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

**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)  
[10]

**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)

**[14]**

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



**QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)****5.1 Brass ring calculations:**

5.1.1 Mean  $\varnothing$  = Inside $\varnothing$  + Plate thickness  
 $= 870 + 30 \checkmark$   
 $= 900 \text{ mm} \checkmark$  (2)


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

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

5.2.1 Square butt   $\checkmark \checkmark$  (2)

5.2.2 V groove   $\checkmark \checkmark$  (2)

5.2.3 U butt   $\checkmark \checkmark$  (2)

5.2.4 J butt   $\checkmark \checkmark$  (2)

5.2.5 Flare-V   $\checkmark \checkmark$  (2)

**5.3 Weld symbol:**

5.3.1 T-joint  $\checkmark$  (1)

**5.3.2 Labels:**

- A – Weld all around  $\checkmark$
- B – Site weld  $\checkmark$
- C – Fillet weld  $\checkmark$
- D – Tail  $\checkmark$
- E – Pitch of weld  $\checkmark$
- F – Length of weld  $\checkmark$
- G – Size of weld  $\checkmark$

(7)  
[23]

**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

$$\begin{aligned}\text{Drill size} &= 10 \overset{\checkmark}{} - 1,5 \overset{\checkmark}{} \\ &= 8,5 \text{ mm } \checkmark\end{aligned}$$

(3)

6.5 **Rolling machines:**

- Off-set pinch rolls ✓
- Horizontal pyramid rolls ✓
- Vertical rolls ✓

(3)

**[18]**

**QUESTION 7: FORCES (SPECIFIC)****7.1 Beams:****7.1.1 Reaction RR:****Take moment about (RL):**

$$\begin{aligned}
 RR \times 7 &= (4 \times 1,5) + (5 \times 3,5) + (3 \times 5,5) \\
 &= 6 + 17,5 + 16,5 \\
 &= 40
 \end{aligned}$$

$$\therefore RR = \frac{40 \text{ Nm}}{7 \text{ m}}$$

$$RR = 5,71 \text{ N} \checkmark$$

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

$$\begin{aligned}
 RL \times 7 &= (3 \times 1,5) + (5 \times 3,5) + (4 \times 5,5) \\
 &= 4,5 + 17,5 + 22 \\
 &= 44
 \end{aligned}$$

$$\therefore RL = \frac{44 \text{ Nm}}{7 \text{ m}}$$

$$RL = 6,29 \text{ N} \checkmark$$

(8)

**7.1.2 Bending moments:**

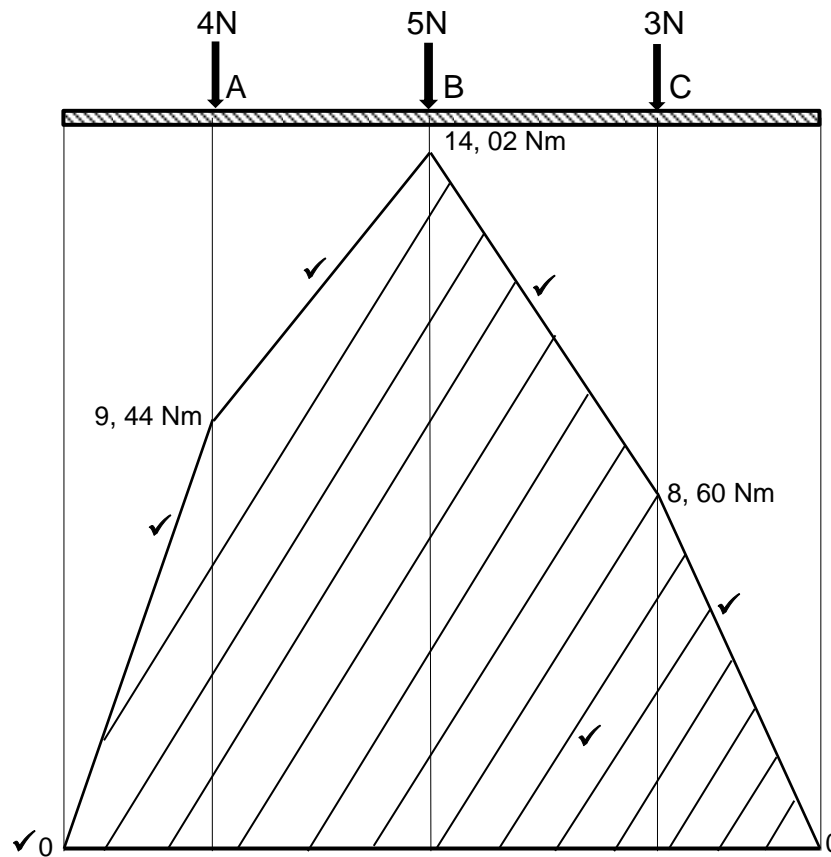
$$BM_A = (6,29 \text{ N} \times 1,5 \text{ m}) - (4 \text{ N} \times 0 \text{ m}) \checkmark = 9,44 \text{ Nm} \checkmark$$

