Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2020

MECHANICAL TECHNOLOGY: WELDING AND METALWORK
MARKING GUIDELINE

MARKS: **200**

This marking guideline consists of 18 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 C ✓ (1)

1.2 B ✓ (1)

1.3 C ✓ (1)

1.4 A ✓ (1)

1.5 B ✓ (1)

1.6 C ✓ (1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Gas welding (PPE)**

- Eye protection ✓
- Overall / leather apron ✓
- Safety boots ✓
- Gloves ✓ (Any 2 x 1) (2)

2.2 **Safety rules that must be followed while the surface grinder is in operation:**

- Make sure that the sparks pose no danger to co-workers. ✓
- Do not force the material onto the grinding wheel. ✓
- Do not plunge grind. ✓
- Bring the material slowly into contact with the grinding wheel. ✓
- Never clean or adjust the machine whilst it is in motion. ✓
- Use cutting fluid. ✓
- Know where the emergency stop is located. ✓
- Stop machine before any adjustment ✓
- Keep tools clear from moving parts. ✓ (Any 2 x 1) (2)

2.3 **Completing a task on any machine**

Switch the machine off. ✓ (1)

2.4 **TWO safety precautions before switching on the angle grinder**

- Make sure that there are no cracks or chips on the disc. ✓
- Make sure that the emery disc that is fitted is rated above the revolutions at which it is turned by the motor. ✓
- Make sure that the space between the tool rest and the emery disc does not exceed 3 mm. ✓
- Ensure that guards are in place ✓
- When switching on the machine, do not stand in front of it, until it reaches its full speed. ✓
- Do not force or bump the work piece against the emery disc. ✓
- Grind only on the front surface of the wheel, not the sides. ✓
- All grinding machines must have a sign indicating the revolutions at which the spindle rotates. ✓ (Any 2 x 1) (2)

2.5 **Importance of a welding helmet**

- To protect your eyes and face from ultra-violet rays and radiation ✓ (1)

2.6 **Types of workshop layouts:**

- Process layout ✓
- Product layout ✓ (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1

MATERIALS	DIFFERENT TYPES OF TESTS		
	Sound	Filing	Bend
Cast iron	Very dull sound ✓	Easy ✓	Cannot bend ✓/ Snaps/breaks ✓/ Fractures easily ✓
Mild steel	Medium metallic sound ✓	Easy ✓	Bends easily ✓

(6)

3.2 **Heat treatment process**

- Is the heating and cooling of metals in their solid state so as to change their properties. ✓ (1)

3.3 **Hardness factors:**

- Workpiece size ✓
- Quenching rate ✓
- Carbon content ✓ (Any 2 x 1) (2)

3.4 **Heat treatment processes:**

3.4.1 **Tempering**

- Is a process applied to steel and it relieves the strain induced during the hardening process. ✓
- It decreases the degree of hardness ✓
- It increases toughness ✓
- It reduces brittleness ✓
- It gives steel fine grain structure ✓ (Any 2 x 1) (2)

3.4.2 **Annealing**

- Relieves internal stress ✓
- Softens the metal ✓
- Makes metal ductile ✓
- Refines the grain structure ✓
- Reduces brittleness ✓ (Any 2 x 1) (2)

3.5 **Hardness of steel depends upon**

- Carbon content ✓ (1)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 **Template loft:** Is the heart of the structural workshop. (2)

5.2 **THREE qualities of a good template loft:**

- Accuracy ✓
- Quietness ✓
- Better lighting ✓
- Separate from main building ✓
- Wooden floor with black matt finish ✓
- Large space to accommodate required work ✓ (Any 3 x 1) (3)

5.3 **Web template**

- Is used to mark out the positions of holes on the webs of the channel iron and girder sections. ✓✓ (2)

