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# **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**

**2022**

**MARKING GUIDELINES**

**MARKS: 200**

**These marking guidelines consist of 19 pages.**

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)**

- |     |     |            |
|-----|-----|------------|
| 1.1 | A ✓ | (1)        |
| 1.2 | B ✓ | (1)        |
| 1.3 | C ✓ | (1)        |
| 1.4 | D ✓ | (1)        |
| 1.5 | A ✓ | (1)        |
| 1.6 | C ✓ | (1)        |
|     |     | <b>[6]</b> |

**QUESTION 2: SAFETY (GENERIC)****2.1 Rated speed of a grinding wheel:**

- Because the wheel could burst/break if it turns faster than its revolution range. / Avoid an accident. ✓
- Effectiveness of the grinding process will be compromised. ✓ **(Any 1 x 1)** (1)

**2.2 Safety precautions of a band saw in operation:**

- Never leave the band saw unattended. ✓
- Use a push stick when cutting. ✓
- Hold the work piece firmly and flat on the table. ✓
- Don't adjust the machine while working. ✓
- Don't open any guard while the machine is on. ✓
- Make relief cuts before cutting tight curves. ✓
- Don't force the material into the blade. ✓
- Keep hands clear from the action point. ✓
- Keep hands braced against the table. ✓
- Keep your hands on either sides of the blade and not in line with the cutting line and the blade. ✓
- Keep loose clothing clear from action point. ✓ **(Any 2 x 1)** (2)

**2.3 Stages in which first aid is applied:**

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

**2.4 Causes of accidents:**

- Unsafe acts ✓
- Unsafe conditions ✓ (2)

**2.5 TWO advantages of the product layout:**

- Handling of material is kept 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. ✓ **(Any 2 x 1)** (2)
- [10]**

**QUESTION 3: MATERIALS (GENERIC)****3.1 Tempering:**

Tempering is a process generally applied to steel to relieve the strains/brittleness/improve ductility ✓ induced during the hardening process. ✓

(2)

**3.2 Annealing:**

- To relieve internal stresses ✓ that may have been set up during working of metal.
- To soften steel ✓ in order to facilitate the machining process.
- To refine their grain structure. ✓
- Reduce brittleness. ✓
- Make the steel ductile. ✓

(Any 3 x 1) (3)

**3.3 Normalising temperature:**

- Above ✓ higher/upper critical temperature ✓
- Above ✓ AC<sub>3</sub> line. ✓

(Any 1 x 2) (2)

**3.4 Spark pattern for carbon steels:**

3.4.1 High-carbon steel ✓ (1)

3.4.2 Low-carbon steel / Mild steel ✓ (1)

3.4.3 Cast-iron ✓ (1)

**3.5 Carbon diagram:**

- A. Temperature range / °C ✓
- B. AC<sub>3</sub> line / Higher/upper critical temperature line ✓
- C. AC<sub>1</sub> line / Lower critical temperature line ✓
- D. Carbon content / % carbon ✓

(4)  
[14]

**QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)**

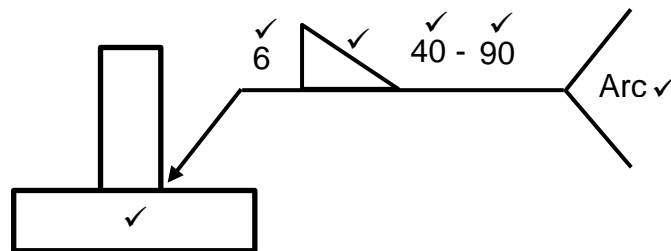
4.1	A ✓	(1)
4.2	C ✓	(1)
4.3	A ✓	(1)
4.4	A ✓	(1)
4.5	A ✓	(1)
4.6	C ✓	(1)
4.7	D ✓	(1)
4.8	D ✓	(1)
4.9	D ✓	(1)
4.10	C ✓	(1)
4.11	C ✓	(1)
4.12	B ✓	(1)
4.13	A ✓	(1)
4.14	D ✓	(1)
		<b>[14]</b>

**QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)****5.1 Template machine tools:**

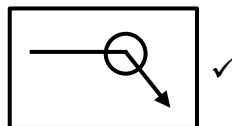
- Planer ✓
- Circular saw ✓
- Drilling machine ✓
- Jig saw ✓
- Sanding machine ✓
- Shears for cutting cardboard ✓
- Any other appropriate machine tools. ✓

**(Any 4 x 1) (4)****5.2 Roof truss:**

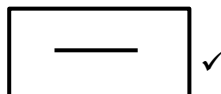
- A. Purlin ✓
- B. Rafter ✓
- C. Bracing member ✓
- D. Main tie / Tie beam ✓
- E. Gusset plate ✓

**(5)****5.3 Welding Symbol:****(6)****5.4 Supplementary symbols:**

5.4.1

**(1)**

5.4.2

**(1)**

5.4.3

**(1)**

5.5 **Steel ring material:**

Mean  $\varnothing$  = Outside Diameter – plate thickness

$$\begin{aligned} & \checkmark \quad \checkmark \\ &= 600 - 30 \\ &= 570 \text{ mm } \checkmark \end{aligned}$$

Mean circumference =  $\pi \times \text{mean } \varnothing$

$$\begin{aligned} &= \pi \times 570 \quad \checkmark \\ &= 1790,71 \text{ mm} \end{aligned}$$

$$\begin{aligned} & \text{OR} \quad \checkmark \\ &= 1791 \text{ mm} \end{aligned}$$

(5)  
[23]



**QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)****6.1 Manual guillotine:**

A – Spring loaded down pedal/Foot pedal ✓

B – Cutting table ✓

C – Pressure plate/Blade guard ✓

(3)

**6.2 Tap wrenches:**

• T- handle / Double handle tap wrench. ✓

• Single handle tap wrench/Ratchet tap wrench. ✓

(2)

**6.3 Angle grinders:**

• Cutting ✓

• Grinding ✓

• Polishing ✓

• Sanding ✓

**(Any 3 x 1)**

(3)

**6.4 Advantages of Inverter:**

Inverters are able to weld a wider variety ✓ of materials ✓ than conventional AC welding machines.

(2)

**6.5 Spot welding:**

• Does not use consumable electrodes ✓

• Efficient ✓

• Quick welding process ✓

• Ideal for mass production ✓

• Cost effective ✓

• Ideal for lightweight/thinner material ✓

• It can be used on a variety of metals ✓

• Ensure uniform joints ✓

**(Any 2 x 1)**

(2)

**6.6 MIG welding procedures:**

• Forehand ✓

• Perpendicular ✓

• Backhand ✓

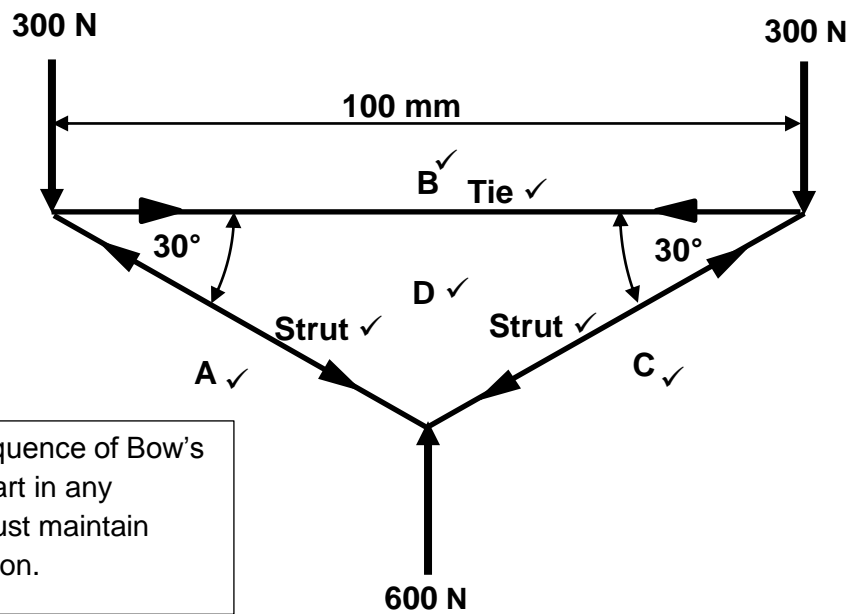
(3)

