basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

NOVEMBER 2021

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 23 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 B ✓ (1)

1.2 A ✓ (1)

1.3 D ✓ (1)

1.4 A / C ✓ (1)

1.5 A ✓ (1)

1.6 C ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **First-aid applications to an open wound:**

- Use surgical gloves. ✓
- Do not remove anything that is stuck to the wound. ✓
- Never use sticky plaster on the wound. ✓
- Cover the wound with a clean, lint-free cloth. ✓
- Avoid using any oily substances or lotions on wounds. ✓
- If necessary, cool wounds with cold water. ✓
- Apply pressure to prevent blood loss if necessary. ✓
- Avoid contact with blood from patient. ✓
- If the wound is on your arm, raise the arm above your head to stop the bleeding. ✓

(Any 2 x 1) (2)

2.2 **Surface grinder: (Already switched on**)

- Never leave the grinder unattended. ✓
- Switch off the machine when leaving. ✓
- Don't try to stop revolving emery wheel with your hand. ✓
- Don't adjust the machine while working. ✓
- Don't open any guard while the machine is on. ✓
- Do not force the grinding wheel on to the work piece. ✓
- Approach the work piece slowly and evenly. ✓
- Don't clean the machine while working. ✓
- Do not put hands near the work piece when grinder is in motion. ✓
- Don't clean or adjust the machine while working.✓
- Check for oil on the floor <u>while working</u> (spilling of cutting fluid on floor while working) ✓
- Check that the grinding wheel is running evenly. ✓

(Any 2 x 1) (2)

2.3 **Gauges calibrated:**

- To ensure accurate readings. ✓
- To prevent overloading. ✓

(Any 1 x 1) (1)

2.4 **Finger protectors' hazards on power driven guillotines:**

- The finger protector prevents the hazards of getting the fingers cut by the blades. ✓
- To be crushed by the hold-downs. ✓ (2)

2.5 **Welding or flame cutting operation safety:**

- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment. ✓
- Ensure that all equipment is in safe working condition. ✓
- Ensure that here are no flammable materials around the welding area. ✓
- Weld area must be well ventilated. ✓
- Fire extinguisher must be in close proximity. ✓

(Any 2 x 1) (2)

2.6 **Workshop layout:**

Product layout. ✓ (1)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **File test:**

3.1.1 Difficult ✓ (1)

3.1.2 Easy ✓ (1)

3.1.3 Difficult ✓ (1)

3.2 **Heat treatment:**

A. – Grain growth. ✓
B. – Recrystallisation. ✓
C. – Recovery. ✓ (3)

3.3 **Bending test:**

- Bend the test piece through a specific angle or around a mandrel or bar, ✓ having a defined radius, ✓ until a rupture in the metal occurs.✓
- Place the material in a vice and bend it ✓ then observe ✓ the ductility of the material. ✓

(Any 1 x 3) (3)

3.4 **Purpose of case hardening:**

Creates a hard surface ✓ with a tough core. ✓ (2)

3.5 **Quenching media for hardening:**

- Water ✓
- Brine (saltwater) ✓
- Oil ✓
- Soluble oil and water ✓
- Nitrogen air-infused air ✓

(Any 3 x 1) (3)
[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 Dimensions of the material:

5.1.1

$$\text{Mean Ø} = \text{Outside Ø} - \text{Plate Thickness}$$
$$= 960 - 60 \quad ✓$$
$$= 900 \text{ mm} \quad ✓$$

(2)

5.1.2

$$\text{Mean circumference} = \pi \times \text{Mean Ø}$$
$$= \pi \times 900 \quad ✓$$
$$= 2827{,}43 \text{ mm} \quad ✓$$
$$\text{Round off to } 2827 \text{ mm} \quad ✓$$

(3)

5.2 Welding symbols:

5.2.1

 ✓✓

(2)

5.2.2

 ✓✓

(2)

5.2.3

 ✓✓

(2)

