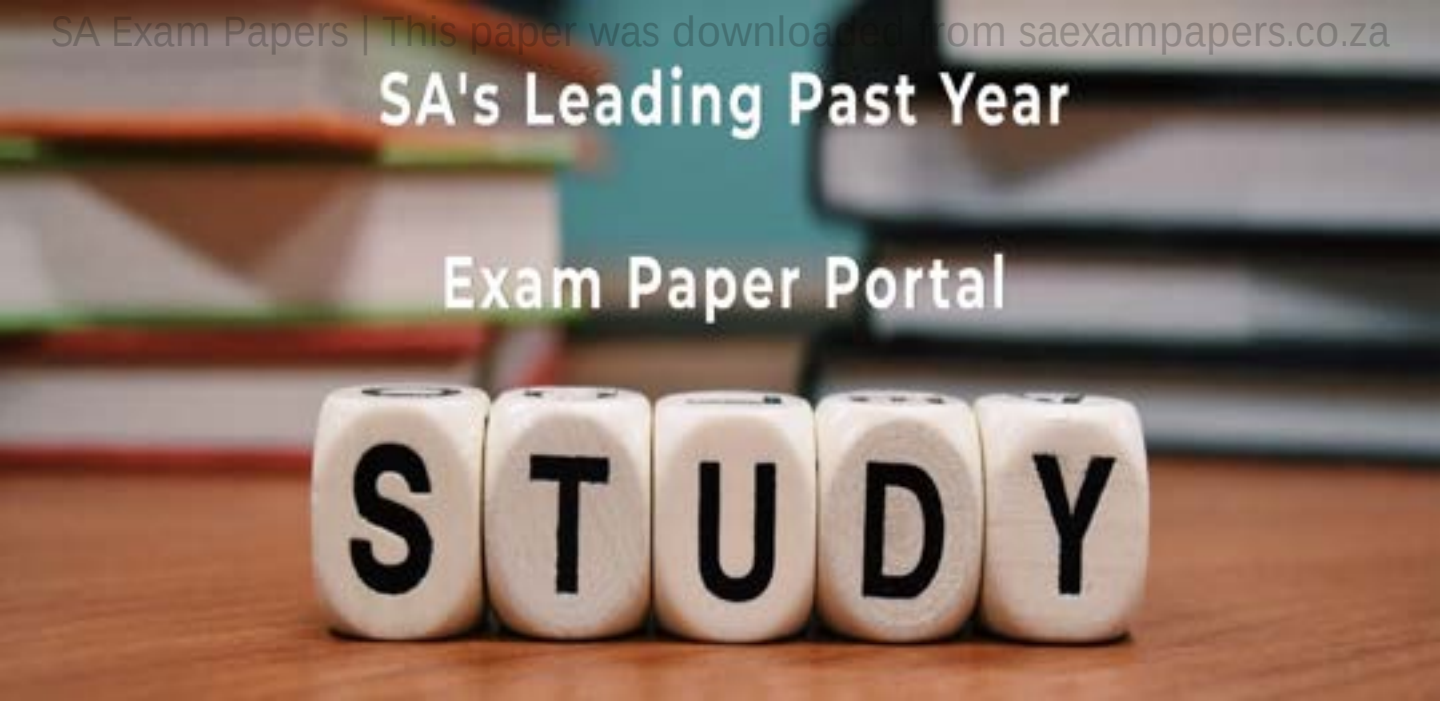

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SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

2023

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 21 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 C ✓ (1)

1.2 A ✓ (1)

1.3 A ✓ (1)

1.4 C ✓ (1)

1.5 B ✓ (1)

1.6 A ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Safety rule after the work procedures:**
Switch off the machine. ✓ (1)

2.2 **Space between the tool rest and the emery wheel:**
- To prevent the work piece from jamming between the wheel and tool rest. ✓
- Prevents the wheel from being damaged. ✓
- Prevents the work piece from being damaged. ✓
- Prevent injury. ✓

(Any 2 x 1) (2)

2.3 **Workshop layouts:**

2.3.1 Process layout. ✓ (1)

2.3.2 Product layout. ✓ (1)

2.4 **Hydraulic press:**
- Safety goggles ✓
- Safety gloves ✓
- Safety shoes ✓
- Overall ✓

(Any 1 x 1) (1)

2.5 **Safety guard on the portable angle grinder:**
- To protect one against sparks/metal particles. ✓
- To protect one from a breaking disc. ✓
- To protect your hand from coming into contact with the disc. ✓

