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Basic Education
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SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

MAY/JUNE 2024

MARKS: 200

TIME: 3 hours

This question paper consists of 16 pages and a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces provided on the ANSWER BOOK.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Start EACH question on a NEW page.
6. Show ALL calculations and units. Round off final answers to TWO decimal places.
7. Candidates may use non-programmable scientific calculators and drawing instruments.
8. The value of gravitational acceleration should be taken as $9,81 \text{ m/s}^2$ or 10 m/s^2 .
9. ALL dimensions are in millimetres, unless stated otherwise in the question.
10. Write neatly and legibly.
11. A formula sheet is attached at the end of the question paper.
12. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME IN MINUTES
GENERIC			
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
SPECIFIC			
4	Multiple-choice Questions	14	10
5	Terminology (Templates)	23	20
6	Tools and Equipment	18	10
7	Forces	45	40
8	Joining Methods (Weld inspection)	23	20
9	Joining Methods (Stresses and Distortion)	18	20
10	Maintenance	8	10
11	Terminology (Development)	21	20
TOTAL		200	180

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.6) in the ANSWER BOOK, e.g. 1.7 E.

- 1.1 Which of the following refers to the Occupational Health and Safety Act (OHSA), 1993 (Act 85 of 1993) when responding to HIV/Aids in the workplace?
- A It is the duty of employers to make sure that rubber gloves and surgical masks are available in all first-aid kits.
 - B This Act emphasises the working relationship between employees and employers.
 - C It explains the minimum standards that employees and employers can expect from one another in the workplace.
 - D The purpose of this Act is to create an environment of equality in the workplace. (1)
- 1.2 Which ONE of the following statements refers to *process layout*?
- A The machines are arranged in the sequence in which operations are carried out.
 - B The different stages of production are carried out in different departments.
 - C The process is ideal for mass production.
 - D The time period of the manufacturing cycle is shorter. (1)
- 1.3 What is the function of the pressure gauge in a hydraulic press?
- A To be able to observe the working pressure
 - B To support the jig on the platform
 - C To stabilise the frame on the support pins
 - D To hold the work piece in place (1)
- 1.4 Why is steel soaked at a specific temperature during heat treatment?
- A To ensure that the outside of the steel becomes hotter than the inside
 - B To ensure that the inside of the steel becomes hotter than the outside
 - C To prevent a loss in the carbon content of the steel
 - D To ensure uniform penetration of heat (1)
- 1.5 Which ONE of the following quenching media is used for the normalising of steel?
- A Oil
 - B Liquid salts
 - C Still air
 - D Brine (1)

1.6 The metal that is best suited for case-hardening:

- A Brass
- B Aluminium
- C Mild steel
- D Cast iron

(1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 State TWO situations when basic first aid should be given to help and support a person at the workplace. (2)

2.2 FIGURE 2.2 below shows a safety sign at a bench grinder. Explain what is meant by the signs labelled A–D.

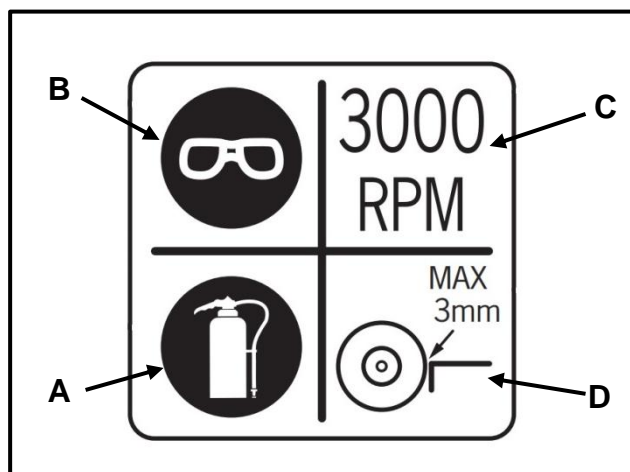


FIGURE 2.2

(4)

2.3 State TWO safety precautions that should be adhered to when using a drill press.

NOTE: All PPE and environmental factors have been taken care of. (2)

2.4 State TWO safety precautions that an operator should adhere to while working on a surface grinder.

NOTE: All PPE and environmental factors have been taken care of. (2)

