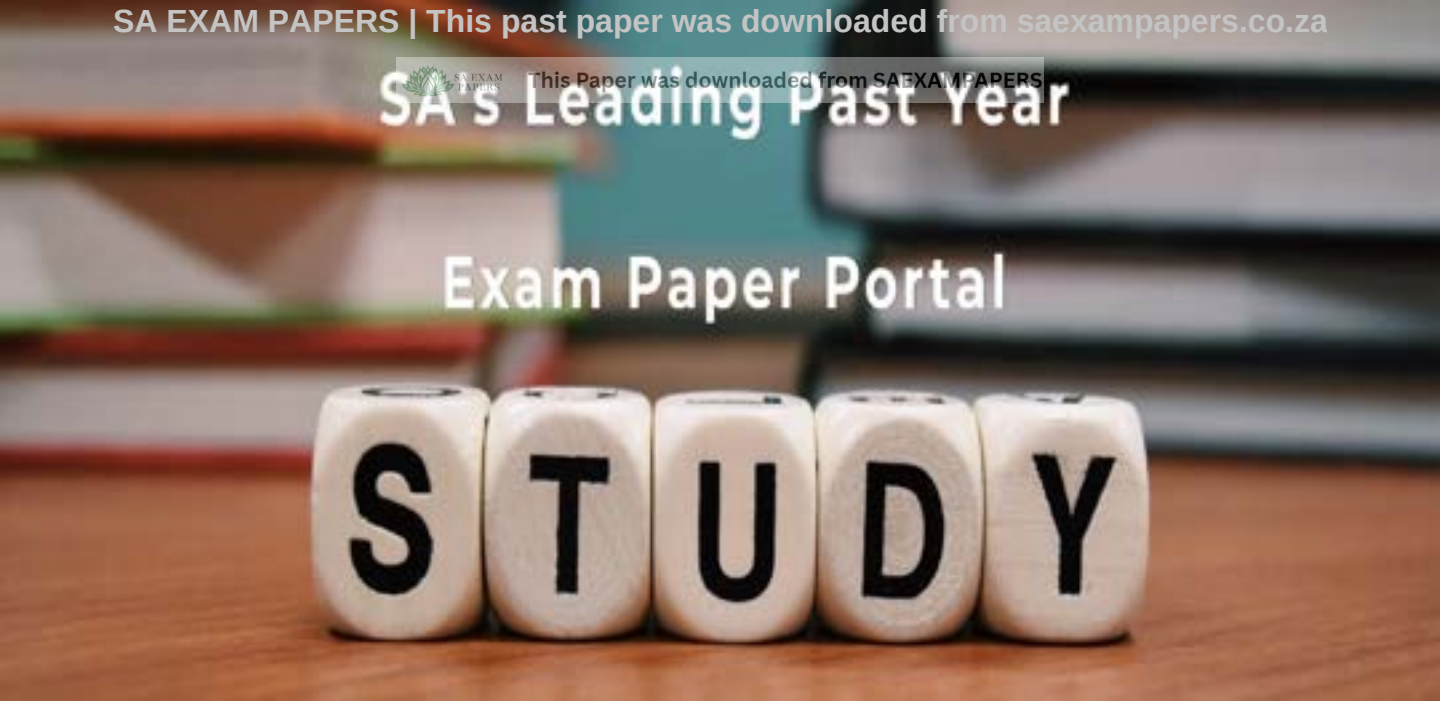

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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2025

MECHANICAL TECHNOLOGY: WELDING AND METALWORK MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 18 pages.

SECTION A: COMPULSORY

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 A ✓
1.2 C ✓
1.3 C ✓
1.4 B ✓
1.5 A ✓
1.6 D ✓ (6 x 1) (6)

QUESTION 2: SAFETY (GENERIC)

2.1 **Safety precautions**

- See that all guards are in place. ✓
- Make sure that there is no oil, grease or obstacles around the machine. ✓
- Select the right blade for the material to be cut. ✓
- Do not adjust guides while the machine is running. ✓
- All materials must be clamped properly before cutting is started. ✓
- Long pieces of material must be supported at the end. ✓
- Always stop machine when you leave it unattended. ✓ (Any 2 x 1) (2)

2.2 **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 2 x 1) (2)

