basic education

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)
**[6]**

## 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 ✓ $AC_3$ 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. $AC_3$ line / Higher/upper critical temperature line ✓
C. $AC_1$ 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) |

**[14]**

## QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

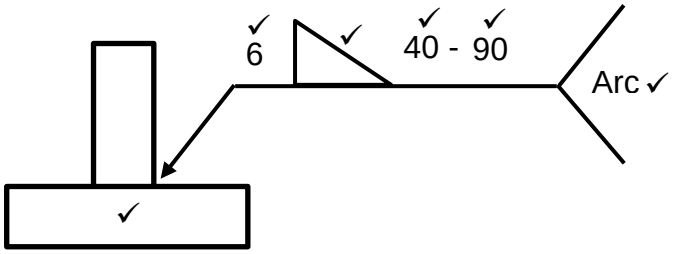
5.1 **Template machine tools:**

- 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)

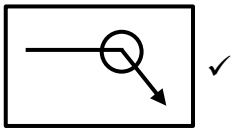
5.3 **Welding Symbol:**




(6)

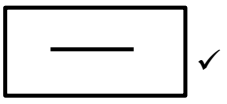
5.4 **Supplementary symbols:**

5.4.1



(1)

5.4.2



(1)

5.4.3


(1)

5.5 **Steel ring material:**

$$\text{Mean } Ø = \text{Outside Diameter} - \text{plate thickness}$$

✓ ✓

$$= 600 - 30$$

$$= 570 \text{ mm} \quad ✓$$

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

$$= \pi \times 570 \quad ✓$$

$$= 1790{,}71 \text{ mm}$$

OR ✓

$$= 1791 \text{ mm}$$

(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)

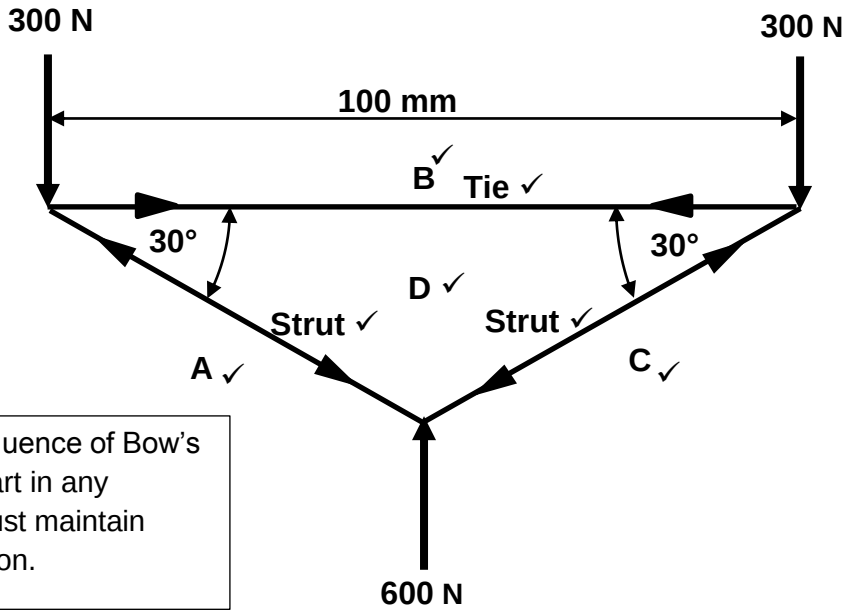
6.6 **MIG welding procedures:**
- Forehand ✓
- Perpendicular ✓
- Backhand ✓ (3)

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**

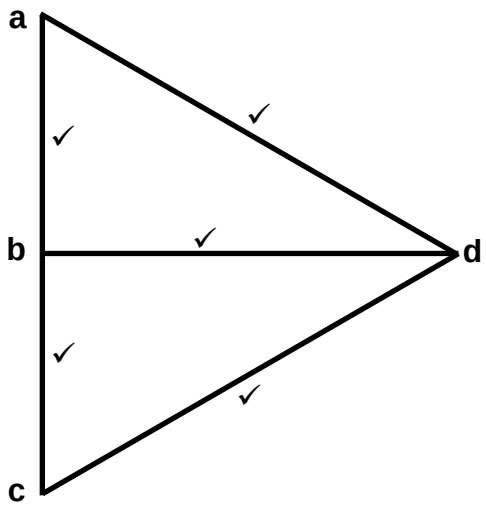



**NOTE:** The sequence of Bow's notation can start in any position, but must maintain clockwise rotation.

(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 ±2 mm. (8)