5.2.4

 ✓✓

(2)

5.2.5

 ✓✓

(2)

5.3 Templates:

5.3.1 Flange template ✓ (1)

5.3.2 Strip template ✓ (1)

5.3.3 Web template ✓ (1)

5.4 **Hand tools: *(Due to the large number of alternatives, marker discretion must be used - discuss with IM)*.**

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

(Any 3 x 1) (3)

5.5 **Template loft machines: *(Due to the large number of alternatives, marker discretion must be used - discuss with IM).***

- Circular saw ✓
- Planer ✓
- Drilling machine ✓
- Jig saw ✓
- Sanding machine ✓
- Shears for cutting cardboard ✓
- Welding machine ✓
- Angle grinder ✓
- Bench grinder ✓
- Guillotine ✓
- Cut–off power saw ✓

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

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Operating principles of a resistance 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)

6.2 **Arc welding:**

6.2.1
A. Arc welding machine / Power source / invertor. ✓
B. Earth clamp / "*skelm*" ✓
C. Electrode / Rod / welding rod ✓
D. Electrode holder ✓ (4)

6.2.2
- Holds the electrode. ✓
- Insulate the person welding ✓
- Provide current to the electrode ✓
- Used with electrode to weld ✓

(Any 1 x 1) (1)

6.3 **Cutting of threads:**

- Secure the die in die wrench/stock ✓ and set die square to the shaft to be cut. ✓
- Rotate the die through half a turn in a clockwise direction ✓ to cut the thread and then turn back a quarter of a turn ✓ to break off waste.
- Continue process until the die has reached the required length of thread ✓ and adjust the centre and side screws until desired thread fit is achieved. ✓ (6)

6.4 **Advantages of using a punch machine:**

- Can punch holes faster. ✓
- Punch various hole profiles ✓
- Less effort is needed ✓

(Any 1 x 1) (1)

6.5 **Pyramid rollers**

- Rolling sheet metal. ✓
- Used to roll round bars ✓

(Any 1 x 1) (1)

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QUESTION 7: FORCES (SPECIFIC)

7.1 **Beams:**

7.1.1 **Calculating reactions:**

Taking moments about RL:

$$RR \times 10 = (80 \times 3) + (60 \times 5) + (100 \times 7)$$
$$= 240 + 300 + 700$$
$$RR = \frac{1240}{10}$$
$$= 124 \text{ N}$$

Taking moments about RR:

$$RL \times 10 = (100 \times 3) + (60 \times 5) + (80 \times 7)$$
$$= 300 + 300 + 560$$
$$RL = \frac{1160}{10}$$
$$= 116 \text{ N}$$

(8)

7.1.2 **Calculating bending moments:**

Bending moments at B, C and D:

