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SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

2021

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 18 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

- | | | |
|-----|-----|------------|
| 1.1 | B ✓ | (1) |
| 1.2 | A ✓ | (1) |
| 1.3 | C ✓ | (1) |
| 1.4 | C ✓ | (1) |
| 1.5 | D ✓ | (1) |
| 1.6 | A ✓ | (1) |
| | | [6] |

QUESTION 2: SAFETY (GENERIC)

2.1 First aid basic treatment:

- Examination ✓
- Diagnosis ✓
- Treatment ✓

(3)

2.2 Drill press (Already been switched on):

- Never leave the drill unattended while in motion. ✓
- Switch off the drill when leaving. ✓
- Use a brush or wooden rod to remove chips. ✓
- When reaching around a revolving drill, be careful that your clothes do not get caught in the drill or drill chuck. ✓
- Don't stop a revolving chuck with your hand. ✓
- Don't adjust the drill while working. ✓
- Don't open any guard while in motion. ✓
- Keep hands away from action points. ✓
- Do not force the drill bit into the material. ✓
- Apply cutting fluid if required. ✓

(Any 2 x 1) (2)

2.3 Isolation of electrode holder:

To prevent electric shock. ✓

(1)

2.4 Disadvantages of the process layout:

- Production is not always continuous. ✓
- Transportation costs between process departments may be high. ✓
- Additional time is spent in testing and sorting as the product moves to the different departments. ✓
- Damage to fragile goods may result from extra handling. ✓

(Any 2 x 1) (2)

2.5 Advantages of the 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. ✓

(2)
[10]
(Any 2 x 1)

QUESTION 3: MATERIALS (GENERIC)

3.1 **Heat-treatment:**

- Heat the metal slowly to a certain temperature. ✓
- Soak the metal for a certain period to ensure a uniform temperature. ✓
- Cool the metal at a certain rate to room temperature. ✓

(3)

3.2 **Quenching mediums:**

- Water ✓
- Brine ✓
- Liquid salts ✓
- Oil ✓
- Soluble oil and water ✓
- Sand ✓
- Molten lead ✓
- Air ✓
- Lime ✓

(Any 3 x 1) (3)

3.3 **Annealing:**

- To relieve internal stresses of the steel ✓
- Soften steel to make machining possible ✓
- Make steel ductile ✓
- Refine grain structure ✓
- Reduce brittleness ✓

(Any 1 x 1) (1)

3.4 **Carbon steels:**

- Low carbon steel ✓
- Medium carbon steel ✓
- High carbon steel ✓

(3)

3.5 **Iron-carbon equilibrium diagram:**

- A Percentage carbon / carbon content ✓
- B Temperature in °C ✓
- C AC3 line / Higher critical temperature ✓
- D AC1 line / Lower critical temperature ✓

(4)

[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 Template loft:

- To save time in marking out. ✓
- Promotes accuracy. ✓

(Any 1 x 1) (1)

5.2 Purlins:

- To support roof covering. ✓ ✓
- To link the roof trusses. ✓ ✓
- Makes the roof structure stronger. ✓ ✓

(Any 1 x 2) (2)

5.3 Roof truss:

- A – Rafter ✓
- B – Cleat ✓
- C – Purlin ✓
- D – Gusset plate ✓
- E – Tie beam/Main tie ✓

(5)

5.4 Material calculation:

$$\begin{aligned}\text{Mean } \varnothing &= \text{Inside } \varnothing + \text{Thickness} \\ &= 230 + 16 \checkmark \\ &= 246 \text{ mm } \checkmark\end{aligned}$$

$$\begin{aligned}\text{Mean circumference} &= \pi \times \text{Mean } \varnothing \\ &= \pi \times 246 \checkmark \\ &= 772,83 \text{ mm } \checkmark \\ &= \text{Round off to } 773 \text{ mm } \checkmark\end{aligned}$$

(6)

5.5 Welding symbols:

- A. Tail ✓
- B. Weld symbol / Fillet weld on the other side / Weld symbol on the other side / Fillet weld ✓
- C. Pitch of weld ✓
- D. Site weld ✓
- E. Arrow ✓
- F. Weld all round ✓

