basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

2022

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 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	15
7	Forces	45	40
8	Joining Methods (Inspection of Welds)	23	20
9	Joining Methods (Stresses and Distortion)	18	20
10	Maintenance	8	10
11	Terminology (Development)	21	15
	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 procedures relates to the operation of a hydraulic press?

A The platform on which the work piece rests must be rigid and perpendicular to the press cylinder.
B Make sure all gas valves in the cylinders are properly adjusted.
C Chips can be removed while the machine press is in operation.
D Ensure that the maximum air pressure is not exceeded in the cylinders. (1)

1.2 Which safety measure is applicable to drilling machines?

A Leave the key in the chuck when the machine is not operated.
B Choose a correctly sharpened drill bit for the type of work you need to do.
C There is no need to wear safety goggles.
D Leave the machine running while having lunch. (1)

1.3 Which ONE of the following types of personal protective equipment (PPE) is required when arc welding a work piece?

A Hard hat
B Welding goggles
C Welding helmet
D Cotton gloves (1)

1.4 Which ONE of the following types of steel is the easiest to cut?

A High-speed steel
B Cast iron
C Cast steel
D Mild steel (1)

1.5 Which method can be used to conduct a sound test?

A Dropping the work piece on a concrete floor
B Drilling into the metal
C Using a surface grinder
D Welding the metal (1)

1.6 Nitriding is done during the ... process.

A hardening
B annealing
C case-hardening
D normalising (1)

[6]

QUESTION 2: SAFETY (GENERIC)

2.1 Why should the rated speed of the grinding wheel never exceed the maximum speed of the grinder? (1)

2.2 State TWO safety precautions that should be observed while the vertical band saw is in operation. (2)

2.3 Identify the THREE stages in which first aid is applied. (3)

2.4 Name the TWO main categories into which the causes of accidents can be divided according to the Occupational Health and Safety Act. (2)

2.5 State TWO advantages of the product workshop layout. (2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Define *tempering* of steel. (2)

3.2 Give THREE reasons why the annealing process is conducted on steel. (3)

3.3 At what approximate temperature is steel heated during the normalising process? (2)

3.4 Identify the type of steel/iron from the spark patterns shown in FIGURES 3.4.1–3.4.3 below.

3.4.1

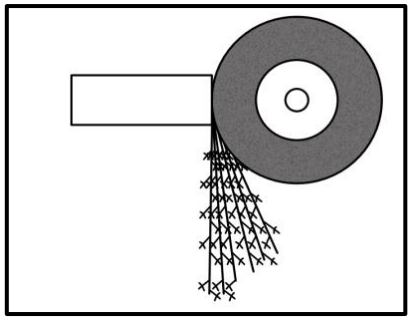


FIGURE 3.4.1 (1)

3.4.2

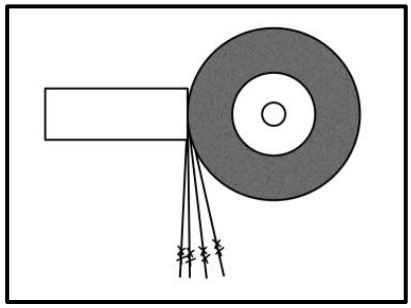


FIGURE 3.4.2 (1)

3.4.3

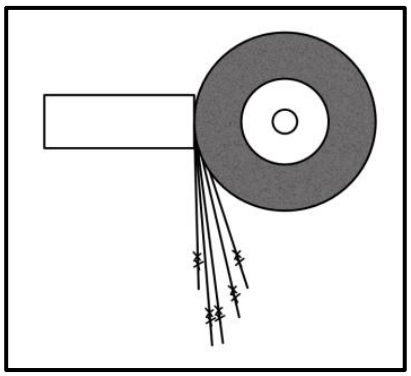


FIGURE 3.4.3 (1)

