basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

# NATIONAL SENIOR CERTIFICATE

## GRADE 12

# MECHANICAL TECHNOLOGY: WELDING AND METALWORK

## NOVEMBER 2018

## MARKING GUIDELINES

**MARKS: 200**

**These marking guidelines consist of 19 pages and Annexure A.**

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

1.1 A ✓ (1)

1.2 C ✓ (1)

1.3 A ✓ (1)

1.4 B ✓ (1)

1.5 D ✓ (1)

1.6 A ✓ (1)

**TOTAL QUESTION 1: [6]**

## QUESTION 2: SAFETY (GENERIC)

2.1 **Angle grinder: (Before using)**

- The safety guard must be in place before starting. ✓
- Protective shields must be placed around the object being grinded to protect the people around. ✓
- Use the correct grinding disc for the job. ✓
- Make sure that there are no cracks in the disc before you start. ✓
- Protective clothing and eye protection are essential. ✓
- Check electrical outlets and cord/plugs for any damages. ✓
- Ensure that lockable switch is disengaged. ✓
- Ensure that the disc and the nut are well secured. ✓
- Ensure that the removable handle is secured. ✓
- Remove all flammable material from the area. ✓
- Secure the work piece. ✓

**(Any 2 x 1)** (2)

2.2 **Welding goggles:**

- To protect your eyes against sparks ✓
- To protect your eyes against heat ✓
- To be able to see where to weld ✓
- To protect your eyes from UV rays / bright light ✓
- To protect your eyes from smoke ✓

**(Any 2 x 1)** (2)

2.3 **PPE for Hydraulic press:**

- Overall ✓
- Safety shoes ✓
- Safety goggle ✓
- Leather gloves ✓
- Leather apron ✓
- Face shield ✓

**(Any 2 x 1)** (2)

2.4 **Workshop layouts:**

- Process layout ✓
- Product layout ✓ (2)

2.5 **Employer's responsibility regarding first-aid:**

- Provision of first-aid equipment ✓
- First aid training ✓
- First-aid services by qualified personnel ✓
- Any first aid procedures ✓
- Display first aid safety signs ✓
- First aid personnel must be identified by means of arm bands or relevant personal signage ✓

**(Any 2 x 1)** (2)

**TOTAL QUESTION 2: [10]**

## QUESTION 3: MATERIALS (GENERIC)

3.1 **Bending test:**

- Ductility ✓✓
- Malleability ✓✓
- Brittleness ✓✓
- Flexibility ✓✓

**(Any 1 x 2)** (2)

3.2 **Heat-treatment:**

3.2.1 **Annealing:**

- To relieve internal stresses ✓
- To soften the steel ✓
- To make the steel ductile ✓
- To refine the grain structure of the steel ✓
- To reduce the brittleness of the steel ✓

**(Any 2 x 1)** (2)

3.2.2 **Case hardening:**

- To produce a wear resistant surface ✓ and it must be tough enough internally ✓ at the core to withstand the applied loads.
- Hard case ✓ and tough core. ✓

**(Any 1 x 2)** (2)

3.3 **Tempering process:**

- To reduce ✓ the brittleness ✓ caused by the hardening process.
- Relieve ✓ strain ✓ caused during hardening process.
- Increase ✓ the toughness ✓ of the steel.

**(Any 1 x 2)** (2)

3.4 **Factors for heat-treatment processes:**

- Heating temperature / Carbon content ✓
- Soaking (Time period at temperature) / Size of the work piece ✓
- Cooling rate / Quenching rate ✓ (3)

3.5 **Hardening of steel:**

- Steel is heated to 30 – 50°C above the higher critical temperature. ($AC_3$) ✓
- It is then kept at that temperature to ensure (soaking) that the whole structure is Austenite. ✓
- The steel is then rapidly cooled by quenching it in clean water, brine or oil. ✓ (3)

