basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

NOVEMBER 2023

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 22 pages.

QUESTION 1: MULTIPLE-CHOICE (GENERIC)

1.1 B ✓ (1)

1.2 A ✓ (1)

1.3 C ✓ (1)

1.4 C ✓ (1)

1.5 A ✓ (1)

1.6 B ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Examination checks:**

- Severe bleeding ✓
- Internal bleeding ✓
- Head injuries ✓
- Neck injuries ✓
- Fractures ✓
- Vital signs ✓
- Physical abnormalities ✓

(Any 2 x 1) (2)

2.2 **Safety devices on the power-driven guillotine:**

- Finger protectors / Fixed guards / Blade guard ✓
- Rear view mirrors ✓
- Rear light curtains ✓
- Automatic sweep-away ✓
- Revolving warning lights ✓
- Two-hand / dual control device ✓
- Additional emergency buttons ✓
- Self-adjusting guards ✓
- Covered footswitch ✓

(Any 2 x 1) (2)

2.3 **Grinding wheel:**

- The wheel should be rated above the speed of the motor. ✓
- Check for cracks on the grinding wheel. ✓
- Check for chips on the grinding wheel. ✓
- Check that the arbor hole is the correct size. ✓
- Must not be contaminated by oil/fluids or grease. ✓
- Correct size of the wheel. ✓
- Correct type of wheel for the material. ✓

(Any 2 x 1) (2)

2.4 **Gas welding equipment – safety devices:**

- Valve guard ✓
- Flash back arrestor ✓
- Pressure regulator ✓
- C-clamps on hoses/Parallel hose clips ✓
- Acetylene spindle key must always be in place. ✓
- Cylinder valves. ✓

(Any 2 x 1) (2)

2.5 **Advantages of process layout of machines are:**

- High machine utilisation. ✓
- Better supervision. ✓
- Less interruption in the flow of work. ✓
- Lower equipment costs. ✓
- Better control of total manufacturing costs. ✓
- Greater flexibility. ✓

(Any 2 x 1) (2)

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QUESTION 3: MATERIALS (GENERIC)

3.1 **Colour code of metal:**

- To identify the type of metal. ✓
- To identify carbon content especially after the metal was stored. ✓
- To identify the profile/size of the metal. ✓

(Any 1 x 1) (1)

3.2 **Tests to determine properties of steel:**

3.2.1 **Sound test:**

- Hardness ✓
- Softness ✓

(Any 1 x 1) (1)

3.2.2 **Bending test:**

- Ductility ✓
- Bend strength ✓
- Fracture strength ✓
- Resistance to fracture
- Brittleness ✓
- Elasticity ✓
- Plasticity ✓
- Flexibility ✓

(Any 1 x 1) (1)

3.2.3 **Machining test:**

- Hardness ✓
- Strength ✓

(Any 1 x 1) (1)

3.3 **Reasons metal soaked during heat treatment:**

- To ensure uniform heat distribution ✓ throughout the metal. ✓
- To achieve a uniform grain structure ✓ after cooling the metal. ✓

(Any 1 x 2) (2)

3.4 **Case hardening:**

- Carburising ✓
- Nitriding ✓
- Cyaniding ✓

(Any 2 x 1) (2)

3.5 **Annealing process:**

Heating the steel slightly above AC_3, (upper critical temperature) ✓ soaking it for a required time/period ✓ and then slow cooling ✓ back to room temperature. (3)

3.6 **Rapid quenching mediums:**

- Brine/Salt water ✓
- Water ✓
- Nitrogen ✓
- Oil ✓

(Any 2 x 1) (2)

3.7 **Heat treatment process:**

Tempering ✓ (1)

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QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

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QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

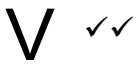
5.1 **Brass ring calculations:**

5.1.1 $\text{Mean Ø} = \text{Inside Ø} + \text{Plate thickness}$
$= 870 + 30$ ✓
$= 900\,\text{mm}$ ✓ (2)