**6.7 Plasma cutting:**

Plasma cutting is a process that cuts through electrically conductive ✓ material by means of an accelerated jet ✓ of hot plasma. ✓

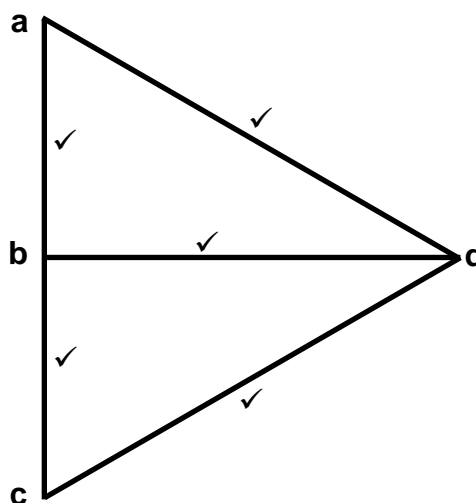
(3)

**[18]**

**QUESTION 7: FORCES (SPECIFIC)****7.1 Steel framework:****7.1.1 Space diagram:****SCALE: 10 mm = 1 m**

**NOTE:** The sequence of Bow's notation can start in any position, but must maintain clockwise rotation.

(7)

**7.1.2****Vector diagram:****SCALE: 1 mm = 10 N**

MEMBER	MAGNITUDE
BD	510 N ✓
CD	590 N ✓
AD	590 N ✓

**NB:** Marker must redraw the diagrams according to the given scale.  
When marking, use a tolerance of  $\pm 2$  mm.

(8)

**7.2 Stress and Strain:****7.2.1 Cross sectional area:**

$$\text{Area} = \frac{\pi(D^2 - d^2)}{4}$$

$$= \frac{\pi(0,06^2 - 0,05^2)}{4}$$

$$= 8,64 \times 10^{-4} \text{ m}^2$$

(3)

**7.2.2 Stress:**

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

$$= \frac{500}{8,639 \times 10^{-4}}$$

$$= 578770,6911 \text{ Pa}$$

$$= 0,58 \text{ MPa}$$

(3)

**7.2.3 Strain:**

$$E = \frac{\text{Stress}}{\text{Strain}}$$

$$\text{Strain} = \frac{\text{Stress}}{E}$$

$$= \frac{578770,6911}{90 \times 10^9}$$

$$= 6,43 \times 10^{-6}$$

(4)

## 7.3 Moments:

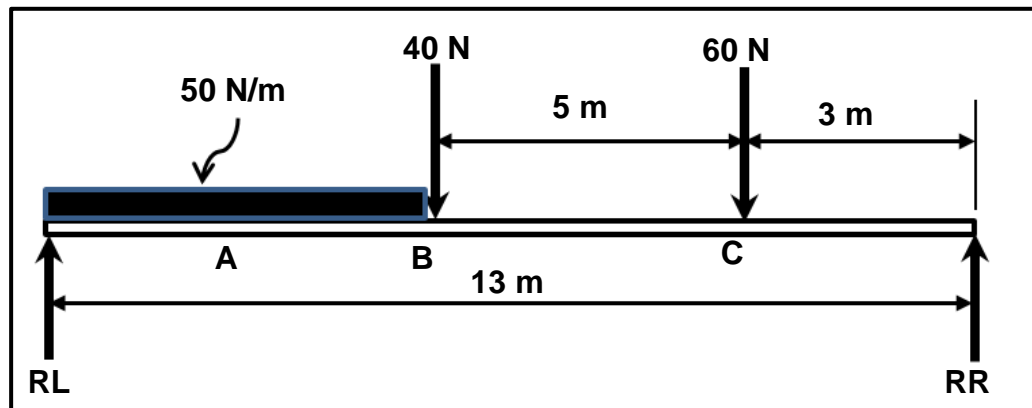


FIGURE 7.3

## 7.3.1 Reactions at LR and RR:

Calculate LR

Take moments about RR

$$\Sigma RHM = \Sigma LHM$$

$$\begin{aligned} LR \times 13 &= (250 \times 10,5) + (40 \times 8) + (60 \times 3) \\ &= 2625 + 320 + 180 \\ &= \frac{3125}{13} \\ LR &= 240,38 \text{ N } \checkmark \end{aligned}$$

