NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2022

MECHANICAL TECHNOLOGY WELDING AND METALWORK

MARKING GUIDELINES

Time: 3 hours 200 marks

These marking guidelines are prepared for use by examiners and sub-examiners, all of whom are required to attend a standardisation meeting to ensure that the guidelines are consistently interpreted and applied in the marking of candidates' scripts.

The IEB will not enter into any discussions or correspondence about any marking guidelines. It is acknowledged that there may be different views about some matters of emphasis or detail in the guidelines. It is also recognised that, without the benefit of attendance at a standardisation meeting, there may be different interpretations of the application of the marking guidelines.

QUESTION 1 MULTIPLE CHOICE (Generic)

1.1 A

1.2 B

1.3 D

1.4 D

1.5 C

1.6 A

QUESTION 2 SAFETY (Generic)

2.1 **Why is it so important to determine an injured person's vital signs after an injury?**
To determine whether the person is bleeding or not, if they are conscious or extent of injuries.

2.2 **Angle grinder safety:**
- Do not use excessive force while grinding.
- Ensure that the sparks do not endanger co-workers.
- Keep hands clear from grinding disc.
- Maintain a firm grip on the angle grinder.
- Ensure that the grinding disc fitted will not turn faster than the manufacturer's recommendation.
- Make sure that there are no cracks or chips in the grinding disc.
- Safety guard must be in place.
- PPE must be worn.
- Beware of lockable switches in the ON position when the machine is plugged in and switched on.
- Check for defective cables.
- Secure work piece properly.
- Grinding angle to be away from body to prevent sparks directly on clothing.
- Make sure disc does not wobble during grinding.

2.3 **Why should a workpiece be clamped securely when using a drill press?**
To prevent the workpiece turning with the drill.
To prevent injury as a result of a rotating workpiece.

2.4 **Advantages of product layout of machines:**
- Handling of material is limited to a minimum.
- Period to manufacture is reduced.
- Production control is automatic.
- Control over operations is easier.
- Greater use of unskilled labour is possible.
- A reduced amount of inspection is required.
- A reduction of total floor space is needed per unit of production.

2.5 **State TWO responsibilities of an employer regarding the safety in the workplace.**

Employers must ensure that employees are not at risk of becoming infected with HIV at work.
The employer must make sure that rubber gloves and surgical masks are available in all first-aid kits.
Employers must provide training in safety.
Employers must provide PPE for employees to carry out daily tasks.
Employers must provide a safe working environment for employees.
Employers must ensure that all employees have access to safety equipment to carry out daily tasks.

QUESTION 3 MATERIALS (Generic)

3.1 **Purpose of heat treatment of steel:**
Heat treatment of steel is done to change the properties/grain structure of steel.

3.2 **Why should ferrous metals be normalised?**
Relieve internal stresses produced by machining, forging and welding.

3.3 **Sound test:**
The metal type can be identified by tapping it with a hammer (or dropping it on the floor), if it has a sharp sound, it is a hard metal (high-carbon steel) and if it has a dull sound, it is a soft metal (mild steel).

3.4 **Heat treatment factors for hardness:**
- Workpiece size
- Quenching rate
- Carbon content

3.5 **Annealing of metal:**
Annealing involves the heating of metal to a prescribed temperature, soaking it for the required time and then cooling back to room temperature.

QUESTION 4 MULTIPLE CHOICE (Specific)

4.1 B

4.2 B

4.3 B

4.4 A

4.5 A

4.6 D

4.7 C

4.8 A

4.9 B

4.10 B

4.11 A

4.12 C

4.13 B

4.14 D

QUESTION 5 TERMINOLOGY (Templates) (Specific)

5.1 **Why is the template loft separate?**

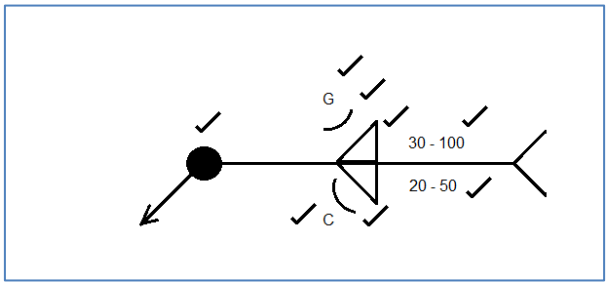
- Noise levels are lower
- Lighting is better
- Wooden floor needs to be kept clean
- Floor will have a matt black finish
- It needs to be large enough to accommodate the required work

