basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

2023

MARKS: 200

TIME: 3 hours

This question paper consists of 17 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 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 (Developments)	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 ONE of the following safety precautions is applicable to the bench grinder?

A Oil the surface of the machine.
B Remove all guards when grinding.
C Wear safety goggles when grinding.
D Ensure that the machine is on. (1)

1.2 What does the Occupational Health and Safety Act state regarding HIV/Aids awareness?

A All employers must make sure that the workplace is safe, and that employees are not at risk of contracting HIV.
B It does not contain common guidelines on how employers, employees and trade unions should respond to persons with HIV in the workplace.
C Employers may demote or promote an employee based on his/her HIV status.
D Employers can simply dismiss a person who has HIV. (1)

1.3 Which ONE of the following procedures is applicable when applying basic medical treatment?

A Examine the injured person.
B Remove the object from the wound.
C Use oily substance or lotion on a burn.
D Phone the insurance company. (1)

1.4 Why is steel heated slowly to a certain temperature during heat treatments? To ensure that …

A high heat is obtained.
B the room temperature is correct.
C a uniform temperature is obtained.
D the safety process is correct. (1)

1.5 Which ONE of the following is an example of case-hardening?

A Frying pans
B Gears
C Wheel rims
D Chisels (1)

1.6 What does the term *quenching rate* during heat treatment mean?

A Cooling rate
B Heating rate
C Tempering rate
D Hardening rate (1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 Which safety precaution must be adhered to after the work on any machine is completed? (1)

2.2 Give TWO reasons why the space between the tool rest and the grinding wheel on a bench grinder must not exceed 3 mm. (2)

2.3 Identify the workshop layouts shown in FIGURES 2.3.1 and 2.3.2 below.

2.3.1

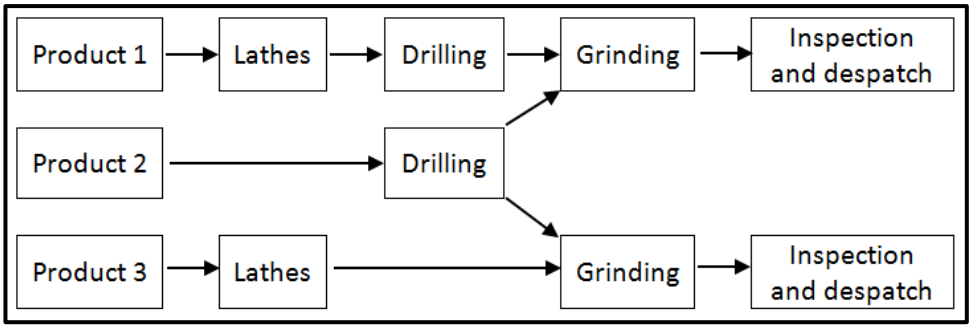


FIGURE 2.3.1 (1)

2.3.2

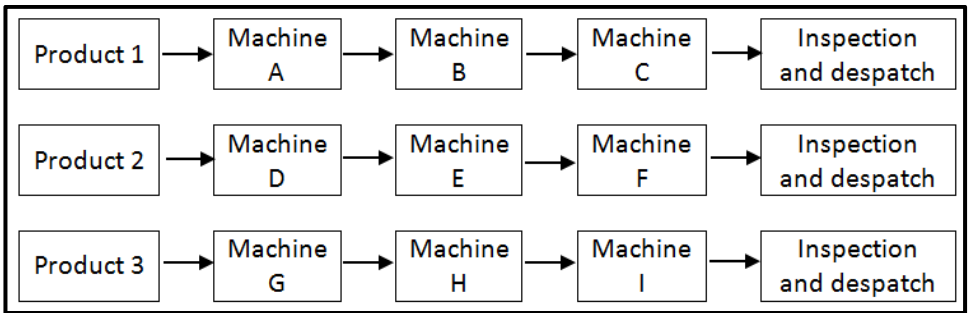


FIGURE 2.3.2 (1)