Calculate RR

Take moments about LR

$$\Sigma LHM = \Sigma RHM$$

$$\begin{aligned} RR \times 13 &= (60 \times 10) + (40 \times 5) + (250 \times 2,5) \\ &= 600 + 200 + 625 \\ &= \frac{1425}{13} \\ RR &= 109,62 \text{ N } \checkmark \end{aligned}$$

(8)

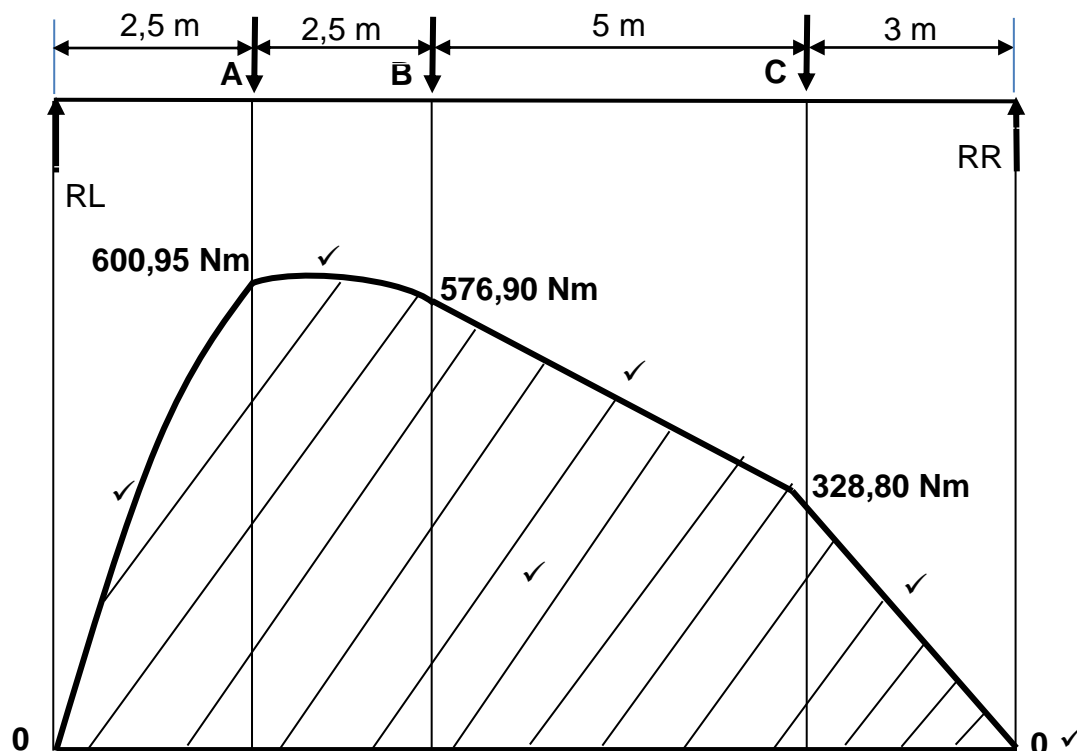
**7.3.2 BENDING MOMENTS:**

$$\begin{aligned} BM_A &= (240,38 \times 2,5) \checkmark \\ &= 600,95 \text{ Nm} \checkmark \end{aligned}$$

$$\begin{aligned} BM_B &= (240,38 \times 5) - (250 \times 2,5) \checkmark \\ &= 1201,90 - 625 \\ &= 576,90 \text{ Nm} \checkmark \end{aligned}$$

$$\begin{aligned} BM_C &= (240,38 \times 10) - (250 \times 7,5) - (40 \times 5) \checkmark \\ &= 2403,8 - 1875 - 200 \\ &= 328,80 \text{ Nm} \checkmark \end{aligned}$$

