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GRADE 12

MECHANICAL TECHNOLOGY: WELDING AND METALWORK

NOVEMBER 2024

MARKS: 200

TIME: 3 hours

This question paper consists of 15 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 your ANSWER BOOK, e.g. 1.7 E. ...

- 1.1 Which statement below is CORRECT in terms of a recommendation for the application of first aid?
- Do NOT ...
- A remove anything that is stuck to the wound.
 - B check the pulse of the patient.
 - C give attention to the loss of blood or breathing difficulties.
 - D check the surroundings for dangerous objects. (1)
- 1.2 Where more than ... employees are employed at a workplace, the employer must provide an accessible first-aid box.
- A 2
 - B 3
 - C 4
 - D 5 (1)
- 1.3 What causes accidents when working with revolving machinery, such as a bench grinder?
- A Overconfidence
 - B Correct wheel size
 - C Gap between tool rest and grinding wheel not exceeding 3 mm
 - D Correctly rated grinding wheel for the bench grinder (1)
- 1.4 Which test does NOT damage a work piece?
- A Spark test
 - B Sound test
 - C Bending test
 - D Machining test (1)
- 1.5 Which of the following products is case-hardened?
- A Tin cans
 - B Machine guards
 - C Hand files
 - D Gears and cams (1)
- 1.6 Which process is the first step in the production of high-strength steel?
- A Normalising
 - B Annealing
 - C Hardening
 - D Tempering (1)



QUESTION 2: SAFETY (GENERIC)

- 2.1 State TWO safety precautions that must be adhered to after the horizontal band saw has been switched on. (2)
- 2.2 Name the THREE stages when basic first-aid treatment is given to help an injured person. (3)
- 2.3 Why must oil or grease NOT be in contact with the oxygen fittings when handling oxygen cylinders? (1)
- 2.4 State TWO disadvantages of the process workshop layout. (2)
- 2.5 State TWO advantages of the product workshop layout. (2)
- [10]**

QUESTION 3: MATERIALS (GENERIC)

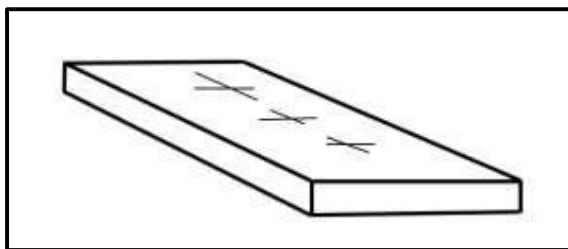
- 3.1 State if the following materials are easy or hard to file during a filing test:
- 3.1.1 Cast iron (1)
- 3.1.2 Cast steel (1)
- 3.1.3 Mild steel (1)
- 3.2 Explain what *heat treatment* is. (3)
- 3.3 Explain what the effects will be if metal is heated too fast during the heat-treatment process. (4)
- 3.4 Name the TWO types of steel best suited for case hardening. (2)
- 3.5 Explain the reason for tempering steel during the heat-treatment process. (2)
- [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 your ANSWER BOOK, e.g. 4.15 E.

- 4.1 A plate girder may be defined as a combination of ...
A a roof truss and a foundation.
B a roof truss and a gusset plate.
C plates welded together.
D plates and an angle iron welded together. (1)
- 4.2 The use of a die during thread cutting is to ...
A cut internal thread.
B cut external thread.
C adjust the feed of a tap.
D adjust a stock. (1)
- 4.3 What is the SI unit of measure for strain?
A Metres (m)
B Pascal (Pa)
C Newton (N)
D No unit (1)
- 4.4 Identify the template shown in FIGURE 4.4 below.

