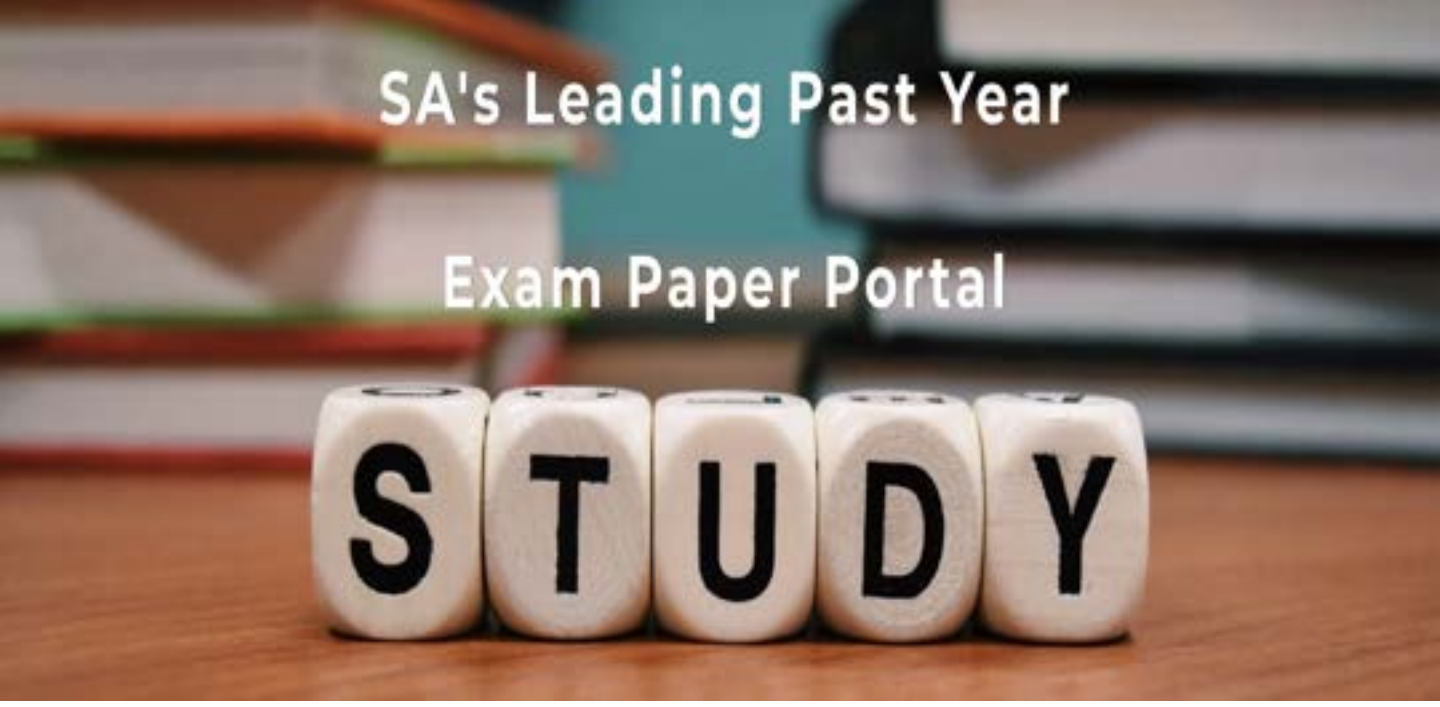

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GRADE 12

SEPTEMBER 2021

MECHANICAL TECHNOLOGY: WELDING AND METALWORK MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 13 pages.

SECTION A: COMPULSORY

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

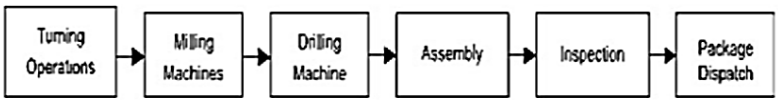
1.1 C ✓
1.2 D ✓
1.3 D ✓
1.4 A ✓
1.5 B ✓
1.6 B ✓ (6 x 1) **[6]**

QUESTION 2: SAFETY (GENERIC)