2.3 **Bench grinder**

- Use safety goggles at all times when grinding metal. ✓
- Do not adjust the tool rest while the wheel is in motion. ✓
- Do not force the workpiece onto or bump it against the emery wheel. ✓
- Keep fingers away from revolving wheel, especially when grinding small pieces. ✓
- Grind only on the front surface and never on the sides of an emery wheel. ✓ (Any 2 x 1) (2)

2.4 **Advantages of product layout**

- Handling of material is limited to a minimum. ✓
- Time period of manufacturing cycle is less. ✓
- Production control is almost automatic. ✓
- Control over operations is easier. ✓
- Greater use of unskilled labour is possible. ✓
- Less total inspection is required. ✓
- Less total floor space is needed per unit of production. ✓
- Reduction in manufacturing costs. ✓ (Any 1 x 1) (1)

2.5 **Categories of OHS**

- Actions ✓
- Conditions ✓ (2)

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QUESTION 3

3.1 **Types of tests to distinguish metals**

- Bending test. ✓
- Filing test ✓
- Machining test ✓
- Sound test ✓
- Spark test. ✓ (Any 3 x 1) (3)

3.2 **Groups of carbon steel:**

- Low carbon steel ✓ 0,15–0,3 % ✓
- Medium carbon steel ✓ 0,3–0,75 % ✓
- High carbon steel ✓ 0,75–1,7 % ✓ (6)

3.3 **Purpose of normalizing ferrous metals:**

- To change ✓ the properties ✓ of steel.
- To change ✓ the grain structure ✓ of steel. (Any 1 x 2) (2)

3.4 **Tempering process of steel:**

- 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. ✓ (3)

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QUESTION 4

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

QUESTION 5: TERMINOLOGY(TEMPLATES)(SPECIFIC)

5.1 **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)

5.2 **Types of templates**

5.2.1 Flange ✓ (1)
5.2.2 Strip ✓ (1)
5.2.3 Web ✓ (1)

5.3 **Dimensions of the material:**

5.3.1 Mean diameter = Outside diameter - plate thickness ✓
= 900 – 60 ✓
= 840 mm ✓ (3)

5.3.2 Mean circumference = π x mean diameter✓
= π x 840 ✓
= 2638,94 mm
≈ 2639 mm ✓ (3)

5.4 **Template loft:**

The template loft is separated from the workshop because …

- it is quieter. ✓
- the lighting is better. ✓
- all equipment is at hand. ✓
- it is a permanent base. ✓
- marking on the floor enhance accuracy. ✓ (Any 3 x 1) (3)

5.5 **Hand tools**

- Hand saws ✓
- Chisels ✓
- Plane ✓
- Hand drill and drill bits ✓
- Steel measuring tape ✓
- Straight edge ✓
- Compass ✓
- Trammel pins ✓
- Carpenter's square ✓
- Protractor ✓
- Chalk line ✓
- Steel rule ✓
- Hammers ✓
- Centre punch ✓
- Calipers ✓

- Scriber ✓
- Combination square ✓
- Spirit level ✓
- Trammel ✓ (Any 3 x 1) (3)

5.6 **Weld dimensions:**

- 30° – the included angle in degree ✓
- 5 – root gap or root opening in mm ✓ (2)

5.7 **Plate girder:**

- Is a combination of plates and angle iron ✓ welded together. ✓ (2)

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QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Function of stock and dies:**

- They are used for cutting or forming external threads on round bar or shaft. ✓ (1)

6.2 **Arc welding equipment:**

6.2.1 A Arc welding machine/ Power source ✓ (1)
B Earth clamp ✓ (1)
C Electrode/Rod/Welding rod ✓ (1)
D Electrode holder ✓ (1)

6.2.2 Electrode holder is used to hold the electrode. ✓ (1)

6.3 **Working principles of the spot-welding machine**

- Current flows through a resistance to fuse plates together. ✓
- Two copper electrodes are pressed against the plates. ✓
- Heavy current is passed between the electrodes. ✓
- High resistance causes intense heat at the point. ✓
- The two plates melt and fuse together, forming a weld nugget or spot weld. ✓ (5)