5.4 **A steel ring:**

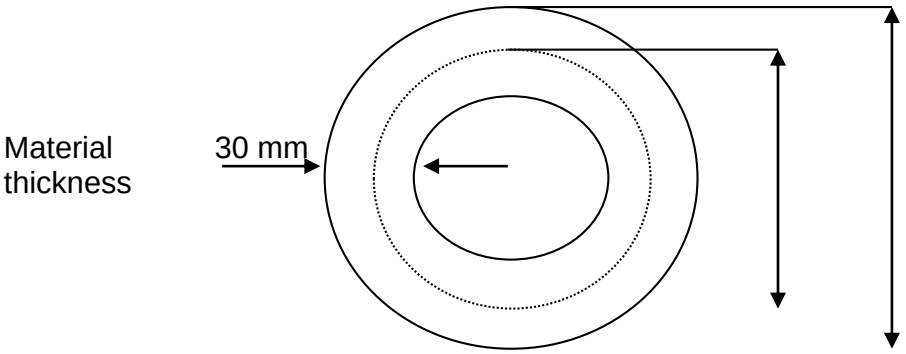
5.4.1 **Dimensions of the required material:**

Mean diameter = Outside diameter – Plate thickness ✓
= 500 – 30 ✓
= 470 mm ✓

Mean circumference = π x Mean diameter ✓
= π x 470 ✓
=1 476,55 mm ✓ (6)

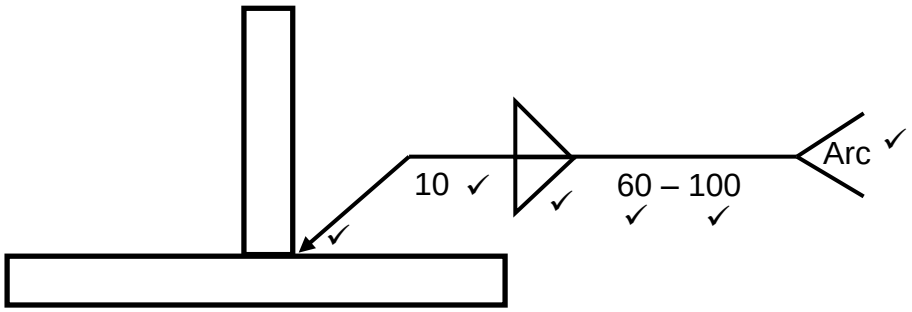
5.4.2 **Make a neat sketch of the steel ring indicating the mean diameter, outside diameter and the thickness of the material:**

1476,55 mm of 30 x 30 mm square steel bar is required to fabricate the ring.



(4)

5.5 **Fillet weld on T-joint:**



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[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 **Uses of the machines**

6.1.1 **Guillotine**
- To cut sheet metal ✓
- To cut plate metal ✓ (2)

6.1.2 **Bench grinder**
- Hand grinding-cutting tools ✓
- Sharpening cutting tools ✓ (2)

6.1.3 **Press machine**
- Is used to install or remove components such as bearings or bushes in machines or mechanical devices ✓✓ (2)

6.2 **Joining equipment labels:**

6.2.1 A – Gauges ✓
B – Outlet ✓
C – Inlet ✓
D – Bonnet ✓ (4)

6.2.2 • Oxygen regulator ✓ (1)

6.3 **Function of stock and dies:**
- They are used to cut internal and external threads of the bolt and nut. ✓ (1)

6.4 **Function of regulators:**
To reduce the cylinder pressure✓ to operating or working pressure. ✓ (2)

6.5 **Operating principle of plasma cutter:**

The process involves creating an electrical channel of ionised gas; ✓ that is the plasma cutter itself, through the work piece that is being cut;✓ this forms an electric circuit back to the plasma cutter via a grounding clamp; ✓ accomplishing this via air that is blowing towards the work piece through a focused nozzle. ✓ (4)

[18]

QUESTION 7: FORCES (SPECIFIC)

7.1 **Term definition**

7.1.1 **Force:** is an influence which changes or tends to change the state of rest of a body or motion ✓✓

OR

It is often more convenient to think about a "pull" or "push"

(Any 1 x 2) (2)

7.1.2 **Hooke's law:** Strain is directly proportional to the stress it caused, provided the limit of proportionality is not Exceeded. ✓✓ (2)