[10]

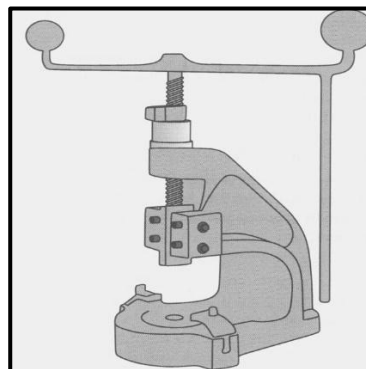
QUESTION 3: MATERIALS (GENERIC)

- 3.1 State whether steel is heated either *below* or *above* the critical temperature during the following heat-treatment processes:
- 3.1.1 Hardening (1)
- 3.1.2 Tempering (1)
- 3.1.3 Normalising (1)
- 3.2 The hardness of a sampled work piece is tested using a drill press. Which TWO aspects should be observed on the cutting chips? (2)
- 3.3 Besides the machinability test, name THREE other tests used to determine the different types of steels. (3)
- 3.4 Name TWO quenching methods used for case-hardening. (2)
- 3.5 How can the temperature of a work piece be determined during the heat-treatment process? (1)
- 3.6 State the THREE basic steps that are involved in all heat-treatment processes according to a time-temperature cycle. (3)
- [14]**

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 E.

- 4.1 Identify the type of equipment shown in FIGURE 4.1 below.

**FIGURE 4.1**

- A Hydraulic press
- B Power-driven press
- C Drill press
- D Fly press (1)

4.2 What does the 10 on the weld symbol in FIGURE 4.2 below represent?

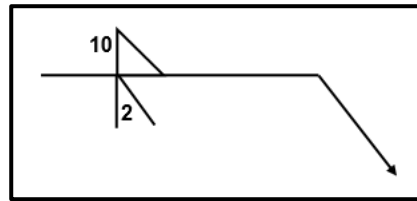


FIGURE 4.2

- A Length of weld
- B Size of weld
- C Pitch of weld
- D Root of weld

(1)

4.3 Which tool is used to cut internal threads?

- A Circular split tap
- B Taper tap
- C Intermediate die
- D Bottoming die

(1)

4.4 Identify the template in FIGURE 4.4 below.

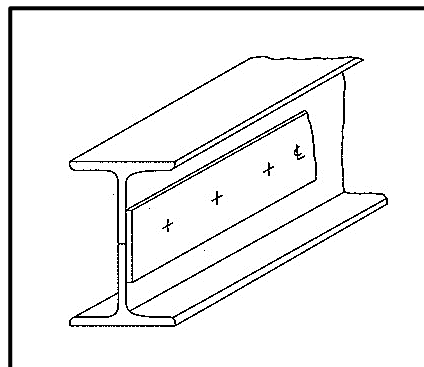


FIGURE 4.4

- A Web template
- B Strip template
- C Gusset plate
- D Flange template

(1)

4.5 What does **C** refer to in supplementary welding symbols?

- A Chase
- B Convex
- C Concave
- D Chisel

(1)

4.6 Which metal type will give a dull sound when conducting a sound test?

- A Low carbon steel
- B High carbon steel
- C Perspex
- D Medium carbon steel

(1)

4.7 Identify the nature of member **XY** in the steel framework shown in FIGURE 4.7 below.

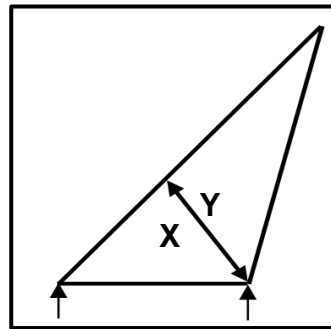


FIGURE 4.7

- A Stress
- B Tie
- C Strut
- D Beam

(1)

4.8 Which ONE of the following steps can reduce transverse cracks in arc welding?

- A Preparing the root gap
- B Slow cooling after welding
- C Quick cooling after welding
- D Using the correct welding current

(1)

4.9 What do you understand by the term *Young's modulus of elasticity*?

- A It is a measurement of the extension or contraction of material due to the load experienced.
- B It is the force value required to produce a unit area in a tensile test specimen.
- C It is a ratio of the deformation because of the application of an external force.
- D It is the ratio between stress and strain in a metal provided that the limit of elasticity is not exceeded.

