These marking guidelines consist of 20 pages.
QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>B ✓</td>
</tr>
<tr>
<td>1.2</td>
<td>B ✓</td>
</tr>
<tr>
<td>1.3</td>
<td>C ✓</td>
</tr>
<tr>
<td>1.4</td>
<td>C ✓</td>
</tr>
<tr>
<td>1.5</td>
<td>A ✓</td>
</tr>
<tr>
<td>1.6</td>
<td>B ✓</td>
</tr>
</tbody>
</table>
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 $\bar{\varnothing} = \text{Outside } \varnothing - \text{plate thickness}
= 920 - 45
= 875 \text{ mm} \checkmark

5.1.2 Mean circumference $= \pi \times \text{Mean } \varnothing
= \pi \times 875 \checkmark
= 2748,89 \checkmark
= 2749 \text{ mm} \checkmark

5.1.3 **Steel ring drawing:**

5.2 **Weld symbols:**

5.2.1 Weld all around $\checkmark$

5.2.2 Flush $\checkmark$

5.2.3 Convex $\checkmark$

5.2.4 Grind $\checkmark$
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:**

If the T-joint was not indicated, then allocate mark here

(8) [23]
QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Punch and shear machine:**
- Cutting steel profiles. ✓
- Punching holes in a steel plate. ✓

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 ✓

[18]
QUESTION 7: FORCES (SPECIFIC)

7.1 Simple Frames:

7.1.1 Space diagram:

[Diagram showing a simple frame with forces labeled A, B, C, and D.]

7.1.2 Force diagram:

[Diagram showing the force components for the simple frame.]

Note to marker:
Marker must redraw the space and force diagrams according to given scales for marking purposes.
7.1.3 Magnitude:

<table>
<thead>
<tr>
<th>Member</th>
<th>Magnitude (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>174 ✓</td>
</tr>
<tr>
<td>BD</td>
<td>100 ✓</td>
</tr>
<tr>
<td>CD</td>
<td>86 ✓</td>
</tr>
</tbody>
</table>

Note to marker: Tolerance ± 2 mm

7.1.4 Nature of members:

<table>
<thead>
<tr>
<th>Member</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Strut ✓</td>
</tr>
<tr>
<td>BD</td>
<td>Strut ✓</td>
</tr>
<tr>
<td>CD</td>
<td>Tie ✓</td>
</tr>
</tbody>
</table>

7.2 Shear forces and bending moments:

7.2.1 The magnitude of the UDL/Point Load:

\[ \text{UDL} = 6 \text{ N/m} \times 5 \text{ m} = 30 \text{ N ✓} \] 

7.2.2 The magnitude RL:

\[ RL \times 10 = (40 \times 2) + (30 \times 4,5) + (20 \times 9) = 80 + 135 + 180 \]

\[ RL = \frac{395}{10} = 39,5 \text{ N ✓} \]

7.2.3 The magnitude RR:

\[ RR \times 10 = (20 \times 1) + (30 \times 5,5) + (40 \times 8) = 20 + 165 + 320 \]

\[ RR = \frac{505}{10} = 50,5 \text{ N ✓} \]

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

<table>
<thead>
<tr>
<th>SF_A</th>
<th>SF_B</th>
<th>SF_UDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 19,5 N ✓</td>
<td>= 19,5 N ✓</td>
<td>= 19,5 N ✓</td>
</tr>
<tr>
<td>SF_UDL = 39,5 – 20 – 30 ✓</td>
<td>SF_UDL = 19,5 – 30 ✓</td>
<td></td>
</tr>
<tr>
<td>= –10,5 N ✓</td>
<td>= –10,5 N ✓</td>
<td></td>
</tr>
<tr>
<td>SF_B = 39,5 – 20 – 30 – 40 ✓</td>
<td>SF_B = –10,5 – 40 ✓</td>
<td></td>
</tr>
<tr>
<td>= –50,5 N ✓</td>
<td>= –50,5 N ✓</td>
<td></td>
</tr>
</tbody>
</table>

OR

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 ✓
7.2.5 Shear force moment diagram:

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:**

\[
\text{Stress} = \frac{\text{Load}}{\text{Area}} = \frac{45000}{0.8 \times 10^{-5}} = 5625 \times 10^8 \text{Pa} = 5625 \text{MPa} \checkmark
\]  

(2)

7.3.2 **Safe working stress MPa:**

\[
\text{Safety factor} = \frac{\text{Maximum Stress}}{\text{Safe working Stress}} \\
\text{Safe working stress} = \frac{\text{Maximum Stress}}{\text{Safety factor}} = \frac{56.25 \times 10^8 \text{Pa}}{4} = 14.06 \times 10^8 \text{Pa} = 1406.25 \text{ MPa} \checkmark
\]  

(3)

7.3.3 **Diameter:**

\[
\text{Area} = \frac{\pi \times d^2}{4} \\
d^2 = \frac{\text{Area} \times 4}{\pi} \\
d = \sqrt{\frac{0.8 \times 10^{-5} \times 4}{\pi}} = 3.191 \times 10^{-3} \text{ m} \\
d = 3.19 \text{ mm} \checkmark
\]  

(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:
\[ A - 2 = \sqrt{600^2 + 200^2 + 600^2} \]
\[ = \sqrt{360000 + 40000 + 360000} \]
\[ = \sqrt{760000} \]
\[ = 871.78 \text{ mm} ✓ \] (4)

(b) A–X:
\[ A - X = \sqrt{200^2 + 400^2 + 600^2} \]
\[ = \sqrt{40000 + 160000 + 360000} \]
\[ = \sqrt{560000} \]
\[ = 748.33 \text{ mm ✓} \] (4)

(c) X–Y:
\[ X - Y = \sqrt{200^2 + 600^2} \]
\[ = \sqrt{40000 + 360000} \]
\[ = 632.46 \text{ mm ✓} \] (3)
11.3 **Cone frustum:**

11.3.1 **True length 1–2.**

\[
1 - 2 = \frac{\pi \times d}{12} \\
= \frac{\pi \times 300}{12} \\
= 78.54 \text{ mm}
\]

(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