(Any 1 x 1) (1)

2.6 **Shearing/Guillotine machine:**
- Follow the manufactures recommendations. ✓
- Keep hands away from action points. ✓
- Do not exceed the maximum material thickness. ✓
- Ensure that all guards are in place and secure. ✓
- Report defects immediately. ✓

(Any 1 x 1) (1)

2.7 **Storing gas cylinders:**

- Upright position ✓
- Stored at 20°C / cool area ✓
- Empty cylinders stored separately from full cylinder. ✓
- Never store cylinders on top of each other. ✓
- Oxygen cylinders separate from fuel cylinders. ✓
- Secure gas cylinders. ✓
- Ensure that cylinders are properly closed. ✓
- Stored away from sparks / flammable material/ electrical switches. ✓
- Stored in a well-ventilated area. ✓
- Safety signs should be displayed. ✓
- Keep cylinders clearly labelled (Full/Empty). ✓

(Any 2 x 1) (2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **Purpose of tempering:**

- To relieve ✓ strain / brittleness. ✓
- To increase ✓ the toughness of the steel. ✓
- To refine ✓ grain structure. ✓

(Any 1 x 2) (2)

3.2 **Heat treatment processes:**

3.2.1 **Case hardening:**

- To obtain a wear-resistant surface ✓ and at the same time be tough enough internally at the core ✓ to withstand the applied loads.
- For a hard case ✓over a tough core. ✓

(Any 1 x 2) (2)

3.2.2 **Annealing:**

- To relieve ✓ internal stresses. ✓
- To soften ✓ steel. ✓
- Facilitate ✓ the machining processes. ✓
- Increase ✓ the steel's ductility. ✓
- Reduce ✓ brittleness. ✓

(Any 1 x 2) (2)

3.3 **Spark test:**

- Hold steel against grinding wheel. ✓
- Observe the spark pattern to identify the type of steel. ✓ (2)

3.4 **Tests:**

3.4.1 **Filing test:**
File on the tip or near the edge ✓ of the material. The bite will determine the hardness. ✓ (2)

3.4.2 **Bend test:**

- Metal is subjected to deformation by bending. ✓
- Observe the rupture of the metal. ✓ (2)

3.5 **Sound test on steel:**

3.5.1 **Low carbon steel (LCS):**
Dull (low pitch)✓ sound. (1)

3.5.2 **High carbon steel (HCS):**
Loud and clear (high pitch) ✓ sound. (1)
[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

[14]

QUESTION 5: TERMINOLOGY(TEMPLATES) (SPECIFIC)

5.1
- Roof covering ✓ is attached ✓ to the purlins.
- Purlins contribute to the rigidity ✓ and correct spacing ✓of the rafters/structure.

(Any 1 x 2) (2)

5.2 **Types of weld symbols:**

5.2.1 Site weld ✓ (1)

5.2.2 Surfacing ✓ (1)

5.2.3 U butt weld ✓ (1)

5.2.4 Seam weld ✓ (1)

5.3 Strip templates are used for longer sections of angle iron. ✓ (1)

5.4 **Dimensions of the material:**

5.4.1 **Mean diameter:**

$$\text{Mean } Ø = \text{Inside } Ø + \text{Thickness}$$
$$= 180 + 12 \checkmark$$
$$= 192\,\text{mm} \checkmark$$

(2)

5.4.2 **Mean circumference:**

$$\text{Mean circumference} = \pi \times \text{Mean } Ø$$
$$= \pi \times 192\,\text{mm} \checkmark$$
$$= 603{,}186\,\text{mm} \checkmark$$
$$\text{Round off to } 603\,\text{mm} \checkmark$$

(3)

5.5 **Welding symbols:**
- Fillet weld both sides ✓
- 8 mm in size ✓
- Length of weld bead is 50 mm ✓
- Pitch of weld is 100 mm ✓

(4)

5.6 **Roof truss:**

A- Purlins ✓
B- Ridging ✓
C- Roof covering ✓
D- Rafter ✓
E- Internal bracing member ✓ (5)

5.7 **Lattice beams:**

- Tends to be very rigid. ✓✓
- Gives good strength to weight ratios over long spans. ✓✓

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

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Bench grinder uses:**

- Sharpening of tools
- Shaping of metal
- Remove unwanted material
- Remove rough edges (burrs)
- Grinding prior to welding of work piece
- Used in conjunction with wire brush wheel to remove rust
- Used in conjunction with buffing wheel to polish work piece