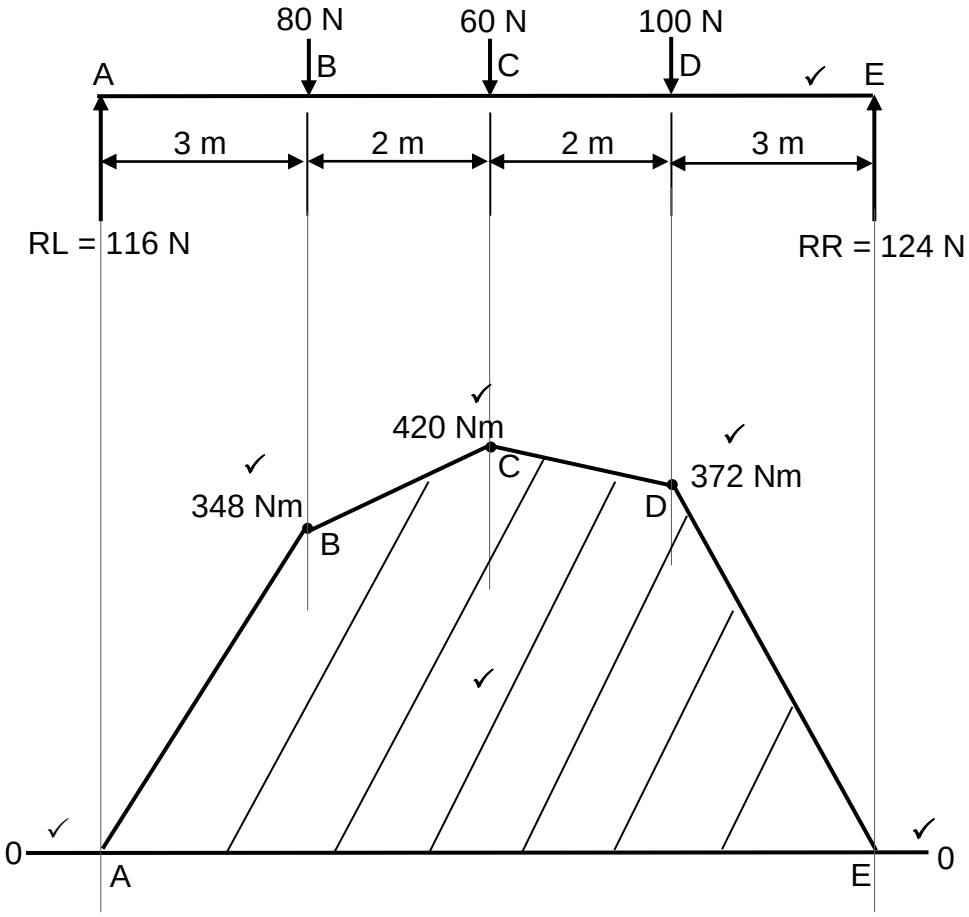
$$BM_B = (116 \times 3)$$
$$= 348 \text{Nm}$$

$$BM_C = (116 \times 5) - (80 \times 2)$$
$$= 420 \text{Nm}$$

$$BM_D = (116 \times 7) - (80 \times 4) - (60 \times 2)$$
$$= 372 \text{Nm}$$

(3)

7.1.3 **Bending moment diagram:**



(7)

NOTE: Draw the bending moment diagram to scale for marking purposes.

7.2 Stress and Strain:

7.2.1 Diameter of a bar:

$$\sigma = \frac{F}{A}$$

$$A = \frac{F}{\sigma} \quad \checkmark$$

$$= \frac{40\times10^{3}}{20\times10^{6}} \quad \checkmark$$

$$= 2\times10^{-3}\,m^{2} \quad \checkmark$$

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

$$D = \sqrt{\frac{4A}{\pi}} \quad \checkmark$$

$$= \sqrt{\frac{4\left(2\times10^{-3}\right)}{\pi}} \quad \checkmark$$

$$= 0{,}05046265\,m \quad \checkmark$$

OR

$$= 50{,}46\,mm \checkmark$$

(6)

7.2.2 Strain:

$$\varepsilon = \frac{\sigma}{E}$$

$$\varepsilon = \frac{20\times10^{6}}{90\times10^{9}} \quad \checkmark$$

$$= 0{,}22\times10^{-3} \quad \checkmark$$

(2)