2.4 State ONE type of personal protective equipment that must be worn when working on a hydraulic press machine. (1)

2.5 State ONE function of the safety guard on a portable angle grinder. (1)

2.6 State ONE safety precaution, other than environmental safety, that must be observed when using a shearing machine/guillotine. (1)

2.7 State TWO safety precautions that must be adhered to when storing gas cylinders. (2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Why is tempering of steel done after hardening? (2)

3.2 Give ONE reason for EACH of the following heat-treatment processes on steel:

3.2.1 Case hardening (2)

3.2.2 Annealing (2)

3.3 Explain how to conduct a spark test to identify the type of steel. (2)

3.4 Explain how you will conduct the following tests:

3.4.1 Filing test (2)

3.4.2 Bend test (2)

3.5 What sound do the following materials make when performing a sound test?

3.5.1 Low-carbon steel (LCS) (1)

3.5.2 High-carbon steel (HCS) (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 materials can be cut using tinsnips when manufacturing a template?

A 3 mm sheet metal
B Hardboard
C Galvanised sheet metal
D Perspex (1)

4.2 What is a *plate girder*?

A Hollow tubing welded together
B Combination of plates and angle iron welded together
C Retro grids welded together
D Combination of plates and round bars welded together (1)

4.3 Supplementary symbols indicate … information about welds.

A additional
B calculated
C difficult
D easy (1)

4.4 A die is used for cutting or forming external threads on round bars and …

A square tubing.
B round tubing.
C plates.
D angle irons. (1)

4.5 Arc welding uses a welding power supply to create an electric arc between an …

A electrode and a base metal.
B electrode and an electrode terminal.
C earth terminal and a base metal.
D electrode and an earthed base metal. (1)

4.6 Which ONE of the following is an advantage of resistance welding?

A It is very good to use when welding material is 10 mm or thicker.
B It is used to weld Perspex.
C Electrical resistance is low.
D It is quick and easy with no filler rod. (1)

4.7 Which member of a framework resists a compressive force?

A Purlin
B Strut
C Rafter
D Tie (1)

4.8 What does the abbreviation *UDL* stand for?

A Uniformly displaced load
B Uniformly displayed load
C Uniformly distorted load
D Uniformly distributed load (1)

4.9 When calculating strain, the original length of a bar is defined as the …

A ratio between stress and strain.
B length by which an object is shortened or lengthened.
C length of an object before an external load is applied.
D length of an object after an external load is applied. (1)

4.10 Which ONE of the following tests is a non-destructive test?

A X-ray test
B Bending test
C Machinability test
D Nick-break test (1)

4.11 Which ONE of the following is a disadvantage of the liquid dye penetration test?

A Detects only subsurface defects
B Not easy to conduct
C Cannot work on porous materials
D Suitable for ferrous materials (1)

4.12 Pearlite structure is a mixture of … in layers.

A iron and iron carbide
B iron and brass
C cast iron and cast steel
D aluminium and copper (1)

4.13 What is the disadvantage of using jigs, fixtures and clamps when welding?

A Decreases internal stress
B Increases external stress
C Decreases external stress
D Increases internal stress (1)

4.14 Identify the type of hopper in FIGURE 4.14 below.

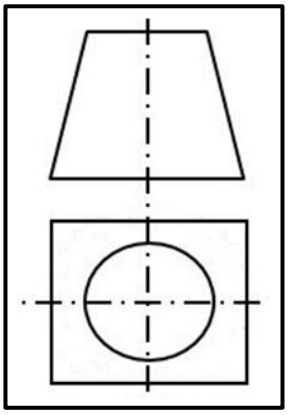


FIGURE 4.14

A Square to square on centre
B Square to round
C Rectangle to square off centre
D Cone frustum (1)

[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 State the purpose of purlins in roof trusses. (2)