5.2 **Purpose of purlins on roof trusses:**
The purpose is to hold the roof trusses firm and also for cladding to be fixed on top

5.3 Mean circumference = Outside circumference – material thickness
= 424 – 30
= 394 mm

Material length = mean circumference × π
= π × 394
= 1 237,79

5.4



5.5 **Advantages of using templates:**

- Unskilled labour can use it
- Production speed is greater
- Accuracy
- Ease of use
- Can be reused
- Cheap to manufacture
- Avoid unnecessary wastages / cost effective
- Uniformity in production

5.6 **What does SANS stand for?**
South African National Standards

QUESTION 6 TOOLS AND EQUIPMENT (Specific)

6.1 **Label the parts of the screw thread A, E and H.**
A. Major diameter
E. Pitch
H. Thread angle

6.2 6.2.1 Oxygen Regulator

6.2.2 To reduce the cylinder pressure to operating or working pressure.

6.2.3
- Written on regulator
- Blue in colour
- Clockwise thread
- No notch in screw-in component (hexagon)

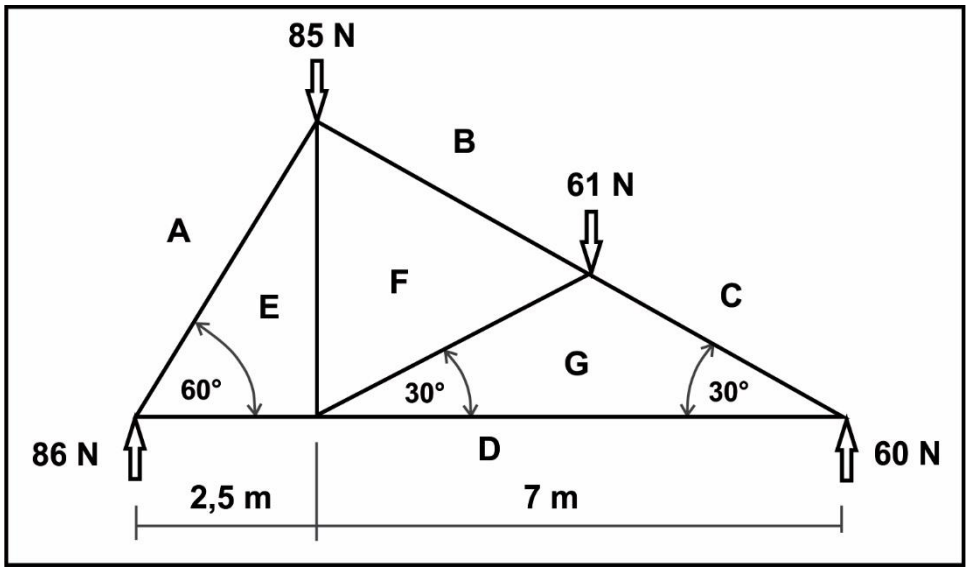
6.3 **Steel** profiles (plates) such as flat iron, angle iron, square and round solid pieces.

6.4 **MIGS/MAGS welding process:**
A – Weld pool / weld bead / molten metal
B – Electrode wire / electrode
C – Gas shroud / electrical contact / nozzle / contact tip
D – Shielding gas

6.5 **Function of flashback arrestor on the torch end**
The function of the flashback arrestor is to stop any flash going back into the pipe and to stop a difference in pressure in the torch from causing a problem.