(Any 3 x 1) (3)

6.2 **MIG:**

Metal inert gas (1)

6.3 **Plasma cutter:**

- The cutter sends an electrical channel of ionized gas through the work piece being cut.
- It forms a complete electric circuit via a grounding clamp.
- Compressed air is blown towards the work piece through a focused nozzle at high speed.
- An electric arc is formed between the gas nozzle and the work piece. (4)

6.4 **Types of taps:**

- Taper tap / first tap
- Intermediate tap / second tap
- Plug tap / bottoming tap (3)

6.5 **Removing slag:**

- Chipping hammer ✓
- Wire brush ✓

(Any 1 x 1) (1)

6.6 **Vertical rollers:**

Used solely for bending / rolling thick, heavy plates**.** ✓ (1)

6.7 **Horizontal band saw:**

- Ensures clean cut.
- Removes shavings / cuttings.
- Blade life span is prolonged.
- Cools the blade.
- Cools the metal.

(Any 2 x 1) (2)

6.8 **Oxy-acetylene equipment - processes:**

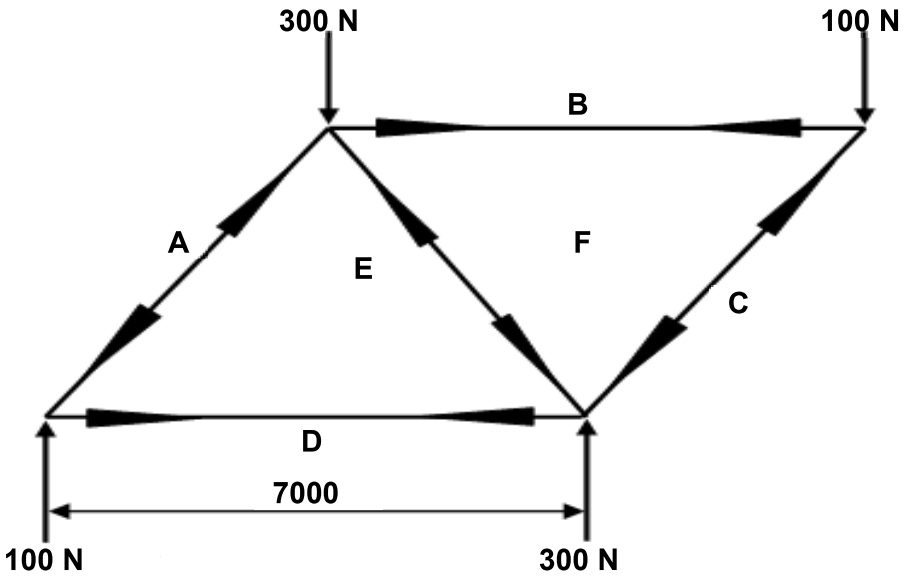
- Gas welding ✓
- Brazing ✓
- Silver soldering ✓
- Heating / Melting ✓
- Cutting ✓
- Gouging ✓

(Any 3 x 1) (3)

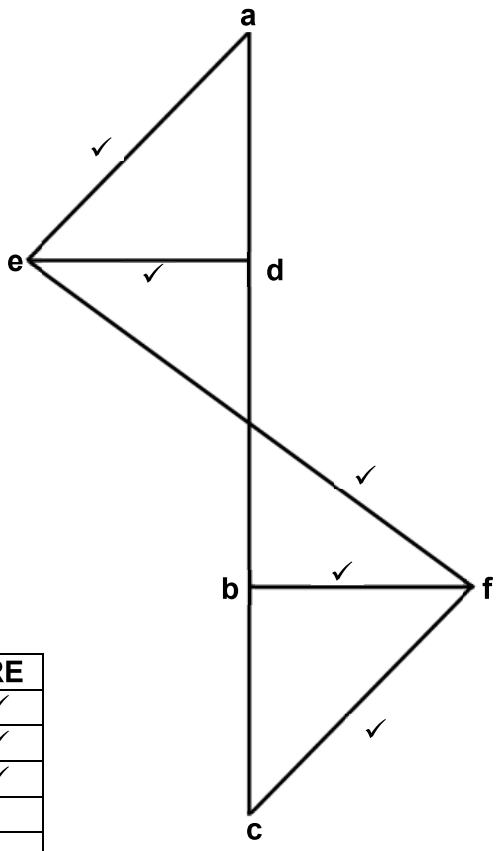
[18]