5.2 Identify the weld symbols in FIGURES 5.2.1 to 5.2.4 below.

5.2.1

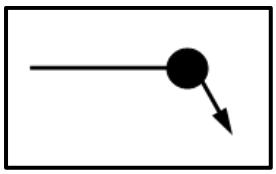


FIGURE 5.2.1 (1)

5.2.2

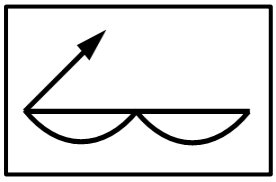


FIGURE 5.2.2 (1)

5.2.3

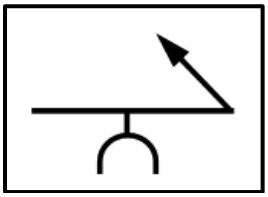


FIGURE 5.2.3 (1)

5.2.4

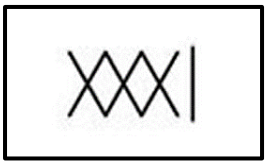


FIGURE 5.2.4 (1)

5.3 State ONE use of a strip template. (1)

5.4 A mild steel ring with an inside diameter of 180 mm must be manufactured from a Ø12 mm round bar.

Calculate the following:

5.4.1 The mean diameter of the ring (2)

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

5.5 FIGURE 5.5 below shows a weld symbol. Fully describe the weld symbol and give the meaning of EACH of the dimensions in the diagram.

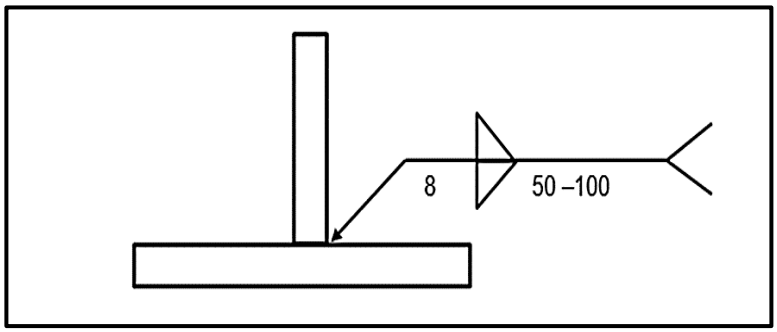


FIGURE 5.5 (4)

5.6 FIGURE 5.6 below shows a roof truss. Label parts **A**–**E**.

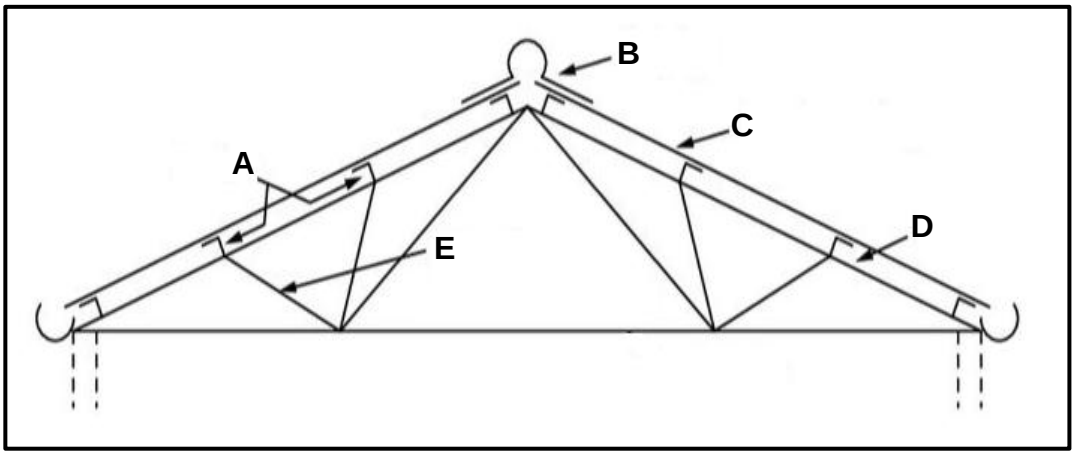


FIGURE 5.6 (5)