5.1.2 $\text{Mean circumference} = \pi \times \text{Mean Ø}$
$= \pi \times 900$ ✓
$= 2827{,}43$ ✓
$= 2827\,\text{mm}$ ✓ (3)

5.2 **Fusion weld symbols: (Symbols can be presented in any direction)**

5.2.1 Square butt  ✓✓ (2)

5.2.2 V groove  ✓✓ (2)

5.2.3 U butt  ✓✓ (2)

5.2.4 J butt  ✓✓ (2)

5.2.5 Flare-V  ✓✓ (2)

5.3 **Weld symbol:**

5.3.1 T-joint ✓ (1)

5.3.2 **Labels:**
A – Weld all around ✓
B – Site weld ✓
C – Fillet weld ✓
D – Tail ✓
E – Pitch of weld ✓
F – Length of weld ✓
G – Size of weld ✓ (7)

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QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Types of metal:**

- Carbon steel/Steel ✓
- Aluminum ✓
- Brass ✓
- Copper ✓
- Cast iron ✓
- Cast steel ✓
- Stainless steel ✓
- Tool steel ✓

(Any 3 x 1) (3)

6.2 **Bench grinder:**

- Polishing ✓
- Sharpening of cutting tools and drill bits. ✓
- To remove rough edges. ✓
- To remove excess material. ✓
- Buffing ✓
- Removing rust from metal. ✓

(Any 3 x 1) (3)

6.3 **Arc welding:**

6.3.1 **Labels of arc welding set up:**

A - Arc welding machine / Power source / Inverter ✓
B - Electrode / Welding rod ✓
C - Electrode holder / Welding rod holder✓
D - Positive- / negative cable / Electrode cable✓
E - Earth cable / negative cable / positive cable ✓ (5)

6.3.2 **Advantages of MIGS/MAGS welding:**

- Less distortion. ✓
- MIG/MAGS welding quality is better. ✓
- Fewer stops and starts. ✓
- MIG/MAGS works with many metals or alloys. ✓
- Greater deposition rates. ✓
- Less post welding cleaning (no slag to chip off weld). ✓
- Better weld pool visibility. ✓
- No stub end losses or wasted man hours caused by changing electrodes. ✓
- Low skill required to operate MIG/MAGS welding gun. ✓
- Can weld in any position. ✓
- The process is easily automated. ✓
- No fluxes required in most cases. ✓

(Any 1 x 1) (1)

6. 4 **Drill size:**

Drill size = Outside Ø - Pitch

✓ ✓

Drill size = 10 -1,5

= 8,5 mm ✓ (3)

6.5 **Rolling machines:**

- Off-set pinch rolls ✓
- Horizontal pyramid rolls ✓
- Vertical rolls ✓ (3)

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QUESTION 7: FORCES (SPECIFIC)

7.1 **Beams:**

7.1.1 **Reaction RR:**
Take moment about (RL):

$$RR \times 7 = (4 \times 1{,}5) + (5 \times 3{,}5) + (3 \times 5{,}5) \quad \checkmark \checkmark \checkmark$$
$$= 6 + 17{,}5 + 16{,}5$$
$$= 40$$
$$\therefore RR = \frac{40\,Nm}{7m}$$
$$RR = 5{,}71N \checkmark$$

Reaction RL:
Take moment about (RR):

$$RL \times 7 = (3 \times 1{,}5) + (5 \times 3{,}5) + (4 \times 5{,}5) \quad \checkmark \checkmark \checkmark$$
$$= 4{,}5 + 17{,}5 + 22$$
$$= 44$$
$$\therefore RL = \frac{44\,Nm}{7m}$$
$$RL = 6{,}29N \checkmark$$ (8)

