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)
[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)
                                                                                                       [14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 **Brass ring calculations:**

      5.1.1   Mean Ø = InsideØ + Plate thickness

$$= 870 + 30 ✓$$

$$= 900\,mm ✓$$
(2)

      5.1.2   Mean circumference $= \pi \times$ Mean Ø

$$= \pi \times 900 ✓$$

$$= 2827,43 ✓$$

$$= 2827\,mm ✓$$
(3)

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

      5.2.1   Square butt   ‖ ✓✓
(2)

      5.2.2   V groove   V ✓✓
(2)

      5.2.3   U butt   Y ✓✓
(2)

      5.2.4   J butt   Ⴒ ✓✓
(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)
[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

             ✓   ✓

Drill size = 10 -1,5

          = 8,5 mm ✓   (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):

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

            Reaction RL:
            Take moment about (RR):

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

        (8)

    7.1.2   **Bending moments:**

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

$BM_B = (6{,}29 \text{ N} \times 3{,}5 \text{ m}) - (4 \text{ N} \times 2 \text{ m}) - (5 \text{ N} \times 0 \text{ m}) \checkmark$

      $= 14{,}02 \text{ Nm} \checkmark$

$BM_C = (6{,}29 \text{ N} \times 5{,}5 \text{ m}) - (4 \text{ N} \times 4 \text{ m}) - (5 \text{ N} \times 2\text{m}) - (3 \text{ N} \times 0 \text{ m}) \checkmark$

      $= 8{,}60 \text{ Nm} \checkmark$

        (6)

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

4N   5N   3N

A   B   C

14, 02 Nm

9, 44 Nm

8, 60 Nm

0   0
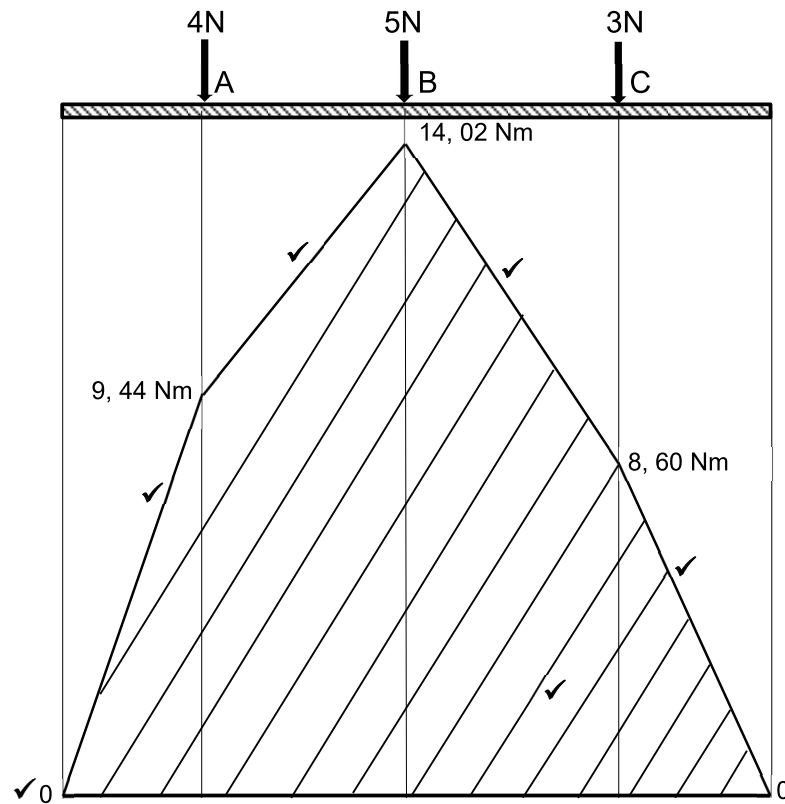
Note to marker:
Marker must redraw the bending moment diagram according to the scales for marking purposes.

