basic education

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]

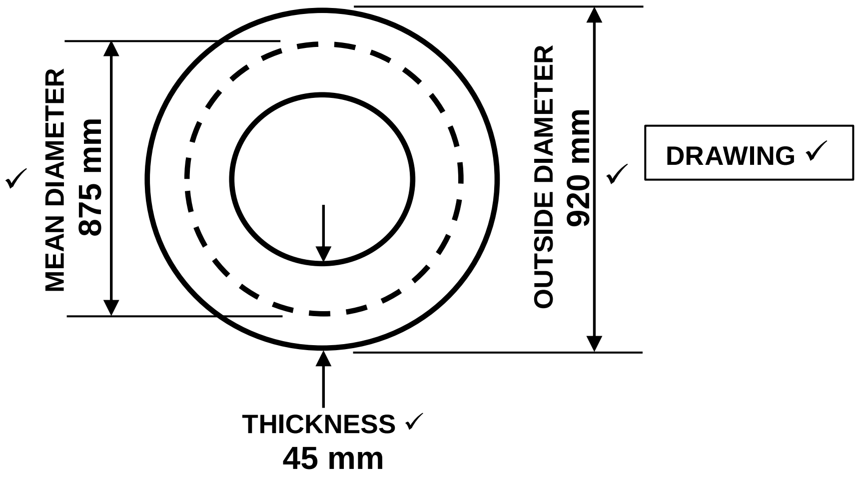
QUESTION 5: TERMINOLOGY(TEMPLATES) (SPECIFIC)

5.1 **Steel ring calculations:**

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

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

5.1.3 **Steel ring drawing**:



(4)

5.2 **Weld symbols:**

5.2.1 Weld all around ✓ (1)

5.2.2 Flush ✓ (1)

5.2.3 Convex ✓ (1)

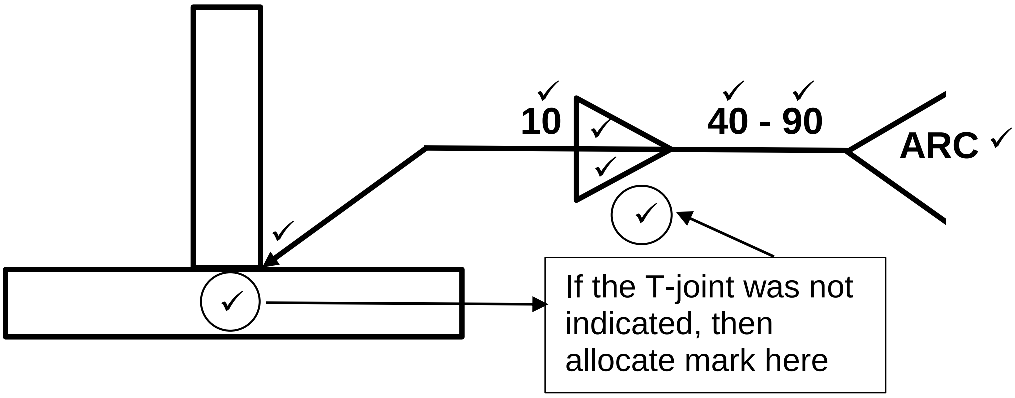
5.2.4 Grind ✓ (1)

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:**

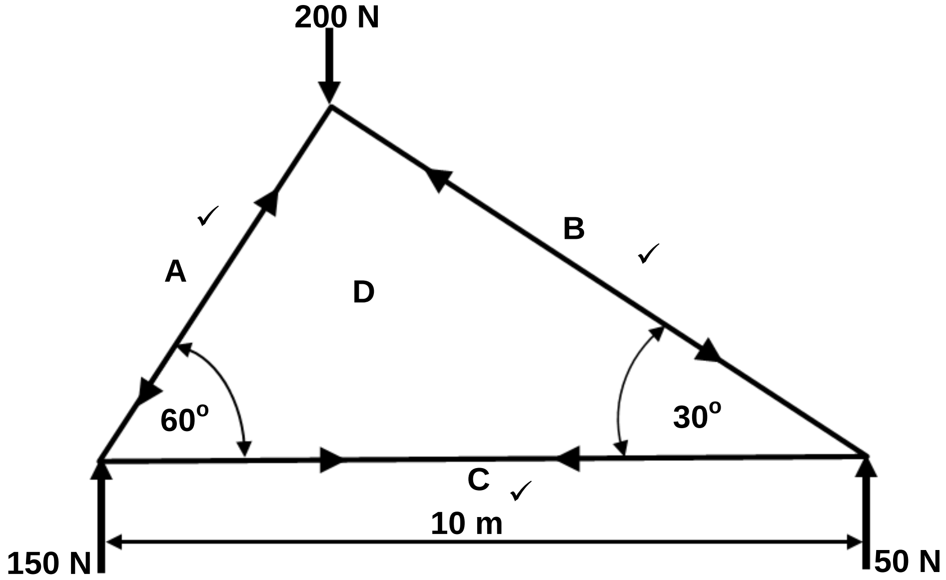
A – Adjustment hole ✓
B – Pressure gauge / Gauge ✓
C – Platform / Rest / Table ✓
D – Cylinder / Piston / Plunger ✓
E – Handle / Lever ✓
F – Base / Stand / Legs ✓ (6)