(6)

5.6



(3)

[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 Plasma cutter:

- Creating an electrical channel of ionised gas (plasma), ✓ from the plasma cutter itself through the work piece that is being cut.
- It forms a completed electric circuit ✓ via a grounding clamp.
- Compressed air is blown toward the work piece through a focused nozzle at high speed. ✓
- A high frequency, electrical arc is then formed within the gas between an electrode near or integrated into the gas nozzle and the work piece itself. ✓

(4)

6.2 Hydraulic press:

- For removing bearings or bushes. ✓
- Fitting of bearings or bushes. ✓
- To shape material. ✓
- Testing of welded joints ✓

(Any 2 x 1) (2)

6.3 Internal thread cutting process:

- Drill the required core diameter. ✓
- Use the three taps in order – taper / intermediate / plug. ✓
- Check thread with thread pitch gauge/bolt when complete. ✓

(3)

6.4 Power saw:

To cut sections of metal / material. ✓

(1)

6.5 Gas welding:

6.5.1 Oxygen regulator / Acetylene regulator / regulator ✓

(1)

- 6.5.2
- A. Gauge ✓
 - B. Outlet ✓
 - C. Inlet ✓
 - D. Pressure adjusting knob ✓

(4)

6.6 Acetylene gas cylinder:

Red / maroon ✓

(1)

6.7 Flashback arrestor:

To prevent ✓ back feeding / flashback of flame ✓

(2)

[18]

QUESTION 7: FORCES (SPECIFIC)

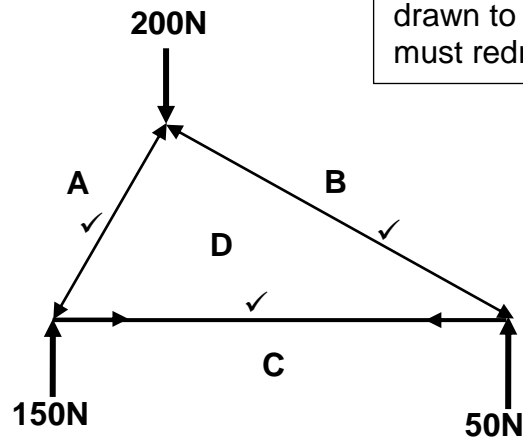
7.1 Define:

7.1.1 **Stress:**
The internal resistance ✓ in a body to an external force or load. ✓ (2)

7.1.2 **Hooke's law:**
Strain is directly proportional to the stress it causes; ✓ provided the limit of elasticity is not exceeded. ✓ (2)

7.2 Frameworks:

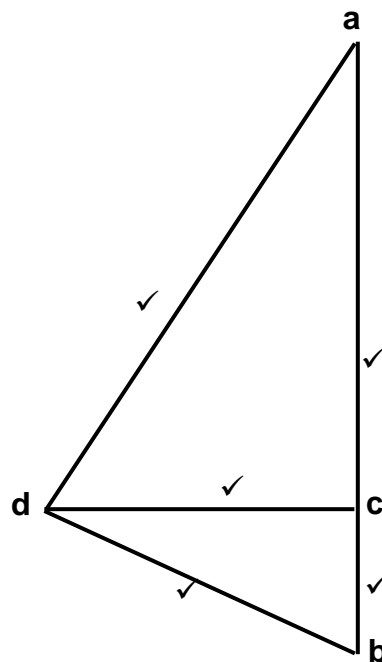
7.2.1. Space diagram:



✓ for
labelling

(4)

7.2.2 Vector diagram:



NOTE: ±2mm
tolerance on scale
drawing. Marks
awarded for scale
accuracy.