(1)

4.10 X-ray testing uses ... to record flaws in welded joints.

- A film
- B sound
- C liquid
- D dye

(1)

4.11 What will the effect be when cold-worked metal is heated to not higher than 650 °C?

- A Hardening
- B Boiling
- C Relief of internal stress
- D Melting

(1)

4.12 What is the length of X in FIGURE 4.12 below?

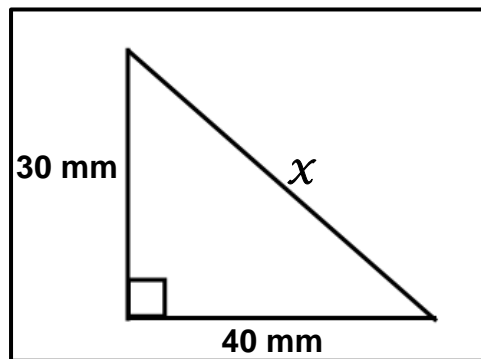


FIGURE 4.12

- A 30 mm
- B 40 mm
- C 50 mm
- D 60 mm

(1)

4.13 What type of movement will force **A** cause on the see-saw in FIGURE 4.13 below?

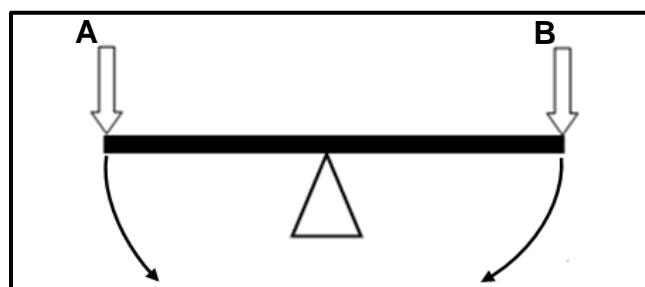


FIGURE 4.13

- A Clockwise movement
- B Anti-clockwise movement
- C Horizontal movement
- D Vertical movement

(1)

