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GRADE 12

SEPTEMBER 2023

**MECHANICAL TECHNOLOGY:
WELDING AND METALWORK**

MARKS: 200

TIME: 3 hours

This question paper consists of 19 pages, including a 1-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. Write your NAME 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. You may use a non-programmable scientific calculator and drawing instruments.
8. The value of gravitational force should be taken as 10 m/s^{-2} .
9. All dimensions are in millimeters, unless stated otherwise in the question.
10. A formula sheet is attached to the question paper.
11. Write neatly and legibly.
12. Use the criteria below to assist you in managing your time management.

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)	23	20
9	Joining (stresses and distortion)	18	20
10	Maintenance	8	10
11	Terminology (Developments)	21	15
TOTAL		200	180

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC) (COMPULSORY)

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

- 1.1 Which of the following options below describes the Labour Relation Act (LRA No. 66 of 1995) in South Africa that protect the people living with HIV/Aids?
- A All employers must ensure that the workplace is safe, and that employees are not at risk of becoming infected with HIV at work.
 - B Elaborates how everybody has the right to fair labour practice.
 - C Employer cannot simply dismiss an employee who is infected with HIV.
 - D Promotes non-discrimination in the workplace. (1)
- 1.2 Examination procedure is one of the processes undertaken to determine the type of first aid measures to be administered to an employee who is involved in an accident in a workplace.
Identify the option below that best describe this process.
- A Environmental observation
 - B Visible signs and symptoms
 - C Indicators to diagnosis
 - D All of the above (1)
- 1.3 The following safety precautions must be followed when handling gas bottles:
- A All cylinders must be kept in horizontal position
 - B Use completely insulated electrode holders
 - C Never stack cylinders on top of each another
 - D The colour code of an oxygen cylinder is green (1)
- 1.4 Which ONE of the heat treatment process is used to remove internal strain and brittleness caused by hardening?
- A Annealing
 - B Case-hardening
 - C Tempering
 - D Normalising (1)
- 1.5 Which of the following test is used to determine the carbon content of steel?
- A Sound test
 - B Bend test
 - C Filing test
 - D All of the above (1)

1.6 Why is it important to clamp a small workpiece securely before drilling operation can be carried out?

- A To reduce friction
- B To prevent the drill bit from breaking as well as preventing accident
- C To keep the cutting tool and workpiece cool
- D All of the above

(1)

[6]

QUESTION 2: SAFETY (GENERIC)

- 2.1 Give THREE safety precautions you must take into consideration before arc welding operation can commence. (3)
- 2.2 State TWO safety precautions that you must adhere to when you are operating a pedestal drilling machine to drill a hole on a solid square bar. (2)
- 2.3 What is the maximum thickness of a steel plate that a manual guillotine can accommodate if cutting with it? (1)
- 2.4 Give TWO advantages of each of the following workshop layouts:
- 2.4.1 Product layout of machines (2)
- 2.4.2 Process layout of machines (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

- 3.1 State the TWO main purpose of case hardening mild steel. (2)
- 3.2 Why can high carbon steel not be used for case hardening? (1)
- 3.3 State THREE factors that determine the hardness of steel during heat treatments of metal. (3)
- 3.4 List THREE types of quenching mediums. (3)
- 3.5 What is the purpose of the colour coding marked on engineering materials? (1)
- 3.6 State the type of test that can be used to obtain the following properties of metals:
- 3.6.1 Hardness (1)
- 3.6.2 Carbon content (1)
- 3.6.3 Ductility (1)
- 3.7 List the machine that is used for a spark test. (1)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (GENERIC) (COMPULSORY)