(5)

7.2.3 **Magnitude and nature of members:**

MEMBER	MAGNITUDE	NATURE
AD	172 N – 176 N ✓	Strut ✓
BD	100 N – 104 N ✓	Strut ✓
CD	87 N – 91 N ✓	Tie ✓

(6)

7.3 **Beam:**

7.3.1 **Calculate RL:**

Taking moment about right reaction (RR)

$$\begin{aligned}
 RL \times 10 &= (25 \times 2) + (30 \times 6,5) + (15 \times 8) \checkmark \\
 &= 50 + 195 + 120 \\
 &= \frac{365}{10} \checkmark \\
 RL &= 36,5 \text{ N } \checkmark
 \end{aligned}$$

Calculate RR:

Taking moment about left reaction (RL)

$$\begin{aligned}
 RR \times 10 &= (15 \times 2) + (30 \times 3,5) + (25 \times 8) \checkmark \\
 &= 30 + 105 + 200 \\
 &= \frac{335}{10} \checkmark \\
 RR &= 33,5 \text{ N } \checkmark
 \end{aligned}$$

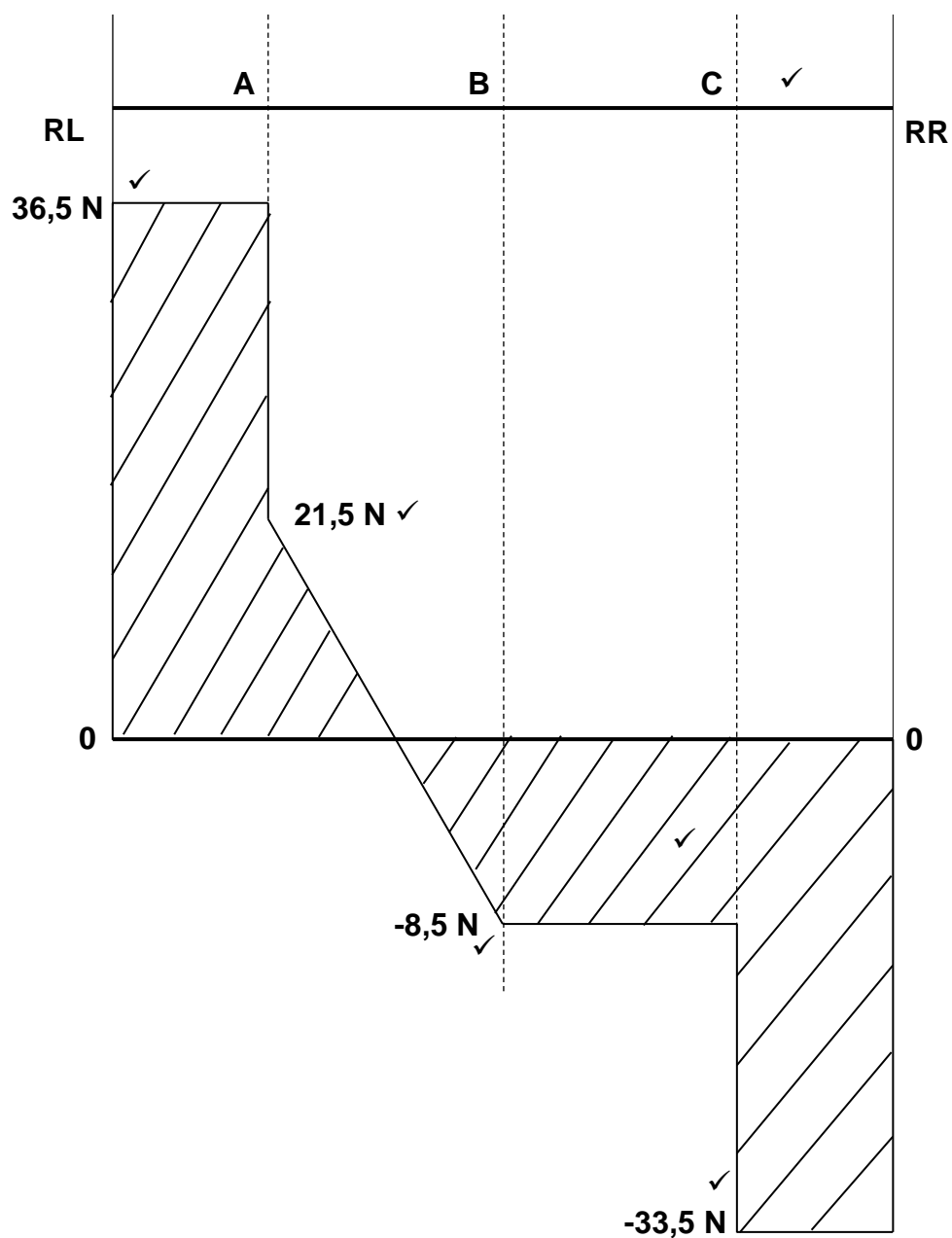
(6)

