basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

2021

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 18 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 B ✓ (1)

1.2 A ✓ (1)

1.3 C ✓ (1)

1.4 C ✓ (1)

1.5 D ✓ (1)

1.6 A ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **First aid basic treatment:**

- Examination ✓
- Diagnosis ✓
- Treatment ✓ (3)

2.2 **Drill press (Already been switched on):**

- Never leave the drill unattended while in motion. ✓
- Switch off the drill when leaving. ✓
- Use a brush or wooden rod to remove chips. ✓
- When reaching around a revolving drill, be careful that your clothes do not get caught in the drill or drill chuck. ✓
- Don't stop a revolving chuck with your hand. ✓
- Don't adjust the drill while working. ✓
- Don't open any guard while in motion. ✓
- Keep hands away from action points. ✓
- Do not force the drill bit into the material. ✓
- Apply cutting fluid if required. ✓

(Any 2 x 1) (2)

2.3 **Isolation of electrode holder:**

To prevent electric shock. ✓ (1)

2.4 **Disadvantages of the process layout:**

- Production is not always continuous. ✓
- Transportation costs between process departments may be high. ✓
- Additional time is spent in testing and sorting as the product moves to the different departments. ✓
- Damage to fragile goods may result from extra handling. ✓

(Any 2 x 1) (2)

2.5 **Advantages of the 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. ✓ (2)
- Reduction in manufacturing costs. ✓ **[10]**

(Any 2 x 1)

QUESTION 3: MATERIALS (GENERIC)

3.1 **Heat-treatment:**

- Heat the metal slowly to a certain temperature. ✓
- Soak the metal for a certain period to ensure a uniform temperature. ✓
- Cool the metal at a certain rate to room temperature. ✓

(3)

3.2 **Quenching mediums:**

- Water ✓
- Brine ✓
- Liquid salts ✓
- Oil ✓
- Soluble oil and water ✓
- Sand ✓
- Molten lead ✓
- Air ✓
- Lime ✓

(Any 3 x 1) (3)

3.3 **Annealing:**

- To relieve internal stresses of the steel ✓
- Soften steel to make machining possible ✓
- Make steel ductile ✓
- Refine grain structure ✓
- Reduce brittleness ✓

(Any 1 x 1) (1)

3.4 **Carbon steels:**

- Low carbon steel ✓
- Medium carbon steel ✓
- High carbon steel ✓

(3)

3.5 **Iron-carbon equilibrium diagram:**

A Percentage carbon / carbon content ✓
B Temperature in °C ✓
C AC3 line / Higher critical temperature ✓
D AC1 line / Lower critical temperature ✓

(4)
[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 **Template loft:**

- To save time in marking out. ✓
- Promotes accuracy. ✓

(Any 1 x 1) (1)

5.2 **Purlins:**

- To support roof covering. ✓ ✓
- To link the roof trusses. ✓✓
- Makes the roof structure stronger. ✓✓

(Any 1 x 2) (2)

5.3 **Roof truss:**

A – Rafter ✓
B – Cleat ✓
C – Purlin ✓
D – Gusset plate ✓
E – Tie beam/Main tie ✓ (5)

5.4 **Material calculation:**

$$\text{Mean } Ø = \underset{\checkmark}{\text{Inside } Ø} + \text{Thickness}$$
$$= 230 + 16 \checkmark$$
$$= 246 \text{ mm} \checkmark$$

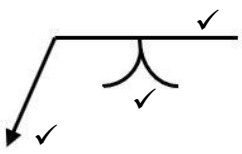
$$\text{Mean circumferance} = \pi \times \text{Mean } Ø$$
$$= \pi \times 246 \checkmark$$
$$= 772{,}83 \text{ mm} \checkmark$$
$$= \text{Round off to } 773 \text{ mm} \checkmark$$

(6)

5.5 **Welding symbols:**

A. Tail ✓
B. Weld symbol / Fillet weld on the other side / Weld symbol on the other side / Fillet weld ✓
C. Pitch of weld ✓
D. Site weld ✓
E. Arrow ✓
F. Weld all round ✓ (6)

5.6



(3)
[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Plasma cutter:**

- Creating an electrical channel of ionised gas (plasma), ✓ from the plasma cutter itself through the work piece that is being cut.
- It forms a completed electric circuit ✓ via a grounding clamp.
- Compressed air is blown toward the work piece through a focused nozzle at high speed. ✓
- A high frequency, electrical arc is then formed within the gas between an electrode near or integrated into the gas nozzle and the work piece itself. ✓ (4)