[18]

QUESTION 7: FORCES (SPECIFIC)

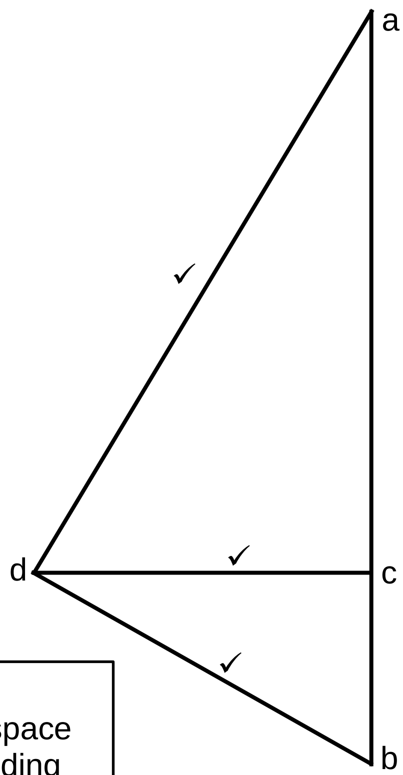
7.1 **Simple Frames:**

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:**

$$UDL = 6\ N/m \times 5\ m$$
$$= 30\ N ✓$$

(1)

7.2.2 **The magnitude RL:**

$$RL \times 10 = (40 \times 2)✓ + (30 \times 4{,}5)✓ + (20 \times 9)✓$$
$$= 80 + 135 + 180$$
$$RL = \frac{395}{10} ✓$$
$$= 39{,}5\ N ✓$$

(5)

7.2.3 **The magnitude RR:**

$$RR \times 10 = (20 \times 1)✓ + (30 \times 5{,}5)✓ + (40 \times 8)✓$$
$$= 20 + 165 + 320$$
$$RR = \frac{505}{10} ✓$$
$$= 50{,}5\ N ✓$$

(5)