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

- 4.1 What is the function of inert gas in the MIG welding process?
- A Stabilise the arc on the metal being welded.
 - B Shields the arc and the molten metal being welded.
 - C Allow smooth transfer of metal from the weld to the molten pool.
 - D All the above-mentioned. (1)
- 4.2 What is the reason for doing a bend test?
- A To train welders.
 - B To check the size of the welded joint.
 - C To approve welds to certain standards.
 - D To test the ductility of the welded material. (1)
- 4.3 Compressive stress is an internal force in a material resisting a ... load.
- A pulling
 - B shearing
 - C pushing
 - D All the above-mentioned. (1)
- 4.4 An oxygen cylinder regulator used in flame cutting may freeze because the ...
- A gas withdrawal rate is exceeded.
 - B cylinder content is too low.
 - C cylinder is on its side.
 - D needle valve on the regulator is not fully opened. (1)
- 4.5 Slow cooling of heated/welded steel will result in the grain structure ...
- A enlarging.
 - B becoming smaller.
 - C separating.
 - D melting. (1)
- 4.6 During the deposition of manual metal arc welding, a certain percentage of the core wire is lost, this is due to ...
- A excessive build up.
 - B short arc length.
 - C blow holes.
 - D spatter. (1)

- 4.7 The colour code used to indicate safety equipment is ...
A white and green.
B yellow and white.
C blue and white.
D black and yellow. (1)
- 4.8 Case hardening is a heat treatment process that is performed to ...
A obtain a tougher material by decreasing its brittleness.
B produce a hard case over a tough core.
C relieve stress induced during the hardening process. (1)
D make metal hard to resist wear and cut.
- 4.9 When using a surface grinder, the following safety precautions must be taken into consideration. Which ONE does not fit in?
A Understand the operating instructions applicable to your machine.
B Do NOT operate the surface grinder unless all guards and safety devices are in place and working correctly.
C Never lean against or adjust the machine while it is in motion.
D When the surface grinder is grinding, the grinding wheel must be cooled down with a coolant. (1)
- 4.10 What is the best way of dealing with a hazard to ensure others are not put at risk?
A Remove it immediately.
B Leave it for the supervisor to sort out.
C Not placing a barrier tape around it. (1)
D Display a notice and warning sign.
- 4.11 Supplementary symbols indicate ... information about the weld.
A easy
B calculated
C difficult (1)
D additional
- 4.12 Who is responsible for the provision of safety equipment in the workplace?
A Employee
B Employer
C Customer
D Foreman (1)
- 4.13 Which structure of steel is characterised as soft and ductile?
A Ferrite
B Pearlite
C Cementite
D Ausenite (1)

4.14 Which ONE of the following tests is an example of a destructive test?

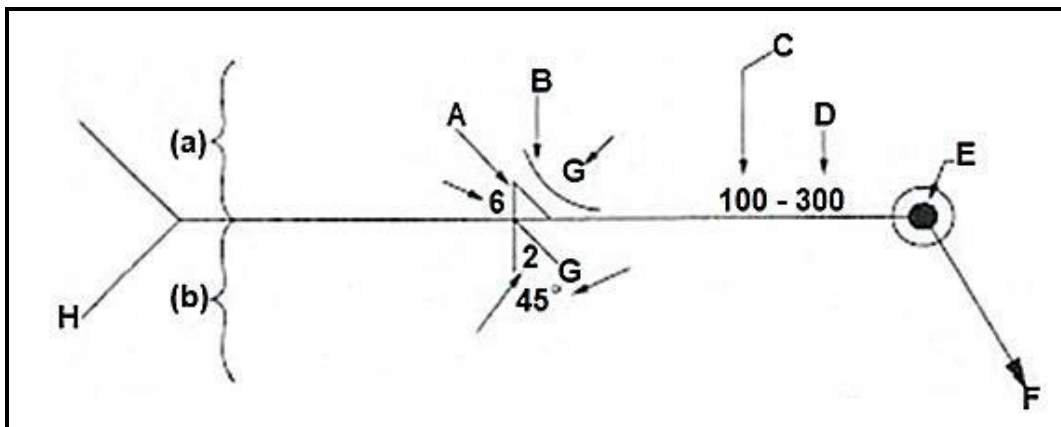
- A Dye penetration test
- B Ultrasonic test
- C X-ray test
- D Machinability test

(1)

[14]

QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

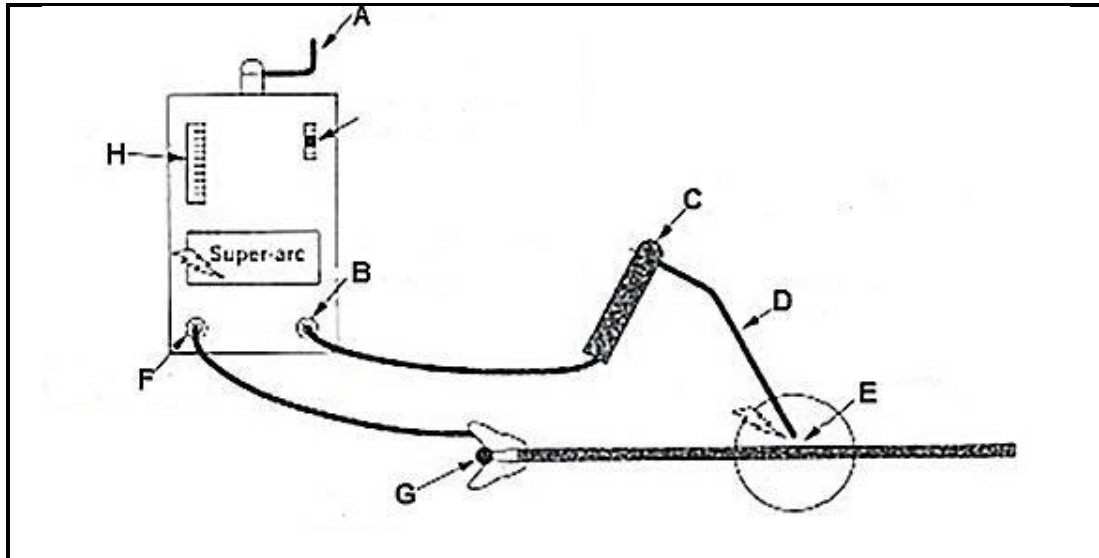
- 5.1 What does 'OSU' indicate on templates? (1)
- 5.2 Make a neat sketch of a roof truss with labels, depicting the following:
- Purlin (1)
 - Internal bracing (1)
 - Ridging (1)
 - Roof sheets (1)
 - Rafter (1)
 - Main tie (1)
- 5.3 A steel ring with an outside diameter of 520 mm must be fabricated from 42 mm round tubing.
- 5.3.1 Calculate the dimensions of the required material to make this ring. (4)
- 5.3.2 Make a neat sketch of the steel ring indicating the outside diameter, inside diameter, the thickness and the mean diameter. (4)
- 5.4 Identify the labels of the elements of the welding symbols below.



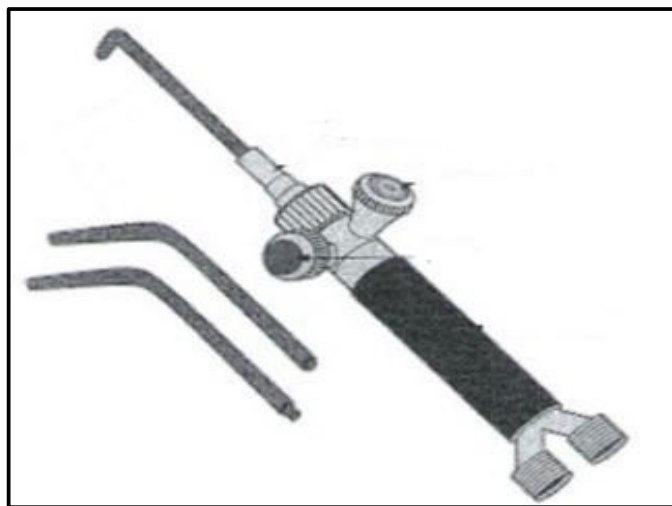
(8)
[23]

QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1 FIGURE 6.1 below depicts the basic operating principles of a welding circuit.

**FIGURE 6.1**

- 6.1 Label parts **A–H**. (8)
- 6.2 What does the abbreviation MIG stand for? (1)
- 6.3 Name TWO gases that can be used in MIG welding. (2)
- 6.4 What is the difference between a *power saw* and a *band saw*? (4)
- 6.5 FIGURE 6.5 below shows the picture a blowtorch. (3)

**FIGURE 6.5**

Name the THREE main parts depicted in the above picture.

