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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

NOVEMBER 2023

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 Who is responsible for safe working conditions in the workplace?
- A Workers' union
 - B Employer
 - C Employee
 - D Department of Labour
- (1)
- 1.2 Identify the Act that seeks to protect the worker from physical injuries in the workplace:
- A Occupational Health and Safety Act (OHSA), 1993 (Act 85 of 1993)
 - B Labour Relations Act (LRA), 1995 (Act 66 of 1995)
 - C Employment Equity Act (EEA), 1998 (Act 55 of 1998)
 - D Basic Conditions of Employment Act (BCEA), 1997 (Act 75 of 1997)
- (1)
- 1.3 Which safety precaution must be applied when arc welding?
- A Wet the work piece before welding to prevent overheating.
 - B Do not let oil and grease come into contact with the oxygen fittings.
 - C Use completely insulated electrode holders.
 - D Ensure that you always open the acetylene valve slowly.
- (1)
- 1.4 Identify the test shown in FIGURE 1.4 below.

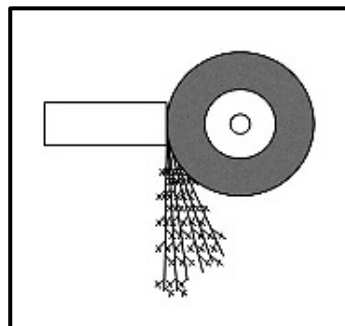


FIGURE 1.4

- A Sound test
 - B Ultrasonic test
 - C Spark test
 - D Cutting test
- (1)

1.5 Which heat-treatment process relieves the internal stresses produced by machining, forging and welding?

- A Normalising
- B Case hardening
- C Tempering
- D Hardening

(1)

1.6 FIGURE 1.6 below shows the changes in metal structures during the annealing process. What change is indicated at Y?

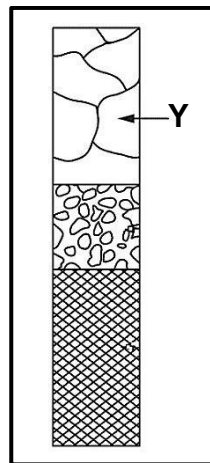


FIGURE 1.6

- A Recovery
- B Grain growth
- C Recrystallisation
- D Grain crystallisation

(1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 State TWO checks that must be done on injured persons before removing them from a danger zone.

(2)

2.2 Name TWO safety devices fitted to power guillotines.

(2)

2.3 State TWO safety precautions that must be conducted on a grinding wheel before it is fitted to a bench grinder.

(2)

2.4 Name TWO safety devices fitted to gas-welding equipment.

(2)

2.5 State TWO advantages of a workshop with a process layout.

(2)

[10]

QUESTION 3: MATERIALS (GENERIC)

- 3.1 Give ONE reason why the lengths of metals are normally marked or colour-coded at the ends. (1)
- 3.2 State ONE property of metals that can be determined by EACH of the following tests:
- 3.2.1 Sound test (1)
- 3.2.2 Bending test (1)
- 3.2.3 Machining test (1)
- 3.3 Why is metal soaked in heat when performing heat-treatment processes? (2)
- 3.4 State TWO methods of conducting case hardening. (2)
- 3.5 Explain how steel is annealed during heat-treatment processes. (3)
- 3.6 Name TWO quenching mediums that rapidly cool metal after heat-treatment processes. (2)
- 3.7 Which heat-treatment process follows the hardening process of a metal? (1)
- [14]**

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

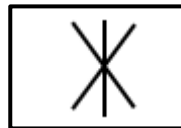
Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 E.