7.2 **Stress and Strain:**

7.2.1 **Cross sectional area:**

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

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

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

(3)

7.2.2 **Stress:**

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

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

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

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

(3)

7.2.3 **Strain:**

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

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

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

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

(4)

7.3 **Moments:**

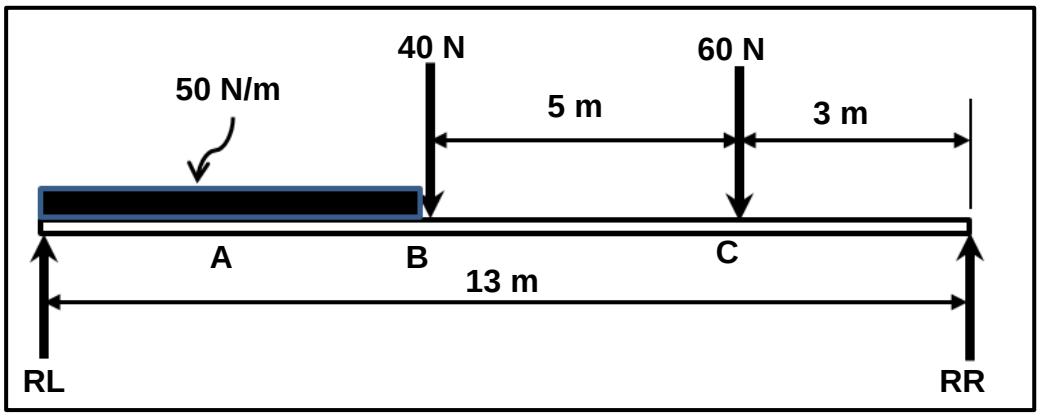



**FIGURE 7.3**

7.3.1 **Reactions at LR and RR:**
**Calculate LR**
**Take moments about RR**

$$\Sigma RHM = \Sigma LHM$$

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

**Calculate RR**
**Take moments about LR**

$$\Sigma LHM = \Sigma RHM$$

$$RR \times 13 = (60 \times 10) + (40 \times 5) + (250 \times 2{,}5) \quad \checkmark\checkmark\checkmark$$
$$= 600 + 200 + 625$$
$$= \frac{1425}{13}$$
$$RR = 109{,}62\,N \quad \checkmark$$ (8)

