



Province of the
EASTERN CAPE
EDUCATION

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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2025

MECHANICAL TECHNOLOGY: WELDING AND METALWORK MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 18 pages.

SECTION A: COMPULSORY**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)**

- 1.1 A ✓
- 1.2 C ✓
- 1.3 C ✓
- 1.4 B ✓
- 1.5 A ✓
- 1.6 D ✓

(6 x 1) (6)

QUESTION 2: SAFETY (GENERIC)**2.1 Safety precautions**

- See that all guards are in place. ✓
- Make sure that there is no oil, grease or obstacles around the machine. ✓
- Select the right blade for the material to be cut. ✓
- Do not adjust guides while the machine is running. ✓
- All materials must be clamped properly before cutting is started. ✓
- Long pieces of material must be supported at the end. ✓
- Always stop machine when you leave it unattended. ✓

(Any 2 x 1) (2)

2.2 Responsibility of employee

- Pay attention to their own and other people's health and safety. ✓
- Co-operate with the employer regarding the OHS Act. ✓
- Carry out a lawful order given to them. ✓
- Report any situation that is unsafe or unhealthy. ✓
- Report all incidents and accidents. ✓
- Not to interfere with any safety equipment or misuse such equipment. ✓
- Obey all safety rules. ✓

(Any 2 x 1) (2)

2.3 Bench grinder

- Use safety goggles at all times when grinding metal. ✓
- Do not adjust the tool rest while the wheel is in motion. ✓
- Do not force the workpiece onto or bump it against the emery wheel. ✓
- Keep fingers away from revolving wheel, especially when grinding small pieces. ✓
- Grind only on the front surface and never on the sides of an emery wheel. ✓

(Any 2 x 1) (2)

2.4 Advantages of 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. ✓
- Reduction in manufacturing costs. ✓

(Any 1 x 1) (1)

2.5 **Categories of OHS**

- Actions ✓
- Conditions ✓

(2)

[10]

QUESTION 3**3.1 Types of tests to distinguish metals**

- Bending test. ✓
- Filing test ✓
- Machining test ✓
- Sound test ✓
- Spark test. ✓

(Any 3 x 1) (3)

3.2 Groups of carbon steel:

- Low carbon steel ✓ 0,15–0,3 % ✓
- Medium carbon steel ✓ 0,3–0,75 % ✓
- High carbon steel ✓ 0,75–1,7 % ✓

(6)

3.3 Purpose of normalizing ferrous metals:

- To change ✓ the properties ✓ of steel.
- To change ✓ the grain structure ✓ of steel.

(Any 1 x 2) (2)

3.4 Tempering process of steel:

- It consists of heating the hardened steel to a temperature below its critical temperature (colour chart). ✓
- Soaking it at this temperature for a period of time. ✓
- Quenching/cooling it rapidly in water, brine or oil. ✓

(3)
[14]

QUESTION 4

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

QUESTION 5: TERMINOLOGY(TEMPLATES)(SPECIFIC)**5.1 Fusion welds:**

- Spot welding ✓
- Projection ✓
- Seam welding ✓
- Foil seam welding ✓
- Flash or resistance butt ✓
- Gas welding ✓
- MIG/MAGS Welding ✓
- Arc welding ✓

(Any 4 x 1) (4)

5.2 Types of templates

- 5.2.1 Flange ✓
- 5.2.2 Strip ✓
- 5.2.3 Web ✓

(1)
(1)
(1)**5.3 Dimensions of the material:**

- 5.3.1 Mean diameter = Outside diameter - plate thickness ✓
= 900 – 60 ✓
= 840 mm ✓

(3)

- 5.3.2 Mean circumference = $\pi \times \text{mean diameter}$ ✓
= $\pi \times 840$ ✓
= 2638,94 mm
≈ 2639 mm ✓

(3)

5.4 Template loft:

The template loft is separated from the workshop because ...