4.14 Identify the type of hopper in FIGURE 4.14 below.

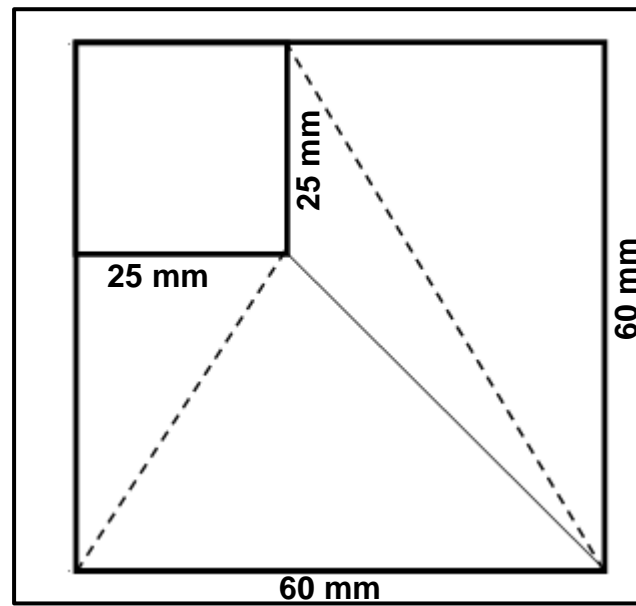


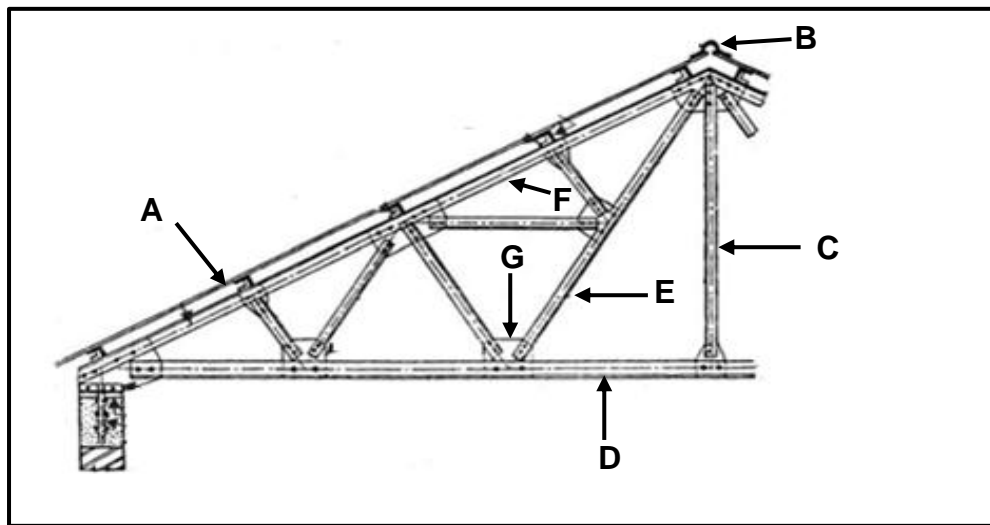
FIGURE 4.14

- A Square-to-rectangle hopper on centre
- B Square-to-square hopper on centre
- C Square-to-rectangle hopper off centre
- D Square-to-square hopper off centre

(1)
[14]

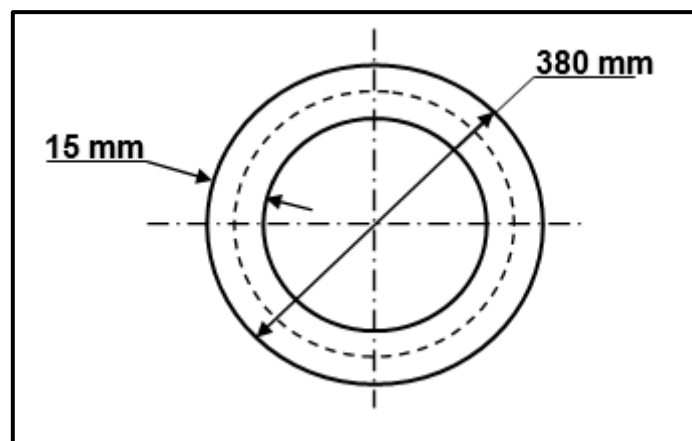
QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 FIGURE 5.1 below shows a drawing of a roof truss. Label parts **A–G**.

**FIGURE 5.1**

(7)

5.2 FIGURE 5.2 below shows a brass ring that must be manufactured using a 15 x 15 mm square bar. The ring has an outside diameter of 380 mm.

**FIGURE 5.2**

Calculate the following:

5.2.1 The mean diameter of the ring (2)

5.2.2 The mean circumference of the ring

Round off your answer to the nearest whole number. (3)

- 5.3 Draw the welding symbol for the joint that needs to be arc welded in FIGURE 5.3 below.

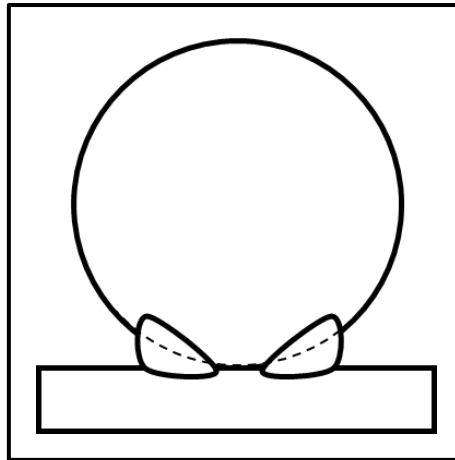


FIGURE 5.3

- (4)
- 5.4 What is the purpose of supplementary weld symbols? (2)
- 5.5 State TWO advantages of using templates. (2)
- 5.6 Name any THREE machines used in a template loft. (3)
- [23]**

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 Explain the working principle of the following machines:

6.1.1 Power-driven guillotine (4)

6.1.2 Pyramid bending rolls (4)

6.2 State TWO uses of the hydraulic press in the mechanical workshop. (2)

6.3 Name TWO types of hardness testers. (2)

6.4 FIGURE 6.4 below shows gas welding in progress. Label parts **A–D**.

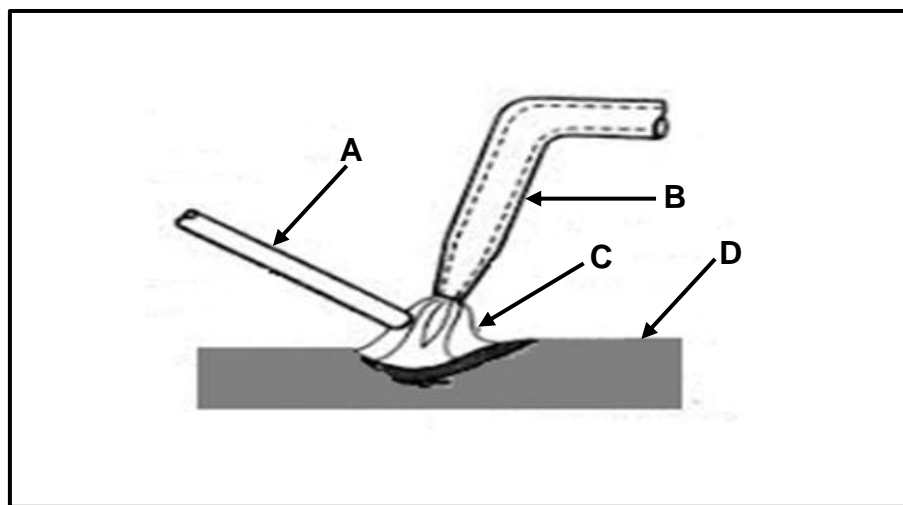


FIGURE 6.4

6.5 State the function of a plasma cutter.

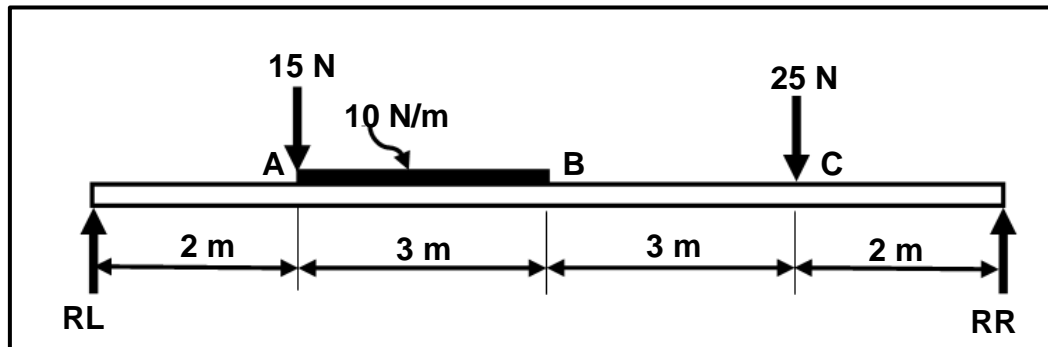
(4)

(2)

[18]

QUESTION 7: FORCES (SPECIFIC)

- 7.1 FIGURE 7.1 below shows a beam supported by two vertical supports, **RL** and **RR**. Two vertical point loads, 15 N and 25 N, are exerted onto the beam. A uniformly distributed load of 10 N/m is exerted over a length of 3 m.

**FIGURE 7.1**

Calculate the following:

- 7.1.1 The magnitude of the point load representing the UDL (1)
- 7.1.2 The reactions at **RL** and **RR** (8)
- 7.1.3 The shear forces at **A**, **B** and **C** on the beam (6)
- 7.1.4 Draw the shear force diagram.

Scale: Space diagram: 1 m = 10 mm

Shear force diagram: 1 N = 1 mm (8)

- 7.2 A round steel bar with a 36 mm diameter is lengthened by 0,6 mm when a tensile load of 110 kN is applied to it. The original length of the bar is 125 mm.

Calculate the following:

- 7.2.1 The stress in the bar (Answer must be in MPa) (5)
- 7.2.2 The strain (3)

- 7.3 FIGURE 7.3 below shows a roof truss. Study the diagram and answer the questions that follow.