QUESTION 7: FORCES (SPECIFIC)

7.1 **Frameworks:**



Note to marker:
Marker must redraw the space and force diagram according to given scales for marking purposes. Tolerance of ±2 mm



MEMBER	FORCE (N)	NATURE
AE	140 N ✓	Strut ✓
EF	285 N ✓	Strut ✓
FC	140 N ✓	Strut ✓
BF	100 N ✓	Tie ✓
ED	100 N ✓	Tie ✓

(15)

7.2 **Beams:**

7.2.1 **Calculate RL:**
Moments about RR:

$$RL \times 10 = (8 \times 8) + (4 \times 5) + (6 \times 2)$$

$$RL = \frac{96}{10}$$

$$RL = 9{,}6 \text{ kN} \checkmark$$ (4)

7.2.2 **Calculate RR:**
Moments about RL:

$$RR \times 10 = (6 \times 8) + (4 \times 5) + (8 \times 2)$$

$$RR = \frac{84}{10}$$

$$RR = 8{,}4 \text{ kN} \checkmark$$ (4)

7.2.3 **Bending moment:**

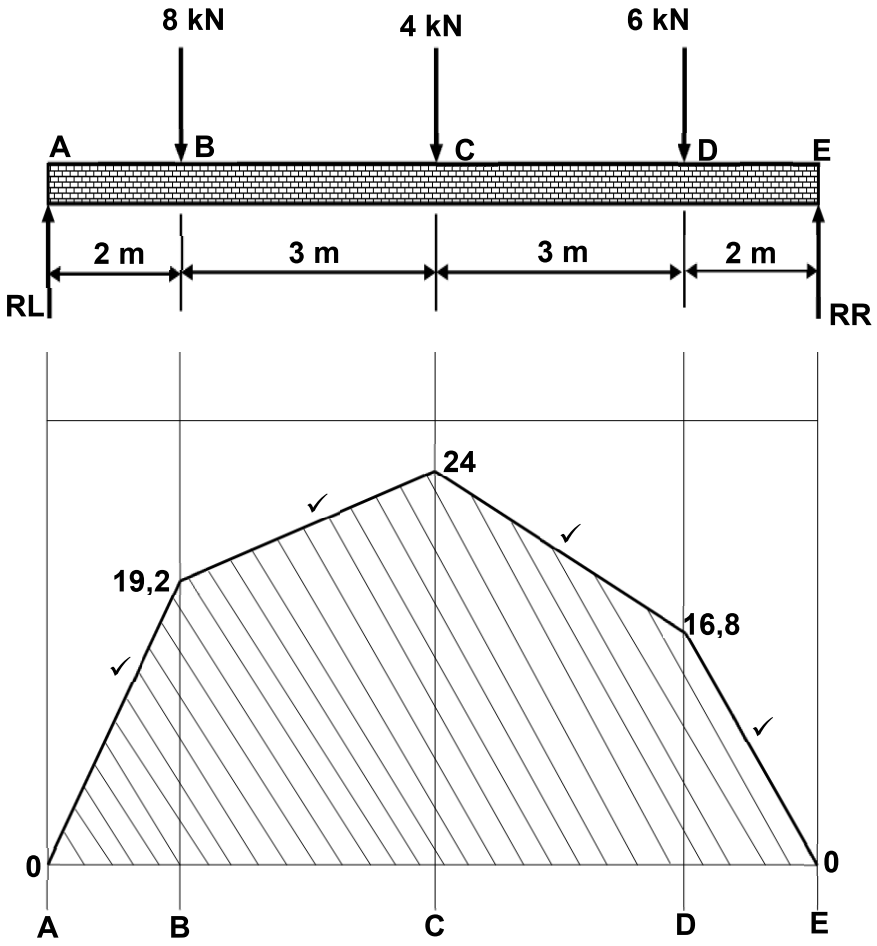
Moment at:

B: 9,6 x 2 = 19,2 kN.m ✓

C: (9,6 x 5) – (8 x 3) = 24 kN.m ✓

D: (9,6 x 8) – (8 x 6) – (4 x 3) = 16,8 kN.m ✓ (6)

7.2.4 **Bending-moment diagram:**



Note to marker:
Marker must redraw the bending-moment diagram according to given scales for marking purposes.