3.5 FIGURE 3.5 below shows an iron-carbon equilibrium diagram. Label **A** to **D**.

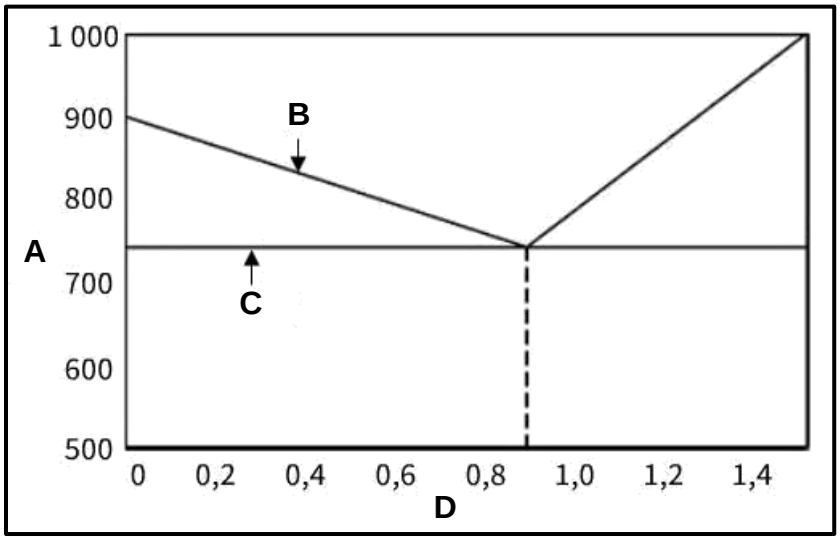


FIGURE 3.5 (4)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

4.1 Which ONE of the following hand tools is used by template makers?

A Plane
B Chipping hammer
C Cut-off saw
D Sanding machine (1)

4.2 What does **F** stand for regarding supplementary welding symbols?

A Finish
B Flange
C Flame
D Flush (1)

4.3 Which ONE of the following components is part of a pedestal/bench grinder?

A Wheel guard
B Finger protector
C Handle
D Horizontal table (1)

4.4 FIGURE 4.4 below shows a welding torch. Identify part **Z**.

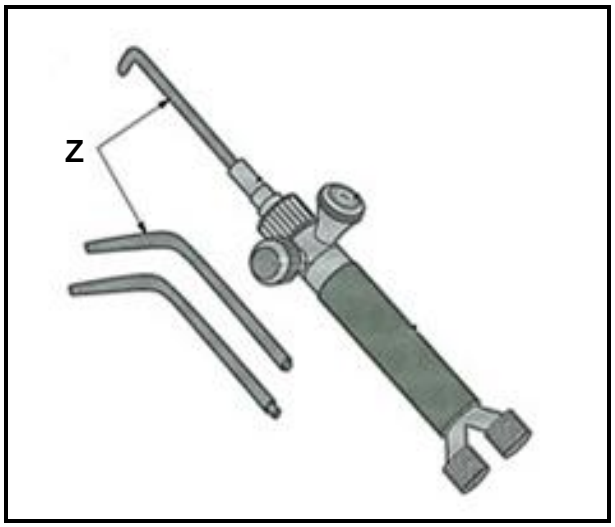


FIGURE 4.4

A Welding nozzle
B Torch valve
C Cutting nozzle
D Torch body (1)

4.5 What is the purpose of purlins?

A Support roof covering
B Support beams
C Support the window frames
D Support the door frames (1)

4.6 How would one describe the term *stress* in materials?

A Internal resistance in a material resisting a shearing load
B Internal resistance in a material resisting a pulling load
C Internal resistance in a material resisting an external load
D Internal resistance in a material resisting a compressive load (1)

4.7 A strut is designed to …

A support columns.
B support pillars.
C resist shearing.
D resist compression. (1)

4.8 Which ONE of the following is an example of a non-destructive test?

A File test
B Machinability test
C Nick-break test
D Ultrasonic test (1)

4.9 Lock-out and tagging of a machine is to inform workers that …

A there is a power failure.
B work on the machine is completed.
C maintenance work on the machine has been completed.
D maintenance work is being carried out on the machine. (1)