**TOTAL QUESTION 3: [14]**

## QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

| | | |
|---|---|---|
| 4.1 | B ✓ | (1) |
| 4.2 | A ✓ | (1) |
| 4.3 | B ✓ | (1) |
| 4.4 | B ✓ | (1) |
| 4.5 | A ✓ | (1) |
| 4.6 | B ✓ | (1) |
| 4.7 | D ✓ | (1) |
| 4.8 | D ✓ | (1) |
| 4.9 | C ✓ | (1) |
| 4.10 | C ✓ | (1) |
| 4.11 | A ✓ | (1) |
| 4.12 | D ✓ | (1) |
| 4.13 | B ✓ | (1) |
| 4.14 | B ✓ | (1) |

**TOTAL QUESTION 4: [14]**

## QUESTION 5: TERMINOLOGY (TEMPLATES) (SPECIFIC)

5.1 **Template loft:**

The template loft is separated from the workshop because…

- it is quieter. ✓
- the lighting is better. ✓
- all equipment is at hand. ✓
- it is a permanent base. ✓
- marking on the floor enhance accuracy. ✓

**(Any 2 x 1)** (2)

5.2 **Purpose of purlins:**

- The purlins support ✓ the roof covering ✓
- Stabilizes ✓ the trusses. ✓

**(Any 1 x 2)** (2)

5.3 **A steel ring calculation:**

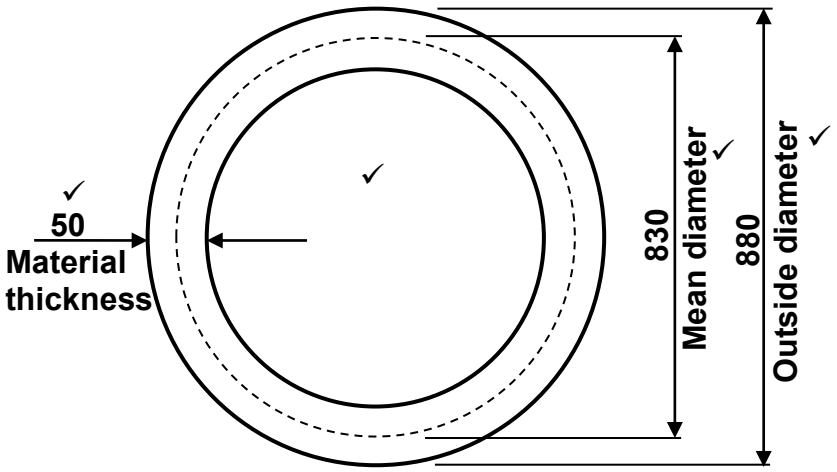
5.3.1 **Dimensions of the required material:**

$$\text{Mean diameter} = \text{Outside diameter} - \text{plate thickness} \quad ✓$$
$$= 880 - 50 \quad ✓$$
$$= 830\text{mm} \quad ✓$$

$$\text{Mean circumference} = \pi \times \text{Mean diameter} \quad ✓$$
$$= \pi \times 830 \quad ✓$$
$$= 2607{,}52\text{mm} \quad ✓$$

2608 mm of 50 x 50 mm ✓ square steel bar is required to fabricate the ring. (7)

5.3.2




(4)

5.4 **Resistance weld symbols:**

5.4.1 Spot weld ✓ (1)

5.4.2 Seam weld ✓ (1)

5.5 **Welding symbols:**

A. Tail ✓
B. Weld symbol (Fillet weld) ✓
C. Pitch of weld ✓
D. Site weld ✓
E. Arrow ✓
F. Weld all round ✓ (6)

**TOTAL QUESTION 5: [23]**

## QUESTION 6: TOOLS AND EQUIPMENT (SPECIFIC)

6.1. **Working Principles:**

6.1.1 **Guillotine:**

- A bottom cutting blade is fixed horizontally. ✓
- With a top cutting blade moving downwards. ✓
- It is driven by an electric motor, flywheel, gearbox and axle ✓ by eccentric motion / action / hydraulic action. ✓

**OR**

- It is activated manually by foot ✓ with lever action. ✓ (4)