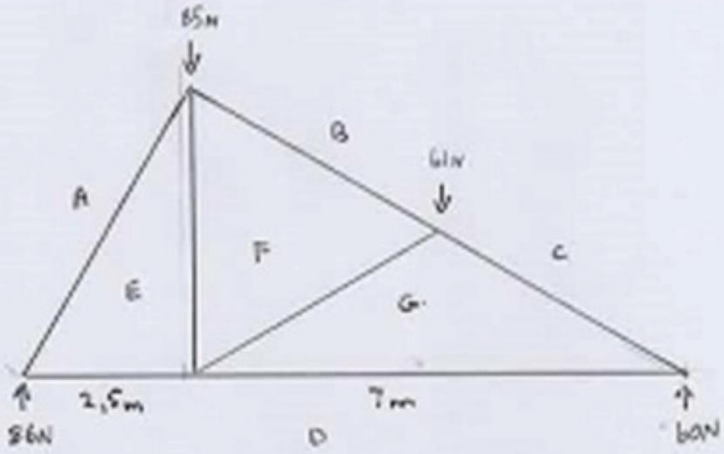
QUESTION 7 FORCES (Specific)

7.1 **Space diagram**
Scale 10 mm = 1 m

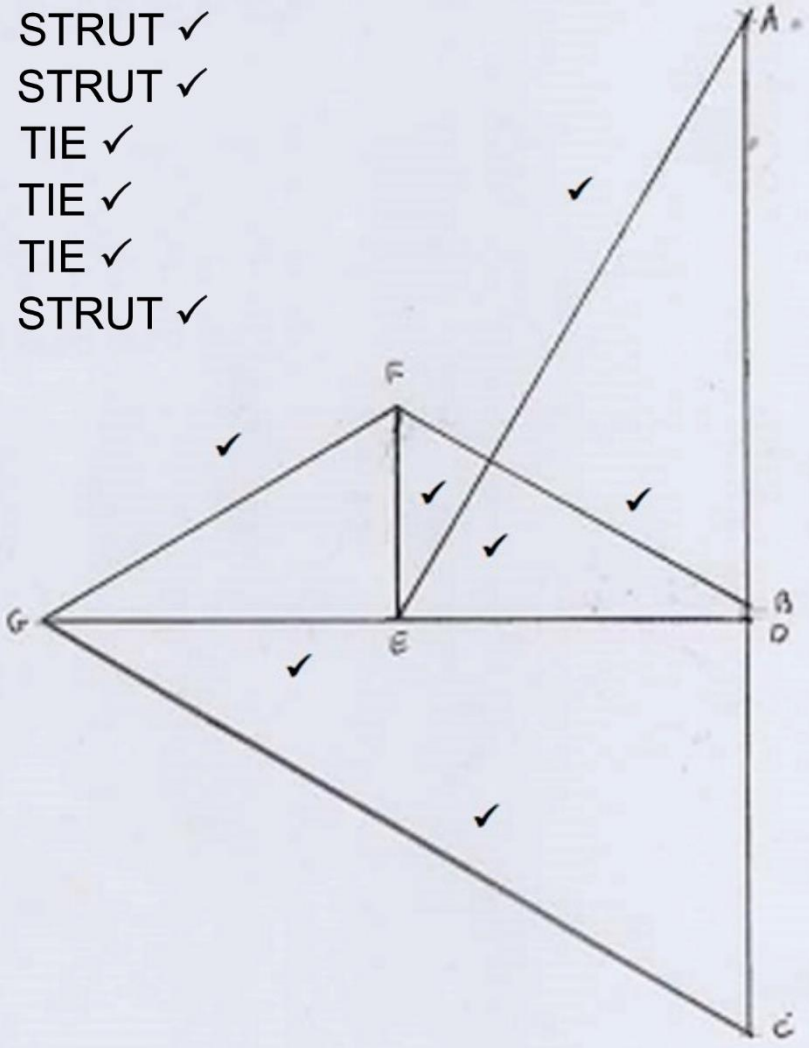


Force diagram
Scale 1 m = 10 mm
1 mm = 1N

Note to markers:
Space and force diagrams are to be drawn to scale before marking commences.
Tolerance of 2 mm is allowed.