7.2.3 **Change in length:**

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

$$\Delta L = \varepsilon \times OL \quad ✓$$

$$= \left(0{,}22 \times 10^{-3}\right) \times 2 \quad ✓$$

$$= 0{,}44 \times 10^{-3} m$$

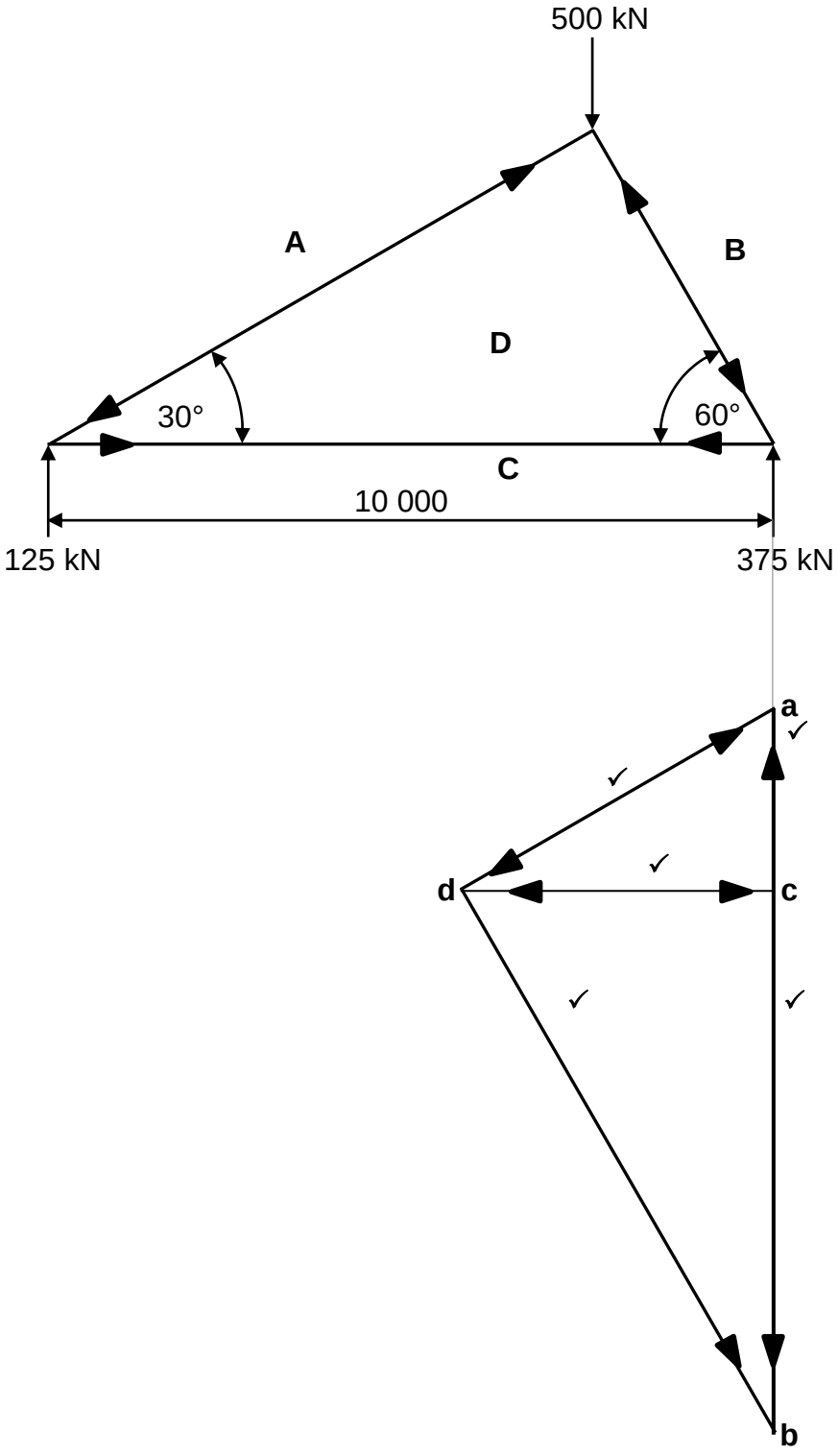
$$= 0{,}44 mm \quad ✓$$ (3)

7.3 **Stress and strain diagram:**

A: Limit of proportionality ✓
B: Elastic limit ✓
C: Yield point ✓
D: Maximum stress ✓
E: Break stress ✓ (5)

7.4 **Simple frame:**

7.4.1 **Vector/Force diagram:**



(5)