6.1.2 **Bending rolls:**

- A bending roll has two fixed rollers next to each other rotating in unison (Manually or Electrical motor). ✓
- A third roller is adjustable, moving in between the two rollers. ✓
- The third roller applies downward pressure onto the metal. ✓
- That causes the metal to deflect and ultimately form the round shape desired. ✓ (4)

6.2. **Regulators on gas cylinders:**
Regulators reduce ✓ the cylinder pressure ✓ to operating or working pressure. ✓ (3)

6.3 **Press machine:**

- The press machine is used for installing ✓ or removing ✓ components on mechanical devices / machines. ✓
- To press ✓ profiles ✓ onto material ✓

**(Any 1 x 3)** (3)

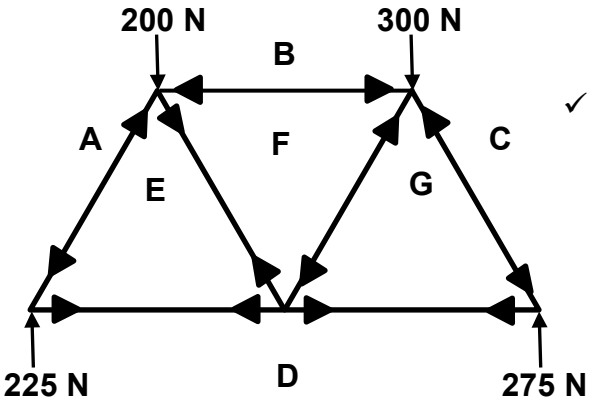
6.4 **MIGS/MAGS welding process:**
A – Weld pool / weld bead / molten metal ✓
B – Electrode wire / electrode ✓
C – Gas shroud / electrical contact / nozzle / contact tip ✓
D – Shielding gas ✓ (4)

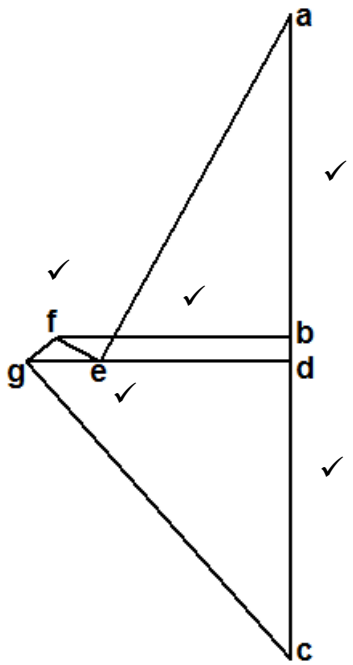
**TOTAL QUESTION 6: [18]**

## QUESTION 7: FORCES (SPECIFIC)

7.1 **Forces in members:**

SCALE: Vector diagram 1 mm = 5 N



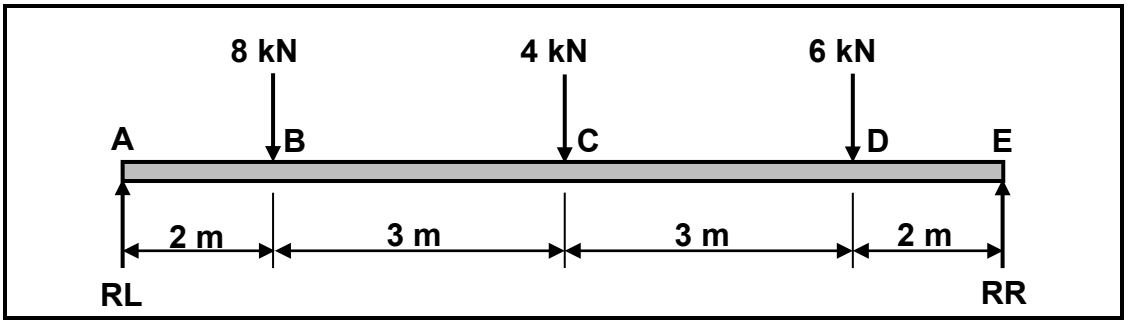




| MEMBER | MAGNITUDE | NATURE |
|---|---|---|
| AE | 260 N ✓ | STRUT ✓ |
| BF | 135 N ✓ | STRUT ✓ |
| CG | 317,5 N ✓ | STRUT ✓ |
| FG | 27,5 N ✓ | STRUT ✓ |
| ED | 130 N ✓ | TIE ✓ |
| EF | 27,5 N ✓ | TIE ✓ |
| GD | 160 N ✓ | TIE ✓ |

(20)

NOTE:
Use a tolerance of 2 mm + and – on the vector diagram.
= a tolerance of 10 N + and – on the answer.