6.4 **Functions of flashback arrestors**

- To prevent back feeding / flashback of flame ✓
- To prevent either oxygen or acetylene gas from flowing towards the cylinders. ✓ (2)

6.5 **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. ✓ (Any 3 x 1) (3)

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

- Mild steel ✓
- Alloy steels ✓
- Stainless steels ✓
- Non-ferrous metals ✓ (Any 2 x 1) (2)

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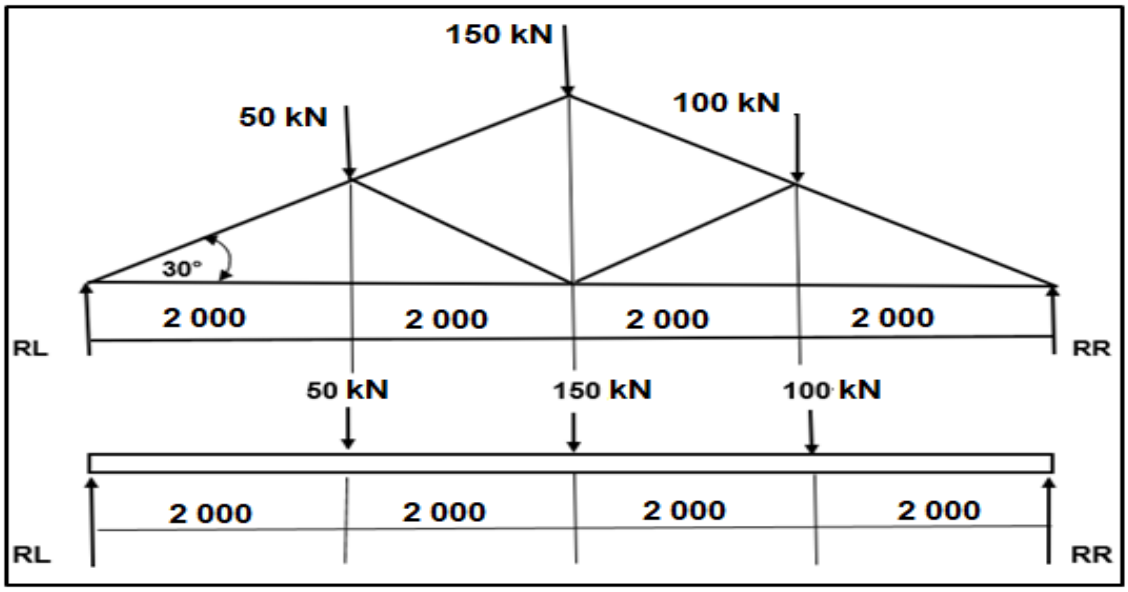
QUESTION 7: FORCES (SPECIFIC)

7.1



Take moments about reaction left (RL) ✓

RR x 8 000 mm = (50 kN x 2 000 mm) + (150 kN x 4 000 mm) + (100 kN x 6 000 mm) ✓

$$\textbf{RR} = \frac{100\,000 + 600\,000 + 600\,000}{8\,000} \quad ✓$$

RR = 162,5 kN ✓ (4)

Take moments about reaction left (RR) ✓

RL x 8 000 mm = (100 kN x 2 000 mm) + (150 kN x 4 000 mm) + (50 kN x 6 000 mm) ✓

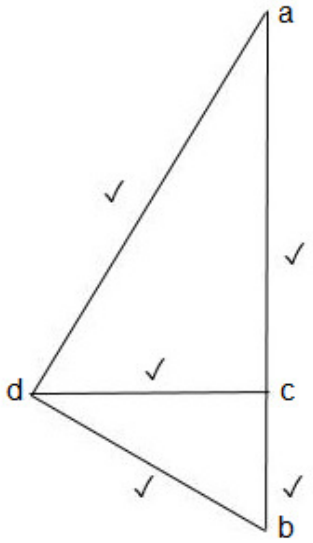
$$\textbf{RL} = \frac{200\,000 + 600\,000 + 300\,000}{8\,000} \quad ✓$$

RL = 137,5 kN ✓ (4)

7.2 **Vector/force diagram**

7.2.1

NOTE TO MARKER:
Marker must redraw the force diagram according to the given scale for marking purposes.