(4)

7.3 **Stress and strain:**

7.3.1 **Cross sectional area m^2:**

$$A = \frac{\pi D^2}{4}$$
$$= \frac{\pi \times 0,03^2}{4} \checkmark$$
$$= 0,71 \times 10^{-3}\ m^2 \checkmark$$ (2)

7.3.2 **Stress MPa:**

$$Stress = \frac{Load}{Area}$$
$$= \frac{80 \times 10^3}{0,71 \times 10^{-3}} \checkmark \checkmark$$
$$= 112676056,3\ Pa$$
$$= 112,68\ MPa \checkmark$$ (3)

7.3.3 **Strain:**

$$Strain = \frac{\Delta L}{OL}$$
$$= \frac{0,06}{3000} \checkmark$$
$$= 0,00002 \quad OR \quad 2 \times 10^{-5} \checkmark$$ (2)

7.3.4 **Young's modulus of elasticity:**

$$E = \frac{Stress}{Strain}$$
$$= \frac{112,68 \times 10^6}{2 \times 10^{-5}} \checkmark \checkmark \quad OR \quad = \frac{112,68 \times 10^6 \checkmark}{2 \times 10^{-5} \checkmark}$$
$$= 5,633802815 \times 10^{12}\ Pa \quad = 5,634 \times 10^{12}\ Pa$$
$$= 5633,80 \times GPa \checkmark \quad = 5634\ GPa \checkmark$$ (3)

7.4 **Maximum stress:**

$$Stress = \frac{Load}{Area}$$
$$= \frac{55 \times 10^3}{0,9 \times 10^{-5}} \checkmark$$
$$= 6111111111\ Pa$$
$$= 6111,11\ MPa \checkmark$$ (2)

[45]

QUESTION 8: JOINING METHODS (INSPECTION OF WELD) (SPECIFIC)

8.1 **Visual inspection:**

- Shape of the profile ✓
- Uniformity of the surface ✓
- Overlap ✓
- Undercutting ✓
- Penetration bead ✓
- Root groove ✓
- Fusion ✓
- Reinforcement ✓
- Porosity ✓
- Spatter ✓
- Slag inclusions ✓
- (ANY WELD DEFECT THAT CAN BE SEEN VISUALLY AFTER WELDED) ✓

(Any 2 x 1) (2)

8.2 **Free bend test:**

- Ductility ✓
- Brittleness ✓
- Malleability ✓
- Elongation ✓
- Elasticity ✓

(Any 1 x 1) (1)

8.3 **Weld defect:**

Weld defect is a result which does not meet ✓ the prescribed requirements of a welded joint. ✓ (2)

8.4 **Causes of welding defects:**

8.4.1 **Undercutting:**

- Current too high ✓
- Current too low ✓
- Wrong electrode angle ✓
- Arc length too long ✓
- Weld speed too fast ✓
- Too low arc voltage ✓
- Faulty electrode manipulation ✓

(Any 2 x 1) (2)

8.4.2 **Blow hole:**

- Presence of contaminants / impurities on the job surface or on electrode flux ✓
- Presence of high sulphur in the job or electrode materials ✓
- Lack of shielding gas ✓
- Using wet electrode ✓

(Any 2 x 1) (2)

8.5 **Destructive tests:**

- Machinability test ✓
- Nick break test ✓
- Free bend test ✓
- Guided bend test ✓

(Any 2 x 1) (2)

8.6 **Procedure for conducting X-ray test:**

- The photographic film is sealed in an envelope (so that the light cannot expose it) and placed behind the object being tested. ✓
- The X-ray or gamma ray source is placed in front of the object being tested. ✓
- The tester should stand behind lead shields and far away from possible harmful exposure. The source is activated for a brief moment and the X-rays penetrate the test piece. ✓
- As they pass through the areas of lower density, the rays expose the defect on the film as a lighter colour on the negative, ✓ indicating a weld defect. ✓
- Photographic films provide a permanent record of the shadow which can be carefully studied. / Shown on a monitor screen ✓ (6)

8.7 **Types of dye:**

- Fluorescent dye ✓
- Brightly coloured dye ✓ (2)

8.8 **Internal weld defects:**

- Cracks ✓
- Slag inclusion ✓
- Lack of fusion ✓
- Lack of root penetration ✓
- Blow hole ✓
- Porosity ✓

(Any 2 x 1) (2)