5.7 What is the advantage of using lattice beams over a longer span? (2)
[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 State THREE main uses of a bench grinder. (3)

6.2 What does *MIG* stand for? (1)

6.3 Describe the operating principle of a plasma cutter. (4)

6.4 Name the THREE types of taps used to cut internal screw thread. (3)

6.5 Name the hand tool that is used to remove slag from an arc-welded joint. (1)

6.6 What is the function of the vertical rollers on a vertical rolling machine? (1)

6.7 Give TWO reasons why coolant is used on a horizontal band saw. (2)

6.8 Name THREE processes where oxy-acetylene equipment is used. (3)
[18]

QUESTION 7: FORCES (SPECIFIC)

7.1 FIGURE 7.1 below shows a framework with members **AE**, **BF**, **CF**, **DE** and **EF**. Graphically determine the magnitude and type/nature of each member.

Scale: Space diagram: 1 **:** 100
Force diagram: 1 mm = 5 N

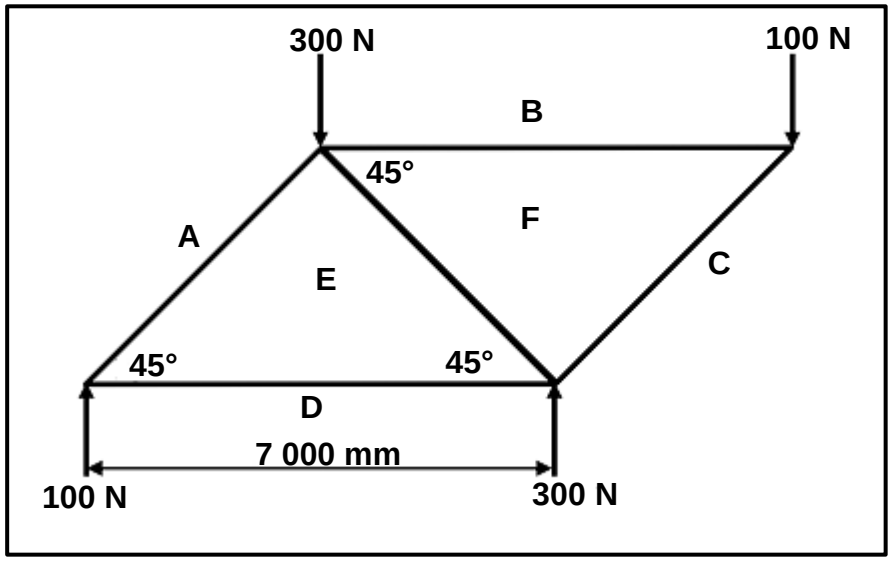


FIGURE 7.1 (15)

7.2 FIGURE 7.2 below shows a uniform supported beam that is subjected to three point loads.

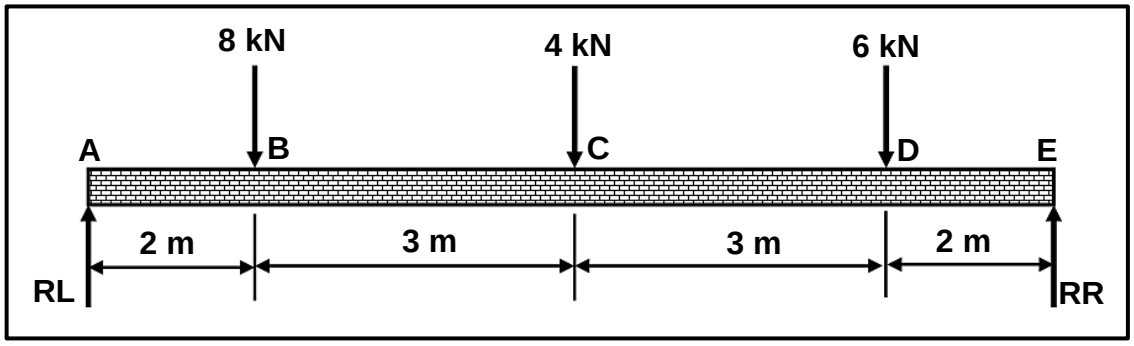


FIGURE 7.2

Calculate the following:

7.2.1 The magnitude of the reaction at support **RL** (4)

7.2.2 The magnitude of the reaction at support **RR** (4)

7.2.3 The bending moments at points **B**, **C** and **D** (6)

7.2.4 Draw a bending-moment diagram of the beam.

Scale: Beam: 1 **:** 100 (distances)
Bending moments: 2 mm = 1 kNm (4)

7.3 A compressive load of 80 kN is exerted onto a round bar with a diameter of 30 mm. The original length of the round bar is 3 m.

Calculate the following:

7.3.1 The cross-sectional area of the bar in m^2 (2)

7.3.2 The stress caused in the material in MPa (3)

7.3.3 The strain caused if the change in length of the bar is 0,06 mm (2)

7.3.4 Young's modulus of elasticity in GPa (3)

7.4 A round steel bar with a cross-sectional area of $0,9 \times 10^{-5}$ m^2 is subjected to a maximum tensile load of 55 kN.

Calculate the maximum stress. (2)
[45]

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

8.1 State TWO aspects to check when doing a visual inspection on welded joints. (2)

8.2 State ONE property that is tested when conducting a free-bend test on a welded joint. (1)

8.3 Define *weld defect*. (2)

8.4 State TWO causes of the following weld defects:

8.4.1 Undercutting (2)

8.4.2 Blow hole (2)

8.5 Name TWO examples of destructive tests done on welded joints. (2)

8.6 Explain how to conduct an X-ray test on a welded joint. (6)

8.7 Name the TWO types of dyes that can be used for a liquid dye penetration test. (2)

8.8 State TWO examples of internal weld defects. (2)

8.9 State TWO methods of reducing centre-line cracks. (2)
[23]

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

9.1 State TWO factors that affect distortion and residual stress in a welded joint. (2)

9.2 Describe *shrinkage* in a welded joint. (2)

9.3 State TWO factors that affect the grain size of cold-worked steel. (2)

9.4 Describe the difference between *cold working* and *hot working* of steel. (4)

9.5 State FOUR methods used to reduce distortion. (4)

9.6 Identify the types of distortion in FIGURES 9.6.1 and 9.6.2 below.

9.6.1

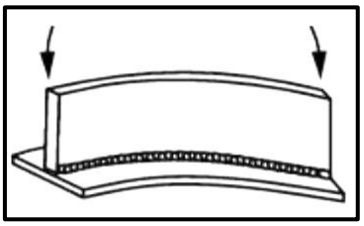


FIGURE 9.6.1 (1)

9.6.2

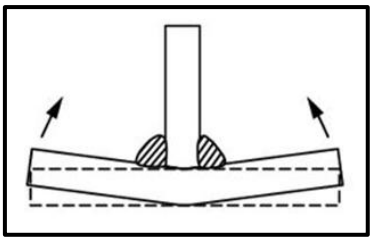


FIGURE 9.6.2 (1)

9.7 Explain the result when metal is cooled rapidly. Refer to the internal and external areas of the metal. (2)
[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 Define *maintenance.* (3)

10.2 State TWO general maintenance guidelines for a drill press. (2)

10.3 What is the function of tagging plates? (1)

10.4 Give TWO reasons why it is important to keep service records of machines. (2)
[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENTS) (SPECIFIC)

11.1 FIGURE 11.1 below shows the top view of a hopper with a vertical height (VH) of 450 mm. Answer the questions that follow.