- it is quieter. ✓
- the lighting is better. ✓
- all equipment is at hand. ✓
- it is a permanent base. ✓
- marking on the floor enhance accuracy. ✓

(Any 3 x 1) (3)

5.5 Hand tools

- Hand saws ✓
- Chisels ✓
- Plane ✓
- Hand drill and drill bits ✓
- Steel measuring tape ✓
- Straight edge ✓
- Compass ✓
- Trammel pins ✓
- Carpenter's square ✓
- Protractor ✓
- Chalk line ✓
- Steel rule ✓
- Hammers ✓
- Centre punch ✓
- Calipers ✓

- Scriber ✓
- Combination square ✓
- Spirit level ✓
- Trammel ✓

(Any 3 x 1) (3)

5.6 Weld dimensions:

- 30° – the included angle in degree ✓
- 5 – root gap or root opening in mm ✓

(2)

5.7 Plate girder:

- Is a combination of plates and angle iron ✓ welded together. ✓

(2)

[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)**6.1 Function of stock and dies:**

- They are used for cutting or forming external threads on round bar or shaft. ✓ (1)

6.2 Arc welding equipment:

- 6.2.1
- | | | |
|---|-------------------------------------|-----|
| A | Arc welding machine/ Power source ✓ | (1) |
| B | Earth clamp ✓ | (1) |
| C | Electrode/Rod/Welding rod ✓ | (1) |
| D | Electrode holder ✓ | (1) |

- 6.2.2 Electrode holder is used to hold the electrode. ✓ (1)

6.3 Working principles of the spot-welding machine

- Current flows through a resistance to fuse plates together. ✓
- Two copper electrodes are pressed against the plates. ✓
- Heavy current is passed between the electrodes. ✓
- High resistance causes intense heat at the point. ✓
- The two plates melt and fuse together, forming a weld nugget or spot weld. ✓ (5)

6.4 Functions of flashback arrestors

- To prevent back feeding / flashback of flame ✓
- To prevent either oxygen or acetylene gas from flowing towards the cylinders. ✓ (2)

6.5 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 factor required to operate MIG/MAGS welding torch. ✓
- Can weld in any position. ✓
- The process is easily automated. ✓ (Any 3 x 1) (3)

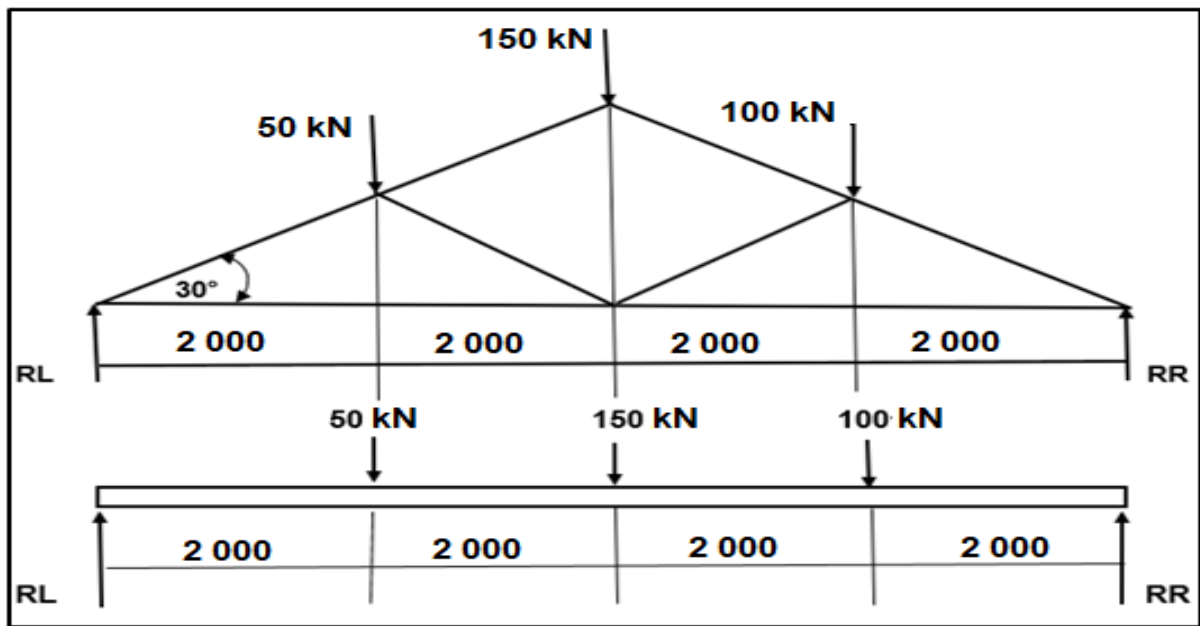
6.6 Materials that can be cut with a plasma cutter:

- Mild steel ✓
- Alloy steels ✓
- Stainless steels ✓
- Non-ferrous metals ✓ (Any 2 x 1) (2)

[18]

QUESTION 7: FORCES (SPECIFIC)