**FIGURE 4.4**

- A Flange template
B Strip template
C Gusset plate
D Web template (1)
- 4.5 What is the function of a drill press chuck?
A Changes the speed of the drill
B Adjusts the feed of the drill
C Holds the drill bit in position
D Adjusts the drill table (1)

4.6 Which ONE of the following tests is an example of a destructive test on a welded joint?

- A Ultrasonic test
- B Nick-break test
- C X-ray test
- D Sound test

(1)

4.7 Identify the member indicated by **A** in the steel framework shown in FIGURE 4.7 below.

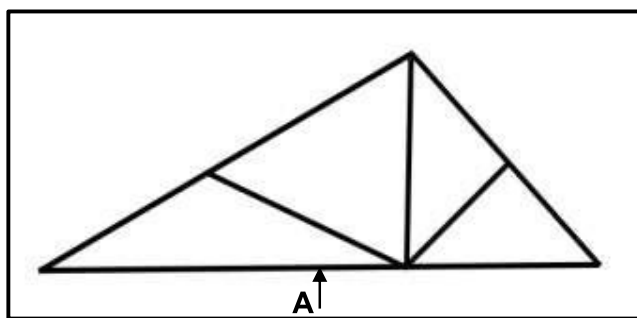


FIGURE 4.7

- A Strut
- B Rafter
- C Main tie beam
- D Internal bracing member

(1)

4.8 Which ONE of the following steps reduces spatter during the welding process?

- A Pre-heating the base metal
- B Slow cooling after welding
- C Using lower strength consumables
- D Selecting the appropriate current setting

(1)

4.9 Which ONE of the following steps reduces crater cracks in arc welding?

- A Preparing the root gap
- B Back-stepping at the end of the weld
- C Quick cooling after welding
- D Using the correct welding current

(1)

4.10 An ultrasonic test uses ... to detect flaws in welded joints.

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

(1)



- 4.11 What will be the first effect when cold-worked metal is heated?
- A Hardening
 - B Melting
 - C Relief of internal stress
 - D Softening
- (1)
- 4.12 The purpose of keeping service records of power machines is the monitoring of the ... in the workshop.
- A condition of machines
 - B machines' operations
 - C lock-out clause of machines
 - D isolation switches
- (1)
- 4.13 The offset pinch roll is used for rolling ...
- A square bars.
 - B thin sheet metal.
 - C round bars.
 - D angle iron.
- (1)
- 4.14 Identify the type of hopper in FIGURE 4.14 shown below.

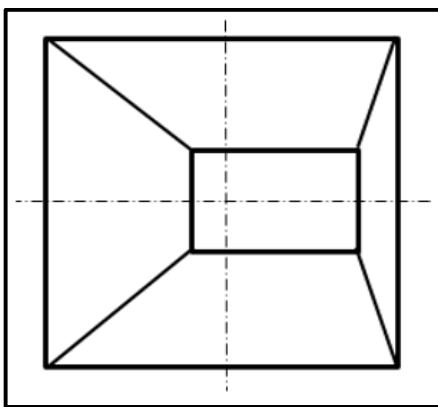
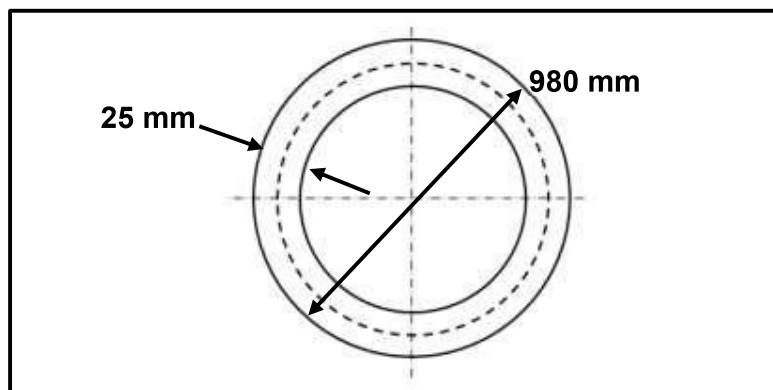


FIGURE 4.14

- A Square-to-rectangle on-centre
 - B Square-to-square off-centre
 - C Square-to-square on-centre
 - D Square-to-rectangle off-centre
- (1)
[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

- 5.1 Why is the template loft separated from the rest of the workshop? (2)
- 5.2 Name THREE tools used in a template loft. (3)
- 5.3 FIGURE 5.3 below shows a steel ring that must be manufactured using a 25 x 25 mm square bar. The ring has an outside diameter of 980 mm.