7.3.2 **Shear forces at point A, B and C:**

$$\begin{aligned}
 SF_A &= 36,5 - 15 \checkmark \\
 &= 21,5 \text{ N } \checkmark \\
 SF_B &= 36,5 - 15 - 30 \checkmark \\
 &= -8,5 \text{ N } \checkmark \\
 SF_C &= 36,5 - 15 - 30 - 25 \checkmark \\
 &= -33,5 \text{ N } \checkmark
 \end{aligned}$$

(6)

7.3.3 Shear force diagram:



(6)

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

7.4 Stress and strain:

7.4.1 Stress:

$$\begin{aligned}\text{Stress} &= \frac{\text{Load}}{\text{Area}} \quad \text{But Area} = \frac{\pi D^2}{4} \\ \text{Area} &= \frac{\pi D^2}{4} \\ &= \frac{\pi(0,03)^2}{4} \checkmark \\ &= 0,71 \times 10^{-3} \text{ m}^2 \quad \text{or } 7,07 \times 10^{-4} \text{ m}^2 \checkmark\end{aligned}$$

$$\begin{aligned}\text{Stress} &= \frac{\text{Force}}{\text{Area}} \\ &= \frac{80 \times 10^3 \text{ N}}{0,71 \times 10^{-3} \text{ m}^2} \checkmark \\ &= 112,68 \times 10^6 \text{ Pa} \checkmark \\ &= 112,68 \text{ MPa} \checkmark\end{aligned}$$

OR

$$\begin{aligned}\text{Stress} &= \frac{\text{Force}}{\text{Area}} \\ &= \frac{80 \times 10^3 \text{ N}}{7,07 \times 10^{-4} \text{ m}^2} \checkmark \\ &= 113154172,6 \text{ Pa} \checkmark \\ &= 113,15 \text{ MPa} \checkmark\end{aligned}$$

(6)

7.4.2 Strain:

$$\begin{aligned}\text{Strain} &= \frac{\Delta L}{OL} \\ &= \frac{0,06}{3000} \checkmark \\ &= 0,02 \times 10^{-3} \checkmark\end{aligned}$$

(If any unit indicated, then NO mark awarded for final answer)

(2)
[45]

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

8.1 Welding defects (Causes):

8.1.1 Slag inclusion:

- Included angle too narrow. ✓
- Rapid chilling. ✓
- Welding temperature too low / current too low. ✓
- High viscosity of molten metal. ✓
- Slag not removed from previous weld run. ✓
- Incorrect welding technique. ✓
- Surface contamination. ✓
- Too big weaving action. ✓
- Too slow speed along the weld joint. ✓
- Too short arc length. ✓

(Any 2 x 1) (2)

8.1.2 Incomplete penetration:

- Speed too fast. ✓
- Poor welding technique. ✓
- Electrode too large. ✓
- Current too low. ✓
- Joint preparation not prepared correctly. ✓
- Weldability of parent metal not good. ✓

(Any 2 x 1) (2)

8.2 Welding defects (Prevention):

8.2.1 Porosity:

- Use correct current. ✓
- Hold a longer arc. ✓
- Use correct electrodes. ✓
- Check for impurities. ✓
- Ensure adequate shielding gas. ✓
- Correct welding technique. ✓
- Check that electrode/ filler metal did not rust. ✓

(Any 2 x 1) (2)