$$\begin{aligned}
 BM_B &= (6,29 \text{ N} \times 3,5 \text{ m}) - (4 \text{ N} \times 2 \text{ m}) - (5 \text{ N} \times 0 \text{ m}) \checkmark \\
 &= 14,02 \text{ Nm} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 BM_C &= (6,29 \text{ N} \times 5,5 \text{ m}) - (4 \text{ N} \times 4 \text{ m}) - (5 \text{ N} \times 2 \text{ m}) - (3 \text{ N} \times 0 \text{ m}) \checkmark \\
 &= 8,60 \text{ Nm} \checkmark
 \end{aligned}$$

(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)

**7.2 Stress and Strain:****7.2.1 Area of the bar:**

$$\begin{aligned}\sigma &= \frac{F}{A} \\ A &= \frac{F}{\sigma} \checkmark \\ &= \frac{65 \times 10^3}{5 \times 10^6} \checkmark \\ &= 13 \times 10^{-3} \text{ m}^2 \checkmark\end{aligned}\quad (3)$$

**7.2.2 Diameter of a bar:**

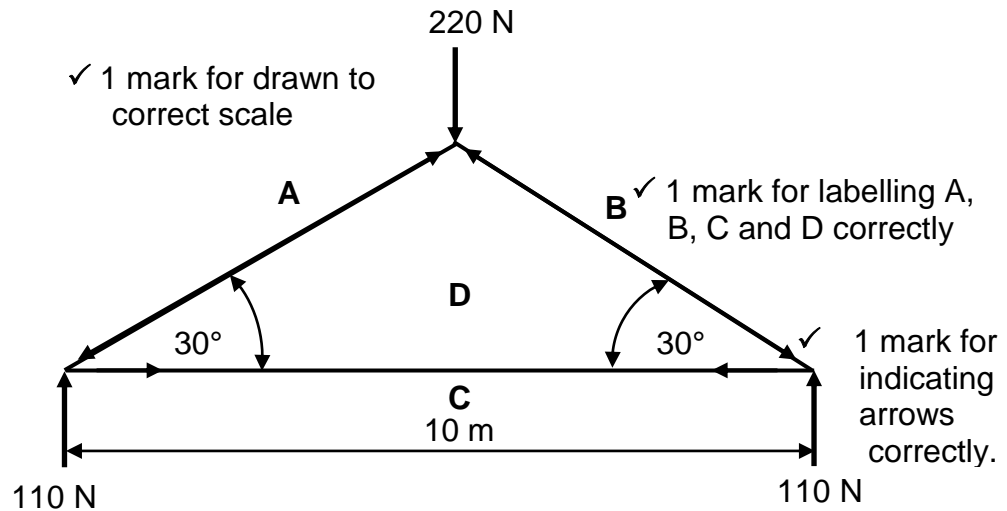
$$\begin{aligned}A &= \frac{\pi D^2}{4} \\ D &= \sqrt{\frac{4A}{\pi}} \checkmark \\ &= \sqrt{\frac{4(13 \times 10^{-3})}{\pi}} \checkmark \\ &= 0,128655019 \text{ m} \\ &= 128,66 \text{ mm} \checkmark\end{aligned}\quad (3)$$

**7.2.3 Strain:**

$$\begin{aligned}\varepsilon &= \frac{\sigma}{E} \\ \varepsilon &= \frac{5 \times 10^6}{75 \times 10^9} \checkmark \\ &= 6,67 \times 10^{-5} \checkmark\end{aligned}\quad (2)$$