2.1 **Safety precautions**

- Pressure gauges must be checked and tested regularly and adjusted or replaced if any malfunctioning occurs. ✓
- Supporting pins that keep the platform at a desired height on the frame must be inspected for damage. ✓
- Check the floor for oil and apparatus for leaks.
- The platform on which the workpiece rests must be rigid and square with the press cylinder. (Any 2 x 1) (2)

2.2 **Product Layout**



✓✓ (2)

2.3 **Perspex shield** is installed to shield flying objects hurting the operator's eye. ✓ (1)

2.4 2.4.1 Identification of machine
Surface grinder ✓ (1)

2.4.2 Labels for parts of a surface grinder
A – Workpiece ✓
B – Machine spindle ✓
C – Magnetic table ✓
D – Grinding wheel ✓ (4 x 1) (4)
[10]

QUESTION 3: MATERIALS (GENERICS)

3.1 Heat treatment refers to heating and cooling of metals under controlled conditions in their solid state so as to change their properties. ✓✓ (2)

3.2 **HEAT TREATMENT PROCESS**

PROCESS		PROPERTY
3.2.1	Hardening	Very hard, maximum tensile and brittle ✓
3.2.2	Tempering	Ductile ✓
3.2.3	Annealing	Soft and ductile. ✓
3.2.4	Normalising	Tough and machinable. ✓

(4 x 1) (4)

3.3 **Purpose for case hardening:**

- It hardens the surface. ✓
- It provides a wear resistant surface. ✓
- Strengthens core to withstand applied loads. ✓ (Any 2 x 1) (2)

3.4 **Carbon effect:**
Steel with low carbon content ✓will not respond very much to the hardening process. ✓ (2)

3.5

- Sound test workshop test on materials ✓
- Bend test ✓
- Filling test
- Machining test (Any 2 x 1) (2)

3.6 **Reasons for annealing:**

- To relieve internal stresses that may have been set up during other processes. ✓
- To soften them to facilitate the machining processes. ✓
- To make material ductile.
- Refine their grain structures.
- Reduce brittleness. (Any 2 x 1) (2)

[14]

QUESTION 4 MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

4.1 D ✓
4.2 C ✓
4.3 B ✓
4.4 D ✓
4.5 A ✓
4.6 C ✓
4.7 B ✓
4.8 B ✓
4.9 A ✓
4.10 B ✓
4.11 D ✓
4.12 D ✓
4.13 B ✓
4.14 D ✓ (14 x 1) **[14]**

QUESTION 5: MATERIALS TEMPLATES – ROLLING AND BENDING

5.1 **Purpose of purlins in roof trusses:**

- Purlins are fastened to the roof trusses ✓ to attach the roof covering. ✓ (2)

5.2 **Reason why stiffeners are used in beams.**

- To strengthen the web of the beam. ✓ (1)

5.3 **The use of strip templates:**

- They are used for longer sections of angle iron to mark off holes to be drilled. ✓ (1)

5.4 **What does templates indicate?**

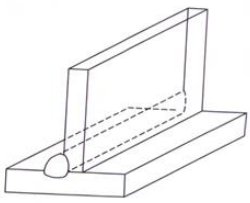
- The correct form and measurements of the project ✓
- The type of material to be used. (thickness and size) ✓
- Job number
- Drawing number
- The number of components required
- This side up or other side up markings
- Coloured or shaped markings to denote hole diameters (Any 2 x 1) (2)

5.5 **Labels of roof truss:**

- A – Purlin ✓
- B – Rafter ✓
- C – Tie beam ✓
- D – Shoe plate ✓
- E – Inclined toe ✓ (5 x 1) (5)

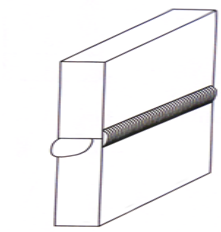
5.6 **Sketches:**

5.6.1



✓✓✓ (3)

5.6.2



✓✓✓ (3)

5.7 **Calculations:**

Mean diameter = 220 + 220 + 12 ÷ 2 ✓

= 452 ÷ 2

= 226 mm ✓ (2)

Circumference = 3,142 x 226 mm

= 710,09 mm ✓ (1)

Length required for 2 straight pieces = 66 mm + 66 mm

= 132 mm ✓

Length of material for 1 clamp = 710,09 mm + 132 mm

= 842,309 mm ✓

Length of material for 20 clamps = 842,309 mm x 20

= 16 841 mm ✓ (3)