7.1

**Take moments about reaction left (RL) ✓**

$$RR \times 8\,000\text{ mm} = (50\text{ kN} \times 2\,000\text{ mm}) + (150\text{ kN} \times 4\,000\text{ mm}) + (100\text{ kN} \times 6\,000\text{ mm}) \quad \checkmark$$

$$RR = \frac{100\,000 + 600\,000 + 600\,000}{8\,000} \quad \checkmark$$

$$RR = 162,5\text{ kN} \quad \checkmark$$

(4)

Take moments about reaction left (RR) ✓

$$RL \times 8\,000\text{ mm} = (100\text{ kN} \times 2\,000\text{ mm}) + (150\text{ kN} \times 4\,000\text{ mm}) + (50\text{ kN} \times 6\,000\text{ mm}) \quad \checkmark$$

$$RL = \frac{200\,000 + 600\,000 + 300\,000}{8\,000} \quad \checkmark$$

$$RL = 137,5\text{ kN} \quad \checkmark$$

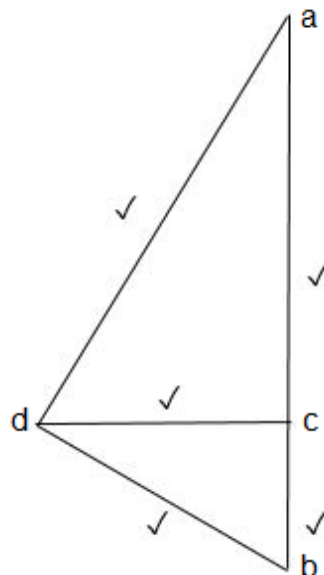
(4)

7.2 Vector/force diagram

7.2.1

NOTE TO MARKER:

Marker must redraw the force diagram according to the given scale for marking purposes.



(5)

7.2.2 Magnitude and nature of members

MEMBER	MAGNITUDE	NATURE
AD	86 N (84 N – 88 N) ✓	Strut ✓
BD	50 N (48 N – 52 N) ✓	Strut ✓
CD	42 N (40 N – 44 N) ✓	Tie ✓

Note to marker: Tolerance: ± 2 mm

(6)

7.3 Beam (UDL)

7.3.1 Calculate RL and RR

Taking moment about right reaction (RR)

$$\begin{aligned}
 RL \times 10 &= (30 \times 2) + (30 \times 4,5) + (20 \times 8) \checkmark \\
 &= 60 + 135 + 160 \\
 &= \frac{415}{10} \checkmark
 \end{aligned}$$

$$RL = 41,5 \text{ N} \checkmark$$

Taking moments about RL

$$\begin{aligned}
 RR \times 10 &= (20 \times 2) + (30 \times 3,5) + (30 \times 8) \checkmark \\
 &= 40 + 105 + 240 \\
 &= \frac{385}{10} \checkmark
 \end{aligned}$$

$$RR = 38,5 \text{ N} \checkmark$$

(6)

7.3.2 Shear forces at point A, B and C

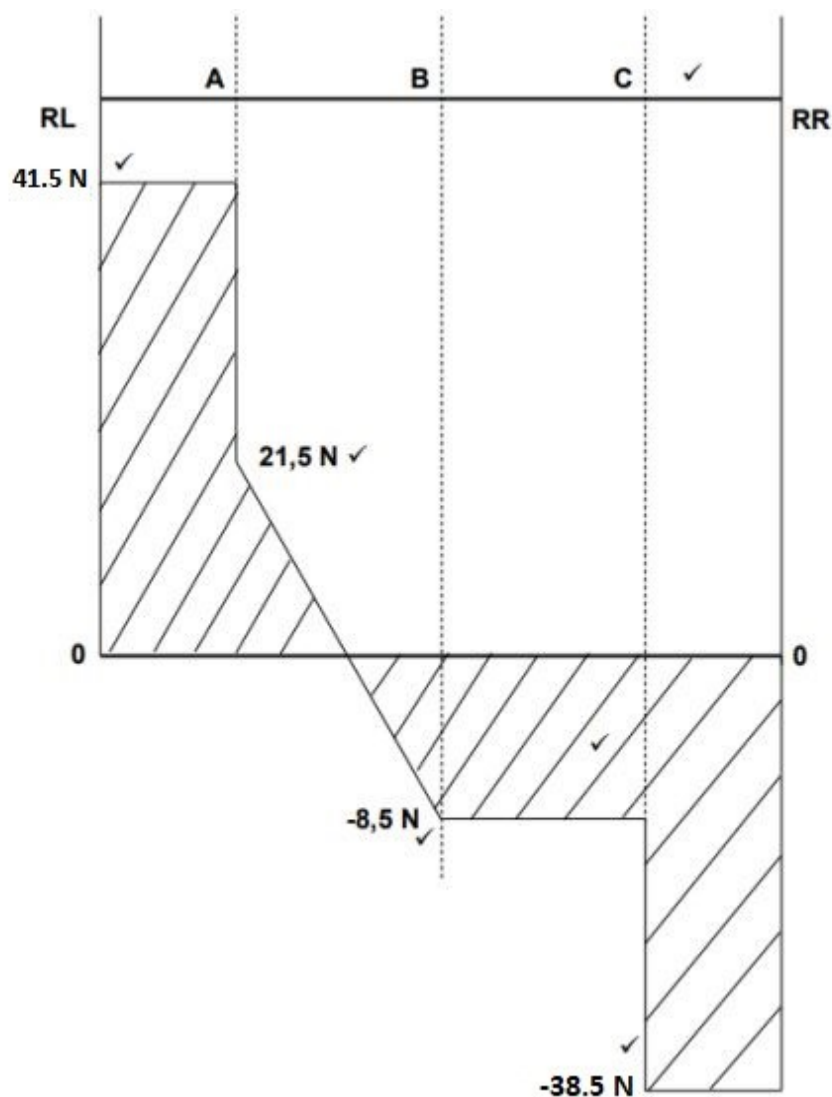
$$\begin{aligned} SF_A &= 41,5 - 20 \checkmark \\ &= 21,5 \checkmark \end{aligned}$$