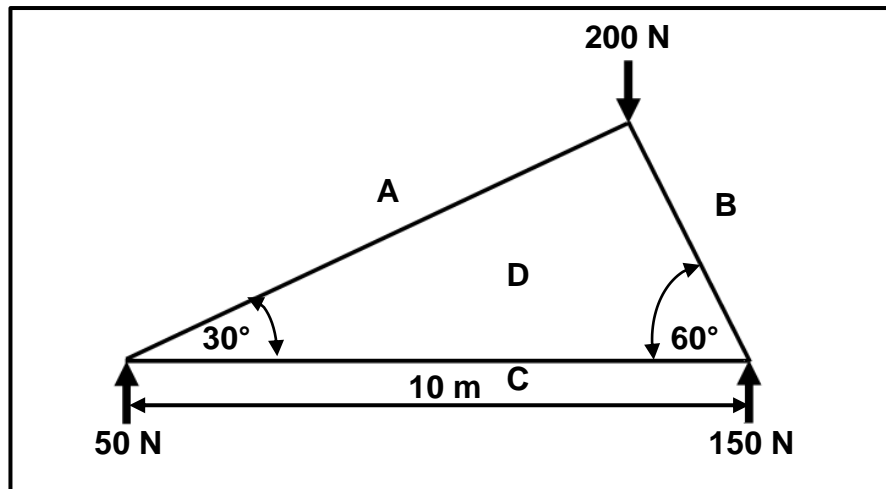


FIGURE 7.3

- 7.3.1 Draw the space diagram to scale 10 mm = 1 m. (4)
- 7.3.2 Draw the vector diagram to scale 1 mm = 2 N. (4)
- 7.3.3 Determine the magnitude and nature of members **AD**, **BD** and **CD**. (6)
- [45]**

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

- 8.1 State THREE measures to prevent incomplete penetration during the arc-welding process. (3)
- 8.2 State TWO common weld defects that can be identified by visual inspection. (2)
- 8.3 Explain the term *fusion* in arc welding. (2)
- 8.4 What can be done to address undercutting in a welded joint? (3)
- 8.5 State TWO purposes of the nick-break test in evaluating weld quality. (2)
- 8.6 Explain the significance of consistent width and height of a weld bead in ensuring weld quality. (3)
- 8.7 Describe THREE factors that should be considered during weld inspection. (3)
- 8.8 Explain how to conduct the liquid dye penetration test on a welded joint. (5)
- [23]**

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

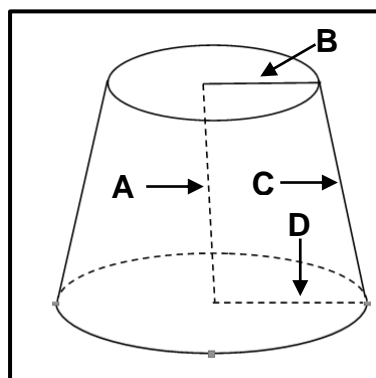
- 9.1 State THREE purposes of relieving stress caused by the heat treatment process. (3)
- 9.2 State THREE factors that can contribute to distortion and residual stress in welding. (3)
- 9.3 State FOUR mechanical properties that are affected by temperature change during heat treatment. (4)
- 9.4 State THREE factors that influence the grain size of cold-worked steel. (3)
- 9.5 What is the primary cause of shrinkage in welded joints? (1)
- 9.6 State FOUR welding methods to reduce distortion. (4)
- [18]**

QUESTION 10: MAINTENANCE (SPECIFIC)

- 10.1 State TWO common causes of failure in machines. (2)
- 10.2 State FOUR routine maintenance guidelines for a power-driven guillotine. (4)
- 10.3 State TWO common causes of the failure of rollers in a rolling machine. (2)
- [8]**

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

- 11.1 Name the transformer used to convert square ventilation to round ducting. (2)
- 11.2 FIGURE 11.2 below shows a cone. Answer the questions that follow.