7.4.2 **Magnitude and nature of force:**

Member	**Force**	**Nature**
AD	250 kN ✓	Strut ✓
BD	433 kN ✓	Strut ✓
CD	216 kN ✓	Tie ✓

(6)
[45]

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

8.1 **Arc welding aspects:**

- Rate of rod burning and the progress of the weld ✓
- Amount of penetration and fusion. ✓
- Observe for welding defects while welding ✓
- The sound of the arc indicating correct current and voltage for the particular weld. ✓
- Angle of electrode. ✓
- Arc length. ✓
- Size of molten pool while welding ✓

(Any 3 x 1) (3)

8.2 **Centreline cracks:**

- Aiming at width to depth ratio of 1:1. ✓
- Decreasing the current to prevent excess penetration. ✓
- Decreasing welding voltage ✓
- Slowing travel speed to achieve a flat to convex weld surface. ✓
- Use clamping device. ✓
- Pre – Heating ✓
- Use of correct electrode ✓

(Any 2 x 1) (2)

8.3 **Welding defects:**

8.3.1 **Lack of fusion:**

- Travel speed is too slow. ✓
- Wide weld joint. ✓
- Weld current too low. ✓
- Too big weaving action. ✓
- Included angle not correct. ✓
- Contaminated parent metal surface ✓
- Weld metal not permitted to roll in front of arc. ✓
- Arc not kept on leading edge of molten pool. ✓
- Travel speed too fast. ✓
- Excessive mill scale (iron oxide) ✓

(Any 2 x 1) (2)

8.3.2 **Porosity:**

- Contaminated weld surface. ✓
- Wet or dirty electrodes. ✓
- Shielding gas supply is interrupted. ✓
- Welding in windy conditions. ✓

(Any 2 x 1) (2)

8.3.3 **Incomplete penetration:**

- Welding current too low. ✓
- Welding speed too fast. ✓
- Incorrect electrode angle. ✓
- Poor joint preparation. ✓
- Insufficient root gap. ✓
- Electrode too big. ✓
- Too long arc. ✓
- Contaminated weld surface. ✓

(Any 2 x 1) (2)

8.4 **Setting oxy-acetylene torch flame to a neutral flame:**

- Open acetylene torch valve ¼ turns or less and ignite. ✓
- Adjust the acetylene torch valve further until the black smoke disappears. ✓
- Open oxygen torch valve until the flame is no longer burning yellow. ✓
- Inner cone of the flame must be rounded. ✓

(Any 3 x 1) (3)

8.5 **Guided bend test:**

- Specimen is placed across the supports of the die. ✓
- Apply force to the specimen to bend into shape of the die. ✓
- Determine the percentage of elongation of the weld metal. ✓ (3)

8.6 **Free bend test:**

- Determine the ductility of the weld. ✓
- Determine the ductility of the heat – affected area adjacent to the weld. ✓
- Determine the percentage of elongation ✓

(Any 2 x 1) (2)

8.7 **Types of dye:**

- Type A: Fluorescent that emits visible light when viewed using a Black light. ✓
- Type B: Brightly coloured liquid dyes that can be inspected in regular light. ✓ (2)

8.8 **Nick-break test:**

- Determines internal ✓ quality of the weld metal. ✓
- Reveals internal defects ✓ such as slag inclusions, porosity and lack of fusion. ✓

(Any 1 x 2) (2)

[23]

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

9.1 **Causes of residual stress in welds:**

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

(Any 2 x 1) (2)

9.2 **Factors of cooling rate:**

- Size of work piece. ✓
- Weld thickness. ✓
- Thermal conductive properties of parent metal. ✓

(**Any 3 x 1)** (3)

9.3 **Effect of cold working:**

- The effect of cold working is to break down the crystal structure ✓ elongating the grains. ✓
- An elongated and distorted crystal structure of this kind gives the metal greater hardness ✓ and tensile strength. ✓
- Reduces ductility. ✓
- Referred to as work hardening. ✓ (4)