$$\begin{aligned} SF_B &= 41,5 - 20 - 30 \checkmark \\ &= -8,5 \checkmark \end{aligned}$$

$$\begin{aligned} SF_C &= 41,5 - 20 - 30 - 30 \checkmark \\ &= -38,5 \checkmark \end{aligned}$$

(6)

7.3.3 Shear force diagram:



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

(6)

7.4 Stress and Strain:

7.4.1 Stress in the shaft:

$$\begin{aligned} \text{Area} &= \frac{\pi D^2}{4} \\ &= \pi \left(\frac{32^2}{4 \times 10^6} \right) \checkmark \\ &= 0,8 \times 10^{-3} \text{ m}^2 \checkmark \\ \text{Stress} &= \frac{\text{load}}{\text{area}} \checkmark \\ &= \frac{120 \times 10^3}{0,8 \times 10^{-3}} \checkmark \end{aligned}$$

$$\text{Stress} = 150\,000\,000 \text{ N/m}^2 \text{ or } 150 \times 10^6 \text{ Pa or } 150 \text{ MPa} \checkmark \quad (5)$$

7.4.2 Strain of shaft:

$$\begin{aligned} \epsilon &= \frac{\Delta L}{OL} \checkmark \\ &= \frac{0,5}{32} \checkmark \\ &= 4,17 \times 10^{-3} \checkmark \end{aligned}$$

(3)
[45]

QUESTION 8: JOINING METHODS (WELD INSPECTION)**8.1 Inspection during arc welding:**

- Amount of penetration and fusion. ✓
 - Rate of electrode burning and progress of the weld. ✓
 - The way the weld metal is flowing (no slag inclusion). ✓
 - The sound of the arc, indicating correct current and voltage for the particular weld. ✓
- (Any 3 x 1) (3)

8.2 Visual inspection process:

- Shape of profile ✓
 - Uniformity of the surface ✓
 - Overlap ✓
 - Undercutting ✓
 - Penetration bead ✓
 - Root groove ✓
- (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. ✓
- (Any 1 x 1) (1)

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 Causes of welding defects**8.5.1 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)

8.5.2 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)

8.6 Welding defects:

8.6.1 Incomplete penetration ✓ (1)

8.6.2 Undercut ✓ (1)

8.7 Nick break test:

- Make a hacksaw cut at both edges, through the centre of the weld. ✓
- Place specimen on two steel supports. ✓
- 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, etc. ✓

(4)

8.8 Factors determining current setting for welding:

- Base metal type. ✓
- Base metal thickness. ✓
- Electrode diameter. ✓
- Position of the weld. ✓

(Any 3 x 1) (3)

[23]

QUESTION 9: JOINING METHODS (STRESSES AND DISTORTION) (SPECIFIC)**9.1 Distortion:**

- Do not over weld ✓
 - Use intermittent welding ✓
 - Place welds near the neutral axis ✓
 - Use as few passes as possible ✓
 - Use backstep welding ✓
 - Anticipate the shrinkage forces ✓
 - Plan the welding sequence ✓
 - Use strong backs ✓
 - Use clamps, jigs and fixtures ✓
 - Pre-heating the workpiece ✓
 - Tack welding ✓
 - Allow slow cooling after welding. ✓
- (Any 2 x 1) (2)