8.2.2 Lack of fusion:

- Use correct included angle. ✓
- Use the correct size of electrode. ✓
- Use the correct current setting. ✓
- Prepare the plate bevel/V-groove accordingly. ✓

(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 Welding cracks:

- Heat affected zone (HAZ) cracks. ✓
- Centre line / longitude cracks. ✓
- Crater cracks. ✓
- Transverse cracks. ✓

(Any 3 x 1) (3)

8.5 Oxy-acetylene welding process:

- Correct flame for the work on hand. ✓
- Correct angle of nozzle. ✓
- Correct angle of rod. ✓
- Depth of fusion. ✓
- The amount of penetration. ✓
- The rate of progress along the joint. ✓

(Any 2 x 1) (2)

8.6 Nick-break test:

- Each side of the weld is slotted by means of a saw. ✓
- Place the specimen on two steel supports / In a bench vice. ✓
- Break the specimen ✓ by striking it with a hammer. ✓
- Inspect the weld metal for exposed defects. ✓

(5)

8.7 Non-destructive tests:

- It does not involve the destruction/damage of the test piece ✓
- The test piece can still be used after test is done. ✓

(Any 1 x 1) (1)

8.8 Machinability test:

- To determine the ease of machining ✓
- To determine the quality of the finish ✓

(2)

[23]

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

- 9.1 **Cold worked steel:**
- Melting point ✓
 - Its composition and constitution ✓
 - The amount of cold work ✓
 - Annealing time ✓
- (4)
- 9.2 **Shrinkage in a welded joint:**
- 9.2.1 **Electrode type:**
Thermal properties have a greater potential to cause deformation. ✓ (1)
- 9.2.2 **Electrode size:**
The larger the electrode diameter the higher the current the greater the deformation. ✓ (1)
- 9.2.3 **Welding current:**
The higher welding current the higher the welding temperature the higher the deformation. ✓ (1)
- 9.3 **Factors that determine the cooling rate:**
- Size of work piece ✓
 - Weld thickness ✓
 - Thermal conductive properties of parent metal ✓
- (Any 2 x 1) (2)
- 9.4 **Definition:**
- 9.4.1 **Distortion:**
Weld distortion is the warping of the base metal ✓ caused by heat from the welding arc/flame. ✓ (2)
- 9.4.2 **Shrinkage:**
Weld shrinkage is a form of plastic deformation ✓ where the metal has deformed as a result of contraction on cooling. ✓ (2)
- 9.5 **Factors affecting distortion and residual stress:**
- When the metal is heated and expansion is resisted then deformation will occur. ✓
 - When cooling occurs and contraction is resisted, then stress will occur. ✓
 - If applied stress causes movement, the distortion occurs. ✓
 - If applied stress does not cause movement then there will be residual stress in the welded joint. ✓
- (Any 3 x 1) (3)

9.6 **Causes of residual stress:**

- During welding, the welds and Heat Affected Zone (HAZ) are heated to temperatures well above those of the surrounding material. ✓
- The weld and HAZ deform plastically because their thermal expansion is restricted by the surrounding material. ✓
- As the weld cools and contracts, tensile stresses develop elastically. ✓
- Welds develop tensile stresses that approach yield stress. ✓

(Any 2 x 1)

(2)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 Overloading:

10.1.1 Shearing machines:

- Dulling or breaking blades. ✓
- Putting strain on the motor and drive mechanism. ✓

(Any 1 x 1) (1)

10.1.2 Drill press:

- Damage / breakage to the drill bit. ✓
- It puts strain on the drive components. ✓

(Any 1 x 1) (1)

10.2 Friction:

10.2.1 Guillotine:

Excessive wear / damage to moving parts. ✓

(1)

10.2.2 Horizontal band saw:

- Overheating of the cutting blade. ✓
- Damage to the cutting blade. ✓
- Excessive wear to moving parts. ✓

(Any 1 x 1) (1)

10.3 Maintenance of a power saw:

- Check the mains electrical switches. ✓
- Check the wiring and conduits for cracks. ✓
- Check for broken control mechanisms. ✓
- Check electrical connections. ✓
- Check for loose electrical components. ✓
- Check that cutting fluid does not come in contact with electrical wiring and switches. ✓