4.10 The ability of a material to be drawn into wire form is known as …

A elasticity.
B malleability.
C ductility.
D plasticity. (1)

4.11 What is the colour of the acetylene cylinder used in oxy-acetylene welding?

A Black
B Blue
C Maroon
D Yellow (1)

4.12 Identify the type of load applied to the work piece in FIGURE 4.12 below.

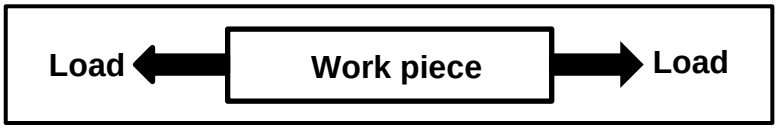


FIGURE 4.12

A Compressive
B Tensile
C Shear
D Twisting (1)

4.13 Which ONE of the following factors influences the rate of cooling of the weld metal during the welding process?

A Weld metal thickness
B Amount of oxygen used in the process
C Current setting of the welding machine
D Electrode thickness (1)

4.14 Which ONE of the following methods may be used to reduce distortion during the welding process?

A Continuous welding
B Controlled cooling
C Round-step welding
D Back-step welding (1)

[14]

QUESTION 5: TERMINOLGY (TEMPLATES) (SPECIFIC)

5.1 Name FOUR machine tools used in the template loft. (4)

5.2 FIGURE 5.2 below shows part of a roof truss. Label parts **A**–**E**.

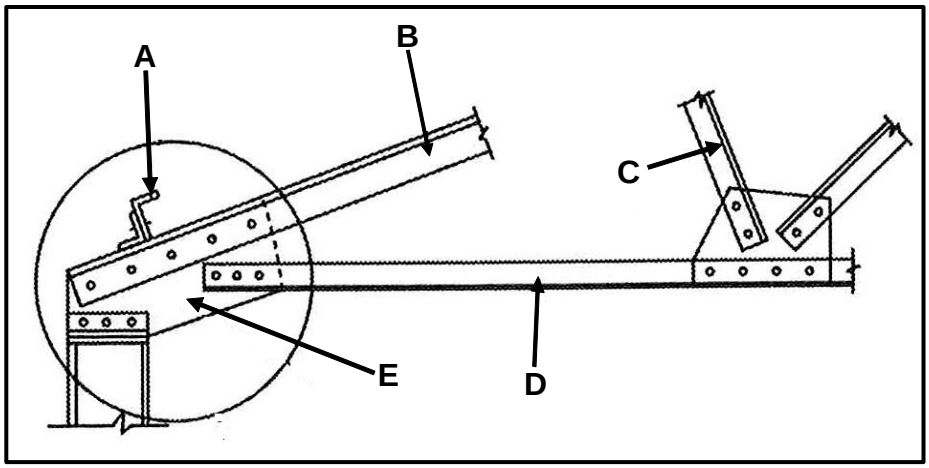


FIGURE 5.2 (5)

5.3 Draw a neat sketch of a welding symbol indicating the following information on a T-joint done with arc welding:

- The fillet weld on the other side is 6 mm in size.
- The lengths of the weld beads are 40 mm each and the pitch of the weld is 90 mm. (6)

5.4 Draw the following supplementary weld symbols indicating additional information about the weld:

5.4.1 Weld all round (1)

5.4.2 Flush contour (1)

5.4.3 Machine finish (1)

5.5 A steel ring with an outside diameter of 600 mm must be fabricated from a 30 x 30 mm square bar. Calculate the mean circumference of the required material. (5)

[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 FIGURE 6.1 below shows a manual guillotine. Label parts **A**–**C**.