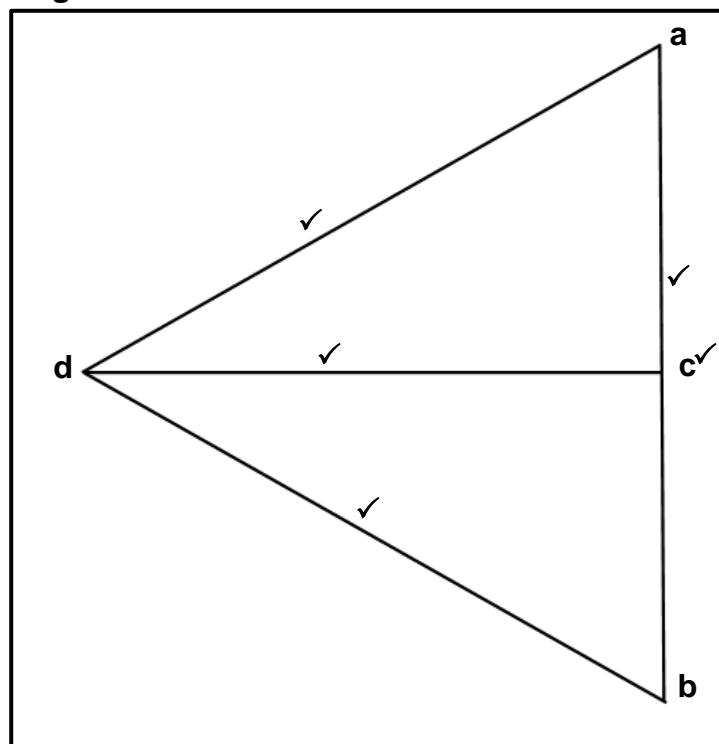
**7.2.4 Change in length:**

$$\begin{aligned}\varepsilon &= \frac{\Delta L}{OL} \\ \Delta L &= \varepsilon \times OL \checkmark \\ &= (6,67 \times 10^{-5}) \times 250 \text{ mm} \checkmark \\ &= 0,02 \text{ mm} \checkmark\end{aligned}\quad (3)$$

**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)

**[45]**



**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)  
[23]**

**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)****[18]**

**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:**

$$\begin{aligned}
 A - 2 &= \sqrt{\overset{\checkmark}{180^2} + \overset{\checkmark}{350^2} + \overset{\checkmark}{400^2}} \\
 &= \sqrt{32400 + 122500 + 160000} \\
 &= \sqrt{314900} \\
 &= 561,16 \text{ mm } \checkmark
 \end{aligned}
 \tag{4}$$

**11.1.2 B-3:**

$$\begin{aligned}
 B - 3 &= \sqrt{\overset{\checkmark}{410^2} + \overset{\checkmark}{150^2} + \overset{\checkmark}{400^2}} \\
 &= \sqrt{168100 + 22500 + 160000} \\
 &= \sqrt{350600} \\
 &= 592,11 \text{ mm } \checkmark
 \end{aligned}
 \tag{4}$$

**11.1.3 C-4:**

$$\begin{aligned}
 C - 4 &= \sqrt{\overset{\checkmark}{380^2} + \overset{\checkmark}{90^2} + \overset{\checkmark}{400^2}} \\
 &= \sqrt{144400 + 8100 + 160000} \\
 &= \sqrt{312500} \\
 &= 559,02 \text{ mm } \checkmark
 \end{aligned}
 \tag{4}$$

**11.2 Square to round transformer:****11.2.1 True length 5–6:**

$$\begin{aligned}
 5-6 &= \frac{\pi \times D}{12} \checkmark \\
 &= \frac{\pi \times 500}{12} \\
 &= 130,90 \text{ mm } \checkmark
 \end{aligned}
 \tag{2}$$

**11.2.2 True length 3–6:**

$$\begin{aligned}
 3-6 &= \frac{3 \times \pi \times D}{12} \checkmark \\
 &= \frac{3 \times \pi \times 500}{12} \checkmark \\
 &= 392,70 \text{ mm } \checkmark
 \end{aligned}
 \quad \text{OR} \quad
 \begin{aligned}
 3-6 &= \frac{\pi \times D}{4} \checkmark \\
 &= \frac{\pi \times 500}{4} \checkmark \\
 &= 392,70 \text{ mm } \checkmark
 \end{aligned}
 \tag{3}$$

**11.2.3 True length B–6:**

$$\begin{aligned}
 B-6 &= \sqrt{\overset{\checkmark}{300^2} + \overset{\checkmark}{50^2} + \overset{\checkmark}{400^2}} \\
 &= \sqrt{90000 + 2500 + 160000} \\
 &= \sqrt{252500} \\
 &= 502,49 \text{ mm } \checkmark
 \end{aligned}
 \tag{4}$$

**[21]**

**TOTAL: 200**