[23]

QUESTION 6: TOOLS

6.1 **TWO different types of tap wrenches:**
- T-handle or double handle **OR** ✓
- Adjustable wrenches ✓ (2)

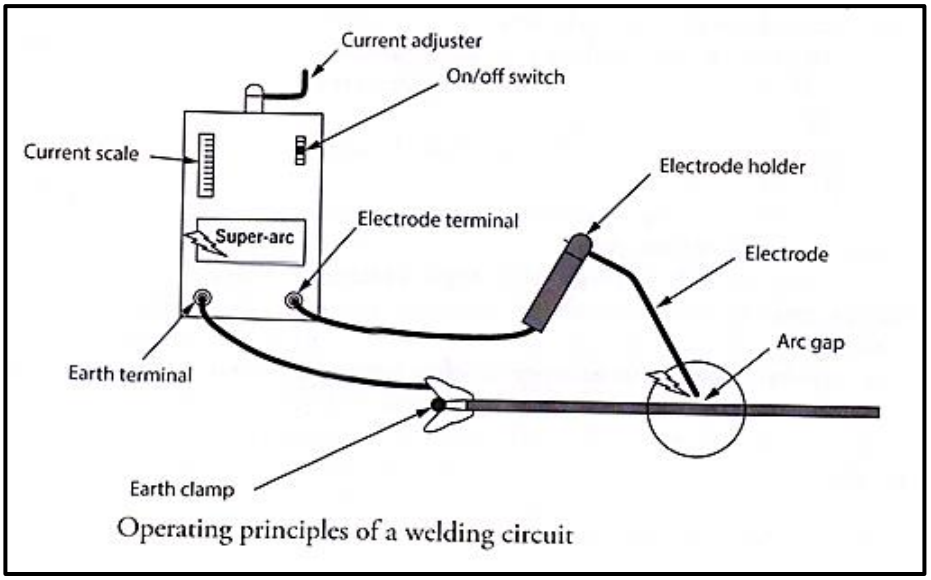
6.2 **Uses of bench grinders:**
- Grinding off excess material ✓
- Cleaning surfaces with a wire wheel ✓
- Polishing or buffing (Any 2 x 1) (2)

6.3 **Purpose of a powersaw:**
- It is used to rough cut large sections of metal. ✓ (1)

6.4 **Determine the drilling speed of a pedestal drilling machine:**
- Slower speed – for large diameters ✓
- Faster speed – for small diameter holes. ✓ (2)

6.5 **Reasons why guillotines have material thickness cutting limits:**
- To preserve the shearing blades. ✓
- Thicker or harder material will chip the brittle blade and result in poor future cuts or jamming of the guillotine. ✓ (2)

6.6 **Sketch of basic AC arc welding machine:**



Operating principles of a welding circuit

(Any 7 labels x 1) (7)

6.7 **The use of shielding gas in MIG welding**:
- MIG welding machines use a shielding gas to protect the weld pool ✓ from atmospheric gases. ✓ (2)

[18]

QUESTION 7: FORCES

7.1 7.1.1 **Stress**

- This is an internal force in material resisting a load. ✓✓ (2)

7.1.2 **Strain**

- This is the measurement of the deformation produced by the external forces and is determined by the ratio between deformation and original length. ✓✓ (2)

7.1.3 **Safety factor**

- This is the maximum number of times with which the maximum stress is decreased to obtain a safe stress. ✓✓ (2)

7.2 7.2.1 **The stress in the material:**

$$\text{Stress} = \frac{\text{Load}}{\text{Area}}$$

$$\text{but Area} = \frac{\pi d^2}{4}$$

$$= \frac{\pi \times (0{,}05)^2}{4} \quad \checkmark$$

$$1{,}964 \times 10^{-3}\,\text{m}^2 \quad \checkmark$$

$$\text{Stress} = \frac{50 \times 10^3}{1{,}964 \times 10^{-3}} \quad \checkmark$$

$$= 25{,}46 \times 10^6\,\text{Pa}$$

$$= 25{,}46\,\text{MPa} \quad \checkmark$$ (4)