**FIGURE 11.2**

- 11.2.1 Identify the type of cone. (1)
- 11.2.2 Label A–D. (4)

11.3 FIGURE 11.3 below shows a hopper off-centre.

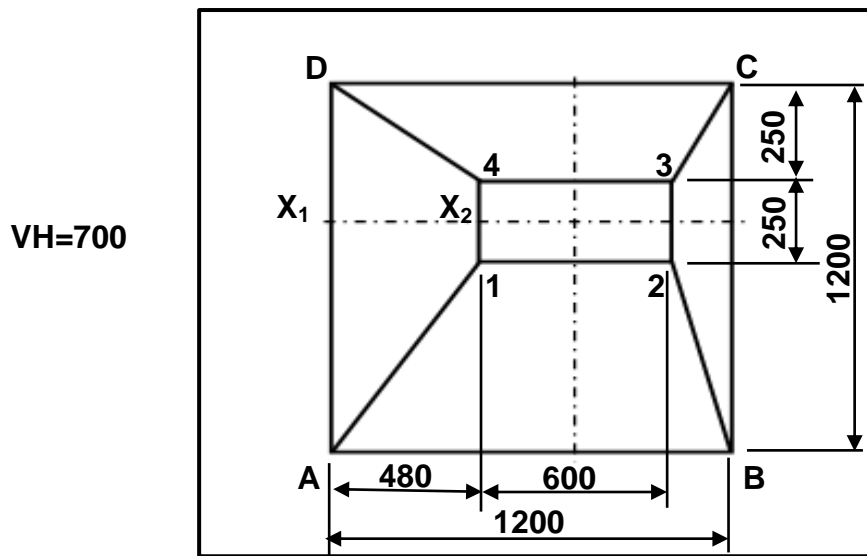


FIGURE 11.3

Calculate the true length of the following:

- | | | |
|--------|------------------------------------|-------------|
| 11.3.1 | A–1 | (5) |
| 11.3.2 | C–3 | (5) |
| 11.3.3 | X₁–X₂ | (4) |
| | | [21] |

TOTAL: 200

**FORMULA SHEET FOR MECHANICAL TECHNOLOGY:
WELDING AND METALWORK****1. STRESS AND STRAIN**

$$1.1 \quad A_{shaft} = \frac{\pi d^2}{4}$$

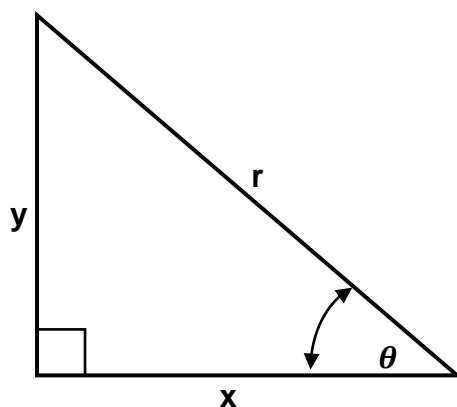
$$1.2 \quad A_{pipe} = \frac{\pi(D^2 - d^2)}{4}$$

$$1.3 \quad \text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$$

$$1.4 \quad \text{Stress} = \frac{\text{Force}}{\text{Area}} \quad \text{OR} \quad \sigma = \frac{F}{A}$$

$$1.5 \quad \text{Strain} = \frac{\text{Change in length}}{\text{Original length}} \quad \text{OR} \quad \varepsilon = \frac{\Delta L}{oL}$$

$$1.6 \quad \text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}} \quad \text{OR} \quad E = \frac{\sigma}{\varepsilon}$$

2. PYTHAGORAS' THEOREM AND TRIGONOMETRY

$$2.1 \quad \sin \theta = \frac{y}{r}$$

$$2.2 \quad \cos \theta = \frac{x}{r}$$

$$2.3 \quad \tan \theta = \frac{y}{x}$$

$$2.4 \quad r^2 = x^2 + y^2$$

3. TEMPLATES AND DEVELOPMENTS

3.1 $\text{Mean } \varnothing = \text{Outside } \varnothing - \text{Plate thickness}$

OR

$$\text{Mean } \varnothing = \text{Inside } \varnothing + \text{Plate thickness}$$

3.2 $\text{Mean circumference} = \pi \times \text{Mean } \varnothing$

(where \varnothing = diameter)

4. SCREW THREADS

$$\text{Drill size} = \text{Outside } \varnothing - \text{Pitch}$$