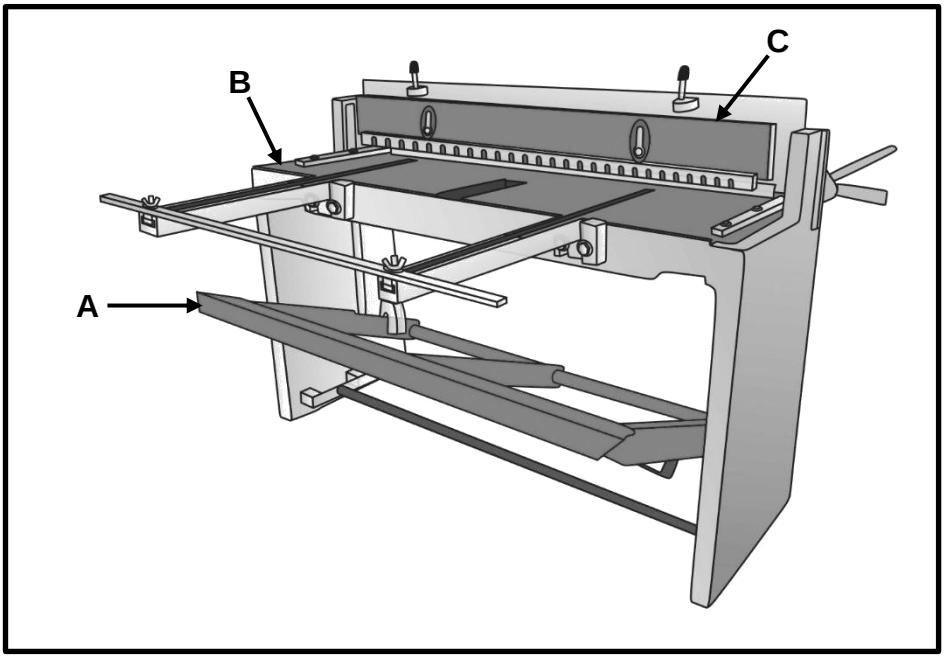


FIGURE 6.1 (3)

6.2 Name TWO different types of tap wrenches. (2)

6.3 Name THREE uses of an angle grinder. (3)

6.4 What is the advantage of welding with an inverter compared to a conventional AC welding machine? (2)

6.5 State TWO advantages of spot welding. (2)

6.6 Name THREE MIG welding processes. (HINT: Pistol position and movement) (3)

6.7 Explain the *plasma-cutting process*. (3)

[18]

QUESTION 7: FORCES (SPECIFIC)