6.2 **Hydraulic press:**

- For removing bearings or bushes. ✓
- Fitting of bearings or bushes. ✓
- To shape material. ✓
- Testing of welded joints ✓

(Any 2 x 1) (2)

6.3 **Internal thread cutting process:**

- Drill the required core diameter. ✓
- Use the three taps in order – taper / intermediate / plug. ✓
- Check thread with thread pitch gauge/bolt when complete. ✓ (3)

6.4 **Power saw:**

To cut sections of metal / material. ✓ (1)

6.5 **Gas welding:**

6.5.1 Oxygen regulator / Acetylene regulator / regulator ✓ (1)

6.5.2 A. Gauge ✓
B. Outlet ✓
C. Inlet ✓
D. Pressure adjusting knob ✓ (4)

6.6 **Acetylene gas cylinder:**

Red / maroon ✓ (1)

6.7 **Flashback arrestor:**

To prevent ✓ back feeding / flashback of flame ✓ (2)

[18]

QUESTION 7: FORCES (SPECIFIC)

7.1 **Define:**

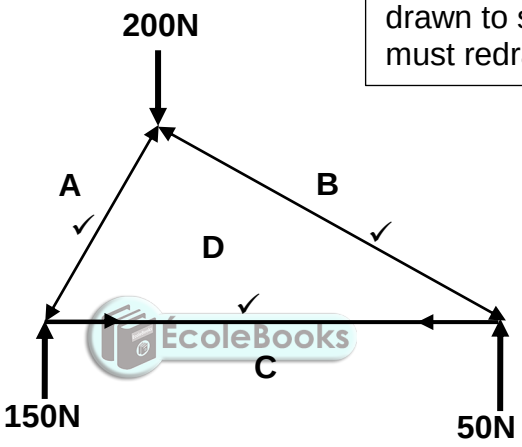
7.1.1 **Stress:**
The internal resistance ✓ in a body to an external force or load. ✓ (2)

7.1.2 **Hooke's law:**
Strain is directly proportional to the stress it causes; ✓ provided the limit of elasticity is not exceeded. ✓ (2)

7.2 **Frameworks:**

7.2.1. **Space diagram:**

NB: Diagrams are not drawn to scale. Markers must redraw the diagrams.

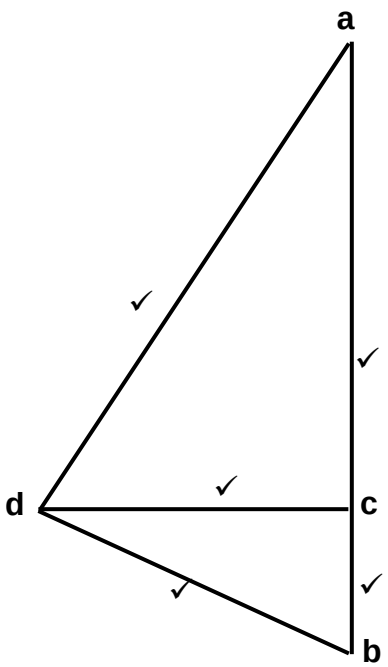


✓ for labelling

(4)

7.2.2 **Vector diagram:**

NOTE: ±2mm tolerance on scale drawing. Marks awarded for scale accuracy.



(5)

7.2.3 **Magnitude and nature of members:**

MEMBER	MAGNITUDE	NATURE
AD	172 N – 176 N ✓	Strut ✓
BD	100 N – 104 N ✓	Strut ✓
CD	87 N – 91 N ✓	Tie ✓

(6)

7.3 **Beam:**

7.3.1 **Calculate RL:**
Taking moment about right reaction (RR)

$$RL \times 10 = (25 \times 2) + (30 \times 6{,}5) + (15 \times 8) \checkmark$$
$$= 50 + 195 + 120$$
$$= \frac{365}{10} \checkmark$$
$$RL = 36{,}5 \text{ N} \checkmark$$

Calculate RR:
Taking moment about left reaction (RL)

$$RR \times 10 = (15 \times 2) + (30 \times 3{,}5) + (25 \times 8) \checkmark$$
$$= 30 + 105 + 200$$
$$= \frac{335}{10} \checkmark$$
$$RR = 33{,}5 \text{ N} \checkmark$$

