



# basic education

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Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **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)        |
|     |     | <b>[6]</b> |

## 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)
		<b>[14]</b>

**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:**
- Mean  $\varnothing$  = Inside  $\varnothing$  + Thickness  
= 180 + 12 ✓  
= 192 mm ✓ (2)
- 5.4.2 **Mean circumference:**
- Mean circumference =  $\pi \times$  Mean  $\varnothing$   
=  $\pi \times 192$  mm ✓  
= 603,186 mm ✓  
Round off to 603 mm ✓ (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)

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## 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 ✓

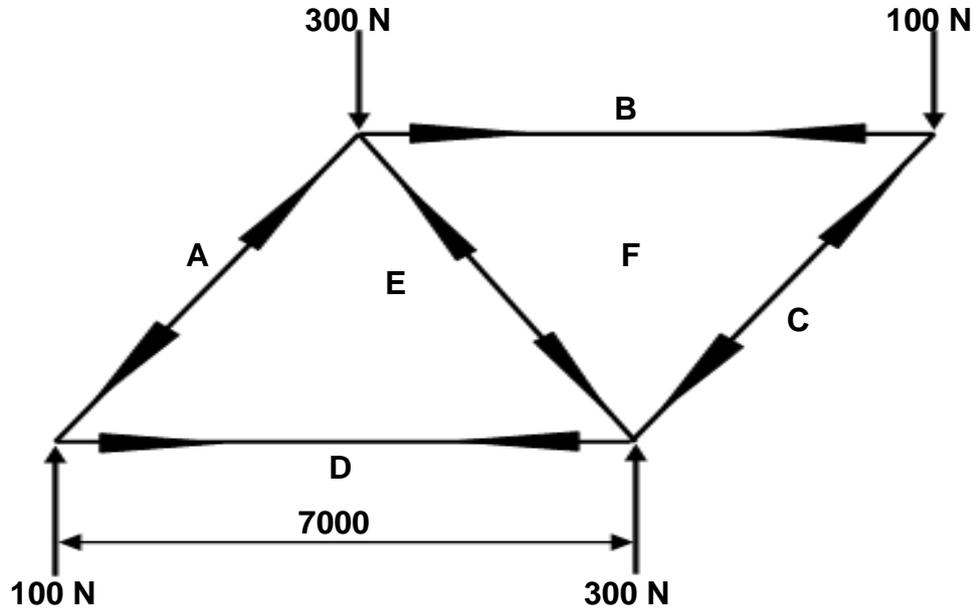
**(Any 3 x 1)**

**(3)**

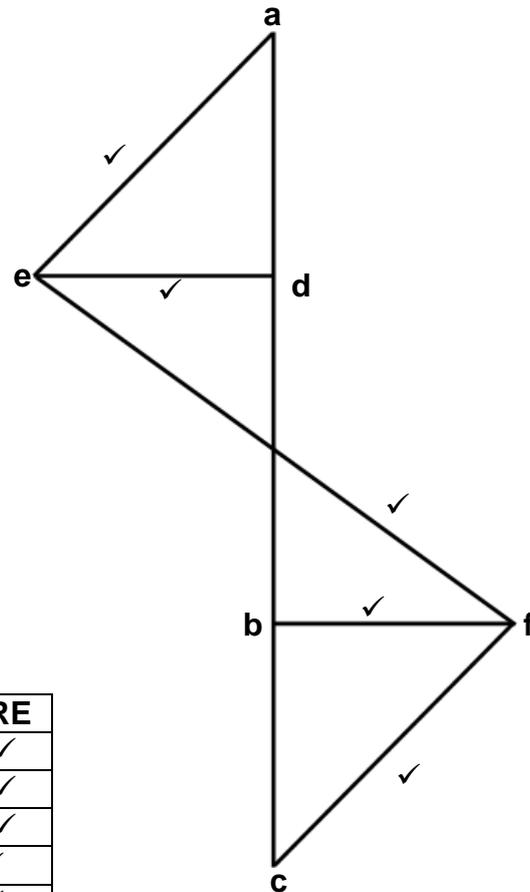
**[18]**

**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  $\pm 2$  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:

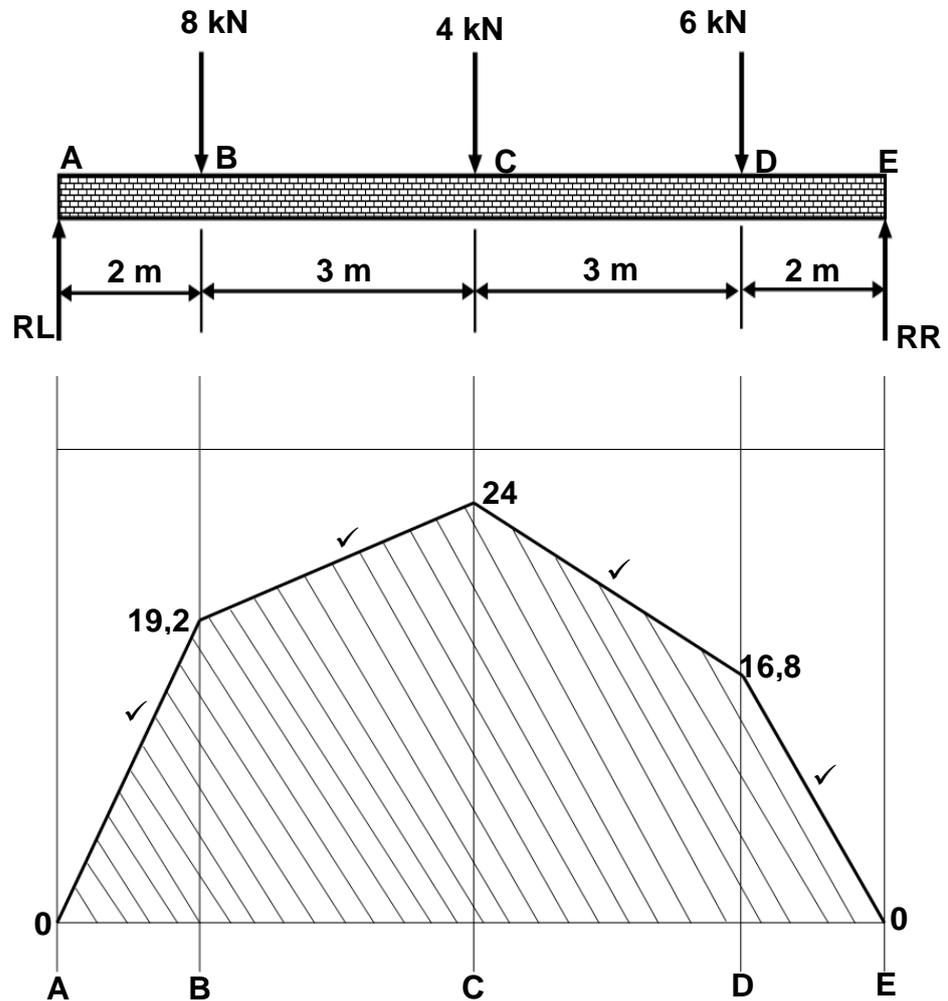
$$\mathbf{B: } 9,6 \times 2 = 19,2 \text{ kN.m } \checkmark$$

$$\mathbf{C: } (9,6 \times 5) - (8 \times 3) = 24 \text{ kN.m } \checkmark$$

$$\mathbf{D: } (9,6 \times 8) - (8 \times 6) - (4 \times 3) = 16,8 \text{ kN.m } \checkmark$$

(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<sup>2</sup>:**

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

7.3.2 **Stress MPa:**

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

7.3.3 **Strain:**

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

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

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