(5)

7.2.2 **Magnitude and nature of members**

MEMBER	MAGNITUDE	NATURE
AD	86 N (84 N – 88 N) ✓	Strut ✓
BD	50 N (48 N – 52 N) ✓	Strut ✓
CD	42 N (40 N – 44 N) ✓	Tie ✓

Note to marker: Tolerance: ± 2 mm

(6)

7.3 **Beam (UDL)**

7.3.1 **Calculate RL and RR**

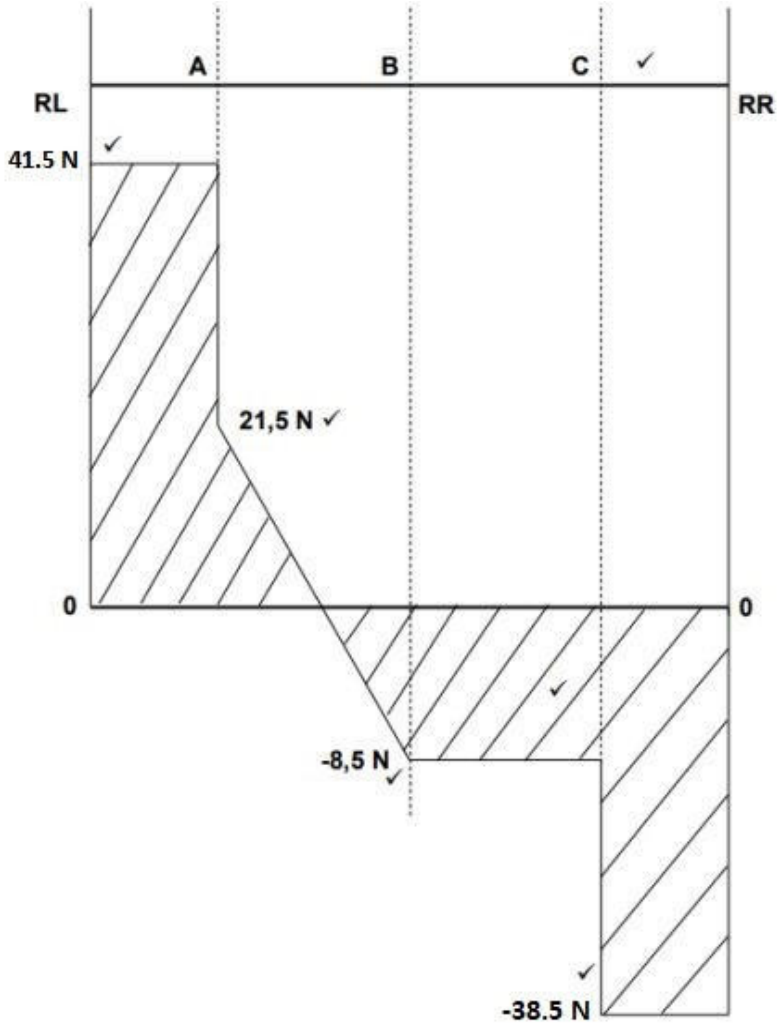
Taking moment about right reaction (RR)
RL x 10 = (30 x 2) + (30 x 4,5) + (20 x 8) ✓
= 60 + 135 + 160
$= \frac{415}{10}$ ✓
RL = 41,5 N ✓
Taking moments about RL
RR x 10 = (20 x 2) + (30 x 3,5) + (30 x 8) ✓
= 40 + 105 + 240
$= \frac{385}{10}$ ✓
RR = 38,5 N ✓

(6)

7.3.2 **Shear forces at point A, B and C**

SF_A = $41{,}5 - 20$ ✓
= $21{,}5$ ✓
SF_B = $41{,}5 - 20 - 30$ ✓
= $-8{,}5$ ✓
SF_C = $41{,}5 - 20 - 30 - 30$ ✓
= $-38{,}5$ ✓ (6)

7.3.3 **Shear force diagram:**



NB: Diagram is not according to scale. Markers must redraw the diagram

(6)

7.4 **Stress and Strain:**

7.4.1 Stress in the shaft:

Area = $\frac{\pi D^2}{4}$

$= \pi(\frac{32^2}{4\times10^6})$ ✓

$= 0{,}8 \times 10^{-3}\ m^2$ ✓

$Stress = \frac{load}{area}$ ✓

$= \frac{120 \times 10^3}{0{,}8 \times 10^{-3}}$ ✓

Stress $= 150\ 000\ 000\ \text{N/m}^2$ or $150 \times 10^6\ Pa$ or 150 MPa ✓ (5)