7.2 **Stress and strain**

7.2.1 Area = $\frac{\pi D^2}{4}$

$= \frac{\pi \text{ x } (0{,}024)^2}{4}$

$= 4{,}525 \text{ x } 10^{-4} m^2$

Stress = $\frac{Force}{Area}$

$= \frac{60\ x\ 10^3}{4{,}525\ x\ 10^{-4}}$ ✓

$= 132{,}579 \text{ x } 10^6$ Pa ✓ (2)

7.2.2 Strain = $\frac{\text{Change in length}}{\text{Original length}}$

$= \frac{0{,}22 \text{ x } 10^{-3}}{212 \text{ x } 10^{-3}}$ ✓

$= 1{,}038 \text{ x } 10^{-3}$

$= 1{,}04 \text{ x } 10^{-3}$ ✓ (2)

7.2.3 Young's modulus of elasticity (E) = $\frac{Stress}{Strain}$ ✓

$= \frac{132{,}58 \text{ x } 10^6}{1{,}04 \text{ x } 10^{-3}}$ ✓

$= 127{,}48 \text{ x } 10^9$ ✓

$= 127{,}48$ GPa ✓ (4)

7.3 Calculations of the reactions, bending moments and shear force

7.3.1 Moments about RL: RR X 8 = (2 x 4) + (6 x 5) + (3 x 6) ✓
= 8 + 30 + 18
= 56 ✓
RR = 7 N ✓

Moments about RR: RL X 8 = (3 x 2) + (6 x 3) + (2 x 4) ✓
= 6 + 18 + 8
= 32 ✓
RL = 4 N ✓ (6)

7.3.2 **The bending moments at points A, B and C**.

BM_A = (4 x 4) = 16 N ✓

BM_B = (4 x 6) – (2 x 2) – (6 x 1) = 14 N ✓

BM_C = (4 x 7) – (2 x 3) – (6 x 2) – (3 x 1) = 7 N ✓ (3)

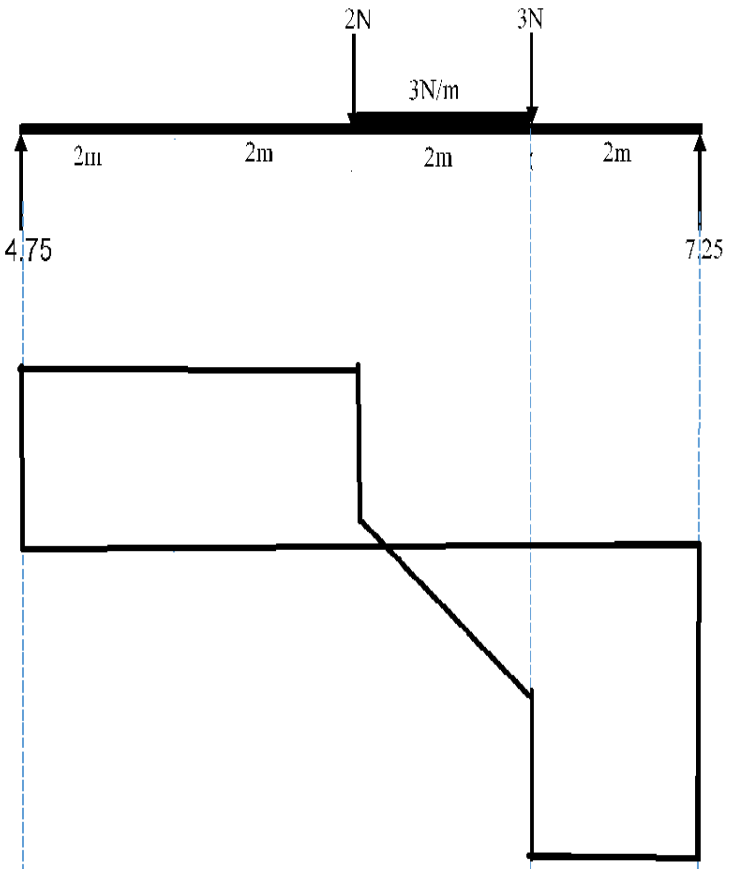
7.3.3 **Shear forces at points, A, B and C**