AE	100 N ✓	STRUT ✓
BF	58 N ✓	STRUT ✓
CG	117 N ✓	STRUT ✓
DG	101 N ✓	TIE ✓
DE	55 N ✓	TIE ✓
EF	30 N ✓	TIE ✓
FG	59 N ✓	STRUT ✓



7.2 7.2.1 Take reactions around LR

$(RR \times 7,5) = (24 \times 6,5) + (60 \times 5,5) + (30 \times 3,5)$

$(RR \times 7,5) = 156 + 330 + 105$

$$RR = \frac{591}{7,5}$$

$RR = 78,8$ kN

Take reactions around RR

$(LR \times 7,5) = (30 \times 4) + (60 \times 2) + (24 \times 1)$

$(LR \times 7,5) = 120 + 120 + 24$

$$LR = \frac{264}{7,5}$$

$LR = 35,2$ kN

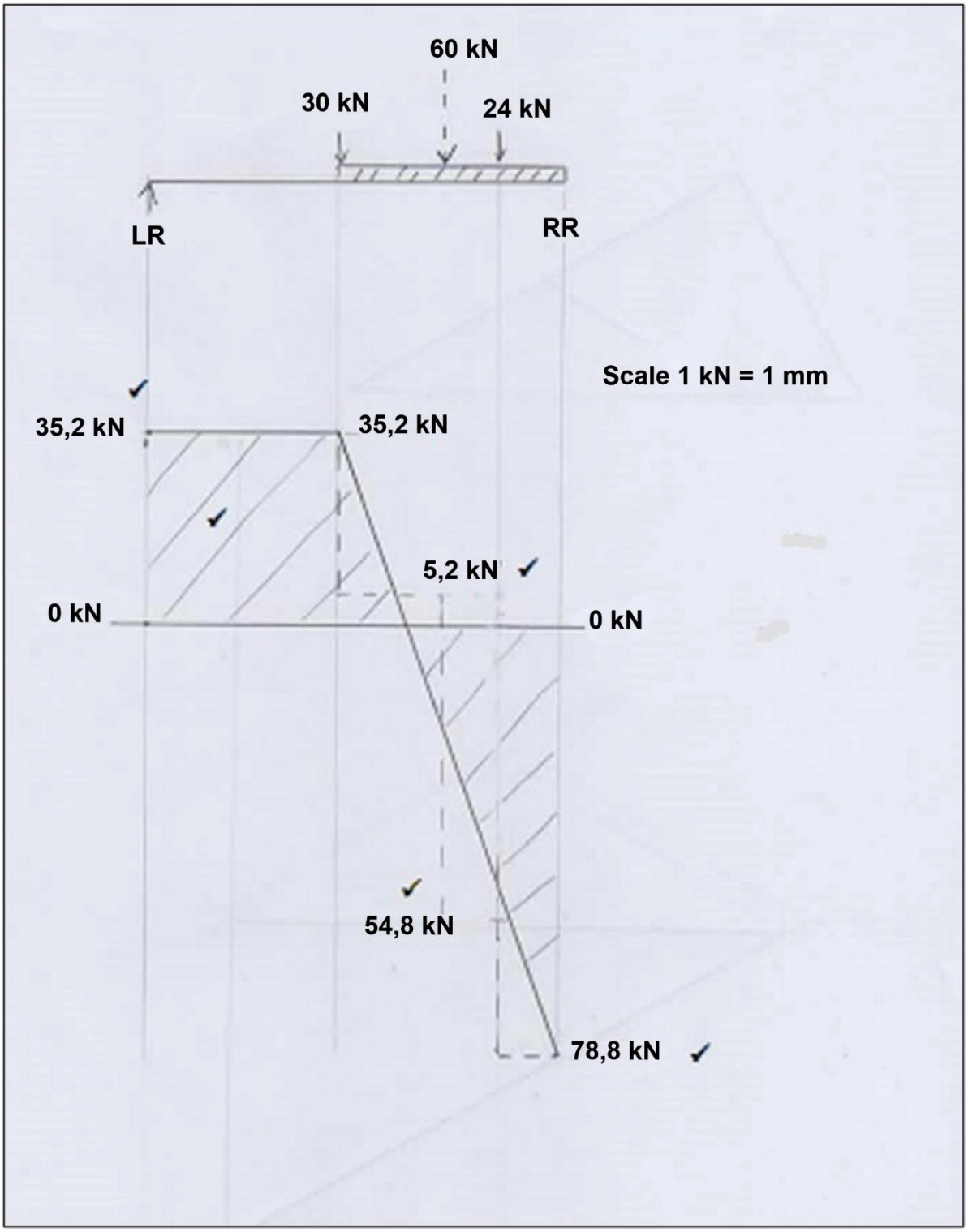
7.2.2 BM A = $(35,2 \times 3,5) – (30 \times 0) = 123,2$ kN/m