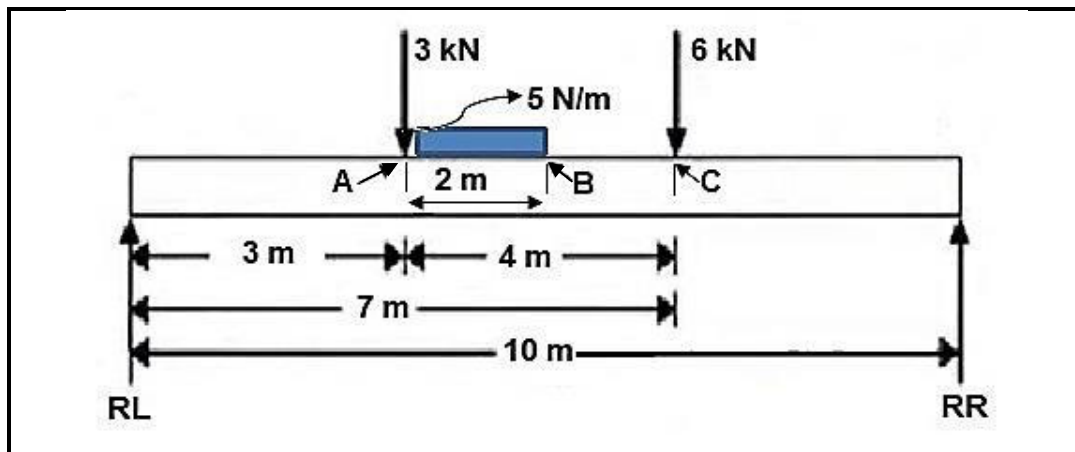
(3)
[18]

QUESTION 7: FORCES (SPECIFIC)

- 7.1 A load of 80 kN causes a tensile stress of 30 MPa in a round bar. The original length of the round bar is 4 m and Young's Modulus of Elasticity is 90 GPa.

Calculate:

- 7.1.1 The diameter of the bar (5)
- 7.1.2 The strain (3)
- 7.1.3 The change in length (3)
- 7.2 A beam is subjected to two point loads and one UDL and is supported at either end by RL and RR.



Calculate the following:

- 7.2.1 The magnitudes of RL and RR (6)
- 7.2.2 The bending moments at points **A**, **B** and **C** (5)

- 7.3 Determine graphically (Bow's notation) the magnitude and nature of the forces of the members in the framework in FIGURE 7.3 below.
 Scale: Space diagram 1 : 100
 Force diagram 10 mm = 10 N

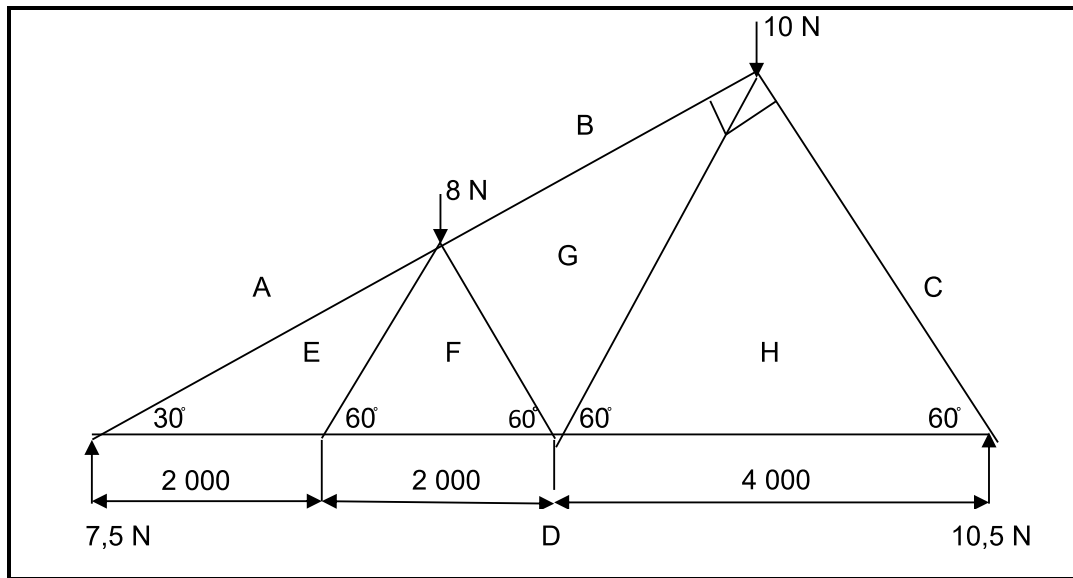


FIGURE 7.3

(23)
[45]