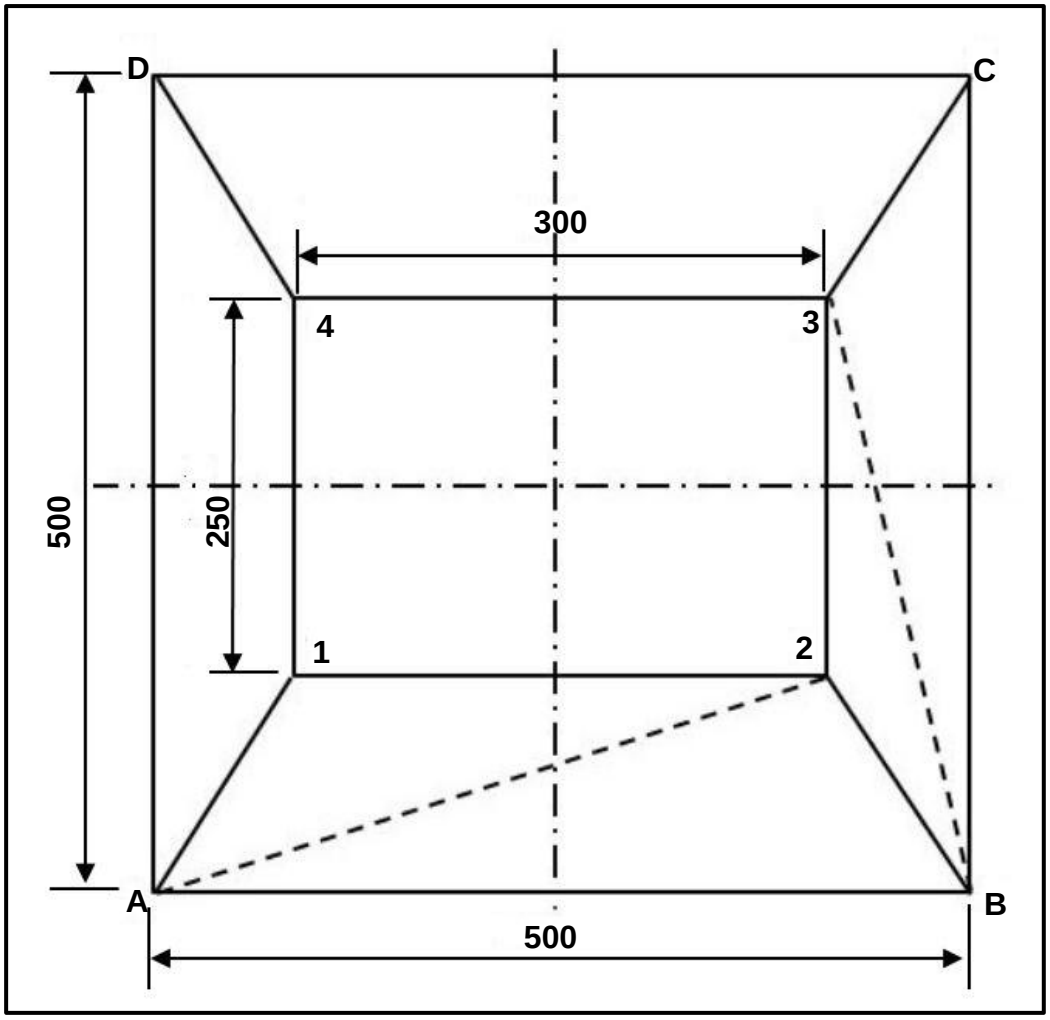


FIGURE 11.1

11.1.1 Identify the hopper in FIGURE 11.1. (3)

11.1.2 Calculate the true lengths of the following:

(a) **A–1** (2)

(b) **A–2** (2)

(c) **B–3** (2)

11.2 FIGURE 11.2 below shows the top view of a cone frustum. The vertical height is 500 mm. The large diameter is 800 mm and the small diameter is 600 mm. Answer the questions that follow.