7.2 Bending moments:




7.2.1 Moments about RR

✓ ✓

$$RL \times 10 = (8 \times 8) + (4 \times 5) + (6 \times 2)$$

$$RL = \frac{96}{10} \quad ✓$$

$$RL = 9{,}6\text{kN} \quad ✓$$

Moments about RL

✓ ✓

$$RR \times 10 = (6 \times 8) + (4 \times 5) + (8 \times 2)$$

$$RR = \frac{84}{10} \quad ✓$$

$$RR = 8{,}4\text{kN} \quad ✓$$

(8)

7.2.2 **Bending moments at point A, B, C, D and E:**

Scale $2\text{ mm} = 1\text{ kN.m}$

Moment at A = 0 kN.m ✓

B = $RL \times 2 = 19{,}2$ kN.m ✓

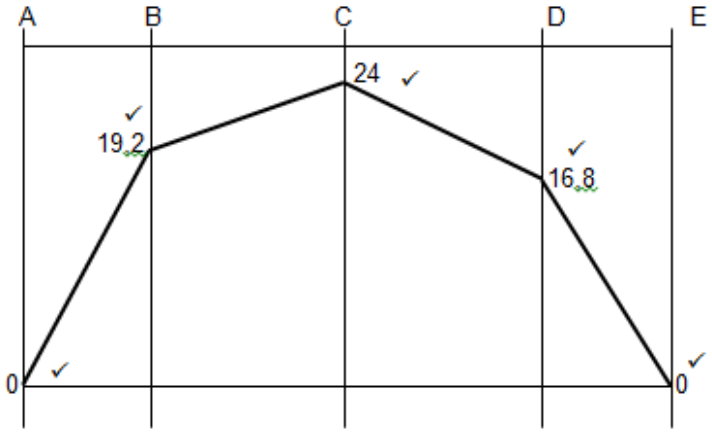
C = $(RL \times 5) - (8 \times 3) = 24$ kN.m ✓

D = $(RL \times 8) - (8 \times 6) - (4 \times 3) = 16{,}8$ kN.m ✓

E = $(RL \times 10) - (8 \times 8) - (4 \times 5) - (6 \times 2) = 0$ kN.m ✓

(5)

7.2.3




(5)

NOTE:
Use a tolerance of 2 mm + and – on the bending moment diagram.

7.3 **Stress and strain:**

$$A = \frac{\pi d^2}{4} \quad \checkmark$$

$$A = \frac{\pi (0{,}02)^2}{4} \quad \checkmark$$

$$A = 0{,}314 \times 10^{-3}\ m^2 \quad \checkmark$$

$$\left.\begin{aligned} \text{Stress} &= \frac{\text{Load}}{\text{Area}} \\ \text{Load} &= \text{Stress} \times \text{Area} \end{aligned}\right\} \checkmark$$

$$\text{Load} = \left(80 \times 10^6\right) \times \left(0{,}314 \times 10^{-3}\right) \quad \checkmark \quad \checkmark$$

$$\text{Load} = 25{,}133\ \text{kN} \quad \checkmark$$

(7)

**TOTAL QUESTION 7: [45]**

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

8.1 **Factors to be observed during oxy-acetylene welding:**

- Correct flame for the work on hand. ✓
- Correct angle of welding torch and welding rod. ✓
- Depth penetration and amount of fusion. ✓
- The rate of progress along the joint. ✓
- The distance of the nozzle from the parent metal. ✓

**(Any 2 x 1)** (2)

8.2 **Abbreviation 'HAZ':**

Heat Affected Zone ✓ (1)