(6)

**7.3.3 BM diagram:**  
**SCALE: 1 mm = 10 Nm****NB:** Marker must redraw the diagrams according to the given scale.

(6)

**[45]**

**QUESTION 8: JOINING METHODS (INSPECTION OF WELDS) (SPECIFIC)****8.1 Weld gauge:**

To check:

- angle of preparation. ✓
- weld alignment. ✓
- fillet weld leg length/dimensions. ✓
- excess weld metal. ✓
- fillet weld throat. ✓
- undercut. ✓
- for porosity. ✓

**(Any 4 x 1) (4)****8.2 Causes of welding defects:****8.2.1 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)****8.2.2 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)**

**8.3 Prevention of welding defects:****8.3.1 Porosity:**

- Cleaning the welding surface ✓
- Ensuring that arc welding electrodes are dry ✓
- Do not welding in a windy condition ✓
- Insufficient root gap ✓
- Ensure that the shielding gas supply is not interrupted ✓
- Use correct type of electrode ✓
- Reduce arc distance/length ✓
- Reduce arc travel speed ✓

**(Any 2 x 1) (2)****8.3.2 Undercutting:**

- Maintain correct arc travel speed. ✓
- By raising arc voltage. ✓
- Using a leading electrode/torch angle. ✓
- Reduce arc length ✓

**(Any 2 x 1) (2)****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 Weld craters:**

- Formed at the end of a weld run ✓ when the electrode ✓ is removed too soon. ✓
- Not allowing ✓ enough filler ✓ material to fill the crater. ✓
- Having ✓ a too big/erratic ✓ weaving action. ✓

**(Any 1 x 3) (3)****8.6 Nick-break test:**

- Make a hacksaw cut at both edges, through the center of the weld. ✓
- Place specimen on two supports/bench vice. ✓
- 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 (or other welding defects). ✓

**(5)  
[23]**

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

- 9.1 **Elastic deformation:**  
It is the ability of a joint/material to return to its original position/dimensions ✓ after the stresses have been relieved. ✓ (2)
- 9.2 **Shrinkage on steel:**  
It is a form of plastic deformation where the metal has deformed ✓ as a result of contraction on cooling. ✓ (2)
- 9.3 **Distortion:**
- 9.3.1 Transverse shrinkage ✓ (1)
- 9.3.2 Longitudinal shrinkage ✓ (1)
- 9.4 **Effects of shrinkage:**
- 9.4.1 **Electrode size:**
- Larger electrode size ✓ requires higher current and causes higher welding temperature ✓ that causes more deformation / shrinkage.
  - Smaller electrode size ✓ requires lower current and causes lower welding temperature ✓ that causes less deformation / shrinkage. (Any 1 x 2) (2)
- 9.4.2 **Welding speed:**
- Decreased ✓ welding speed tends to increase localised heat that increases distortion. ✓
  - Increased ✓ welding speed tends to decrease localised heat that decreases distortion. ✓ (Any 1 x 2) (2)
- 9.5 **Disadvantages of using jigs:**  
It increases ✓ internal stresses ✓ in the welded joint because the metal's movement is restricted. ✓ (3)
- 9.6 **Carbon composition of steels:**
- 9.6.1 **Tool steel:**
- 0,71 – 1,5% ✓ (1)
- 9.6.2 **Spring steel:**
- 0,31 – 0,70% ✓ (1)
- 9.6.3 **Mild steel:**
- 0,07 – 0,30% ✓ (1)



9.7 **Quenching mediums:**

- Water ✓
- Oil ✓
- Brine (salt and water) ✓
- Molten metal salts ✓
- Sand ✓
- Air ✓
- Ash ✓
- Lime ✓
- Molten lead ✓
- Infused nitrogen air ✓

(Any 2 x 1)

(2)  
[18]