4.1 Which ONE of the following components is part of a portable electric angle grinder?

- A Safety guard
- B Stand
- C Tool rest
- D Grinding wheel dresser

(1)

4.2 What does the weld symbol in FIGURE 4.2 represent?

**FIGURE 4.2**

- A Projection
- B Spot
- C Foil seam
- D Resistance butt

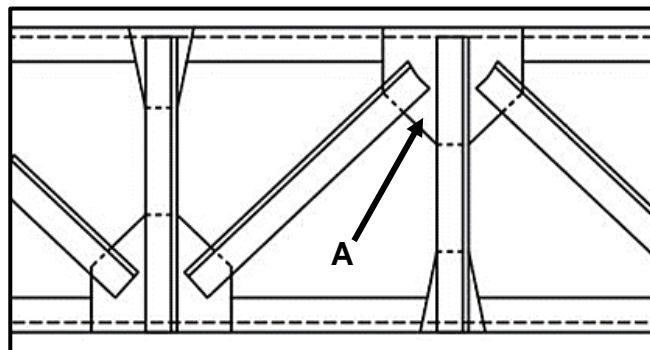
(1)

4.3 Which ONE of the following taps is used second when cutting internal threads?

- A Taper tap
- B Starting tap
- C Intermediate tap
- D Bottoming tap

(1)

4.4 A steel framework is shown below in FIGURE 4.4. Identify part A.

**FIGURE 4.4**

- A Top flange
- B Purlin
- C Ridging
- D Gusset plate

(1)

- 4.5 What does **M** refer to in supplementary welding symbols?
- A Machine
 - B Millimetre
 - C Mega
 - D Metre
- (1)
- 4.6 Which ONE of the following is an example of case-hardened material?
- A Drill bits
 - B Camshafts
 - C Woodwork saws
 - D Screwdrivers
- (1)
- 4.7 Which method can be used to reduce distortion during arc welding?
- A Back-step welding
 - B Round-step welding
 - C Cooling in water
 - D Forward welding
- (1)
- 4.8 What is the disadvantage of using jigs when welding?
- A It restricts the metal movement.
 - B It allows the metal to stretch.
 - C It allows the metals to move.
 - D It allows the metal to harden.
- (1)
- 4.9 What is the purpose of annealing steel?
- A To harden
 - B To temper
 - C To harden the core
 - D To relieve internal stress
- (1)
- 4.10 Define *porosity* in a welded joint:
- A Occurs as a cavity at the end of a welded joint
 - B Small pinholes in weld metal due to atmospheric contamination
 - C Occurs as a cavity at the beginning of a welded joint
 - D Metal found in weld metal due to surface contamination
- (1)
- 4.11 What is the structure for pure iron called with reference to the iron-carbon equilibrium diagram?
- A Ferrite
 - B Pearlite
 - C Cementite
 - D Austenite
- (1)

4.12 Identify the type of test carried out in FIGURE 4.12 below.

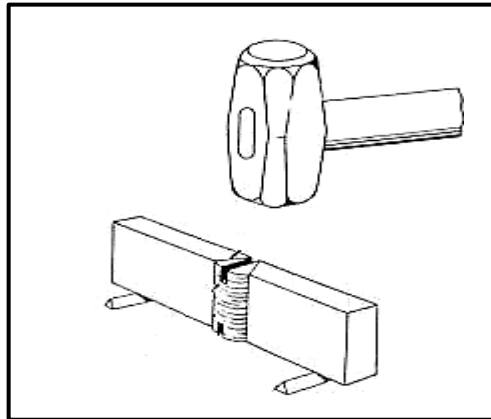


FIGURE 4.12

- A Nick-break test
- B Nick-bend test
- C Visual inspection
- D Ultrasonic test

(1)

4.13 Identify the type of force exerted on the rivet in FIGURE 4.13 below when the plates are pulled apart.

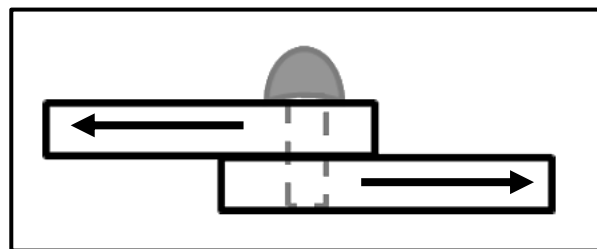


FIGURE 4.13

- A Stress force
- B Strain force
- C Compressive force
- D Shear force

(1)

4.14 Which tool is used to dress an unevenly worn grinding wheel?

- A Screwdriver dresser
- B Huntington dresser
- C File dresser
- D Hack-saw dresser

(1)

[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

- 5.1 A brass ring must be manufactured using a 30 x 30 mm square bar. The ring has an inside diameter of 870 mm.