(6)

`

7.2   **Stress and Strain:**

7.2.1   **Area of the bar:**

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

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

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

$$= 13 \times 10^{-3} \, m^2 \checkmark \tag{3}$$

7.2.2   **Diameter of a bar:**

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

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

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

$$= 0,128655019 \, m$$

$$= 128,66 \, mm \checkmark \tag{3}$$

7.2.3   **Strain:**

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

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

$$= 6,67 \times 10^{-5} \checkmark \tag{2}$$

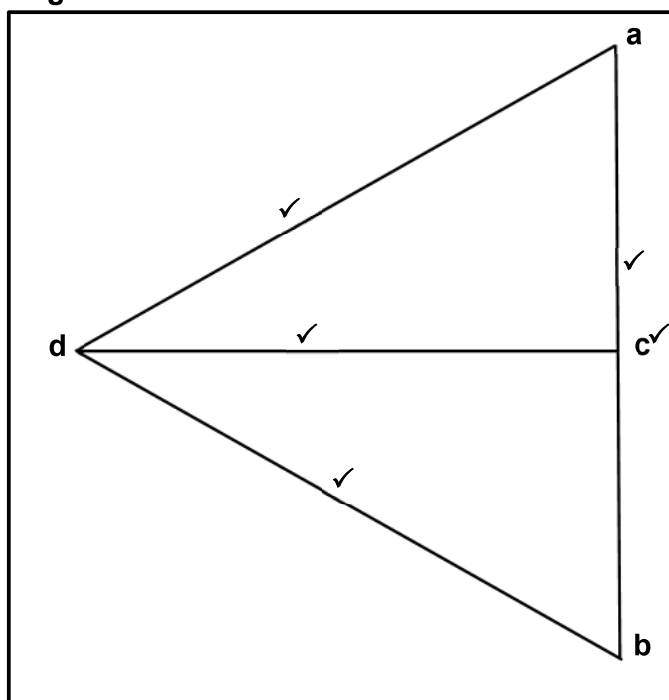7.2.4   **Change in length:**

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

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

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

$$= 0,02 \, mm \checkmark \tag{3}$$

7.3   **Simple frame:**

7.3.1   **Space diagram:**

✓ 1 mark for drawn to
correct scale

220 N

A

B ✓ 1 mark for labelling A,
B, C and D correctly

D

30°   30°

✓ 1 mark for
indicating
arrows
correctly.

C
10 m

110 N   110 N
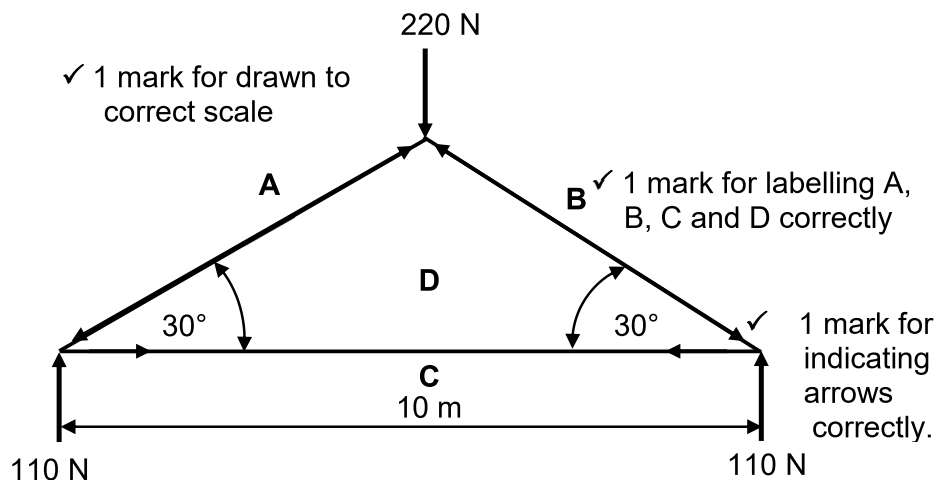
NOTE: Draw to scale on transparency for marking purpose
.   Mark allocation is for indication of arrows.   (3)

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

a

✓

✓

d   ✓   c ✓

✓

b

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:**

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

(4)

11.1.2   **B–3:**

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

(4)

11.1.3   **C–4:**

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

(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:**

$$3-6 = \frac{3 \times \pi \times D}{12} \checkmark \qquad\qquad 3-6 = \frac{\pi \times D}{4} \checkmark$$
$$= \frac{3 \times \pi \times 500}{12} \checkmark \qquad \text{OR} \qquad = \frac{\pi \times 500}{4} \checkmark$$
$$= 392,70 \text{ mm} \checkmark \qquad\qquad\qquad = 392,70 \text{ mm} \checkmark$$

(3)

11.2.3   **True length B–6:**

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

(4)

[21]

TOTAL: 200