8.3 **Causes of weld defects:**

8.3.1 **Spatter:**

- Disturbance in the molten weld pool. ✓
- Too low welding voltages. ✓
- Too high welding current / amps. ✓
- Inadequate shielding gas flow. ✓
- Too fast travel speed ✓
- Arc length too long ✓
- Wet electrode ✓
- Wrong polarity ✓
- Arc length too short ✓
- Wrong included electrode angle ✓
- Wrong electrode used ✓
- Arc blow ✓

**(Any 2 x 1)** (2)

8.3.2 **Undercutting:**

- Too fast travel speed ✓
- Rapid solidification ✓
- Too low arc voltage ✓
- Arc length too long ✓
- Excessive welding current ✓
- Too slow movement over weld ✓
- Current / amps too high ✓
- Electrode too big ✓
- Wrong electrode ✓
- Wrong included electrode angle ✓
- Excessive weaving ✓
- Wrong joint design ✓

**(Any 2 x 1)** (2)

8.3.3 **Incomplete penetration:**

- Welding current too low ✓
- Too fast travel speed ✓
- Incorrect electrode angle ✓
- Poor edge preperation ✓
- Insufficient root gap ✓
- Electrode too big ✓
- Wrong electrode ✓
- No pre-heating done ✓
- Wrong shielding gas used ✓
- Too long arc ✓

**(Any 2 x 1)** (2)

8.4 **Types of cracks:**

8.4.1 **Transverse cracks:**

- Pre-heating the base metal ✓
- Using lower strength consumables / welding rod ✓
- Slow cooling after welding ✓
- Use clamping device. ✓
- Weld toward the unrestrained side of the weld. ✓

**(Any 2 x 1)** (2)

8.4.2 **Centreline cracks:**

- Ensure that width-to-depth ratio is 1:1. ✓
- Decrease the current to decrease excess penetration. ✓
- Decreasing welding voltage setting or slowing travel speed to achieve a flat to convex weld surface. ✓
- Use clamping device. ✓

**(Any 2 x 1)** (2)

8.5 **Differences between non-destructive and destructive tests:**

- Non-destructive test does not destroy the welded joint. ✓
- Destructive test destroys the welded joint. ✓ (2)

8.6 **Ultrasonic test:**

- No defects will occurs during a ultrasonic test ✓✓
- Detect internal ✓ flaws as well as surface flaws. ✓
- Porosity ✓✓
- Slag inclusions ✓✓
- Cracks ✓✓

**(Any 1 x 2)** (2)

8.7 **Nick break test for internal defects:**

- Slag inclusion ✓
- Porosity ✓
- Lack of fusing ✓
- Oxidised metal ✓
- Burned metal ✓

**(Any 2 x 1)** (2)

8.8 **Machinability test:**

- To determine the hardness ✓ and strength ✓of the welded joint.
- To determine ✓ the machinability. ✓

**(Any 1 x 2)** (2)

8.9 **Visual requirements of welds:**

- Shape of the profile ✓
- Uniformity of the surface ✓
- Overlap ✓
- Free from any external defects ✓
- Penetration bead ✓
- Root groove ✓

**(Any 2 x 1)** (2)

**TOTAL QUESTION 8: [23]**

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

9.1 **Residual stress:**
Residual stresses are stresses that exist ✓ in a metal after cooling / welding. ✓ (2)

9.2 **Factors affecting grain size:**
- The amount of cold work. ✓
- The temperature and time of annealing process. ✓
- The composition and constitution. ✓
- The recrystallisation temperature of cold worked metal. ✓
- The melting point. ✓

**(Any 2 x 1)** (2)

9.3 **Quenching medias:**
- Oil ✓
- Water ✓
- Sand ✓
- Air ✓
- Brine / Salt water ✓
- Lime ✓
- Liquid salts ✓
- Molten lead ✓
- Ash ✓

**(Any 2 x 1)** (2)

9.4 **Weld distortion**:
- Distortion in a weld results from the uneven expansion and contraction (warping) ✓ of the weld metal ✓ and adjacent base metal ✓ during the heating and cooling cycle ✓ of the welding process. (4)