7.2.2 **The strain if the final length of the bar is 3,00 m.**

$$Strain = \frac{\Delta L}{OL}$$

but

$$Final\ length = OL + \Delta L$$

$$\Delta L = final\ length - OL \quad \checkmark$$

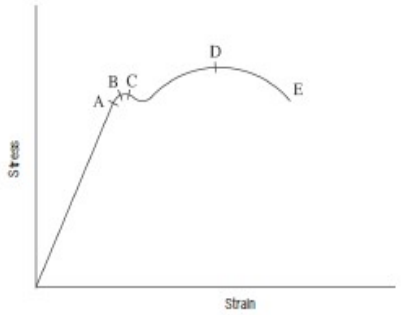
$$= 3{,}005 - 3$$

$$= 0{,}005\,m \quad \checkmark$$

$$Strain = \frac{0{,}005}{3}$$

$$= 1{,}67 \times 10^{-3} \quad \checkmark$$ (3)

7.3 **Labelled sketch of the stress strain graph.**



KEY

A limit of proportionality

B Elastic limit

C Yield point

D Maximum stress

E Break stress

(Each label x 1) (7)

7.4 7.4.1 **Calculate the reactions at the supports LR and RR**

CALCULATING REACTIONS

Take moments about RR
LR x 13 = (50 x 5 x 10,5) + (400 x 8) + (600 x 3) ✓
= 2 625 + 3 200 + 1 800 ✓
LR = 586,5 N ✓
Take moments about LR
RR x 13 = (600 x 10) + (400 x 5) + (50 x 5 x 2,5) ✓
= 6000 + 2000 + 625 ✓
RR = 663,5 N ✓ (6)

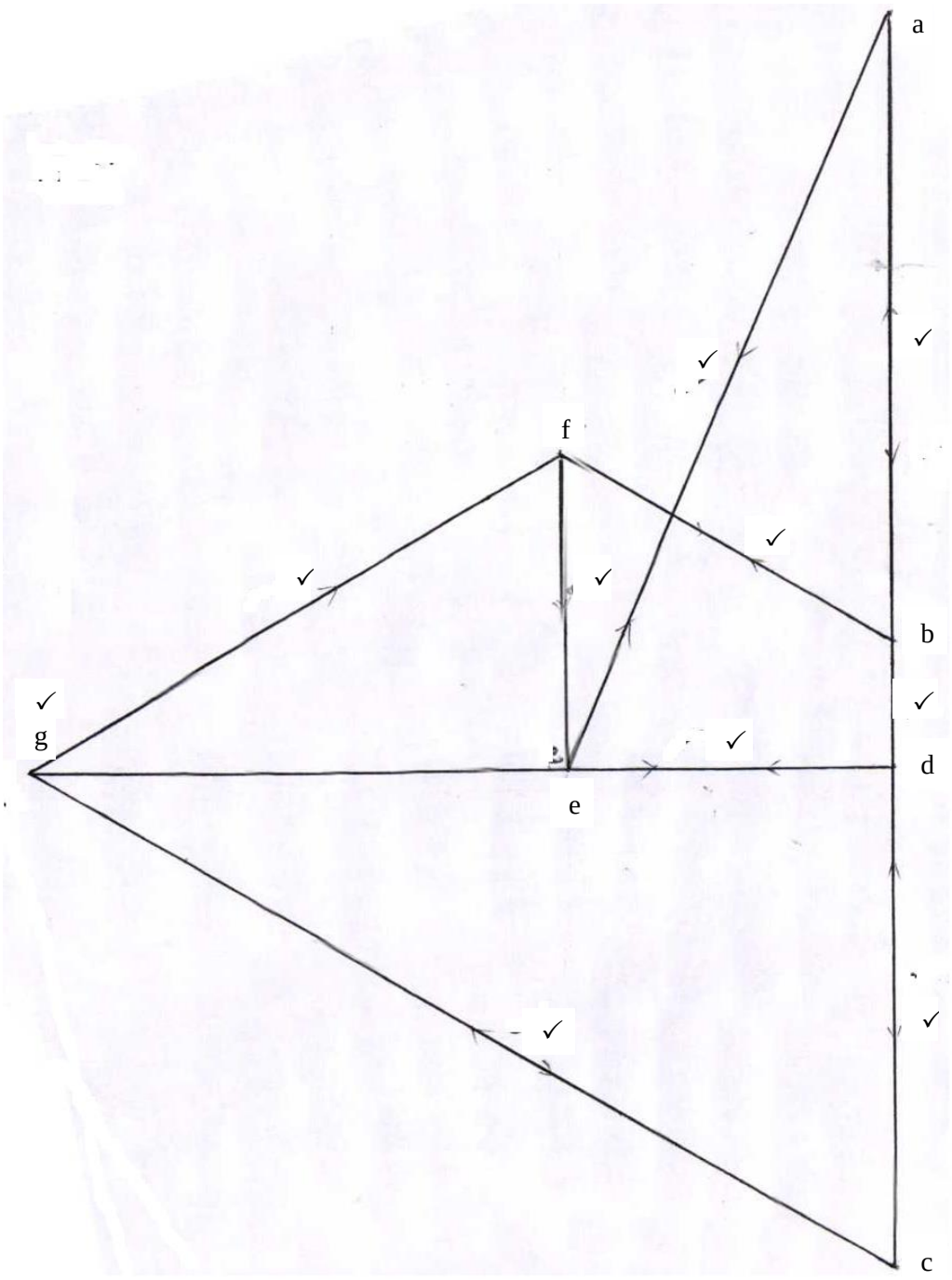
7.4.2 **Calculate the BM at each point of the beam A, B, C and D.**