7.4.2 **Strain of shaft:**

$\boldsymbol{\varepsilon} = \frac{\Delta L}{OL}$ ✓

$= \frac{0{,}5}{32}$ ✓

$= 4{,}17 \times 10^{-3}$ ✓ (3)

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QUESTION 8: JOINING METHODS (WELD INSPECTION)

8.1 **Inspection during arc welding:**

- Amount of penetration and fusion. ✓
- Rate of electrode burning and progress of the weld. ✓
- The way the weld metal is flowing (no slag inclusion). ✓
- The sound of the arc, indicating correct current and voltage for the particular weld. ✓ (Any 3 x 1) (3)

8.2 **Visual inspection process:**

- Shape of profile ✓
- Uniformity of the surface ✓
- Overlap ✓
- Undercutting ✓
- Penetration bead ✓
- Root groove ✓ (Any 2 x 1) (2)

8.3 **Destructive and non-destructive tests:**

8.3.1 **Free-bend:**

- Used to determine the percentage of elongation of the welded metal. ✓
- To determine the ductility of the weld metal and heat affected area. ✓ (Any 1 x 1) (1)

8.3.2 **X-ray test:**

- To determine whether there has been full depth penetration. ✓
- Determine if correct fusion between welded pieces took place. ✓
- To detect internal defects like pin holes, slag inclusions, cracks etc. ✓ (Any 1 x 1) (1)

8.4 **Types of flames:**

8.4.1 Neutral flame. ✓ (1)

8.4.2 Carburising flame. ✓ (1)

8.4.3 Oxidising flame. ✓ (1)

8.5 **Causes of welding defects**

8.5.1 **Welding spatter:**

- Disturbance in the molten weld pool ✓
- Too low welding current/amperage ✓
- Too high welding current/amperage ✓
- Arc length too long ✓
- Wet/contaminated electrode ✓
- Wrong polarity ✓
- Arc length too short ✓
- Incorrect type of electrode used ✓
- Incorrect included angle ✓
- Too fast travel speed ✓
- Surface contamination ✓
- Erratic wire feeding ✓ (Any 2 x 1) (2)

8.5.2 **Incomplete penetration:**

- Too low welding current/amperage ✓
- Too slow travel speed ✓
- Incorrect torch angle ✓
- Insufficient root gap ✓
- Poor edge/joint preparation ✓
- Excessive root gap ✓
- Too fast travel speed ✓
- Too large electrode diameter ✓
- Arc length too long ✓
- Wet/contaminated electrodes ✓ (Any 2 x 1) (2)

8.6 **Welding defects:**

8.6.1 Incomplete penetration ✓ (1)

8.6.2 Undercut ✓ (1)

8.7 **Nick break test:**

- Make a hacksaw cut at both edges, through the centre of the weld. ✓
- Place specimen on two steel supports. ✓
- Use a sledgehammer to break the specimen in the area of the cuts. ✓
- Inspect the exposed weld metal in the break for incomplete fusion, slag inclusion, etc. ✓ (4)

8.8 **Factors determining current setting for welding:**

- Base metal type. ✓
- Base metal thickness. ✓
- Electrode diameter. ✓
- Position of the weld. ✓ (Any 3 x 1) (3)

[23]

QUESTION 9: JOINING METHODS (STRESSES AND DISTORTION) (SPECIFIC)

9.1 **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 strong backs ✓
- Use clamps, jigs and fixtures ✓
- Pre-heating the workpiece ✓
- Tack welding ✓
- Allow slow cooling after welding. ✓ (Any 2 x 1) (2)

9.2 **Definition of terms:**

9.2.1 **Weld distortion:** Takes place in a welded joints due to uneven expansion and contractions ✓ as a result of intense heat of the arc or oxy-acetylene flame. ✓ (2)

9.2.2 **Residual Stress:** The internal stress distribution locked into the material; ✓ these stresses are present even after all external loads/forces are removed. ✓ (2)

