$$\begin{aligned}
 \text{Area} &= \frac{\pi \times d^2}{4} \\
 d^2 &= \frac{\text{Area} \times 4}{\pi} \quad \checkmark \\
 d &= \sqrt{\frac{0,8 \times 10^{-5} \times 4}{\pi}} \quad \checkmark \\
 &= 3,191 \times 10^{-3} \text{ m} \\
 d &= 3,19 \text{ mm} \quad \checkmark
 \end{aligned}$$

(3)

[45]

QUESTION 8: JOINING METHODS (INSPECTION OF WELD) (SPECIFIC)**8.1 Arc welding process:**

- Rate of electrode burning. ✓
- Progress of the weld / weld speed. ✓
- Amount of penetration and fusion (melting). ✓
- Arc length. ✓
- The way the weld metal is flowing (no slag inclusion). ✓
- The sound of the arc, indicating correct current and voltage for the particular weld. ✓
- Electrode angle. ✓

(Any 3 x 1) (3)**8.2 Oxy-acetylene welding:**

- Correct flame for the work on hand. ✓
- Correct angle of welding torch and welding rod. ✓
- Depth penetration and amount of fusion. ✓
- The rate of progress along the joint.

(Any 2 x 1) (2)**8.3 Welding defects:**8.3.1 Undercut. ✓ **(1)**8.3.2 Incomplete penetration. ✓ **(1)****8.4 Welding defects:****8.4.1 Welding spatter:**

- Use correct welding voltage. ✓
- Set correct welding current. ✓
- Adequate shielding gas. ✓
- Use correct arc length. ✓
- Use anti spatter spray. ✓
- Use correct electrode angle. ✓
- Use correct welding speed. ✓
- Use correct polarity. ✓
- Use dry electrodes ✓
- Check weld ability of base metal/Carbon content. ✓

(Any 2 x 1) (2)

8.4.2 Porosity:

- Avoid rust ✓
- Cleaning the welding surface. ✓
- Ensure that supply of shielding gas is not interrupted. ✓
- Avoid welding in windy conditions. ✓
- Use dry electrodes. ✓
- Lower the welding temperature ✓
- Ensure good weld ability of base metal ✓

(Any 2 x 1) (2)**8.5 Welding defect:****8.5.1 Nick break test:**

- Slag inclusion ✓
- Porosity ✓
- Lack of fusion ✓
- Oxidised / burnt metal ✓

(Any 2 x 1) (2)**8.5.2 Bend test:**

- Lack of fusion ✓
- Cracks ✓
- Incomplete penetration ✓

(Any 2 x 1) (2)**8.6 Liquid dye penetrant:**

- Clean the surface to be tested. ✓
- Spray the liquid dye penetrant onto the surface. ✓
- Allow liquid dye to penetrate. ✓
- Remove excess dye with a cleaner / water. ✓
- Spray a developer onto the surface to bring out the colour / Using a UV light to show defects. ✓
- Observe surface for defects. ✓

(6)**8.7 Ultrasonic test:**

- Internal flaws ✓
- External flaws ✓
- OR
- Slag inclusion ✓
- Undercut ✓
- Porosity ✓
- Incomplete penetration ✓
- Cracks ✓
- Lack of fusion ✓

(Any 2 x 1) (2)**[23]**

QUESTION 9: JOINING METHODS (STRESSES AND DISTORTION) (SPECIFIC)**9.1 Electrode size:**

- The larger/thicker the electrode diameter ✓ the higher the welding temperature, ✓ the greater the potential to cause deformation. ✓
- The smaller/thinner the electrode diameter ✓ the lower the welding temperature, ✓ the lesser the potential to cause deformation. ✓

(Any 1 x 3) (3)**9.2 Methods of reducing distortion:**

- Do not over weld ✓
- Use intermittent welding ✓
- Place welds near the neutral axis ✓
- Use as few passes as possible ✓
- Use backstep welding ✓
- Anticipate the shrinkage forces ✓
- Plan the welding sequence ✓
- Use strongbacks ✓
- Use clamps, jigs and fixtures ✓
- Pre-heating the workpiece ✓
- Tack welding ✓
- Allow slow cooling after welding. ✓

(Any 2 x 1) (2)**9.3 Disadvantages:**

- Restraining force provided by clamps, fixtures and jigs increases internal stresses in the welded joint. ✓
- Increases the residual stress because the welded joint is not allowed to expand or contract. ✓
- The metals movement is severely restricted and result in increased stress. ✓