7.1.2 **Bending moments:**

BM_A = (6,29 N x 1,5 m) – (4 N x 0m) ✓ = 9,44 Nm ✓

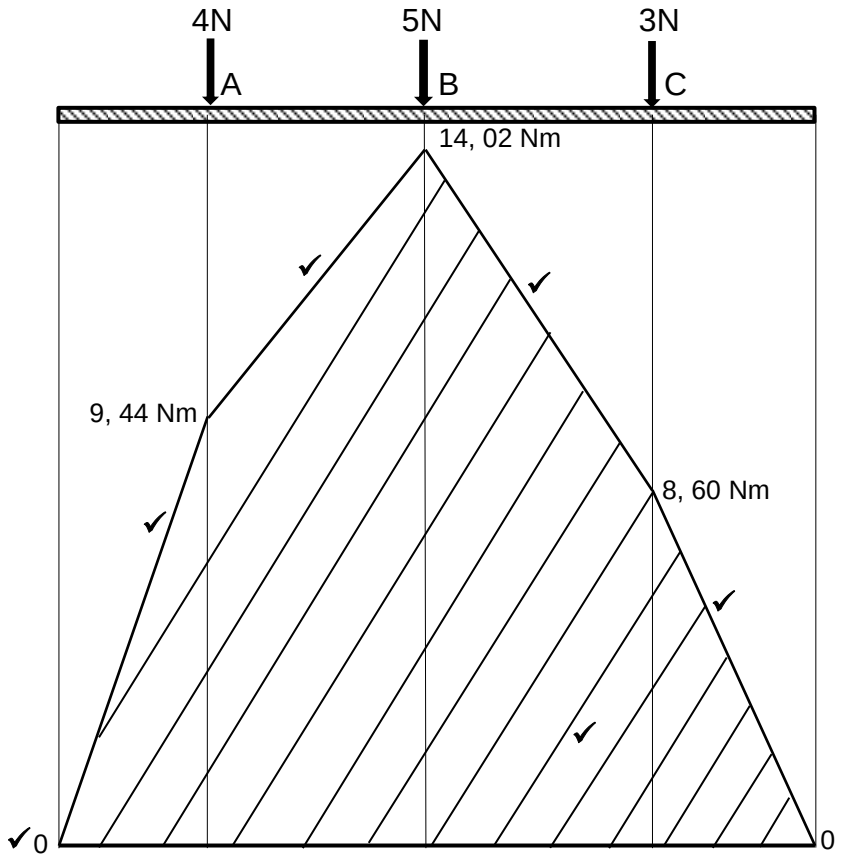
BM_B = (6,29 N x 3,5 m) – (4 N x 2 m) – (5 N x 0 m) ✓

= 14,02 Nm ✓

BM_C = (6,29 N x 5,5 m) – (4 N x 4 m) – (5 N x 2m) – (3 N x 0 m) ✓

= 8,60 Nm ✓ (6)

7.1.3 Bending moment diagram. Scale: 1 m = 10 mm and 1 Nm = 10 mm.



Note to marker:
Marker must redraw the bending moment diagram according to the scales for marking purposes.

(6)

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7.2 Stress and Strain:

7.2.1 Area of the bar:

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

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

$$= \frac{65 \times 10^3}{5 \times 10^6} \checkmark$$

$$= 13 \times 10^{-3} m^2 \checkmark \quad (3)$$

7.2.2 Diameter of a bar:

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

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

$$= \sqrt{\frac{4\left(13 \times 10^{-3}\right)}{\pi}} \checkmark$$

$$= 0{,}128655019 \text{ m}$$

$$= 128{,}66 \text{ mm} \checkmark \quad (3)$$

7.2.3 Strain:

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

$$\varepsilon = \frac{5 \times 10^6}{75 \times 10^9} \checkmark$$

$$= 6{,}67 \times 10^{-5} \checkmark \quad (2)$$

7.2.4 Change in length:

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

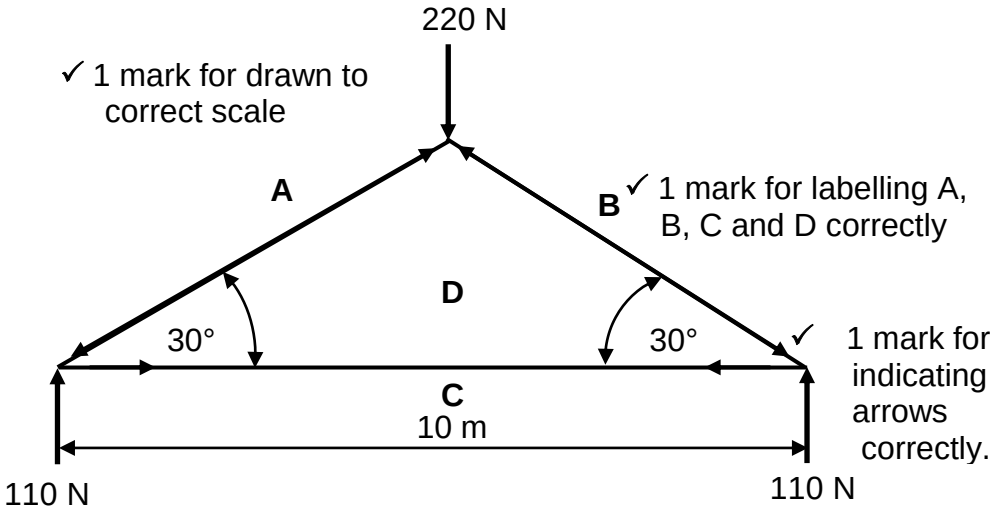
$$\Delta L = \varepsilon \times OL \checkmark$$

$$= \left(6{,}67 \times 10^{-5}\right) \times 250 \text{ mm} \checkmark$$

$$= 0{,}02 \text{ mm} \checkmark \quad (3)$$

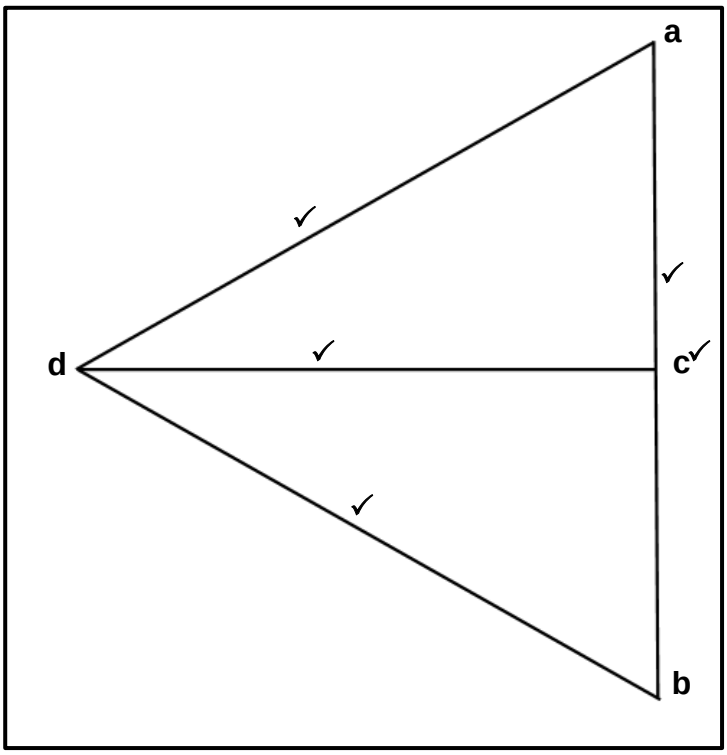
7.3 **Simple frame:**

7.3.1 **Space diagram:**



NOTE: Draw to scale on transparency for marking purpose
. Mark allocation is for indication of arrows. (3)