**FIGURE 5.3**

- 5.3.1 Calculate the mean diameter of the ring. (2)
- 5.3.2 Calculate the mean circumference of the ring. (Round off your answer to the nearest whole number.) (3)
- 5.4 State any TWO factors to be considered when selecting the type of material that must be used to make templates. (2)
- 5.5 Draw a neat sketch of a T-joint done with arc welding on site.
Indicate the following information using welding symbols:
- The fillet welds on both sides are 10 mm in size.
 - The lengths of the weld beads are 50 mm each.
 - The pitch of the weld is 100 mm. (9)
- 5.6 Draw the following welding symbols:
- 5.6.1 Spot-weld (1)
- 5.6.2 Seam weld (1)

[23]

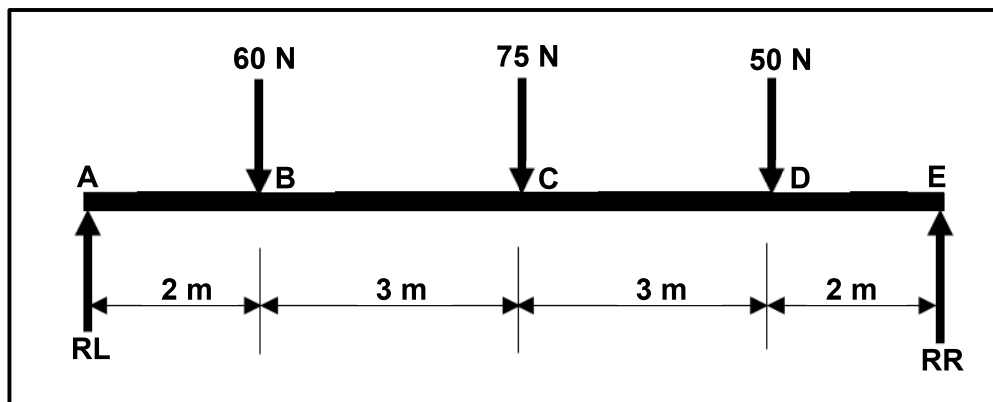
QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

- 6.1 Explain the working principle of the following machines:
- 6.1.1 Punch and cropping machine (4)
 - 6.1.2 Resistance-welding machine (4)
- 6.2 State THREE uses of the drill press. (3)
- 6.3 Name the THREE types of taps that are used for cutting internal thread. (3)
- 6.4 Explain the procedure when conducting a Brinell hardness test. (4)
- [18]**



QUESTION 7: FORCES (SPECIFIC)

- 7.1 The diagram in FIGURE 7.1 below shows a beam that is supported at both ends by **RL** and **RR**. Three vertical point loads are exerted onto the beam. Answer the questions that follow.

**FIGURE 7.1**

- 7.1.1 Calculate the magnitudes of **RL** and **RR**. (8)
- 7.1.2 Calculate the bending moments at **B**, **C** and **D** on the beam. (5)
- 7.1.3 Draw the bending moment diagram.
Use scale: 1 m = 10 mm
10 Nm = 1 mm (6)
- 7.2 A shaft with a diameter of 38 mm is extended by 0,55 mm when a tensile load of 120 kN is applied to it. The original length of the shaft is 125 mm.
- Calculate the following:
- 7.2.1 The resistance area of the shaft (2)
- 7.2.2 The stress in the shaft material (MPa) (3)
- 7.2.3 The strain of the shaft (3)
- 7.2.4 Young's modulus of elasticity of this material (3)



- 7.3 FIGURE 7.3 below shows a steel framework. Answer the questions that follow.