Calculate the following:

- 5.1.1 The mean diameter of the ring (2)

- 5.1.2 The mean circumference of the ring (round off answer to the nearest whole number) (3)

- 5.2 Draw the fusion weld symbols for the following:

- 5.2.1 Square butt (2)

- 5.2.2 V-groove (2)

- 5.2.3 U-butt (2)

- 5.2.4 J-butt (2)

- 5.2.5 Flare V (2)

- 5.3 FIGURE 5.3 below shows a drawing with relevant welding information needed to manufacture a component.

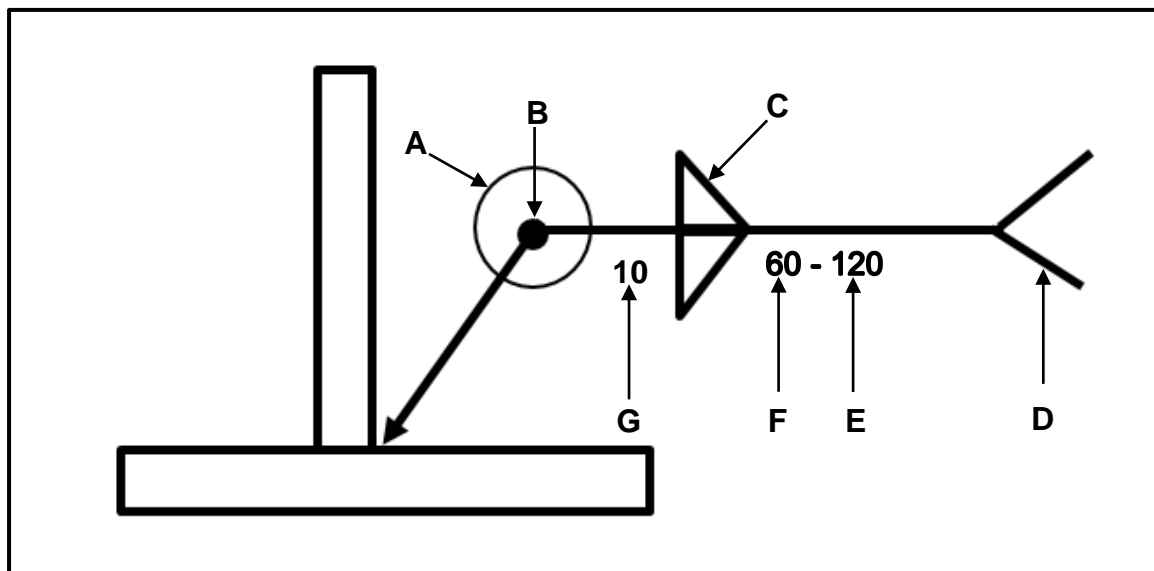


FIGURE 5.3

- 5.3.1 Identify the type of joint. (1)

- 5.3.2 Identify labels **A–G**. (7)
[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 Name THREE types of metal that can be cut with a plasma cutter. (3)