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

- 8.1 Describe how the liquid dye penetrant test is done on a welded joint. (8)
- 8.2 Define *porosity* in a welded joint. (3)
- 8.3 State THREE visual requirements for an acceptable weld. (3)
- 8.4 Name FOUR types of welding defects that are observed when the nick-break test is conducted on a welded joint. (4)
- 8.5 State TWO factors that should be taken into account during oxy-acetylene welding to ensure quality welding. (2)
- 8.6 Give THREE advantages of a physical weld testing method. (3)

[23]

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

- 9.1 How would you go about your welding procedure to prevent warping? (4)
- 9.2 State FIVE factors to take into consideration to minimise shrinkage. (5)
- 9.3 Name the THREE main steel groups of materials and state their carbon content percentages accordingly. (6)
- 9.4 Define *spatter* during the welding process. (3)

[18]

QUESTION 10: MAINTENANCE

10.1 Why should locking plates have multiple holes as depicted below?



(2)

10.2 Explain how a bench grinder can be overloaded.

(2)

10.3 How can friction be reduced during the rolling process?

(2)

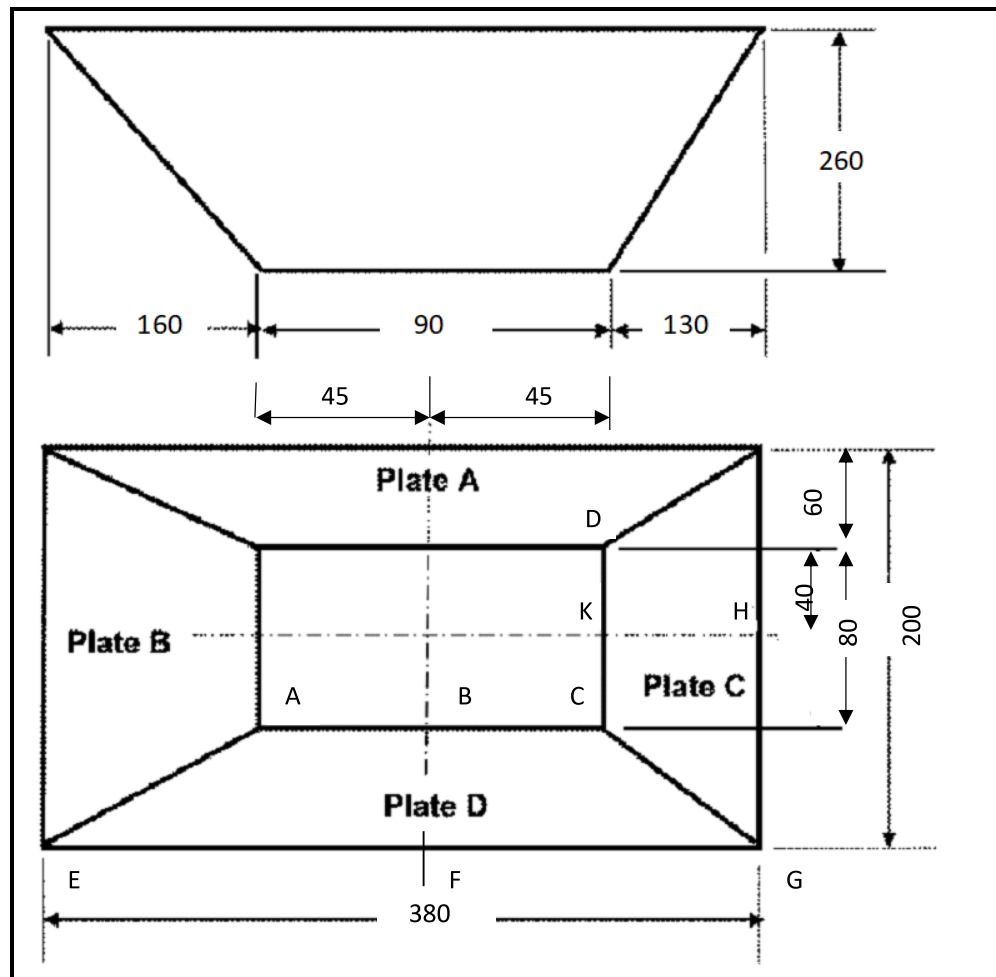
10.4 What is the purpose of keeping service records of machines and equipment?