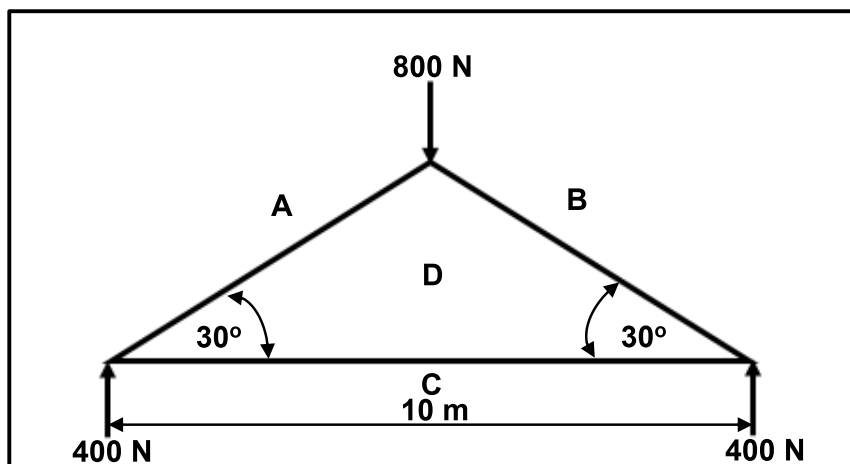


FIGURE 7.3

- 7.3.1 Draw the space diagram to scale 10 mm = 1 m. Using arrows, indicate the struts and ties. (4)
- 7.3.2 Draw the vector diagram to scale 10 N = 1 mm. (5)
- 7.3.3 Determine graphically the magnitude and nature of the following members: **AD**, **BD** and **CD**. (6)
- [45]**

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

- 8.1 State TWO factors to consider during the inspection of welds. (2)
- 8.2 State TWO causes of the following arc welding defects:
 - 8.2.1 Weld spatter (2)
 - 8.2.2 Cracks (2)
- 8.3 State TWO ways to prevent the following defects:
 - 8.3.1 Incomplete penetration (2)
 - 8.3.2 Undercutting (2)
- 8.4 FIGURE 8.4 below shows weld dimensions. Label **A–E**.

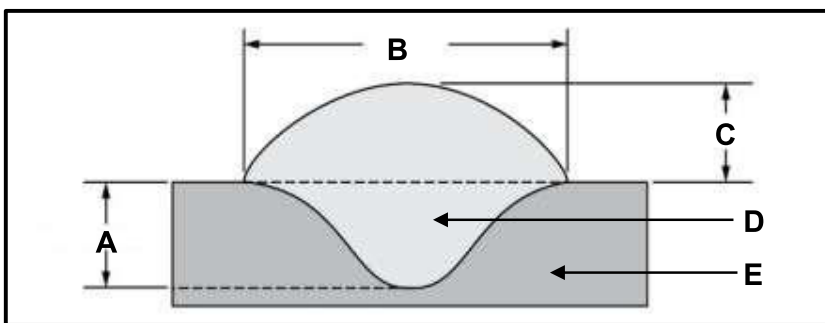


FIGURE 8.4 (5)

- 8.5 State TWO purposes of a machinability test for welded joints. (2)
- 8.6 Give TWO reasons for performing a free-bend test on a welded joint. (2)
- 8.7 FIGURE 8.7 below shows an X-ray test set-up. Label **A–D**.