BM B = $(35,2 \times 6,5) – (30 \times 3) – (60 \times 1) – (24 \times 0) = 78,8$ kN/m

7.2.3 SF A = $35,2 – 30 = 5,2$ kN

SF B = $5.2 – 60 – 24 = –78,8$ kN

7.2.4



Note to markers:
Shear force diagram to be drawn to scale before marking commences. Tolerance of 2 mm allowed.

7.3 Stress and Strain:

7.3.1 Stress

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

$$= \frac{\pi \times 0,01^2}{4}$$

$$A = 7,85 \times 10^{-5}\ m^2$$

$$\text{Stress} = \frac{\text{Load}}{\text{Area}}$$

$$= \frac{50 \times 10^3}{7,85 \times 10^{-5}}$$

$$= 636942675,2\ Pa$$

$$= 636,94MPa$$

7.3.2 Strain:

$$\text{Strain} = \frac{\Delta L}{OL}$$

$$= \frac{0,6 \times 10^{-3}}{20}$$

$$= 3 \times 10^{-5}$$

7.3.3 Final length:

$$\text{Final length} = OL + \Delta L$$

$$= 20 + 0,6 \times 10^{-3}$$

$$= 20,0006\ m$$

QUESTION 8 JOINING METHODS (Inspection of Weld) (Specific)

8.1 **Causes of weld defects during arc welding:**

8.1.1 **Welding spatter:**
- Too high current
- Too long arc length
- Not applying anti-spatter spray
- Electrode angle too small
- Welding speed too fast

8.1.2 **Incomplete penetration:**
- Too low current
- Too slow welding speed
- Electrode angle too small
- Poor joint preparation
- Insufficient root gap

8.2 **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.

8.3 **What test uses photographic films?**
X-ray test

8.4 **Free-bend test**

8.4.1 Measures ductility of the weld deposit and the heat-affected area adjacent to the weld.
Measures the percentage elongation of the weld metal.

8.4.2
- After welding the material is trimmed in the opposite direction of welding.
- Scratch two lines 1,6 mm on the edges of the welding bead and measure the distance.
- Bend the material first 30°.
- Measure the lines again and update percentage extension.

8.4.3
- A crack or tear of more than 1,6 mm appearing during the test.
- Elongation of more than 15% of the welding bead.

8.5 8.5.1 A – Longitudinal cracks
B – Transverse cracks
C – Crater cracks

8.5.2 **Ways to reduce centre-line cracks**
- Keep width-to-depth ratio 1: 1
- Reduce current to reduce excess penetration
- Reduce welding voltage
- Reduce welding speed

8.5.3 **Causes of transverse cracks**

- High residual stress.
- Excessive welding strength.
- Excess hydrogen.

QUESTION 9 JOINING METHODS (Stresses and Distortion) (Specific)

9.1 **What is meant by residual stress:**
As the weld proceeds, the surrounding areas expand and contract at varied rates, which set up stresses in the welded joint. These stresses remain when the weld has cooled and are known as residual stresses.

9.2 **Difference between cold working and hot working of steel:**
Cold working is when deformation of steel takes place below the recrystallisation temperature of the steel.
Hot working is when deformation of steel takes place above the recrystallisation temperature of the steel.

9.3 9.3.1 This will result in a slower cooling rate. Thus, forces resist causing cracks and deformation.

9.3.2 **Factors affecting distortion and residual stress**

- If the expansion is resisted with heating, deformation will occur.
- If contraction with cooling is resisted, a stress in metal forms.
- If applied stress causes movement, deformation occurs.
- If applied stress does not cause movement, post-stress will be in the load

9.3.3 **Back-step welding**
If welding direction of welds is from left to right, interrupted bead-segments are made from right to left, then you must weld back in the direction you came from.

9.3.4 **Methods to reduce distortion**

- Do not over-weld.
- Intermittent welding.
- Place welds near neutral axis.
- Use as few weld runs as possible.
- Anticipate the shrinkage forces.
- Plan welding sequence.
- Use strongback.
- Use clamps, jigs and fixtures.