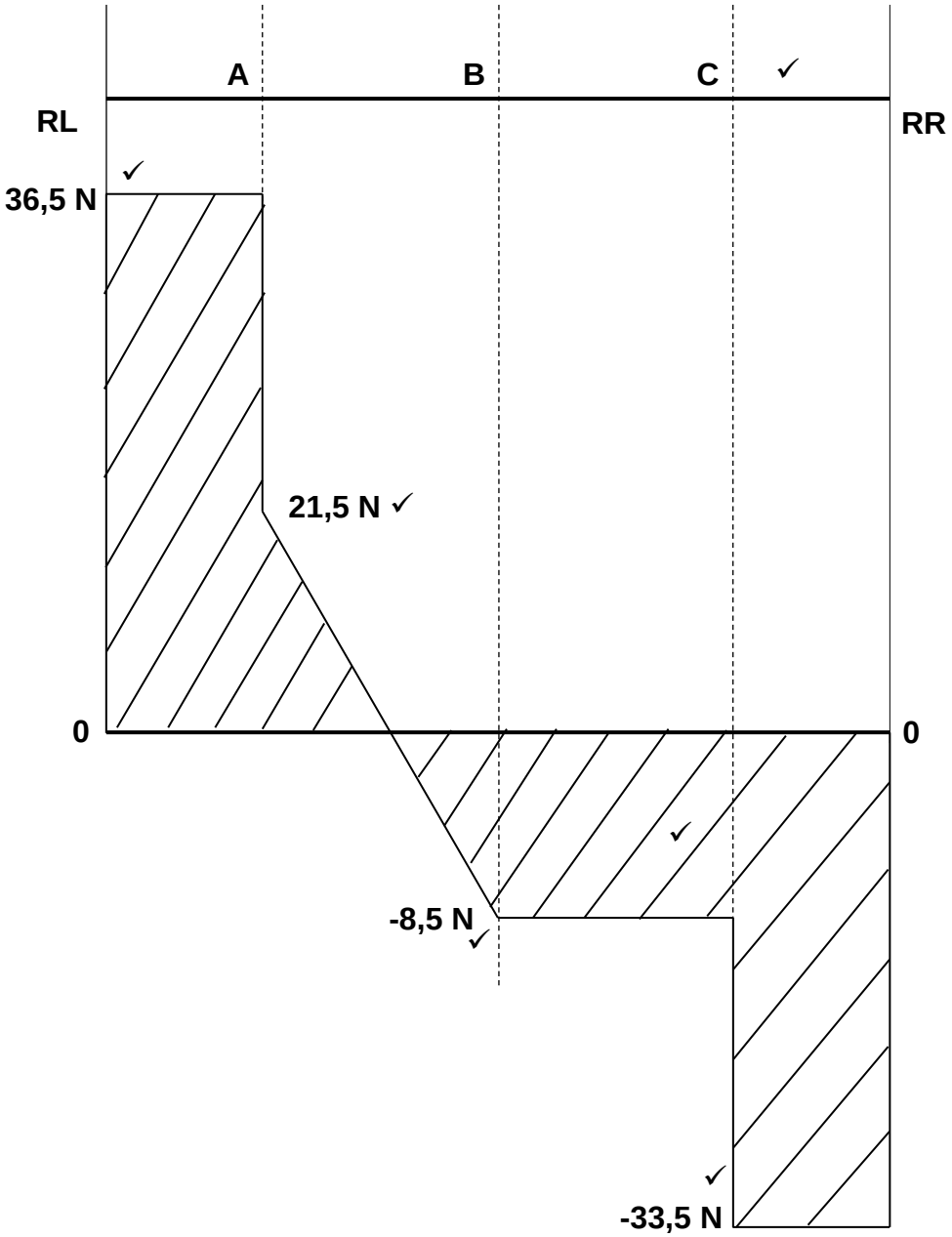
(6)

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

$$SF_A = 36{,}5 - 15 \checkmark$$
$$= 21{,}5 \text{ N} \checkmark$$
$$SF_B = 36{,}5 - 15 - 30 \checkmark$$
$$= -8{,}5 \text{ N} \checkmark$$
$$SF_C = 36{,}5 - 15 - 30 - 25 \checkmark$$
$$= -33{,}5 \text{ N} \checkmark$$

(6)

7.3.3 **Shear force diagram:**



(6)

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

7.4 Stress and strain:

7.4.1 Stress:

$$\text{Stress} = \frac{\text{Load}}{\text{Area}} \quad \text{But Area} = \frac{\pi D^2}{4}$$

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

$$= \frac{\pi(0{,}03)^2}{4} \checkmark$$

$$= 0{,}71 \times 10^{-3}\,\text{m}^2 \text{ or } 7{,}07 \times 10^{-4}\,\text{m}^2 \checkmark$$