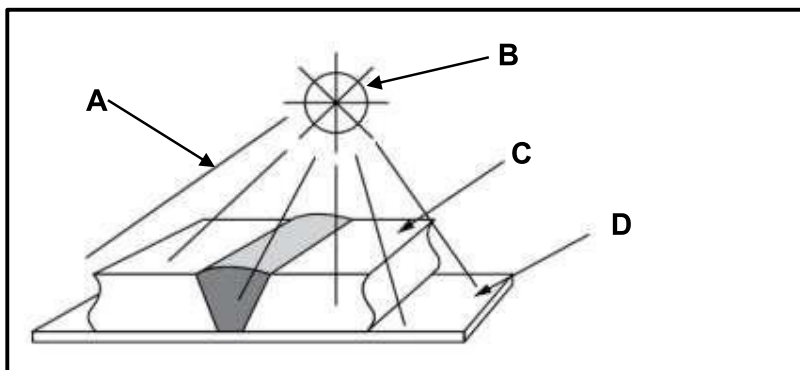


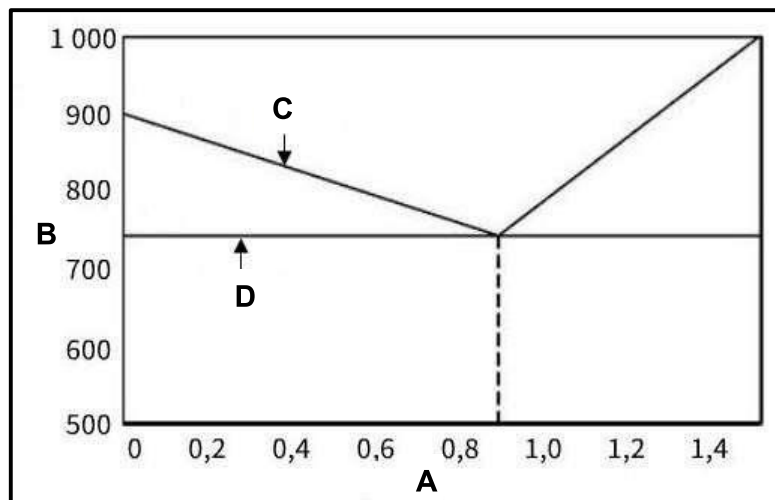
FIGURE 8.7 (4)

[23]



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

- 9.1 State FOUR factors that affect the grain size of steel when it is being cold worked. (4)
- 9.2 State THREE factors that affect distortion and residual stress in welding. (3)
- 9.3 FIGURE 9.3 below shows the iron-carbon equilibrium diagram. Label the diagram as indicated from **A–D**.

**FIGURE 9.3**

- (4)
- 9.4 Name TWO quenching mediums used during the heat treatment of steel. (2)
- 9.5 Name ONE heat-treatment process used in stress relieving. (1)
- 9.6 Define the following terms:
- 9.6.1 Distortion (2)
- 9.6.2 Elastic deformation (2)

[18]**QUESTION 10: MAINTENANCE (SPECIFIC)**

- 10.1 Give TWO reasons why maintenance is important for operating systems or machines. (2)
- 10.2 Give TWO reasons why a lack of lubrication can lead to machine malfunctions. (2)
- 10.3 State TWO potential consequences of overloading a machine. (2)
- 10.4 State TWO maintenance guidelines for a power saw. (2)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

11.1 Describe the purpose of gravity flow with regard to hoppers. (2)

11.2 FIGURE 11.2 below shows a right triangle. Calculate the value of X.

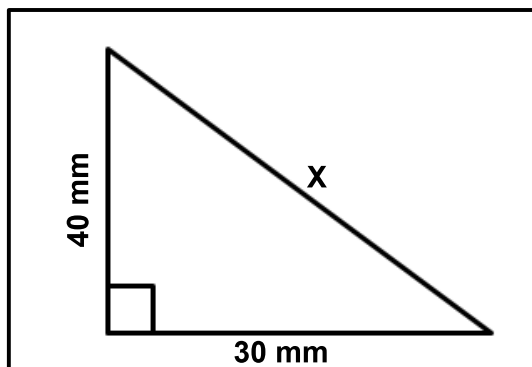


FIGURE 11.2

(3)