6.2 State THREE uses of a bench grinder. (3)

6.3 FIGURE 6.3 below shows an arc welding set-up.

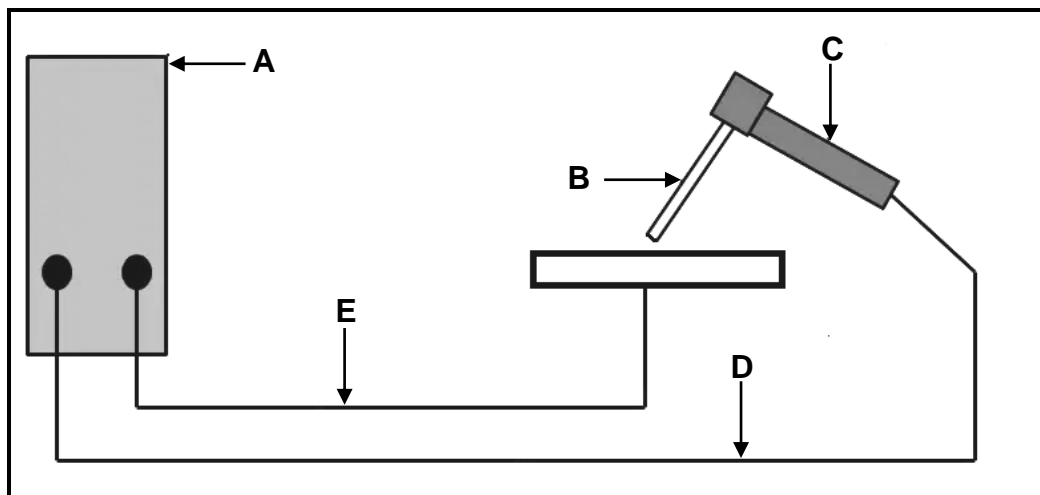


FIGURE 6.3

6.3.1 Label parts A–E. (5)

6.3.2 State ONE advantage of MIG/MAGS welding over arc welding. (1)

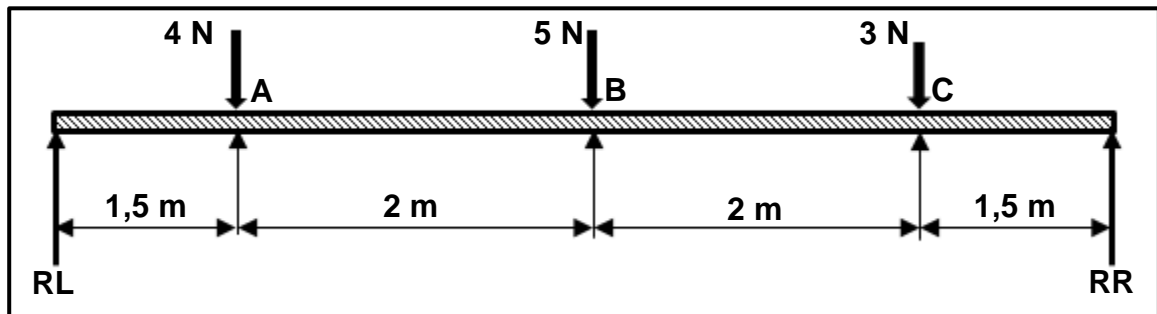
6.4 Determine the drill size required to tap a M10 x 1,5 internal thread. (3)

6.5 Name THREE types of rolling machines. (3)

[18]

QUESTION 7: FORCES (SPECIFIC)

7.1 FIGURE 7.1 below shows a beam subjected to three point loads.

**FIGURE 7.1**

7.1.1 Calculate the magnitude of the reactions at **RL** and **RR**. (8)

7.1.2 Calculate the bending moments at points **A**, **B** and **C**. (6)

7.1.3 Draw a bending-moment diagram.

Scale: Bending moments: 1 m = 10 mm and 1 Nm = 10 mm (6)

7.2 A load of 65 kN causes a tensile stress of 5 MPa in a round aluminium bar. The original length of the bar is 250 mm. Young's modulus for aluminium is 75 GPa.

Calculate the following:

7.2.1 The area of the bar (3)

7.2.2 The diameter of the bar (3)

7.2.3 The strain (2)

7.2.4 The change in length (3)

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

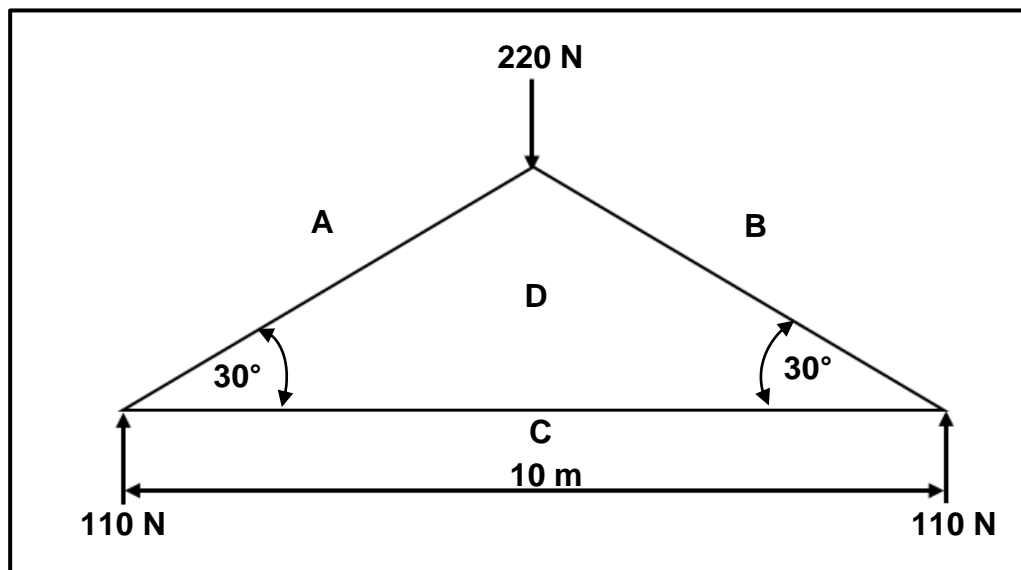


FIGURE 7.3

- 7.3.1 Draw the space diagram to scale 10 mm = 1 m. (3)
- 7.3.2 Draw the vector diagram to scale 1 mm = 2 N. (5)
- 7.3.3 Determine the magnitude of the forces in members **AD**, **BD** and **CD**. Identify the members as struts or ties. (6)
- [45]

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

8.1 Identify the weld defects in FIGURES 8.1.1 and 8.1.2 below.

8.1.1

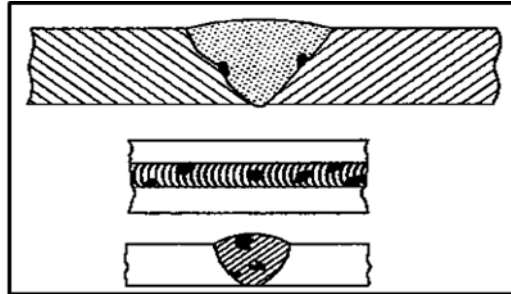


FIGURE 8.1.1

(1)

8.1.2

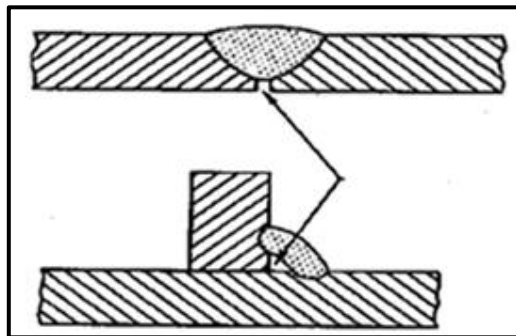


FIGURE 8.1.2

(1)

8.2 What are the main reasons for inspecting welds?

(2)

8.3 State TWO weld defects that can be revealed when conducting the following tests:

8.3.1 Nick-break test

(2)

8.3.2 Guided bend test

(2)

8.4 Define a *non-destructive test* as conducted on welded joints.

(2)

8.5 State THREE methods used to reduce transverse cracks.

(3)

8.6 What causes a crater crack in a welded joint?

(1)

8.7 State THREE advantages of using a liquid dye penetration test on a welded joint.

(3)

8.8 Describe the procedure to follow when performing an ultrasonic test on a welded joint.

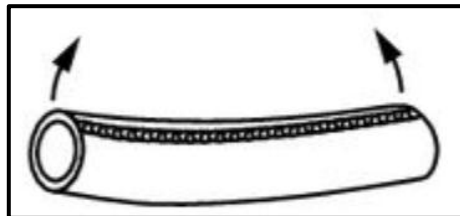
(6)