SF_A = 4 2 = 2 ✓

SF_B = 4 – 2 – 6 = -4 ✓

SF_C = 4 – 2 – 6 – 3 = -7 ✓ (3)

7.3.4



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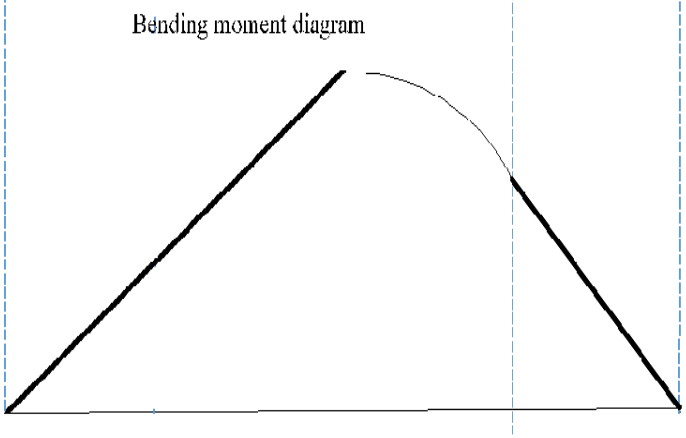
7.3.5



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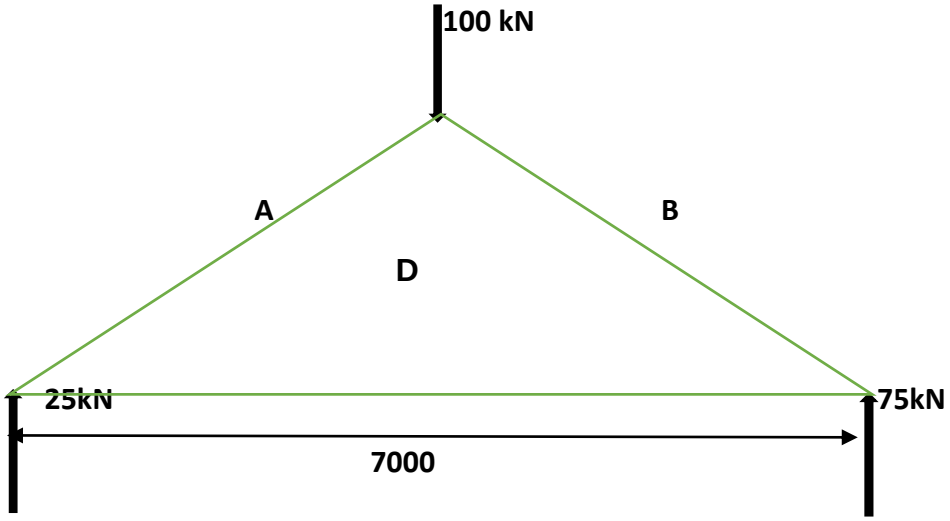
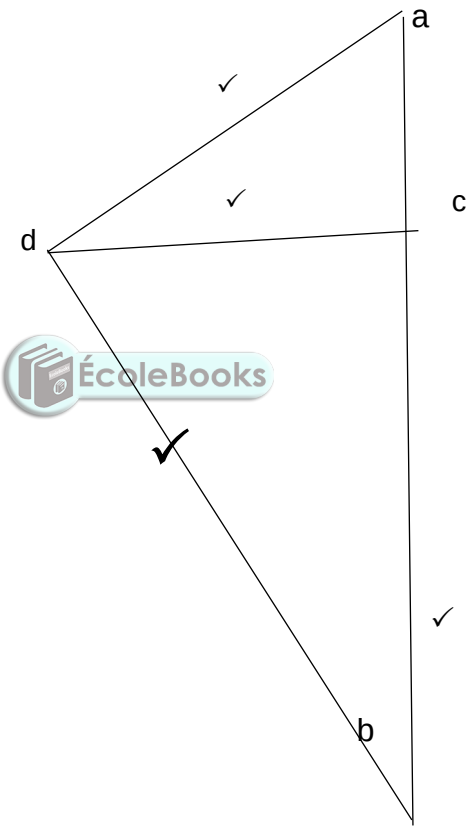
7.4