**QUESTION 10: MAINTENANCE (SPECIFIC)****10.1 Insufficient lubrication:****Pedestal drill:**

- Rusting of components will occur ✓
- Movement between parts will be affected ✓
- Excessive wear and seizure of moving parts ✓
- Excessive heat generation ✓

**(Any 3 x 1) (3)****10.2 Overloading on a bench grinding machine:**

- Resulting in malfunction of the machine ✓
- Excessive wear and reduction of machine lifespan ✓
- Damage to grinding wheel ✓
- Damage to bearing on shaft ✓
- Damage to workpiece ✓

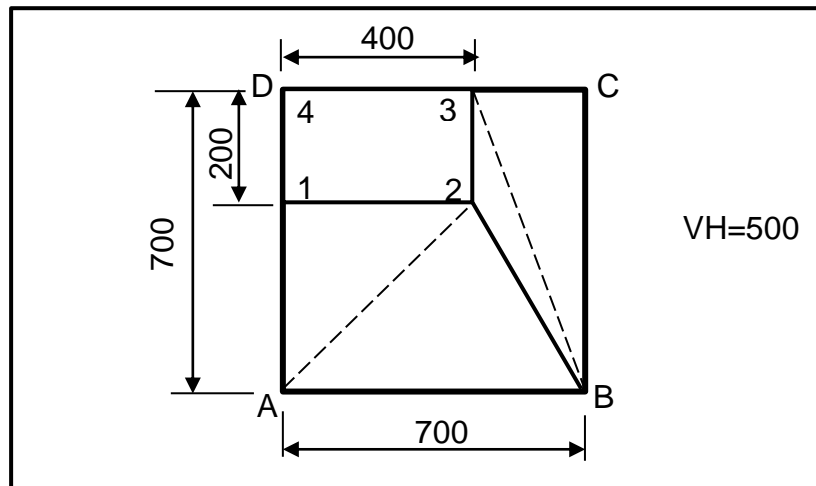
**(Any 3 x 1) (3)****10.3 General maintenance guidelines:**

- The machine should be tested for correct operation. ✓
- All guards must be in place and serviceable. ✓
- The machine must be securely fixed to the floor. ✓
- All bolts, nuts and grub screws must be in place and tight. ✓
- The machine must be in a clean condition. ✓
- Lubrication points should be serviced. ✓
- All moving parts should move freely. ✓

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

**QUESTION 11: TERMINOLOGY (DEVELOPMENTS) (SPECIFIC)****11.1 Transformers:**

Transformers are used to connect ✓ ducting sections ✓ of dissimilar shapes ✓ to each other. (3)

**11.2 Hopper:**

11.2.1 Square to rectangular ✓ hopper off ✓ centre (2)

**11.2.2 True length A-2:**

$$\begin{aligned}
 A-2 &= \sqrt{500^2 + 400^2 + 500^2} \\
 &= \sqrt{250000 + 160000 + 250000} \quad \checkmark \\
 &= 812,4 \text{ mm} \quad \checkmark
 \end{aligned}$$

(5)

**11.2.3 True length B-2:**

$$\begin{aligned}
 B-2 &= \sqrt{500^2 + 300^2 + 500^2} \\
 &= \sqrt{250000 + 90000 + 250000} \quad \checkmark \\
 &= 768,11 \text{ mm} \quad \checkmark
 \end{aligned}$$

(5)

**11.3 Truncated cone:****11.3.1 True length: A- B:**

$$\begin{aligned}
 A-B &= \frac{\pi \times D}{12} \checkmark \\
 &= \frac{\pi \times 920}{12} \checkmark \\
 &= 240,85 \text{ mm} \\
 &= 241 \text{ mm} \checkmark
 \end{aligned}$$

(3)

**11.3.2 True length: 0-1:**

$$\begin{aligned}
 0-1 &= \frac{\pi \times D}{12} \checkmark \\
 &= \frac{\pi \times 860}{12} \checkmark \\
 &= 225,15 \text{ mm} \\
 &= 225 \text{ mm} \checkmark
 \end{aligned}$$

(3)  
[21]**TOTAL: 200**