7.4 **Maximum stress:**

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

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## 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)

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## 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:**

$$\begin{aligned} A-1 &= \sqrt{100^2 + 125^2 + 450^2} \quad \checkmark \\ &= \sqrt{228125} \\ &= 477,62 \text{ mm} \quad \checkmark \end{aligned} \quad (2)$$

(b) **A-2:**

$$\begin{aligned} A-2 &= \sqrt{400^2 + 125^2 + 450^2} \quad \checkmark \\ &= \sqrt{378125} \\ &= 614,92 \text{ mm} \quad \checkmark \end{aligned} \quad (2)$$

(c) **B-3:**

$$\begin{aligned} B-3 &= \sqrt{375^2 + 100^2 + 450^2} \quad \checkmark \\ &= \sqrt{353125} \\ &= 594,24 \text{ mm} \quad \checkmark \end{aligned} \quad (2)$$

**11.2 Cone frustum:**

11.2.1 **A-B:**

$$\begin{aligned} A-B &= \frac{\pi \times D}{12} \quad \checkmark \\ &= \frac{\pi \times 800}{12} \quad \checkmark \\ &= 209,44 \text{ mm} \quad \checkmark \end{aligned} \quad (3)$$

11.2.2 **O-1:**

$$\begin{aligned} O-1 &= \frac{\pi \times d}{12} \quad \checkmark \\ &= \frac{\pi \times 600}{12} \quad \checkmark \\ &= 157,08 \text{ mm} \quad \checkmark \end{aligned} \quad (3)$$

11.2.3 **A-0:**

**Plan length / base line:**

$$\begin{aligned} A-0 &= 400 - 300 \checkmark \\ &= 100 \text{ mm } \checkmark \end{aligned}$$

**True length:**

$$\begin{aligned} A-0 &= \sqrt{100^2 + 500^2} \checkmark \\ &= \sqrt{260000} \\ &= 509,90 \text{ mm } \checkmark \end{aligned}$$

(4)

11.3 **Square to round transformer:**

Use to connect ducting sections  $\checkmark$  of dissimilar shapes to each other.  $\checkmark$

(2)

[21]

**TOTAL: 200**