8.9 **Centreline cracks:**

- Use the correct width to depth ratio. ✓
- Decreasing the current to decrease excess penetration. ✓
- Decreasing welding/arc voltage. ✓

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

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

9.1 **Distortion and residual stress:**

- If the expansion that occurs when metal is heated is resisted then distortion will occur. ✓
- When contraction that occurs on cooling is resisted then a stress will be applied. ✓
- If the applied stress causes movement then distortion occurs. ✓
- If the applied stress does not cause movement then there will be residual stress in the welded joint. ✓

(Any 2 x 1) (2)

9.2 **Shrinkage:**

Shrinkage is a form of plastic deformation where the metal has deformed ✓ as a result of contraction on cooling. ✓ (2)

9.3 **Grain size:**

- The prior amount of cold work ✓
- The temperature and time of the annealing process ✓
- The composition ✓
- The melting point ✓

(Any 2 x 1) (2)

9.4 **Cold working and hot working:**

- Cold working is when deformation ✓ of steel takes place below the recrystallisation temperature (AC_1) ✓ of the steel.
- Hot working is when deformation ✓ of steel takes place above the recrystallisation temperature (AC_1) ✓ of the steel. (4)

9.5 **Distortion:**

- Do not over weld. ✓
- Apply intermittent welding. ✓
- Place welds near the neutral axis. ✓
- Use as few passes as possible. ✓
- Use back-step welding. ✓
- Anticipate the shrinkage forces. ✓
- Plan the welding sequence. ✓
- Use strong backs. ✓
- Use clamps, jigs and fixtures. ✓

(Any 4 x 1) (4)

9.6 **Types of distortion:**

9.6.1 Longitudinal distortion ✓ (1)

9.6.2 Angular distortion ✓ (1)

9.7 **Metal is cooled rapidly:**
Rapid cooling of metal results in large temperature differences that set up stresses, ✓ which cause cracks on the surface. ✓ (2)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 **Maintenance definition:**
Precautionary measures, actions and processes ✓ that are taken to keep a machine or process ✓ in a functional order. ✓ (3)

10.2 **Pedestal drilling machine:**

- Visual checks of electrical wiring, switches. ✓
- 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 and lubricate. ✓
- Ensure cuttings are removed. ✓
- Inspect the Morse taper sleeves for burrs/scratches. ✓
- Check the chuck is correctly fitted and tight. ✓

(Any 2 x 1) (2)

10.3 **Tagging plates:**

- It is to isolate switches of machines before maintenance is undertaken. ✓
- To show workers that maintenance is being carried out on a specific machine. ✓

(Any 1 x 1) (1)

10.4 **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)
[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENTS) (SPECIFIC)

11.1 **Hopper:**

11.1.1 Square ✓ to rectangle ✓ on centre. ✓ (3)

11.1.2 (a) **A–1:**

$$A\text{-}1 = \sqrt{100^2 + 125^2 + 450^2} \checkmark$$
$$= \sqrt{228125}$$
$$= 477{,}62 \text{ mm} \checkmark$$

(2)

(b) **A–2:**

$$A - 2 = \sqrt{400^2 + 125^2 + 450^2} \checkmark$$
$$= \sqrt{378125}$$
$$= 614{,}92 \text{ mm} \checkmark$$

(2)

(c) **B–3:**

$$B - 3 = \sqrt{375^2 + 100^2 + 450^2} \checkmark$$
$$= \sqrt{353125}$$
$$= 594{,}24 \text{ mm} \checkmark$$

(2)

11.2 **Cone frustum:**

11.2.1 **A–B:**

$$A - B = \frac{\pi \times D}{12} \checkmark$$
$$= \frac{\pi \times 800}{12} \checkmark$$
$$= 209{,}44 \text{ mm} \checkmark$$

(3)

11.2.2 **0–1:**

$$0 - 1 = \frac{\pi \times d}{12} \checkmark$$
$$= \frac{\pi \times 600}{12} \checkmark$$
$$= 157{,}08 \text{mm} \checkmark$$

(3)

11.2.3 **A–0:**

Plan length / base line:

A–0 = 400 - 300 ✓
= 100 mm ✓

True length:

$A-0=\sqrt{100^2+500^2}$ ✓
$=\sqrt{260\,000}$
$=509{,}90$ mm ✓ (4)

11.3 **Square to round transformer:**
Use to connect ducting sections ✓ of dissimilar shapes to each other. ✓ (2)
[21]

TOTAL: 200