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

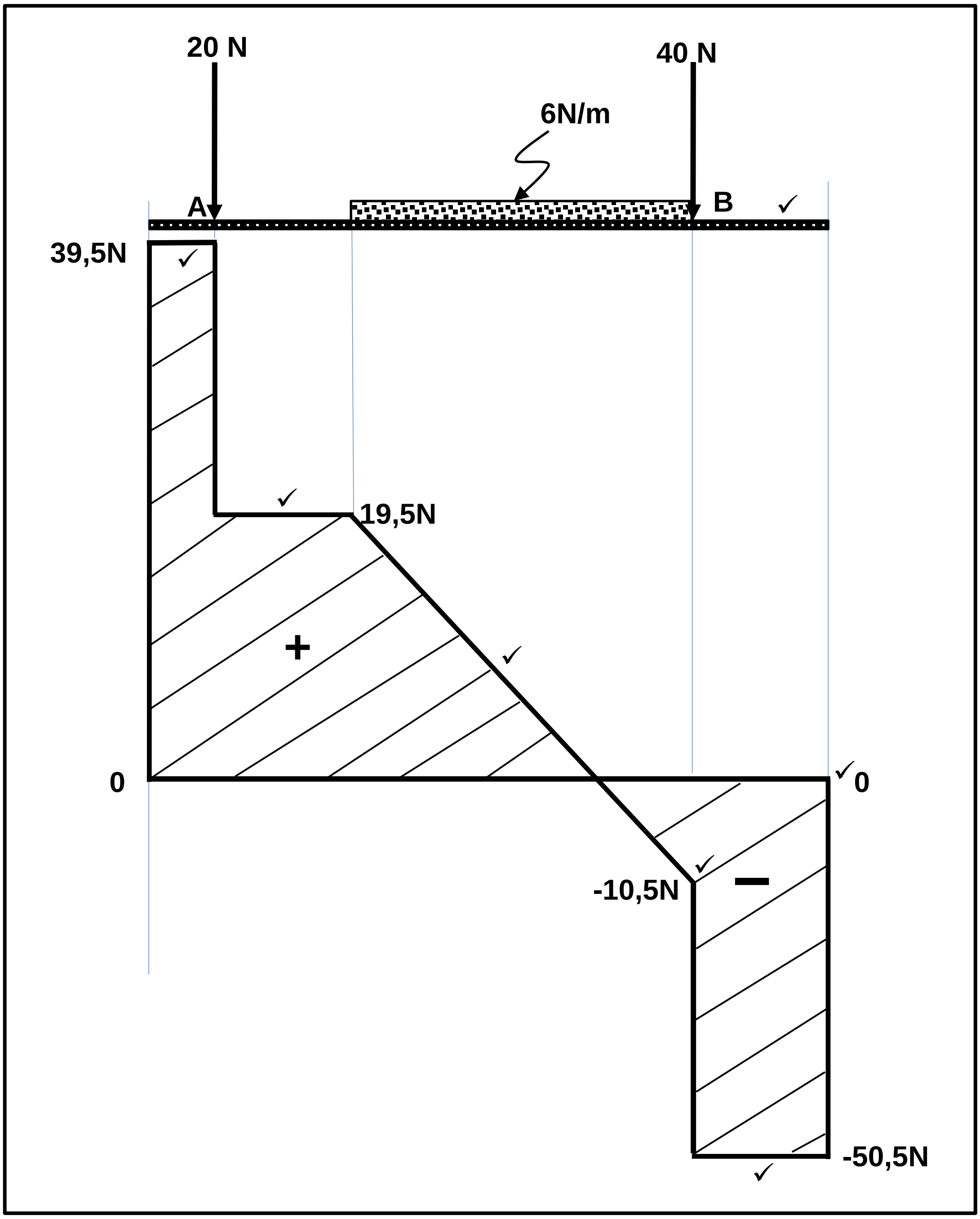
$$SF_A = 39{,}5 - 20 ✓$$
$$= 19{,}5\ N ✓$$
$$SF_{UDL} = 39{,}5 - 20 - 30 ✓$$
$$= -10{,}5\ N ✓$$
$$SF_B = 39{,}5 - 20 - 30 - 40 ✓$$
$$= -50{,}5\ N ✓$$

OR

$$SF_A = 39{,}5 - 20 ✓$$
$$= 19{,}5\ N ✓$$
$$SF_{UDL} = 19{,}5 - 30 ✓$$
$$= -10{,}5\ N ✓$$
$$SF_B = -10{,}5 - 40 ✓$$
$$= -50{,}5\ N ✓$$

(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:**

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

(2)

7.3.2 **Safe working stress MPa:**

$$\text{Safety factor} = \frac{\text{Maximum Stress}}{\text{Safe working Stress}}$$

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

(3)

7.3.3 **Diameter:**

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

(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:**

$$A - 2 = \sqrt{\overset{\checkmark}{600^2} + \overset{\checkmark}{200^2} + \overset{\checkmark}{600^2}}$$
$$= \sqrt{360000 + 40000 + 360000}$$
$$= \sqrt{760000}$$
$$= 871{,}78 \text{ mm } \checkmark$$

(4)

(b) **A–X:**

$$A - X = \sqrt{\overset{\checkmark}{200^2} + \overset{\checkmark}{400^2} + \overset{\checkmark}{600^2}}$$
$$= \sqrt{40000 + 160000 + 36000}$$
$$= \sqrt{560000}$$
$$= 748{,}33 \text{ mm} \checkmark$$

(4)

(c) **X–Y:**

$$X - Y = \sqrt{\overset{\checkmark}{200^2} + \overset{\checkmark}{600^2}}$$
$$= \sqrt{40000 + 360000}$$
$$= \sqrt{400000}$$
$$= 632{,}46 \text{ mm} \checkmark$$

(3)

11.3 **Cone frustum:**

11.3.1 **True length 1–2**.

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

(3)

11.3.2 **True length A–B**.

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

(3)
[21]

TOTAL: 200