9.4 **Effects of welding speed on distortion:**

- Increase in welding speed increases distortion due to larger flame in oxy-acetylene welding. ✓
- Larger diameter electrode requires increased current causing more localised heat. ✓
- Causing more residual stress.✓
- Causing more distortion. ✓

(Any 3 x 1) (3)

9.5 **Quenching media:**

- Water ✓
- Oil ✓
- Brine ✓
- Liquid salts ✓
- Sand ✓
- Air ✓
- Ash ✓
- Lime ✓
- Molten lead ✓
- Nitrogen air-infused air ✓

(Any 3 x 1) (3)

9.6 **Reducing welding distortion:**

- Do not over-weld. ✓
- Intermittent welding. ✓
- Place welds near the neutral axis. ✓
- Use a few passes as possible. ✓
- Use back step welding. ✓
- Anticipate the shrinkage forces. ✓
- Use clamps, jigs and fixtures. ✓
- Use strongbacks. ✓
- Heating metal before welding. (pre- heating) ✓
- Slowing the cooling rate ✓

(Any 3 x 1) (3)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 **Locking out of machine:**

- Isolation switches must be switched off. ✓
- The only key to the lock is in possession of the person carrying out the maintenance / Each maintenance person must have own lock. ✓ (2)

10.2 **Tagging plates:**

More than one technician can lock out machine simultaneously. ✓ (1)

10.3 **Minor service for a power-driven guillotine:**

The minor service is designed to minimise ✓ major mechanical and electrical failures. ✓ (2)

10.4 **Cutting fluid:**

- Keep the blade cool.✓
- Keep the work piece cool ✓
- Prolong the life span of the blade ✓
- Washes cuttings away ✓
- Improves cutting efficiency ✓
- Reduces friction during cutting process. ✓
- Better finish given to workpiece. ✓
- Also prevents further corrosion. ✓

(Any 2 x 1) (2)

10.5 **Overloading a rolling machine:**

- Limit the life span of components ✓
- Can result in costly damage ✓
- Damage to bearings/bushes ✓
- Damage to gearbox ✓
- Damage to motor ✓

(Any 1 x 1) (1)
[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENTS) (SPECIFIC)

11.1 **True length of AC:**

$$AC^2 = AB^2 + BC^2$$

$$\text{but } BC = \frac{90-50}{2} \checkmark$$

$$= \frac{40}{2}$$

$$= 20 \text{ mm} \checkmark$$

$$AC^2 = AB^2 + BC^2$$

$$= 50^2 + 20^2 \checkmark$$

$$AC = \sqrt{2500+400} \checkmark$$

$$= 53{,}85 \text{mm} \checkmark$$

$$= 54 \text{mm} \checkmark$$

(6)

11.2 **Development:**

Square/rectangle ✓ to round ✓ transformer / transition piece / on centre. ✓ (3)

11.3 **Square to rectangle on centre hopper:**

11.3.1 **True length of A-1:**

$$A-1 = \sqrt{200^2 + 130^2 + 500^2} \quad (\checkmark \ \checkmark \ \checkmark)$$

$$= \sqrt{40000+16900+250000}$$

$$= \sqrt{306900}$$

$$= 553{,}99$$

$$= 554 \text{ mm} \checkmark$$

(4)

11.3.2 **True length of C-2:**

$$C-2 = \sqrt{470^2 + 200^2 + 500^2} \quad (\checkmark\ \checkmark\ \checkmark)$$

$$= \sqrt{220900 + 40000 + 250000}$$

$$= \sqrt{510900}$$

$$= 714{,}77$$

$$= 715\ mm \quad \checkmark$$ (4)

11.4 **Hoppers:**

11.4.1 Square to rectangle ✓ hopper off centre ✓ (2)

11.4.2 Square to square ✓ hopper on centre ✓ (2)

[21]

TOTAL: 200