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{80 \times 10^3\ \text{N}}{0{,}71 \times 10^{-3}\,\text{m}^2} \checkmark \checkmark$$

$$= 112{,}68 \times 10^6\,\text{Pa} \checkmark$$

$$= 112{,}68\ \text{MPa} \checkmark$$

OR

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$

$$= \frac{80 \times 10^3\ \text{N}}{7{,}07 \times 10^{-4}\,\text{m}^2} \checkmark \checkmark$$

$$= 113154172{,}6\ \text{Pa} \checkmark$$

$$= 113{,}15\ \text{MPa} \checkmark$$

(6)

7.4.2 Strain:

$$\text{Strain} = \frac{\Delta L}{OL}$$

$$= \frac{0{,}06}{3000} \checkmark$$

$$= 0{,}02 \times 10^{-3} \checkmark$$

(If any unit indicated, then NO mark awarded for final answer) (2)

[45]

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

8.1 **Welding defects (Causes):**

8.1.1 **Slag inclusion:**

- Included angle too narrow. ✓
- Rapid chilling. ✓
- Welding temperature to low / current too low. ✓
- High viscosity of molten metal.✓
- Slag not removed from previous weld run. ✓
- Incorrect welding technique. ✓
- Surface contamination. ✓
- Too big weaving action. ✓
- Too slow speed along the weld joint. ✓
- Too short arc length. ✓

(Any 2 x 1) (2)

8.1.2 **Incomplete penetration:**

- Speed too fast. ✓
- Poor welding technique. ✓
- Electrode too large. ✓
- Current too low. ✓
- Joint preparation not prepared correctly. ✓
- Weldability of parent metal not good. ✓

(Any 2 x 1) (2)

8.2 **Welding defects (Prevention):**

8.2.1 **Porosity:**

- Use correct current. ✓
- Hold a longer arc. ✓
- Use correct electrodes. ✓
- Check for impurities. ✓
- Ensure adequate shielding gas. ✓
- Correct welding technique. ✓
- Check that electrode/ filler metal did not rust.✓

(Any 2 x 1) (2)

8.2.2 **Lack of fusion:**

- Use correct included angle. ✓
- Use the correct size of electrode. ✓
- Use the correct current setting. ✓
- Prepare the plate bevel/V-groove accordingly. ✓

(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. ✓

(1)

(Any 1 x 1)

8.4 **Welding cracks:**
- Heat affected zone (HAZ) cracks. ✓
- Centre line / longitude cracks. ✓
- Crater cracks. ✓
- Transverse cracks. ✓

(Any 3 x 1) (3)

8.5 **Oxy-acetylene welding process:**
- Correct flame for the work on hand. ✓
- Correct angle of nozzle. ✓
- Correct angle of rod. ✓
- Depth of fusion. ✓
- The amount of penetration. ✓
- The rate of progress along the joint. ✓

(Any 2 x 1) (2)

8.6 **Nick-break test:**
- Each side of the weld is slotted by means of a saw. ✓
- Place the specimen on two steel supports / In a bench vice. ✓
- Break the specimen ✓ by striking it with a hammer. ✓
- Inspect the weld metal for exposed defects. ✓ (5)

8.7 **Non-destructive tests:**
- It does not involve the destruction/damage of the test piece ✓
- The test piece can still be used after test is done. ✓

(Any 1 x 1) (1)

8.8 **Machinability test:**
- To determine the ease of machining ✓
- To determine the quality of the finish ✓

(2)
[23]

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

9.1 **Cold worked steel:**

- Melting point ✓
- Its composition and constitution ✓
- The amount of cold work ✓
- Annealing time ✓ (4)

9.2 **Shrinkage in a welded joint:**

9.2.1 **Electrode type:**
Thermal properties have a greater potential to cause deformation.✓ (1)

9.2.2 **Electrode size:**
The larger the electrode diameter the higher the current the greater the deformation.✓ (1)

9.2.3 **Welding current:**
The higher welding current the higher the welding temperature the higher the deformation. ✓ (1)

9.3 **Factors that determine the cooling rate:**

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

(Any 2 x 1) (2)

9.4 **Definition:**

9.4.1 **Distortion:**
Weld distortion is the warping of the base metal ✓ caused by heat from the welding arc/flame. ✓ (2)

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

9.5 **Factors affecting distortion and residual stress:**

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

(Any 3 x 1) (3)

9.6 **Causes of residual stress:**

- During welding, the welds and Heat Affected Zone (HAZ) are heated to temperatures well above those of the surrounding material. ✓
- The weld and HAZ deform plastically because their thermal expansion is restricted by the surrounding material. ✓
- As the weld cools and contracts, tensile stresses develop elastically. ✓
- Welds develop tensile stresses that approach yield stress. ✓

(Any 2 x 1) (2)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 **Overloading:**

10.1.1 **Shearing machines:**
- Dulling or breaking blades. ✓
- Putting strain on the motor and drive mechanism. ✓