QUESTION 10 MAINTENANCE (Specific)

10.1 **Electric guillotine maintenance safety for technicians:**

Proper planning should be done to ensure all safety regulations are adhered to.
Maintenance plan must be communicated with technicians and employees.
Schedule maintenance to minimise risk.
Isolation switches to be turned off and locked out.
Only key to unlock in possession of person carrying out maintenance.
In cases where switches are manual, mechanical components must be guarded and locked.
Provide the correct tools for the job to be done.
Safety boards must be displayed to show employees that maintenance is taking place.

10.2 **Factors choice of speed during drilling:**

- Type of material.
- Diameter of the drill bit.
- Material of which the drill is made.
- Condition of the machine.
- Use of cutting fluid.
- Rate of feed.

10.3 **Reasons maintenance of machines:**

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

QUESTION 11 TERMINOLOGY (Development) (Specific)

Calculate the relevant true lengths of a cone frustum with a base diameter of 800 mm, top diameter of 400 mm and a vertical height of 800 mm, as shown in Figure 11.1.

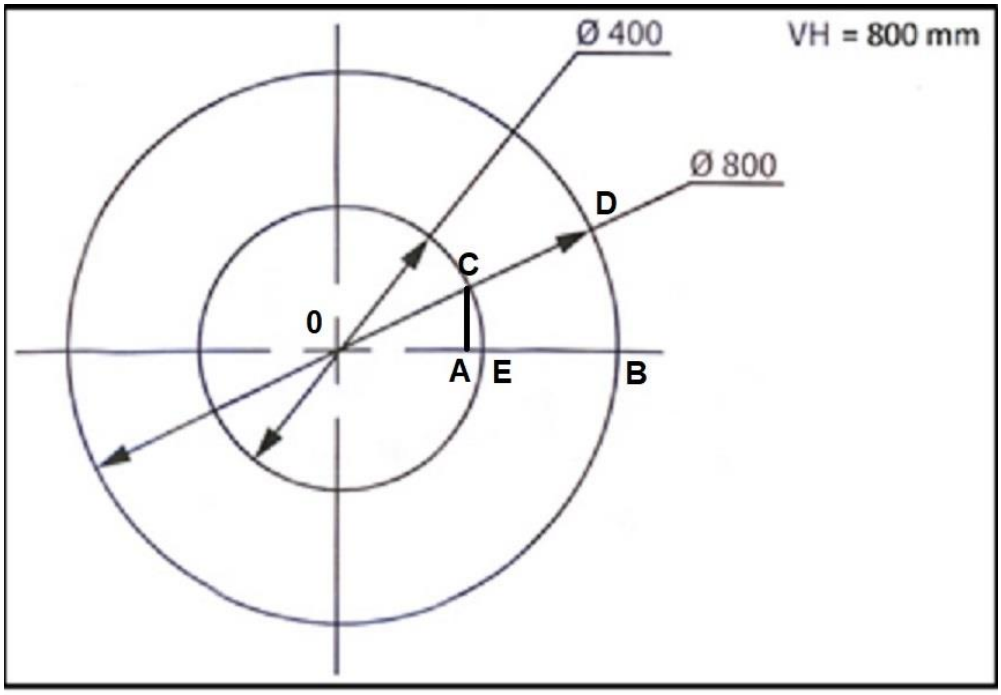


FIGURE 11.1

11.1 C – E $= \frac{\pi D}{12}$

$= \frac{\pi 400}{12}$

$= 104{,}72$

11.2 B – D $= \frac{\pi D}{12}$

$= \frac{\pi 800}{12}$

$= 209{,}44$

11.3 E – B $= 800^2 + 200^2$

$= \sqrt{680\,000}$

$= 824{,}621$ mm

11.4 C – B

O – A = 0,87 × r = 174 mm

C – A = Sin 30º × 200 = 100 mm

400 – 174 = 226 mm

$\sqrt{226^2 + 100^2}$

$\sqrt{61076}$

$\sqrt{247{,}135^2 + 800^2}$

$\sqrt{701076}$

= 837,30 mm

Total: 200 marks