BENDING MOMENTS
BMA: = 586,5 x 0 = 0 Nm ✓
BMB: = (586,5 x 5) – (250 x 2,5) = 2307,5 Nm ✓
BMC: = (586,5 x 10) – (250 x 7,5) – (400 x 5) = 1 990 Nm ✓
BMD: = (586,5 x 13) – (250 x 10,5) – (400 x 8) – (600 x 3) = 0 m ✓ (4)

7.4.3 **Calculate the shear force at A, B, C and D.**

SHEAR FORCE
SFA: 586,5 N ✓
SFB: 586,5 – 250 = 336,5 N ✓
SFC: 586,5 – 250 – 400 = -64,5 N ✓
SFD: 586,5 – 250 – 400 – 600 = -663,5 N ✓ (4)

7.5 Vector diagram: Scale 10 mm = 1 N



(11)
[45]

QUESTION 8: JOINING METHODS (INSPECTION OF WELDS)

8.1 **Internal defects – Nickbreak test:**

- Slag inclusion ✓
- Porosity ✓
- Lack of fusion ✓
- Oxidised metal
- Burned metal (Any 3 x 1) (3)

8.2 **Visual requirements for an acceptable weld:**

- Shape of the profile ✓
- Uniformity of the surface ✓
- Overlap ✓
- Free from any external defects
- Penetration bead
- Root groove (Any 3 x 1) (3)

8.3 **Elements during the visual inspection in welding:**

- Shape of profile ✓
- Uniformity of the surface ✓
- Overlap ✓
- Undercutting
- Penetration bead
- Root groove (Any 3 x 1) (3)

8.4 **Performing an X-ray test on a welded joint:**

- The X-ray or gamma ray source is placed in front of the object being tested. ✓
- Once the tester is standing behind lead shields and far away from possible harmful exposure, the source is activated for a brief moment ✓ and the X-rays penetrate the test piece. ✓
- As they pass through the areas of lower density (air pockets, cracks or inclusions) the rays expose the film as lighter on the negative, indicating a welding defect. ✓
- Photographic films are useful because they provide a permanent record of the shadow which can be carefully studied. ✓ (5)

8.5 **Factors that determine the current setting in arc welding.**

- Base metal type ✓
- Base metal thickness ✓
- Electrode thickness ✓ (3 x 1) (3)

8.6 **Factors that should be considered during oxyacetylene welding to ensure quality welding:**

- Correct flame for the work at hand ✓
- Correct angle of welding torch and rod ✓
- Depth of fusion ✓
- The welding rate (Any 3 x 1) (3)

8.7 **Preventative measures for porosity during MIG welding:**

- Cleaning the welding surface. ✓
- Avoid rust in MIG wire electrode. ✓
- Ensure that supply of shielding gas is not interrupted. ✓
- Avoid welding in windy condition. (Any 3 x 1) (3)