[23]

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

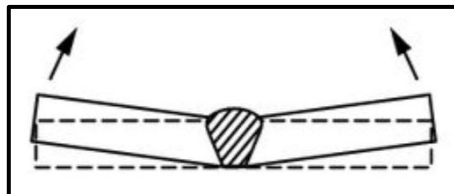
- 9.1 State THREE factors that have an effect on shrinkage in a welded joint. (3)
- 9.2 Explain what *peening* is. (2)
- 9.3 Name TWO types of strongbacks used to control distortion during the butt welding of plates. (2)
- 9.4 Describe the effect of hot working on steel. (3)
- 9.5 State THREE factors causing residual stress in welds. (3)
- 9.6 Identify the types of distortions shown in FIGURES 9.6.1 and 9.6.2 below.

9.6.1

**FIGURE 9.6.1**

(1)

9.6.2

**FIGURE 9.6.2**

(1)

- 9.7 State THREE effects of the rate of cooling on a welded joint. (3)
- [18]**

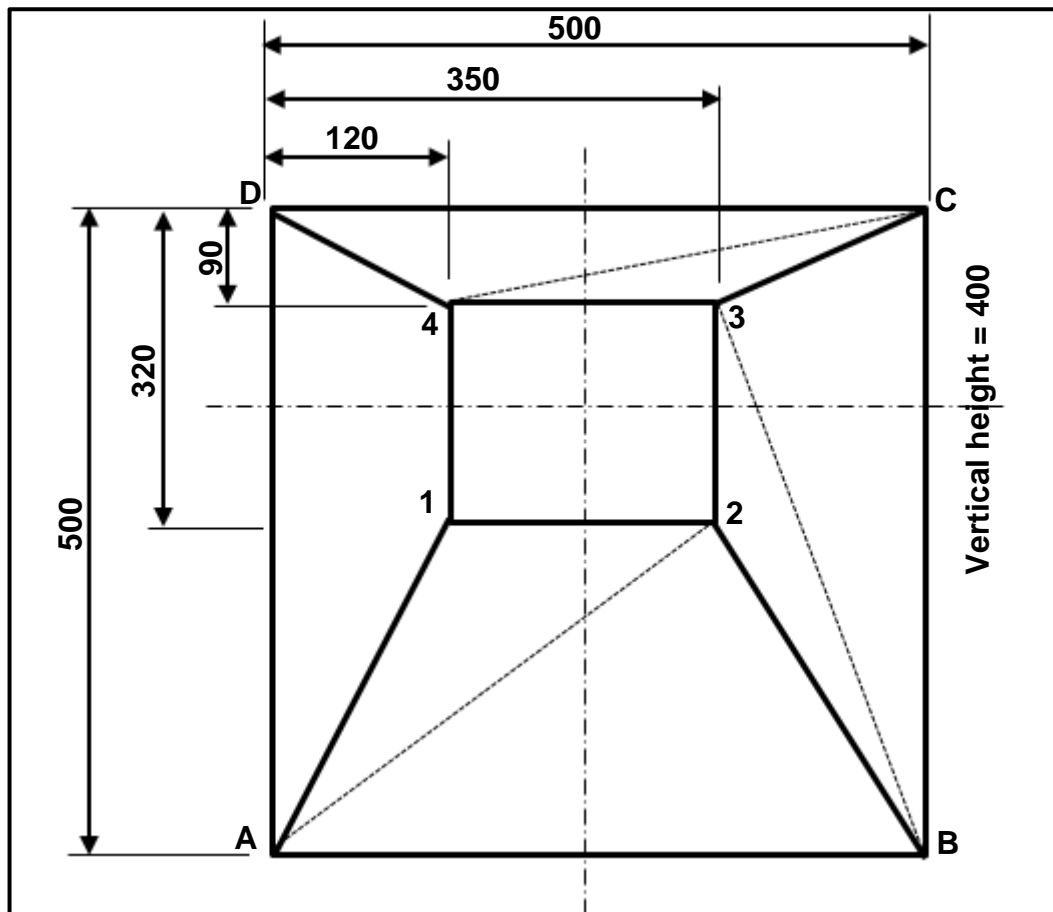
QUESTION 10: MAINTENANCE (SPECIFIC)