7. 3.2 **Vector diagram: Scale 1 mm = 2 N**



NOTE: Draw to scale on transparency for marking purpose. (5)

7.3.3 **Magnitude and nature of force:**

Member	**Force (N)**	**Nature**
AD	220 (216-224) ✓	Strut ✓
BD	220 (216-224) ✓	Strut ✓
CD	190 (186-194) ✓	Tie ✓

NOTE TO A MARKER:
ALLOW FOR A DEVIATION OF 2 mm (UP OR DOWNWARDS). (6)

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

8.1 **Weld defects:**

8.1.1 Slag inclusion ✓ (1)

8.1.2 Incomplete penetration ✓ (1)

8.2 **Inspection of welds:**
- To check for weld quality. ✓
- To check for specification. ✓ (2)

8.3 **Welding defects:**

8.3.1 **Nick break test:**
- Lack of fusion ✓
- Internal quality ✓
- Porosity ✓
- Slag inclusion ✓
- Oxidized / burnt metal ✓
- Incomplete penetration ✓

(Any 2 x 1) (2)

8.3.2 **Guided bend test:**
- Quality of face of the weld joint. ✓
- Quality of root of the weld joint. ✓
- Degree of penetration. ✓
- Degree of fusion. ✓

(Any 2 x 1) (2)

8.4 **Non-destructive test:**
It is a method of testing a welded joint without destroying ✓ the finished product. ✓ (2)

8.5 **Transverse cracks:**
- Preheat the base metal. ✓
- Using lower strength consumables. ✓
- Slow cooling after weld. ✓ (3)

8.6 **Crater crack:**
- It is caused by lack of filler at the end of the weld. ✓
- Metal of not good weldability ✓

(Any 1 x 1) (1)

8.7 **Advantages of liquid dye penetrant test:**

- Low cost. ✓
- Easy to apply. ✓
- Easy to interpret. ✓
- Minimal training required. ✓
- Good for ferrous metals. ✓
- Good for non-ferrous metals. ✓
- Can be used in complex shapes/areas. ✓
- It is non-destructive. ✓

(Any 3 x 1) (3)

8.8 **Ultrasonic test**

- Clean the area on the metal to be tested. ✓
- Calibrate the equipment before commencement of testing. ✓
- Apply gel, oil or water to the area on the metal to be tested. ✓
- Move probe left-to-right along the area on the metal. ✓
- Soundwaves is sent and received by the equipment. ✓
- Interpret the flaws detected on oscilloscope. ✓ (6)

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

9.1 **Factors having effect on shrinkage:**

- Electrode type. ✓
- Electrode size. ✓
- Welding current. ✓
- Flame size. ✓
- Welding speed. ✓
- Rate of cooling during welding. ✓
- Rate of cooling after welding. ✓
- Workpiece size / thickness. ✓

(Any 3 x 1) (3)

9.2 **Peening:**

- A way to counteract ✓ the shrinkage forces of a weld bead as it cools. ✓
- It is a technique used in welding ✓ to help strengthen the joint. ✓
- It is the hammering ✓ of the weld immediately after welding ✓ is done.

(Any 1 x 2) (2)

9.3 **Types of strongbacks:**

- Clips ✓
- Yokes ✓

(2)

9.4 **Effect of hot working on steel:**

- In hot working, deformation and recrystallization occur simultaneously so that the rate of softening is greater than work hardening. ✓
- The important factor in hot-working is the finishing temperature. ✓
- Hot-working should be finished at a temperature just above the recrystallization temperature, so that a fine grain structure is obtained. ✓
- If the finishing temperature is too high, grain growth will occur while the metal is cooling above the recrystallization temperature. ✓

(Any 3 x 1) (3)

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

- Heat present in the weld. ✓
- Quality of parent metal. ✓
- Quality of filler rod. ✓
- Quality of 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. ✓
- Freeness of joint to be able to contract. ✓
- Rate of cooling. ✓