Space diagram = 1 mark✓



Member	Force	Nature
AD	29 kN ✓	Strut ✓
BD	76 kN ✓	Strut ✓
CD	14 kN ✓	Tie ✓

(11)
[45]

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

8.1 **Arc welding**

- Rate of rod burning and the progress of the weld ✓
- Amount of penetration and fusion ✓
- The way the weld metal is flowing ✓
- The sound of the arc, indicating correct current and voltage for the particular weld ✓ (Any 2 x 1) (2)

Oxy-acetylene

- Correct flame for the work on hand ✓
- Correct angle of blowpipe and rod, depending on the method being used ✓
- Depth of fusion and amount of penetration ✓
- The rate of progress along the joint ✓ (Any 2 x 1) (2)

8.2

- HAZ (Heat-affected zone) ✓
- Centreline cracks ✓
- Crater cracks ✓
- Transverse cracks ✓ (Any 2 x 2) (4)

8.3 A – Penetration ✓
B – Width ✓
C – Height ✓
D – Weld bead ✓
E – Base metal ✓ (5)

8.4

- Shape of profile ✓
- Uniformity ✓
- Overlap ✓
- Undercutting ✓
- Penetration bead ✓
- Root groove ✓ (Any 2 x 1) (2)

8.5 8.5.1 **Spatter**

Caused by voltage being too low ✓ or amperage being too high. ✓ (2)

8.5.2 **Incomplete penetration**

- The weld bead does not penetrate the full depth of the weld or into the root of the weld. ✓
- Two opposing weld beads do not inter-penetrate. ✓
- The weld does not penetrate to the toe of a fillet weld but only bridges across it. ✓

(Any 2 x 1) (2)

8.6 **Arc welding**

- Rate of rod burning and the progress of the weld ✓
- Amount of penetration and fusion ✓
- The way the weld metal is flowing ✓
- The sound of the arc, indicating correct current and voltage for the particular weld ✓ (Any 2 x 1) (2)

8.7 **Testers**

8.7.1 **Nick-break test is done to:**
Determine the internal quality of the weld metal ✓ and can reveal the internal defects ✓ (2)

8.7.2 **Machinability test is done to:**
Determine the hardness ✓ and strength ✓of the welded joint. (2)
[25]

QUESTION 9: JOINING METHODS (STRESSES) (SPECIFIC)

9.1 **Term definition**

9.1.1 **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)

9.1.2 **Residual Stress:** Is the internal stress distribution locked into the material; ✓these stresses are present even after all external loads or forces have been removed. ✓ (2)

9.2 **Factors affecting grain size**

- The prior amount of cold work✓
- The temperature and time of the annealing process ✓
- Composition and constitution ✓
- Its melting point ✓ (Any 2 x 1) (2)

9.3

Low carbon steel ✓	0,15 – 0,30% ✓
Medium carbon steel ✓	0,31 – 0,70% ✓
High carbon steel	0,71 – 1,5%

(Any 2 x 2) (4)

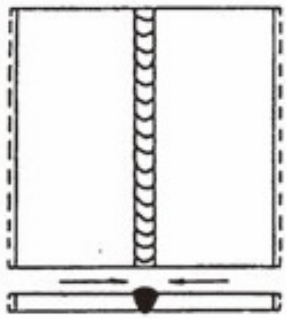
9.4 **Quenching mediums**

- Brine ✓
- Water ✓
- Oil ✓
- Metal salt ✓
- Air ✓ (Any 2 x 1) (2)

9.5 **Factors affecting shrinkage in welding**

- Size of work piece ✓
- Weld thickness ✓
- Thermal conductive properties of parent metal ✓ (Any 2 x 1) (2)