9.3 **Iron-carbon diagram:**

9.3.1 Iron-carbon equilibrium diagram ✓ (1)

9.3.2 A – Temperature/Degrees Celsius ✓
B – Austenite ✓
C – Austenite and Cementite ✓
D – Ferrite and Pearlite ✓
E – Carbon content ✓ (5)

9.4 **Elastic deformation:**

- It is the ability of a joint/material to return to its original position/ dimensions ✓ after the stresses have been relieved. ✓ (2)

9.5 **Effects of shrinkage:**

9.5.1 **Electrode size:**

- Larger electrode size requires higher current and causes higher welding temperature that causes more deformation/shrinkage. ✓
- Smaller electrode size requires lower current lower welding temperature that causes less deformation/ shrinkage. ✓ (2)

9.5.2 **Welding speed:**

- Decreased welding speed tends to increase localised heat that increases distortion. ✓
- Increased welding speed tends to decrease localised heat that decreased distortion. ✓ (2)

[18]

QUESTION 10: MAINTENANCE

10.1 **Reasons for maintenance:**

- Promote cost saving ✓
- Improves safety ✓
- Increases equipment efficiency ✓
- Fewer equipment failure ✓
- Improves reliability of equipment ✓ (Any 2 x 1) (2)

10.2 **Overloading:**

10.2.1 Overloading a guillotine:

- cutting a plate of excessive thickness ✓ or hardness will overload both the blade and hydraulic system. ✓ (2)

10.2.2 Overloading a horizontal band saw:

- the feed speed which is higher than the rate at which the band saw can cut, ✓ effectively results in the blade being forced into the material. ✓ (2)

10.3 **Reasons for keeping service records:**

- Assist in the monitoring of the condition of the machines. ✓
- Assist in upholding warrantees. ✓
- Assist in keeping a history of maintenance and repairs. ✓ (Any 2 x 1) (2)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 **Hoppers:**

11.1.2 Square to square hopper on centre ✓ (1)

11.1.2 Square to rectangle hopper off centre ✓ (1)

11.2 **Cone frustum:**

11.2.1 True length **1 – 2**

$$\mathbf{1-2} = \frac{\pi \times d}{12} \checkmark$$
$$= \frac{\pi \times 300}{12} \checkmark$$
$$= 78{,}54 \text{ mm} \checkmark \quad (3)$$

11.2.2 True length **A – B**

$$\boldsymbol{A-B} = \frac{\pi \times d}{12} \checkmark$$
$$= \frac{\pi \times 600}{12} \checkmark$$
$$= 157{,}08 \text{ mm} \checkmark \quad (3)$$

11.3 **Square to round transition piece:**

11.3.1 The true length **FG**

Plan length $\boldsymbol{FG} = \boldsymbol{FK} - \boldsymbol{GK}$
$= 400 - 250$ ✓
$= 150$ ✓
$\therefore$ TL$\boldsymbol{FG^2} = \boldsymbol{FG^2} + \boldsymbol{VH^2}$
$= 150^2 + 800^2$ ✓
$\boldsymbol{FG} = \sqrt{662500}$ ✓
True length **FG** $= 813{,}94$ units ✓ (5)

11.3.2 To determine the plan length **CI**, the sides **CE** and **EI** of triangle **CEI** must be calculated.

$$\boldsymbol{CE = CF - EF}$$
$$= 400 - 125$$
$$= 275 \checkmark$$

But **EI = FH**

$$\boldsymbol{FH = FK - HK}$$
$$= 400 - 217{,}5$$
$$= 182{,}5 \checkmark$$

True length $\boldsymbol{CI^2} = \boldsymbol{CE^2 + EI^2}$
$$= 275^2 + 182{,}5^2 \checkmark$$
$$= \sqrt{108931{,}25} \checkmark$$

True length $\boldsymbol{CI} = 330{,}05 \checkmark$ (5)

11.3.3 **JI** is one-twelfth of the circumference

$$\text{circumference} = \pi \times MD$$
$$= \pi \times 500$$
$$= 1570{,}80 \checkmark$$
$$\frac{1}{12} \times \text{circumference} = \frac{1570{,}80}{12} \checkmark$$
$$= 130{,}9 \checkmark$$ (3)

[21]

TOTAL: 200