9.5 **Factors that affect distortion and residual stress:**
- If the expansion that occurs when metal is heated is resisted ✓ then deformation will occur. ✓
- When contraction that occurs on cooling is resisted ✓then a stress will be applied. ✓
- If this applied stress causes movement ✓ then distortion occurs. ✓
- If the applied stress does not cause movement ✓ then there will be residual stress in the welded joint. ✓

**(Any 2 x 2)** (4)

9.6 **Result when metal is cooled rapidly:**
- Rapid cooling of metal results in large temperature differences ✓ between the internal and external areas ✓ of the metal that set up stresses, ✓ which cause cracks ✓ on the surface.
- It will harden ✓✓ and the grain structure ✓ will change. ✓

**(Any 1 x 4)** (4)

**TOTAL QUESTION 9: [18]**

## QUESTION 10: MAINTENANCE (SPECIFIC)

10.1 **Reasons maintenance:**

- Promote cost saving ✓
- Improves safety ✓
- Increases equipment efficiency ✓
- Fewer equipment failure ✓
- Improves reliability of equipment ✓

**(Any 2 x 1)** (2)

10.2 **Lockout on machines:**

To ensure that nobody can turn on the machine ✓ while maintenance is being carried out. ✓ (2)

10.3 **Reasons for service records:**

- Assist in the monitoring of the condition of the machines. ✓
- Assist in upholding warrantees. ✓
- Assist in keeping a history of maintenance and repairs. ✓

**(Any 2 x 1)** (2)

10.4 **Methods of reducing friction:**

- By reducing both drill speed and feed speed. ✓
- By applying lubrication. (cutting fluid) ✓
- Use the correct drill bit ✓
- Drill a pilot hole ✓

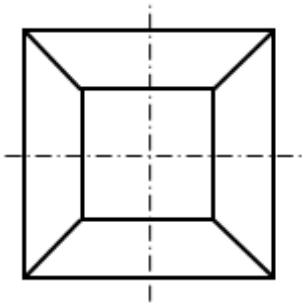
**(Any 2 x 1)** (2)

**TOTAL QUESTION 10: [8]**

## QUESTION 11: TERMINOLOGY (DEVELOPMENT) (SPECIFIC)

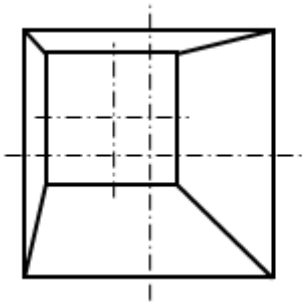
11.1 **Use of transformers:**
Transformers are used to connect ✓ ducting sections of dissimilar ✓ shapes to each other. ✓ (3)

11.2 **On-centre hopper:**



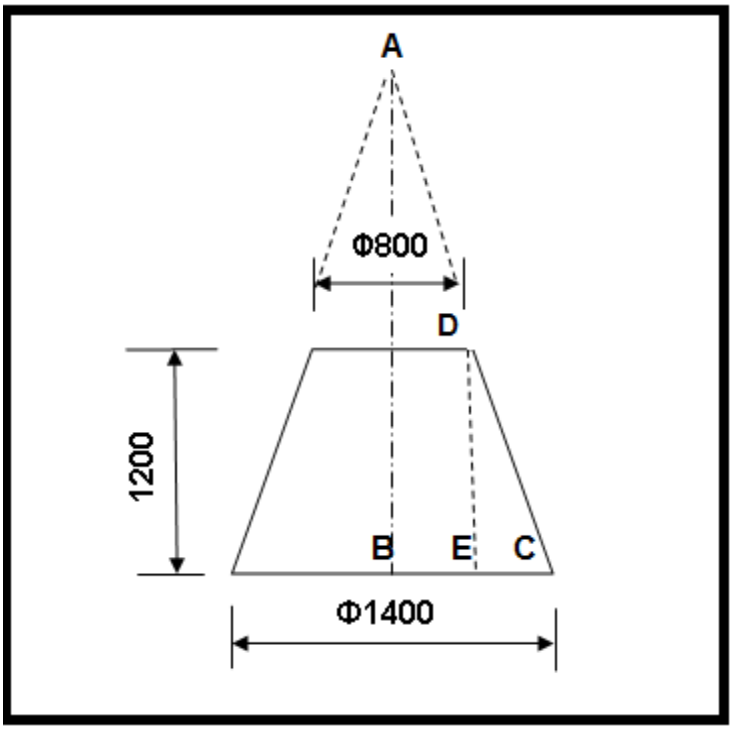
(1)