(Any 3 x 1) (3)

9.6 **Types of distortions:**

9.6.1 Longitudinal distortion. ✓ (1)

9.6.2 Angular distortion. ✓ (1)

9.7 **Effects of cooling rates:**

- Distortion ✓
- Mechanical properties ✓
- Internal stresses ✓
- Potential cracking ✓

(Any 3 x 1) (3)

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QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 **Lubrication:**

It is the process or technique of using a lubricant ✓ between two surfaces. ✓ (2)

10.2 **Overloading the machine:**

10.2.1 **Punch and shearing machine:**

- Dulling or breaking blades/punches. ✓
- Putting strain on the motor. ✓
- Putting strain on the drive mechanism.
- Machine will stop working. ✓
- Machine will cut out. ✓

(Any 1 x 1) (1)

10.2.2 **Guillotine machine:**

- Damage to the blade. ✓
- Damage to the hydraulic system. ✓
- Damage to the electric motor. ✓
- Machine will stop working. ✓
- Machine will cut out. ✓

(Any 1 x 1) (1)

10.3 **Tagging plates:**

It has multiple holes so that more than one technician ✓ can lock out the machine simultaneously. ✓ (2)

10.4 **Maintenance:**

- Promote cost saving. ✓
- Improves safety. ✓
- Increases equipment efficiency. ✓
- Fewer equipment failure. ✓
- Improves reliability of equipment. ✓

(Any 1 x 1) (1)

10.5 **Friction:**

- By reducing drill speed. ✓
- By reducing feed speed. ✓
- By applying lubricant / (cutting fluid).
- Use sharp drill bit. ✓
- Use correct drill bit. ✓

(Any 1 x 1) (1)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 Square to square Hopper (off centre):

11.1.1 **A–2:**

$$A-2 = \sqrt{180^2 + 350^2 + 400^2} \quad (\checkmark\ \checkmark\ \checkmark)$$
$$= \sqrt{32400 + 122500 + 160000}$$
$$= \sqrt{314900}$$
$$= 561{,}16 \text{ mm} \checkmark$$

(4)

11.1.2 **B–3:**

$$B-3 = \sqrt{410^2 + 150^2 + 400^2} \quad (\checkmark\ \checkmark\ \checkmark)$$
$$= \sqrt{168100 + 22500 + 160000}$$
$$= \sqrt{350600}$$
$$= 592{,}11 \text{ mm} \checkmark$$

(4)

11.1.3 **C–4:**

$$C-4 = \sqrt{380^2 + 90^2 + 400^2} \quad (\checkmark\ \checkmark\ \checkmark)$$
$$= \sqrt{144400 + 8100 + 160000}$$
$$= \sqrt{312500}$$
$$= 559{,}02 \text{ mm} \checkmark$$

(4)

11.2 **Square to round transformer:**

11.2.1 **True length 5–6:**

$$5-6=\frac{\pi\times D}{12}\ \checkmark$$
$$=\frac{\pi\times 500}{12}$$
$$=130{,}90\ \text{mm}\ \checkmark$$

(2)

11.2.2 **True length 3–6:**

$$3-6=\frac{3\times\pi\times D}{12}\ \checkmark$$
$$=\frac{3\times\pi\times 500}{12}\ \checkmark$$
$$=392{,}70\ \text{mm}\ \checkmark$$

OR

$$3-6=\frac{\pi\times D}{4}\ \checkmark$$
$$=\frac{\pi\times 500}{4}\ \checkmark$$
$$=392{,}70\ \text{mm}\ \checkmark$$

(3)

11.2.3 **True length B–6:**

$$B-6=\sqrt{300^2+50^2+400^2}\quad \checkmark\ \checkmark\ \checkmark$$
$$=\sqrt{90000+2500+160000}$$
$$=\sqrt{252500}$$
$$=502{,}49\ \text{mm}\ \checkmark$$

(4)

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TOTAL: 200