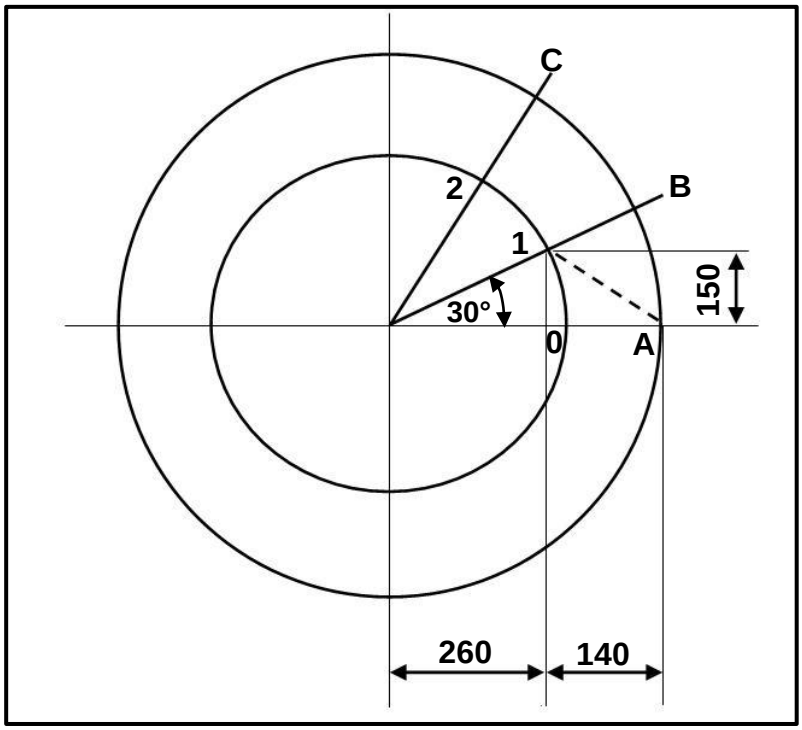


FIGURE 11.2

Calculate the true lengths of the following:

11.2.1 **A–B** (3)

11.2.2 **0–1** (3)

11.2.3 **A–0** (4)

11.3 Where is a square-to-round transformer usually used? (2)
[21]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY
WELDING AND METALWORK

1. STRESS AND STRAIN

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

1.2 $A_{pipe} = \dfrac{\pi\left(D^2 - d^2\right)}{4}$

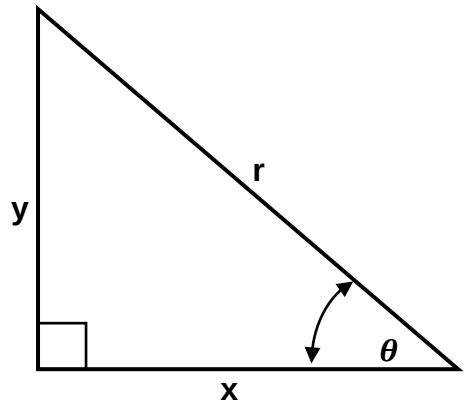
1.3 $Safety\ factor = \dfrac{Maximum\ stress/Break\ stress}{Safe\ working\ stress}$

1.4 $Stress = \dfrac{Force}{Area}$ *OR* $\sigma = \dfrac{F}{A}$

1.5 $Strain = \dfrac{Change\ in\ \ length}{Original\ \ length}$ *OR* $\varepsilon = \dfrac{\Delta l}{ol}$

1.6 $Young's\ modulus = \dfrac{Stress}{Strain}$ *OR* $E = \dfrac{\sigma}{\varepsilon}$

2. PYTHAGORAS' THEOREM AND TRIGONOMETRY



2.1 $\sin\theta = \dfrac{y}{r}$

2.2 $\cos\theta = \dfrac{x}{r}$

2.3 $\tan\theta = \dfrac{y}{x}$

2.4 $r^2 = x^2 + y^2$ *OR* $a^2 = b^2 + c^2$

3. TEMPLATES AND DEVELOPMENTS

3.1 *Mean Ø = Outside Ø – Plate thickness*

OR

Mean Ø = Inside Ø + Plate thickness

3.2 *Mean circumference = π × Mean Ø*

(where Ø = diameter)