9.2 Definition of terms:

9.2.1 **Weld distortion:** Takes place in a welded joints due to uneven expansion and contractions ✓ as a result of intense heat of the arc or oxy-acetylene flame. ✓ (2)

9.2.2 **Residual Stress:** The internal stress distribution locked into the material; ✓ these stresses are present even after all external loads/forces are removed. ✓ (2)

9.3 Iron-carbon diagram:

9.3.1 Iron-carbon equilibrium diagram ✓ (1)

9.3.2 A – Temperature/Degrees Celsius ✓
B – Austenite ✓
C – Austenite and Cementite ✓
D – Ferrite and Pearlite ✓
E – Carbon content ✓ (5)

9.4 Elastic deformation:

- It is the ability of a joint/material to return to its original position/ dimensions ✓ after the stresses have been relieved. ✓ (2)

9.5 Effects of shrinkage:**9.5.1 Electrode size:**

- Larger electrode size requires higher current and causes higher welding temperature that causes more deformation/shrinkage. ✓
- Smaller electrode size requires lower current lower welding temperature that causes less deformation/ shrinkage. ✓ (2)

9.5.2 Welding speed:

- Decreased welding speed tends to increase localised heat that increases distortion. ✓
- Increased welding speed tends to decrease localised heat that decreased distortion. ✓

(2)

[18]**QUESTION 10: MAINTENANCE****10.1 Reasons for maintenance:**

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

(Any 2 x 1) (2)

10.2 Overloading:**10.2.1 Overloading a guillotine:**

- cutting a plate of excessive thickness ✓ or hardness will overload both the blade and hydraulic system. ✓

(2)

10.2.2 Overloading a horizontal band saw:

- the feed speed which is higher than the rate at which the band saw can cut, ✓ effectively results in the blade being forced into the material. ✓

(2)

10.3 Reasons for keeping service records:

- Assist in the monitoring of the condition of the machines. ✓
- Assist in upholding warranties. ✓
- Assist in keeping a history of maintenance and repairs. ✓

(Any 2 x 1) (2)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)**11.1 Hoppers:**

11.1.2 Square to square hopper on centre ✓ (1)

11.1.2 Square to rectangle hopper off centre ✓ (1)

11.2 Cone frustum:

11.2.1 True length **1 – 2**

$$\begin{aligned}
 \mathbf{1 - 2} &= \frac{\pi \times d}{12} \checkmark \\
 &= \frac{\pi \times 300}{12} \checkmark \\
 &= 78,54 \text{ mm} \checkmark
 \end{aligned}
 \quad (3)$$

11.2.2 True length **A – B**

$$\begin{aligned}
 \mathbf{A - B} &= \frac{\pi \times d}{12} \checkmark \\
 &= \frac{\pi \times 600}{12} \checkmark \\
 &= 157,08 \text{ mm} \checkmark
 \end{aligned}
 \quad (3)$$

11.3 Square to round transition piece:

11.3.1 The true length **FG**

Plan length **FG = FK – GK**

$$= 400 - 250 \checkmark$$

$$= 150 \checkmark$$

$$\therefore \text{TLFG}^2 = \text{FG}^2 + \text{VH}^2$$

$$= 150^2 + 800^2 \checkmark$$

$$\mathbf{FG} = \sqrt{662500} \checkmark$$

$$\text{True length } \mathbf{FG} = 813,94 \text{ units} \checkmark \quad (5)$$

- 11.3.2 To determine the plan length **CI**, the sides **CE** and **EI** of triangle **CEI** must be calculated.

$$CE = CF - EF$$

$$= 400 - 125$$

$$= 275 \checkmark$$

But **EI = FH**

$$FH = FK - HK$$

$$= 400 - 217,5$$

$$= 182,5 \checkmark$$

$$\text{True length } CI^2 = CE^2 + EI^2$$

$$= 275^2 + 182,5^2 \checkmark$$

$$= \sqrt{108931,25} \checkmark$$

$$\text{True length } CI = 330,05 \checkmark$$

(5)

- 11.3.3 **JI** is one-twelfth of the circumference

$$\text{circumference} = \pi \times MD$$

$$= \pi \times 500$$

$$= 1570,80 \checkmark$$

$$\frac{1}{12} \times \text{circumference} = \frac{1570,80}{12} \checkmark$$

$$= 130,9 \checkmark$$

(3)

[21]

TOTAL: 200