(Any 1 x 1) (1)

10.1.2 **Drill press:**
- Damage / breakage to the drill bit. ✓
- It puts strain on the drive components. ✓

(Any 1 x 1) (1)

10.2 **Friction:**

10.2.1 **Guillotine:**
Excessive wear / damage to moving parts. ✓ (1)

10.2.2 **Horizontal band saw:**
- Overheating of the cutting blade. ✓
- Damage to the cutting blade. ✓
- Excessive wear to moving parts. ✓

(Any 1 x 1) (1)

10.3 **Maintenance of a power saw:**
- Check the mains electrical switches. ✓
- Check the wiring and conduits for cracks. ✓
- Check for broken control mechanisms. ✓
- Check electrical connections. ✓
- Check for loose electrical components. ✓
- Check that cutting fluid does not come in contact with electrical wiring and switches. ✓

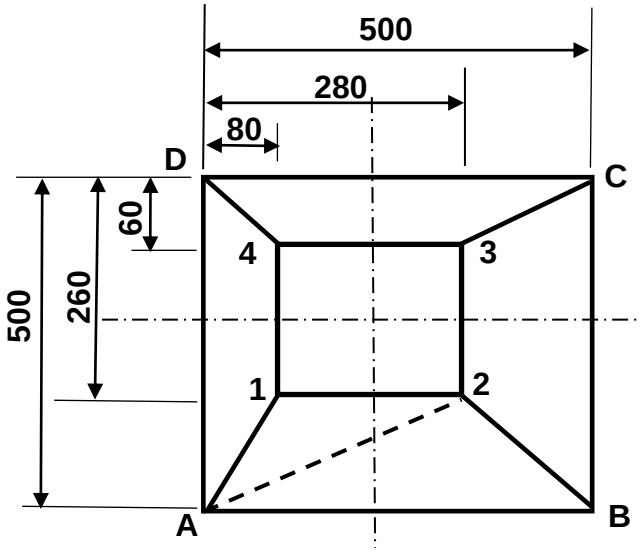
(Any 2 x 1) (2)

10.4 **Methods to reduce friction:**
- Applying cutting fluid. ✓
- Applying oil. ✓
- Prevent excessive pressure / Apply adequate pressure. ✓
- Ensure that the drill bit is sharp. ✓
- Ensure to use correct speed for the size of drill bit. ✓
- Use the correct drill bit. ✓

(Any 2 x 1) (2)
[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 **Square to square off centre hopper:**



11.1.1 **True length of A-2:**

$$\text{True length}(A-2) = \sqrt{240^2 \checkmark + 280^2 \checkmark + 400^2 \checkmark}$$
$$= \sqrt{57600 + 78400 + 160000}$$
$$= \sqrt{296000}$$
$$= 544{,}06\text{ mm} \checkmark \approx 544\text{ mm} \checkmark$$

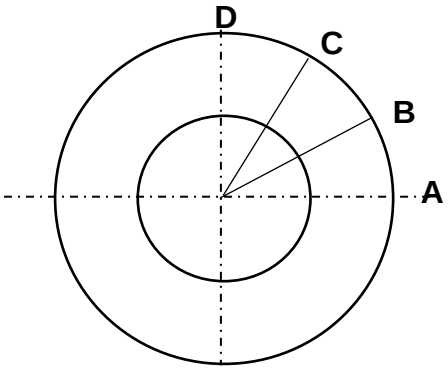
(5)

11.1.2 **True length of C-3:**

$$\text{True length}(C-3) = \sqrt{220^2 \checkmark + 60^2 \checkmark + 400^2 \checkmark}$$
$$= \sqrt{48400 + 3600 + 160000}$$
$$= \sqrt{212000}$$
$$= 460{,}43\text{ mm} \checkmark \approx 460\text{ mm} \checkmark$$

(5)

11.2 **Truncated cone:**



11.2.1 **True length of A-B:**

$$\text{True length}(A-B) = \frac{\pi D}{12} \checkmark$$
$$= \frac{\pi \times 600}{12} \checkmark$$
$$= \frac{1884,96}{12} \checkmark$$
$$= 157,08 \text{ mm} \checkmark \approx 157 \text{ mm} \checkmark$$

(5)

11.2.2 **Circumference of the top circle:**

$$\text{Circumference of top circle} = \pi \times D \checkmark$$
$$= \pi \times 400 \checkmark$$
$$= 1256,64 \text{ mm} \checkmark \approx 1257 \text{mm} \checkmark$$

(4)

11.2.3 600 ✓ mm. ✓ (2)

[21]

TOTAL: 200