7.1 FIGURE 7.1 below is a diagram of a steel framework. Answer the questions that follow. (Use Bow's notation.)

Scale: Space diagram: 10 mm = 1 m
Force/Vector diagram: 1 mm = 10 N

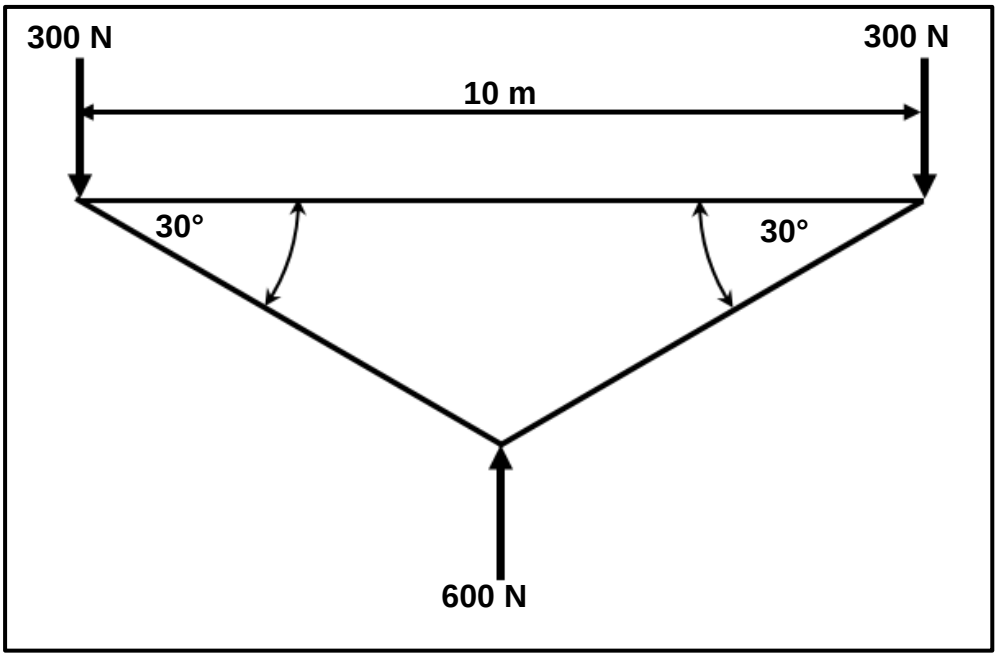


FIGURE 7.1

7.1.1 Draw the space diagram and label the spaces. (Use Bow's notation.) Indicate the nature of each member on the space diagram. (7)

7.1.2 Determine graphically the magnitude of each member of the framework and indicate the nature of each member on the space diagram. (8)

7.2 A load of 500 N is exerted on a brass bush used in a hydraulic press. The external diameter of the brass bush is 60 mm and the internal diameter is 50 mm. The original length of the bush is 80 mm and Young's modulus is 90 GPa.

Calculate the following:

7.2.1 Cross-sectional area of the bush (3)

7.2.2 Stress caused by the load (answer in Mega magnitude) (3)

7.2.3 Strain in the bush material (4)

7.3 FIGURE 7.3 below shows a beam that is supported by two vertical supports, **RL** and **RR**. Two vertical point loads are exerted onto the beam. A uniformly distributed load (**A**) of 50 N/m is exerted over a length of 5 m on the left-hand side of the beam.

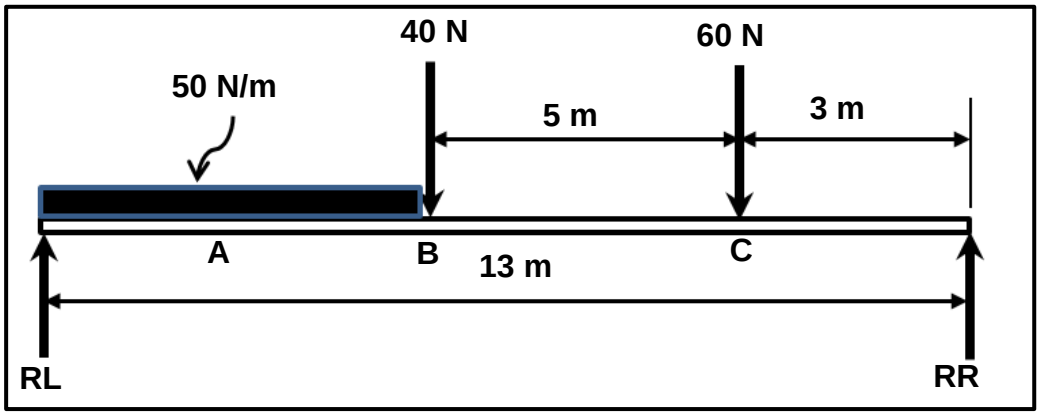


FIGURE 7.3

7.3.1 Calculate the reactions at supports **LR** and **RR**. (8)

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

7.3.3 Use the scale below to draw the bending-moment diagram.

Scale: Length between forces: 10 mm = 1 m
Bending-moment diagram: 1 mm = 10 Nm (6)

[45]