(Any 2 x 1) (2)

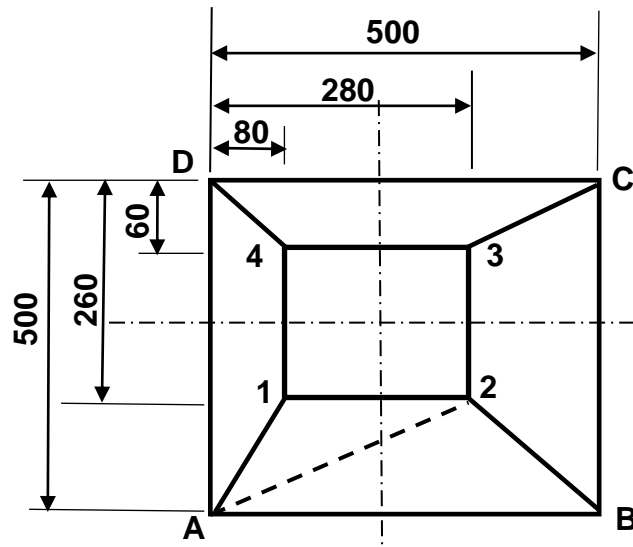
10.4 Methods to reduce friction:

- Applying cutting fluid. ✓
- Applying oil. ✓
- Prevent excessive pressure / Apply adequate pressure. ✓
- Ensure that the drill bit is sharp. ✓
- Ensure to use correct speed for the size of drill bit. ✓
- Use the correct drill bit. ✓

(Any 2 x 1) (2)
[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 Square to square off centre hopper:



11.1.1 True length of A-2:

$$\begin{aligned}
 \text{True length (A-2)} &= \sqrt{240^2 + 280^2 + 400^2} \\
 &= \sqrt{57600 + 78400 + 160000} \\
 &= \sqrt{296000} \\
 &= 544,06 \text{ mm} \checkmark \approx 544 \text{ mm} \checkmark
 \end{aligned}$$

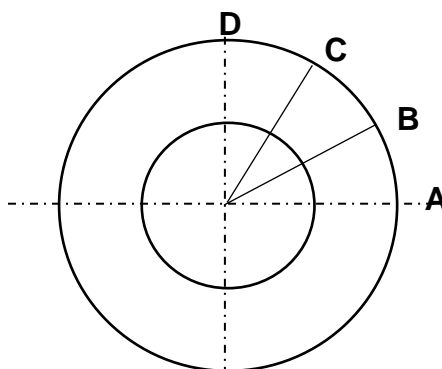
(5)

11.1.2 True length of C-3:

$$\begin{aligned}
 \text{True length (C-3)} &= \sqrt{220^2 + 60^2 + 400^2} \\
 &= \sqrt{48400 + 3600 + 160000} \\
 &= \sqrt{212000} \\
 &= 460,43 \text{ mm} \checkmark \approx 460 \text{ mm} \checkmark
 \end{aligned}$$

(5)

11.2 **Truncated cone:**



11.2.1 **True length of A-B:**

$$\begin{aligned}\text{True length(A - B)} &= \frac{\pi D}{12} \quad \checkmark \\ &= \frac{\pi \times 600}{12} \quad \checkmark \\ &= \frac{1884,96}{12} \quad \checkmark \\ &= 157,08 \text{ mm} \quad \checkmark \approx 157 \text{ mm} \quad \checkmark\end{aligned}\quad (5)$$

11.2.2 **Circumference of the top circle:**

$$\begin{aligned}\text{Circumference of top circle} &= \pi \times D \quad \checkmark \\ &= \pi \times 400 \quad \checkmark \\ &= 1256,64 \text{ mm} \quad \checkmark \approx 1257 \text{ mm} \quad \checkmark\end{aligned}\quad (4)$$

11.2.3 600 \checkmark mm. \checkmark (2)

[21]

TOTAL: 200