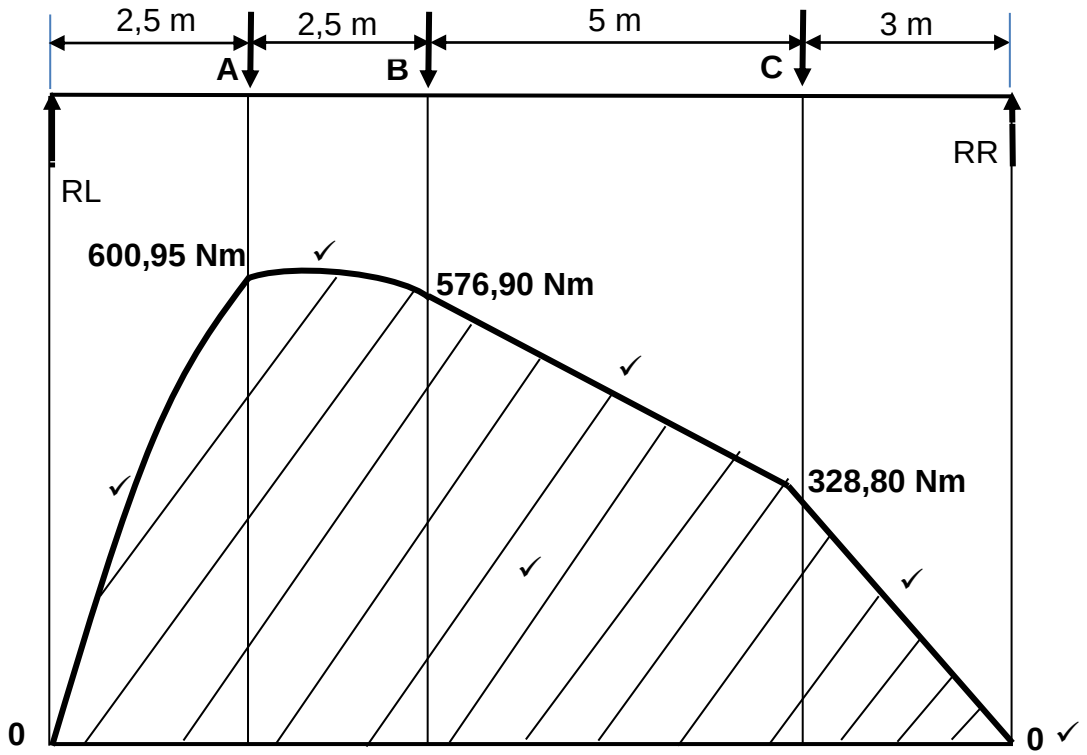
7.3.2 **BENDING MOMENTS:**

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

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

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

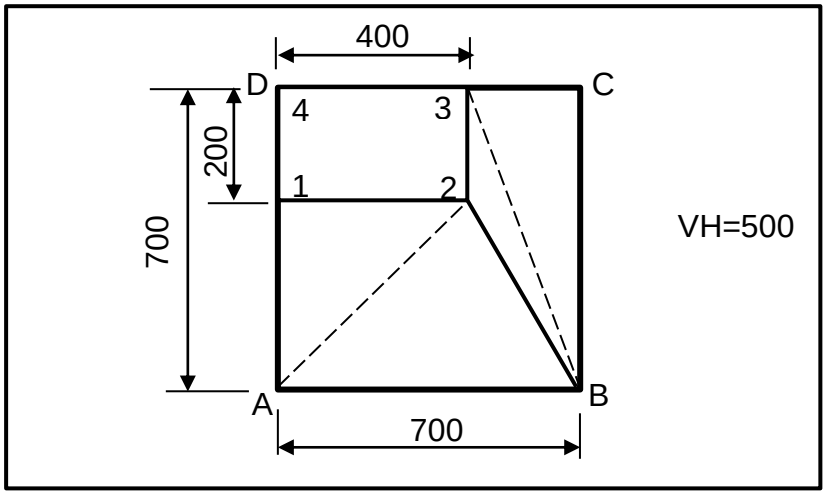
- The machine should be tested for correct operation.✓
- All guards must be in place and serviceable. ✓
- The machine must be securely fixed to the floor. ✓
- All bolts, nuts and grub screws must be in place and tight. ✓
- The machine must be in a clean condition. ✓
- Lubrication points should be serviced.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

$$A-2=\sqrt{500^2\ +400^2\ +500^2}\quad (\checkmark\ \checkmark\ \checkmark)$$
$$=\sqrt{250000+160000+250000}\ \checkmark$$
$$=812{,}4\ mm\ \checkmark$$

(5)

11.2.3 **True length B-2:**

$$B-2=\sqrt{500^2\ +300^2\ +500^2}\quad (\checkmark\ \checkmark\ \checkmark)$$
$$=\sqrt{250000+90000+250000}\ \checkmark$$
$$=768{,}11mm\ \checkmark$$

(5)

11.3 **Truncated cone:**

11.3.1 **True length: A- B:**

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

(3)

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

$$0-1 = \frac{\pi \times D}{12} \checkmark$$
$$= \frac{\pi \times 860}{12} \checkmark$$
$$= 225,15\,mm$$
$$= 225\ mm \checkmark$$

(3)
**[21]**

**TOTAL: 200**