(Any 2 x 1) (2)**9.4 Elastic deformation:**

Elastic deformation occurs when the joint recovers ✓ to its original position once the stress have been removed. ✓

(2)

9.5 Factors responsible for setting up residual stress:

- Heat present in the weld. ✓
- Qualities/type of parent metal. ✓
- Qualities/type of filler rods. ✓
- Qualities/type of electrode. ✓
- Shape and size of weld. ✓
- Number of successive weld runs. ✓
- Comparative weight of weld metal and parent metal. ✓
- Type of welding joint used. ✓
- Welding method used to mitigate stress and distortion. ✓
- Type of structure of adjacent joints. ✓
- Freeness of joint to be able to expand and contract. ✓
- Rate of cooling. ✓
- Stresses already present in the parent metal. ✓

(Any 3 x 1)**(3)****9.6 Iron carbon diagram:**

- A – Ferrite ✓
- B – Ferrite + Pearlite ✓
- C – Pearlite ✓
- D – Pearlite + Cementite ✓
- E – Austenite + Ferrite ✓
- F – Austenite ✓

(6)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)**10.1 Malfunctions in machines:**

- Seized bearings and bushes. ✓
- Excessive worn journals. ✓
- Excessive rust. ✓

(Any 2 x 1) (2)**10.2 Pedestal drilling machine:**

- Visual checks of electrical wiring, switches, etc. ✓
- Verify that all guards are secure and function correctly. ✓
- Lubricate moving parts. ✓
- Use moisture-penetrating oil spray to prevent rust. ✓
- Check for availability of specific tools. ✓
- Check the run-out of the spindle. ✓
- Inspect drive belts for wear. ✓
- Ensure the drive belt is correctly tensioned. ✓
- Check the condition of the rack and pinion mechanisms. ✓
- Ensure cuttings are removed. ✓
- Inspect the Morse taper sleeves for burrs/scratches. ✓
- Machine is properly secured to the floor. ✓

(Any 2 x 1) (2)**10.3 Service records:**

- Assist in the monitoring of the condition of the machines. ✓
- Assist in upholding warranties. ✓
- Assist in keeping a history of maintenance and repairs. ✓

(Any 2 x 1) (2)**10.4 Major and Minor service:**

Major service allows for on-going service procedures that are designed to maintain machines and equipment in premium working condition. ✓

Minor service is designed to minimize major mechanical and electrical failures, by employing the principle of preventative maintenance. ✓

**(2)
[8]**

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)**11.1 Uses of hoppers:**

- Storage of loose materials. ✓
- Ventilation ducting. ✓
- Gravity flow hoppers. ✓

(Any 2 x 1) (2)**11.2 Hopper:**

11.2.1 Square ✓ to square ✓ hopper. (2)

11.2.2 True length:**(a) A–2:**

$$\begin{aligned}
 A - 2 &= \sqrt{\overset{\checkmark}{600^2} + \overset{\checkmark}{200^2} + \overset{\checkmark}{600^2}} \\
 &= \sqrt{360000 + 40000 + 360000} \\
 &= \sqrt{760000} \\
 &= 871,78 \text{ mm } \checkmark
 \end{aligned}$$
(4)

(b) A–X:

$$\begin{aligned}
 A - X &= \sqrt{\overset{\checkmark}{200^2} + \overset{\checkmark}{400^2} + \overset{\checkmark}{600^2}} \\
 &= \sqrt{40000 + 160000 + 360000} \\
 &= \sqrt{560000} \\
 &= 748,33 \text{ mm } \checkmark
 \end{aligned}$$
(4)

(c) X–Y:

$$\begin{aligned}
 X - Y &= \sqrt{\overset{\checkmark}{200^2} + \overset{\checkmark}{600^2}} \\
 &= \sqrt{40000 + 360000} \\
 &= \sqrt{400000} \\
 &= 632,46 \text{ mm } \checkmark
 \end{aligned}$$
(3)

11.3 Cone frustum:**11.3.1 True length 1–2.**

$$\begin{aligned}
 1-2 &= \frac{\pi \times d}{12} \checkmark \\
 &= \frac{\pi \times 300}{12} \checkmark \\
 &= 78,54 \text{ mm } \checkmark
 \end{aligned}$$

(3)

11.3.2 True length A–B.

$$\begin{aligned}
 A-B &= \frac{\pi \times D}{12} \\
 &= \frac{\pi \times 600}{12} \\
 &= 157,08 \text{ mm}
 \end{aligned}$$

(3)

[21]**TOTAL: 200**