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

8.1 State FOUR uses of a welding gauge. (4)

8.2 State TWO causes of EACH of the following welding defects:

8.2.1 Incomplete penetration (2)

8.2.2 Welding spatter (2)

8.3 State TWO preventative measures for EACH of the following welding defects:

8.3.1 Porosity (2)

8.3.2 Undercutting (2)

8.4 FIGURES 8.4.1–8.4.3 below show three different types of flames used in gas welding. Identify each flame.

8.4.1

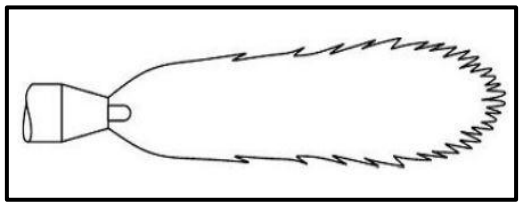


FIGURE 8.4.1 (1)

8.4.2

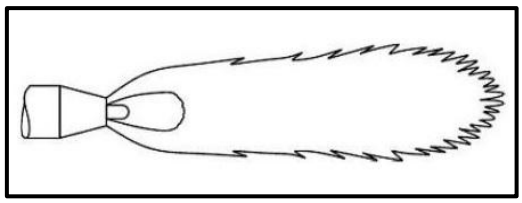


FIGURE 8.4.2 (1)

8.4.3

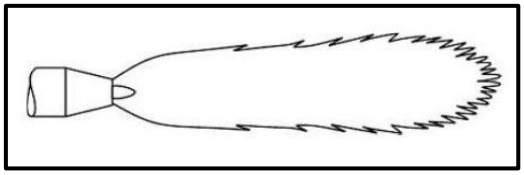


FIGURE 8.4.3 (1)

8.5 Explain how weld craters are formed. (3)

8.6 Describe the process of conducting a nick-break test on a welded joint. (5)

[23]

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

9.1 What is *elastic deformation*? (2)

9.2 Describe *shrinkage* on steel. (2)

9.3 Study FIGURES 9.3.1 and 9.3.2 below and identify EACH distortion.

9.3.1

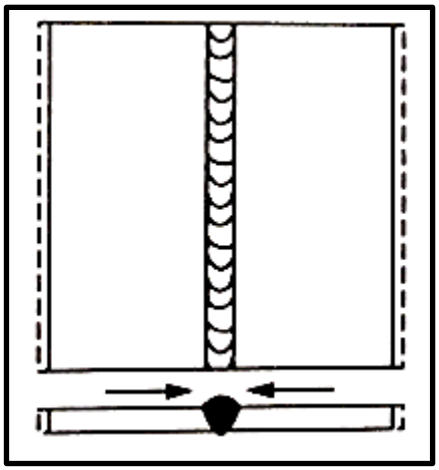


FIGURE 9.3.1 (1)

9.3.2

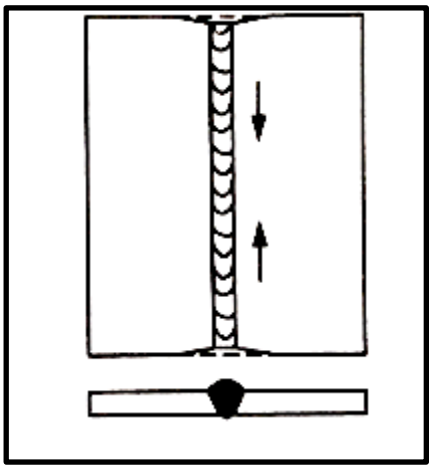


FIGURE 9.3.2 (1)

9.4 What effect do the following factors have on shrinkage of steel during arc welding?

9.4.1 Electrode size (2)

9.4.2 Welding speed (2)

9.5 Explain the disadvantage of using jigs, fixtures and clamps when welding. (3)

9.6 State the carbon content percentages of the following types of steel:

9.6.1 Tool steel (1)

9.6.2 Spring steel (1)

9.6.3 Mild steel (1)

9.7 Name TWO quenching media used during heat treatment. (2)

[18]

QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 State THREE effects of insufficient lubrication of pedestal drilling machines. (3)

10.2 State THREE effects of overloading on a bench grinding machine. (3)

10.3 State TWO general maintenance guidelines for a power-driven guillotine. (2)
[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 Describe the use of transformers/transition pieces in ventilation ducting. (3)