- 10.1 Define the term *lubrication*. (2)
- 10.2 State ONE negative impact of overloading on the following:
- 10.2.1 Punch and shear machines (1)
- 10.2.2 Guillotines (1)
- 10.3 Why do tagging plates have multiple holes? (2)
- 10.4 Give ONE reason why maintenance is conducted. (1)
- 10.5 State ONE method of reducing friction when drilling holes. (1)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 FIGURE 11.1 below shows a square-to-square hopper (off-centre).

**FIGURE 11.1**

Calculate the true length of the following:

11.1.1 **A-2** (4)

11.1.2 **B-3** (4)

11.1.3 **C-4** (4)

11.2 FIGURE 11.2 below shows a top view of a square-to-round transformer.

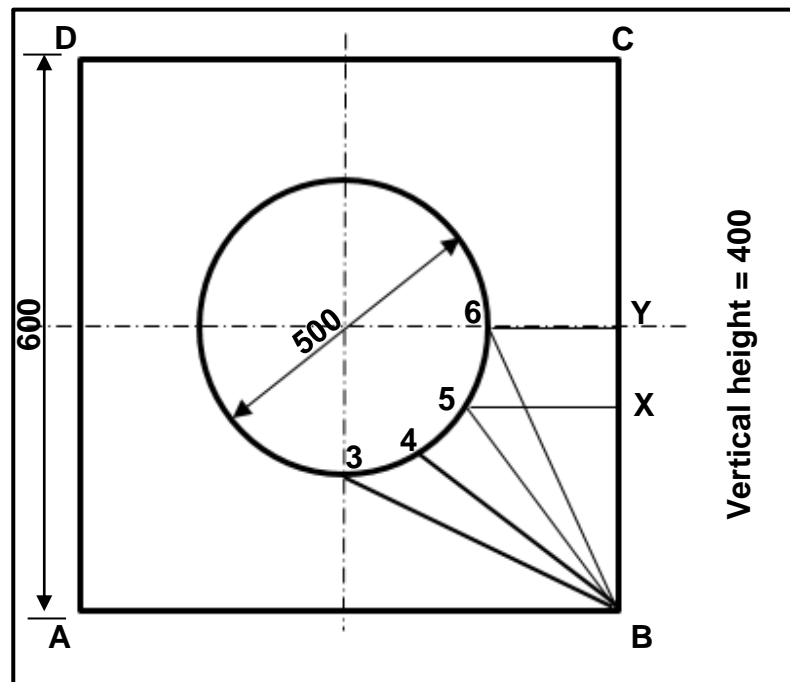


FIGURE 11.2

Calculate the true lengths of the following:

- | | | |
|--------|------------|-------------|
| 11.2.1 | 5–6 | (2) |
| 11.2.2 | 3–6 | (3) |
| 11.2.3 | B–6 | (4) |
| | | [21] |

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: WELDING AND METALWORK

1. STRESS AND STRAIN

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

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

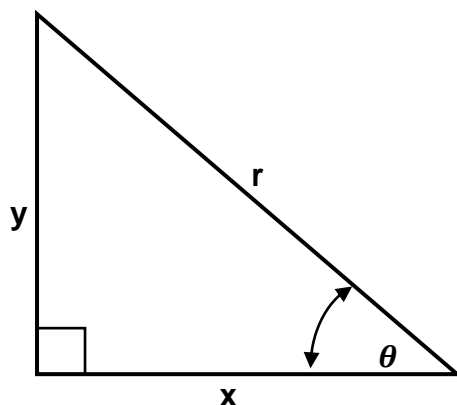
$$1.3 \quad \text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$$

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

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

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

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

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