11.3 FIGURE 11.3 below shows a square-to-square off-centre hopper with a vertical height (VH) of 850 mm.

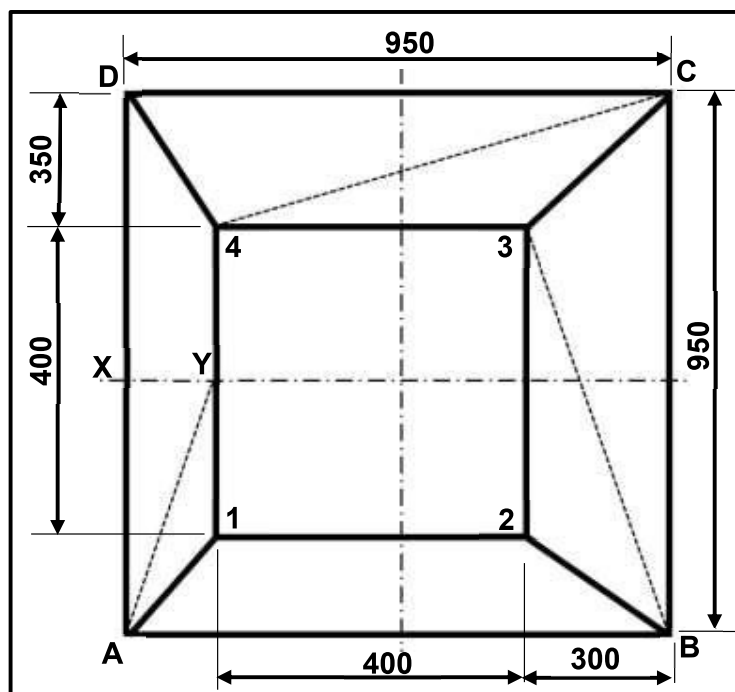


FIGURE 11.3

Calculate the following true lengths:

11.3.1 **B-3** (5)

11.3.2 **X-Y** (4)

11.3.3 **C-4** (5)



11.4 Identify the type of hopper shown in FIGURE 11.4 below.

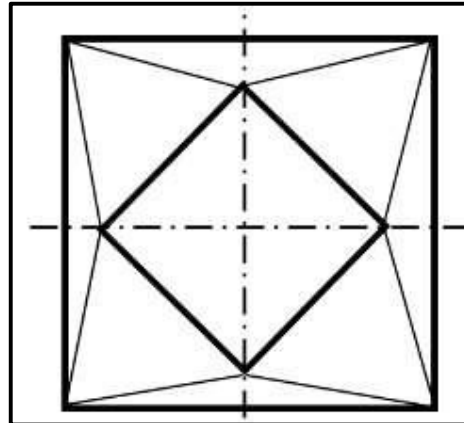


FIGURE 11.4

(2)
[21]

TOTAL: 200



FORMULA SHEET FOR MECHANICAL TECHNOLOGY: WELDING AND METALWORK

1. STRESS AND STRAIN

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

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

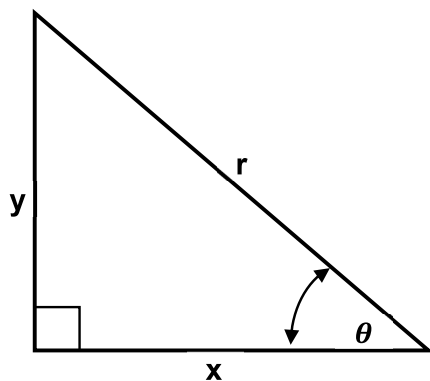
$$1.3 \quad \text{Safety factor} = \frac{\text{Maximum stress/Break stress}}{\text{Safe working stress}}$$

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

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

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

2. PYTHAGORA'S THEOREM AND TRIGONOMETRY



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

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

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

$$2.4 \quad r^2 = x^2 + y^2 \quad \text{OR} \quad a^2 = b^2 + c^2$$



3. TEMPLATES AND DEVELOPMENTS

3.1 $Mean \ \varnothing = Outside \ \varnothing - Plate \ thickness$

OR

$$Mean \ \varnothing = Inside \ \varnothing + Plate \ thickness$$

3.2 $Mean \ circumference = \pi \times Mean \ \varnothing$

(where $\varnothing = diameter$)

4. SCREW THREADS

$$Drill \ size = Outside \ \varnothing - Pitch$$