9.6 9.6.1 **Transverse shrinkage**



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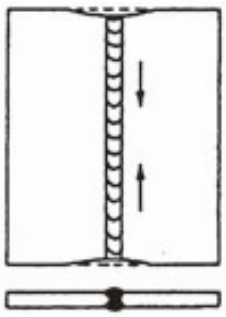
9.6.2 **Longitudinal shrinkage**



(2)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 Keeping records assists in upholding warrantees and guarantees because service requirements inevitably form part of agreements. ✓ (1)

10.2 Due to the danger associated with a large machine, it is critical to isolate the machine completely before any maintenance is undertaken ✓ to ensure nobody can turn on the machine. ✓ (2)

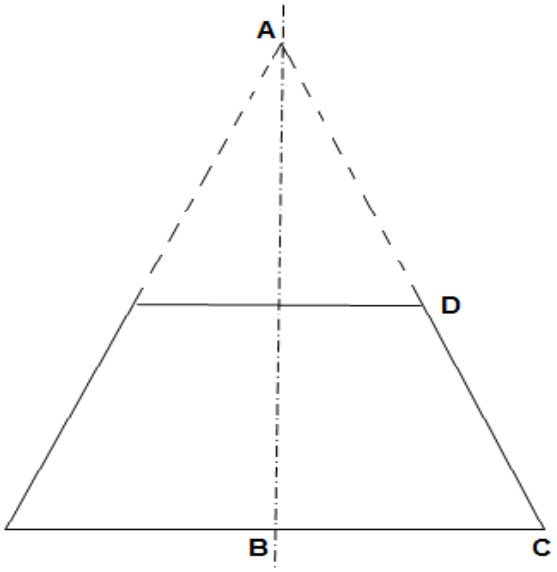
10.3 Friction can be reduced by applying cutting fluid or light oil to the drill bit. ✓ (1)

10.4 10.4.1 Cutting plate of excessive thickness ✓ or hardness will overload both the blade and hydraulic system. ✓ (2)

10.4.2 The feed speed which is higher than the rate at which the power saw can cut, ✓ effectively results in the blade being forced into the materials. ✓ (2)
[8]

QUESTION 11: DEVELOPMENT (SPECIFIC)

11.1 11.1.1



$\hat{C} = 70°$

$EC = BC - BE$

$= 2 - 1$ ✓✓✓✓✓

$= 1m$

$\therefore Cos70° = \frac{EC}{DC}$ $DC = \frac{EC}{Cos70°}$

$DC = \frac{1}{Cos70°}$ $DC = 2.92m$

(5)

11.1.2 $Cos70° = \frac{BC}{AC}$

$AC = \frac{BC}{Cos70°}$ ✓✓✓✓

$AC = \frac{2}{Cos70°}$

$\therefore AC = 5.85m$ (4)

11.1.3 $Circumf. = \pi D$

$= \pi(4)$ ✓✓✓

$= 12.57m$ (3)

11.2 **Square-to-round transition piece:**

11.2.1 **The true length FG is firstly needed to draw the pattern.**

$IK = 300 (2 units)$

$IH = 150 (1 unit)$

$HK = 1\sqrt{3}\ (1 unit \times \sqrt{3})$

The true length FG:

Plan length $FG = FG - GK$ ✓

$= 400 - 300$

$= 100\ mm$ ✓

The true FG is equalto H'F

$H'F^2 = H'G^2 + GF^2$ ✓

$= 800^2 + 100^2$

$H'F = \sqrt{650\,000}$ ✓

True length $FG = 806\ mm$ ✓ (5)

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

$CE = CF - EF$

$= 400 - 150$

$= 250\ mm$ ✓

$But EI = FH$

$FH = FK - HK$

$= 400 - 259,8$

$= 140,2 mm$ ✓

$True\ length (CI) = FH^2 + EI^2$ ✓

$= 250^2 + 140,2^2$

$= \sqrt{82156,04}$

$= 286,63\ mm$ ✓ (4)

[21]

TOTAL: 200