[23]

QUESTION 9: JOINING METHODS (STRESSES AND DISTORTION)

9.1 **Methods used to reduce distortion:**

- Do not over-weld ✓
- Apply intermittent welding ✓
- Place welds near the neutral axis ✓
- Use as few passes as possible ✓
- Use back-step welding ✓
- Anticipate the shrinkage forces
- Plan the welding sequence
- Use strongbacks
- Use clamps, jigs and fixtures (Any 5 x 1) (5)

9.2 **Distortion on a welded joint:**

- Weld distortion is the warping of the base plate ✓ caused by heat from the welding arc/flame. ✓ (2)

9.3 **The meaning of shrinkage in a welded joint:**

- Shrinkage is a form of plastic deformation ✓ where the metal has deformed because of contraction on cooling. ✓ (2)

9.4 **The iron-carbon equilibrium diagram labels:**

A – Ferrite and pearlite ✓
B – Ferrite and austenite ✓
C – Austenite ✓
D – Cementite and austenite ✓
E – Pearlite and cementite ✓ (5)

9.5 **The factors that affect the grain size of steel when it is being cold worked:**

- The prior amount of cold work. ✓
- The temperature and time of the annealing process. ✓
- The composition ✓
- The melting point ✓ (4)

[18]

QUESTION 10: MAINTENANCE

10.1 **Tagging plates have multiple holes**:

- It has multiple holes ✓ so that more than one technician can lock out the machine simultaneously. ✓ (2)

10.2 **General maintenance guidelines for a pedestal drilling machine**:

- Visual checks of electrical wiring, switches, etc. ✓
- Verify that all guards are secure and function correctly✓
- Ensure workspace is clear and without hindrances.
- Confirm availability and conditions of PPE
- Lubricate moving parts.
- Use moisture-penetrating oil spray to prevent rust.
- Check the availability of specific tools.
- Check the run-out of the spindle.
- Inspect belts for wear and tear.
- Ensure the drive belt is correctly tensioned.
- Check the condition of the rack and pinion mechanisms and lubricate.
- Ensure cuttings are removed.
- Inspect the Morse taper sleeves for burrs/scratches. (Any 2 x 1) (2)

10.3 **Reasons for the maintenance of machines in the welding workshop**:

- Promote cost saving. ✓
- Improves safety. ✓
- Increases equipment efficiency.
- Fewer equipment failure.
- Improves reliability of equipment. (Any 2 x 1) (2)

10.4 **Methods to reduce friction when drilling holes**:

- By reducing both drill speed and feed speed. ✓
- By applying lubrication. (cutting fluid) ✓ (2)

[8]

QUESTION 11: TERMINOLOGY (DEVELOPMENT)

Calculations:

11.1 1 – 2 $= \frac{\pi x\ D}{12}$ ✓

$= \frac{3.142 \text{ x } 72}{12}$ ✓

1 – 2 = 18,849 ✓

1 – 2 = 2 – 3 = 3 – 4 = 18,849 ✓ (4)

11.2 1 – X $= \sqrt{(OX - R)^2}$✓ + $Vertical\ height^2$ ✓

$= \sqrt{(45 - 36)^2} + 50^2$ ✓

= 50,8 ✓ (4)

11.3 1 – a $= \sqrt{(1 - x)^2}$ ✓+ $(a - x)^2$✓ + $Vertical\ height^2$ ✓

$= \sqrt{(9)^2} + 45^2 + 50^2$ ✓

= 67,868 ✓ (5)

11.4 2 – a $= \sqrt{(o - x) - R\ Cos\ 30^o)^2}$✓ + $[(a - x) - R\ Sin\ 30^o)]^2$✓ + $height^2$✓

$= \sqrt{(45 - 36\ Cos\ 30^o)^2}$ + [(a-x) – R Sin30^o] + $height^{\ 2}$

$= \sqrt{(45 - 36\ Cos\ 30^0)^2} + (45 - 36\ Sin\ 30^0)^2 + 50^2$ ✓

$= \sqrt{(13{,}823^2} + 27^2 + 50^2$ ✓

= 58,481 ✓ (6)

11.5 a – x = 90 ÷ 2 ✓

= 45 ✓ (2)

[21]

TOTAL: 200