(2)

[8]

QUESTION 11: TERMINOLOGY (SPECIFIC)

- 11.1 FIGURE 11.1 shows a rectangle-to-rectangle off-centre hopper with a vertical height of 260 mm.

**FIGURE 11.1**

Calculate the true lengths of the following:

- | | | |
|--------|-----------|-----|
| 11.1.1 | Length CG | (2) |
| 11.1.2 | Length BG | (2) |
| 11.1.3 | Length AE | (2) |
| 11.1.4 | Length GD | (2) |
| 11.1.5 | Length HC | (2) |
| 11.1.6 | Length HK | (2) |

- 11.2 FIGURE 11.2 shows a truncated cone. The vertical height of the truncated cone is 450 mm and the base and top diameters are 800 mm and 350 mm respectively. Answer the questions that follows.

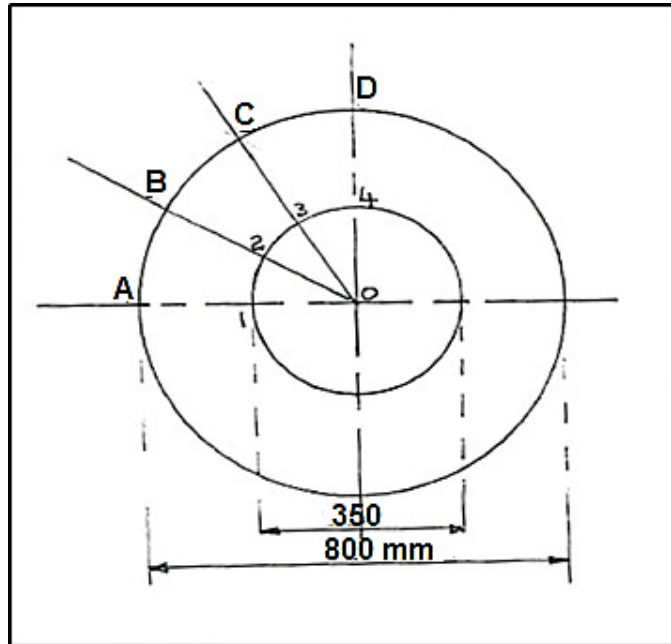


FIGURE 11.2

- 11.2.1 Calculate the true length of AB. (3)
- 11.2.2 Calculate the circumference of the top circle. (3)
- 11.2.3 Calculate O–2. (3)

[21]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY (WELDING AND METALWORK)

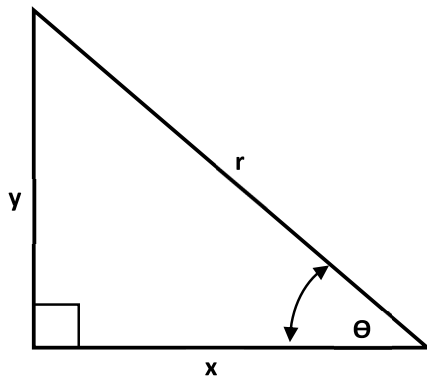
1. STRESS AND STRAIN

$$1.1 \quad \text{Stress} = \frac{\text{Force}}{\text{Area}} \quad \text{or} \quad \sigma = \frac{F}{A}$$

$$1.2 \quad \text{Young's modulus} = \frac{\text{Stress}}{\text{Strain}} \quad \text{or} \quad E = \frac{\sigma}{\epsilon}$$

$$1.3 \quad \text{Strain} = \frac{\text{Change in length}}{\text{Original length}} \quad \text{or} \quad \epsilon = \frac{\Delta l}{l}$$

2. PYTHAGORAS' THEOREM AND TRIGONOMETRY



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

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

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

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

3. TEMPLATES AND DEVELOPMENTS

$$3.1 \quad \text{Mean } \phi = \text{Outside } \phi - \text{Plate thickness} \quad \text{or}$$

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

$$3.2 \quad \text{Mean circumference} = \pi \times \text{Mean } \phi$$