11.2 FIGURE 11.2 below shows a hopper. Answer the questions that follow.

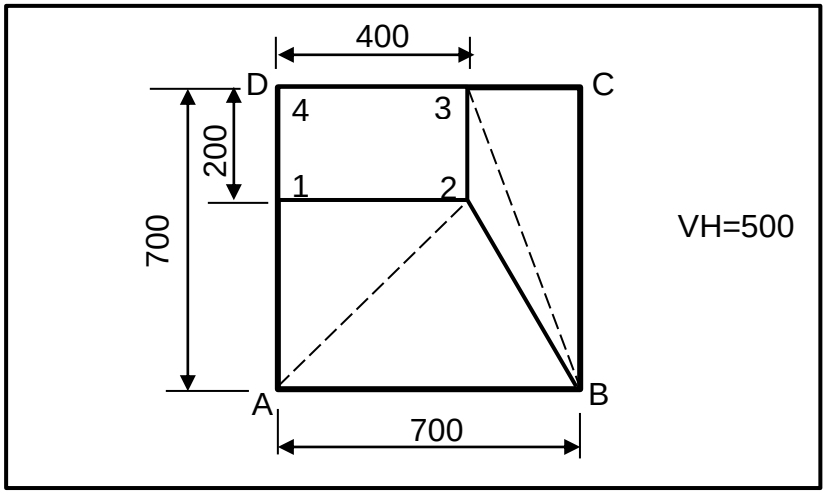


FIGURE 11.2

11.2.1 Identify the type of hopper in FIGURE 11.2 above. (2)

Calculate the following true lengths:

11.2.2 **A–2** (5)

11.2.3 **B–2** (5)

11.3 FIGURE 11.3 below shows the top view of a truncated cone with slight taper (cone frustum). Both **A**–**B** and **0**–**1** represent one twelfth of the circle circumference. Answer the questions that follow.

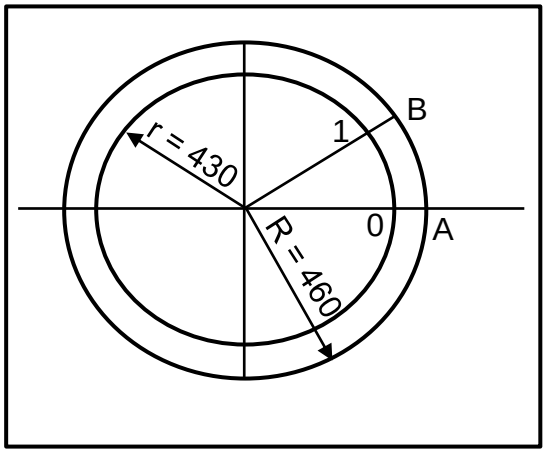


FIGURE 11.3

Calculate the true lengths of the following:

11.3.1 **A–B** (3)

11.3.2 **0–1** (3)
[21]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY: WELDING AND METALWORK

1. STRESS AND STRAIN

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

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

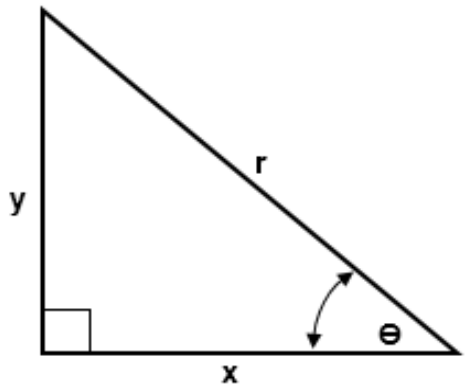
1.3 $$\text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$$

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

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

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

2. PYTHAGORAS THEOREM AND TRIGONOMETRY



2.1 $$\text{Sin}\,\theta = \frac{y}{r}$$

2.2 $$\text{Cos}\,\theta = \frac{x}{r}$$

2.3 $$\text{Tan}\,\theta = \frac{y}{x}$$

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

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)