**Off-centre hopper:**



(1)

11.3 **Truncated cone:**




11.3.1 **Base circumference:**

Circumference = π × Base diameter ✓
= π × 1400 ✓
= 4398,23 mm ✓ (3)

11.3.2 **Main radius (AC):**

Triangles ABC and CED has the same shape:

$$AC : DC = BC : EC$$

$$\text{Thus } \frac{AC}{DC} = \frac{BC}{EC} \quad ✓$$

$$\text{From where } AC = \frac{BC \times DC}{EC} \quad ✓$$

$$\text{and } CE = \frac{\text{Base Dia} - 800}{2} \quad ✓$$

$$= \frac{1400 - 800}{2} \quad ✓$$

$$CE = 300 \text{ mm} \quad ✓$$

$$\text{For : } DC$$

$$DC^2 = DE^2 + CE^2 \quad ✓$$

$$DC = \sqrt{1200^2 + 300^2} \quad ✓$$

$$DC = 1236{,}93 \text{ mm} \quad ✓$$

$$\text{rounded} = 1237 \text{ mm}$$

$$AC = \frac{BC \times DC}{EC}$$

$$= \frac{700 \times 1237}{300} \quad ✓$$

$$= 2886{,}17 \text{ mm} \quad ✓$$

$$\text{rounded} = 2886 \text{ mm}$$

(10)

11.3.3 **Small radius (AD):**

$$AD = AC - DC \quad ✓$$

$$= 2886 - 1237 \quad ✓$$

$$AD = 1649 \text{ mm } (1649{,}24 \text{ mm}) \quad ✓$$

(3)

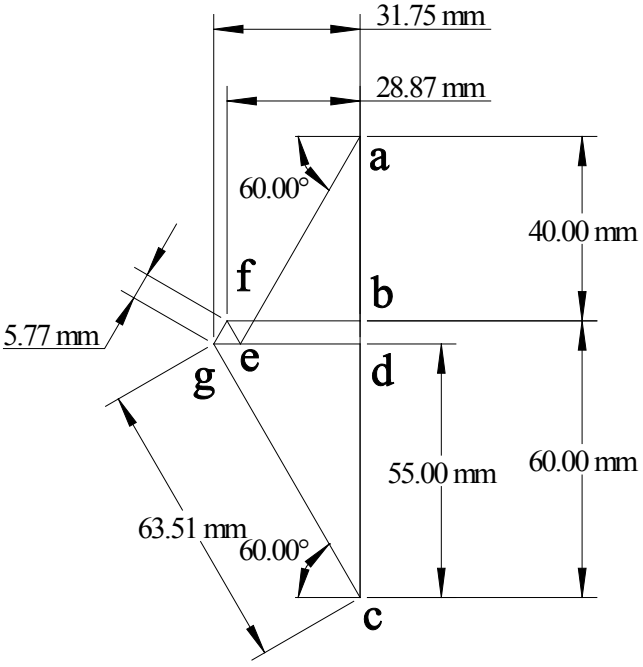
**TOTAL QUESTION 11: [21]**

**GRAND TOTAL: 200**

## Annexure A
## Question 7.1

The CM need to redraw to check the scale and to photocopy it to a transparency.

| member | mm | N | nature | |
|---|---|---|---|---|
| AE | 52 | | | |
| BF | 29 | | | |
| CG | 63 | | | |
| FG | 6 | | | |
| ED | 25 | | | |
| EF | 6 | | | |
| GD | 32 | | | |
| AB | 40 | | | |
| BC | 60 | | | |
| CD | 55 | | | |
| AD | 45 | | | |
| | | | | |




## Question 7.2.3