These marking guidelines consist of 23 pages.
## QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 B ✓ (1)  
1.2 B ✓ (1)  
1.3 C ✓ (1)  
1.4 C ✓ (1)  
1.5 A ✓ (1)  
1.6 B ✓ (1)  

[6]
QUESTION 2: SAFETY (GENERIC)

2.1 Vital functions:
- Breathing ✓
- Heart rate / pulse ✓
- State of consciousness ✓

(Any 2 x 1) (2)

2.2 Safety glasses during grinding:
- To prevent any injuries to the operator's eyes. ✓
- To protect eyes from sparks and debris. ✓
- To prevent blindness due to injury. ✓

(Any 1 x 1) (1)

2.3 Type of guards:
- Fixed guard ✓
- Automatic sweep-away ✓
- Self-adjusting / automatic guard ✓
- Electronic presence sensing device ✓
- Two-hand control device. ✓

(Any 2 x 1) (2)

2.4 Precautions before gas welding operations can be undertaken:
- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment (PPE). ✓
- Ensure that fire equipment is at hand. ✓
- Ensure that the equipment is in a safe working condition. ✓
- Ensure the gas equipment is set-up correctly. ✓
- Ensure the area is well ventilated. ✓
- Ensure that the working area is safe. ✓

(Any 3 x 1) (3)

2.5 TWO disadvantages of the product layout:
- Lack of flexibility. ✓
- Optimum use of equipment is not possible. ✓

(2)

[10]
QUESTION 3: MATERIALS (GENERIC)

3.1 THREE properties:
- Toughness ✓
- Hardness / Wear resistance ✓
- Softness ✓
- Case hardness ✓
- Ductility ✓
- Malleability ✓
- Elasticity ✓
- Britteness ✓
- Strength ✓

(Any 3 x 1) (3)

3.2 Heat treatment processes:

3.2.1 Tempering:
- It consists of heating the hardened steel ✓ to a temperature below its critical temperature (colour chart). ✓
- Soaking it at this temperature for a period of time, ✓
- Quenching/cooling it rapidly in water, brine or oil. ✓

(4)

3.2.2 Hardening:
- The steel is heated slightly higher than the upper critical temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in water, brine or oil. ✓

(3)

3.3 Examples of case-hardening:
- Bearing cases ✓
- Bearing ball ✓
- Bearing needles ✓
- Crankshafts ✓
- Gears ✓
- Camshafts ✓
- Cylinder sleeves ✓
- Hammer head ✓
- Jack Hammer drill bits ✓

(Any 2 x 1) (2)

3.4 Why steels are cooled down in still air away from draughts:
This prevents sudden cooling of localised spots, ✓ which might cause distortion/cracks. ✓

(2) [14]
QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

[14]
QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

5.1 TWO advantages of cutting using the tailstock set-over method:
   - Long tapers can be cut.
   - The automatic feed can be used.
   - Good finish is obtained

   (Any 2 x 1) (2)

5.2 Big diameter of taper:
\[ \tan \frac{\theta}{2} = \frac{D - d}{2 \times l} \]

\[ D = \tan \frac{\theta}{2} (2 \times l) + d \]

\[ = \tan \frac{8^\circ}{2} (2\times290) + 42 \]

\[ = \tan 4^\circ (580) + 42 \]

\[ D = 82,56 \text{ mm} \] (4)

5.3 Calculation of parallel key:

5.3.1 Width = \( \frac{D}{4} \)

\[ = \frac{65}{4} \]

\[ = 16,25 \text{ mm} \] (2)

5.3.2 Thickness = \( \frac{D}{6} \)

\[ = \frac{65}{6} \]

\[ = 10,83 \text{ mm} \] (2)

5.3.3 Length = 1,5 \times \text{diameter of shaft}

\[ = 1,5 \times 65 \]

\[ = 97,5 \text{ mm} \] (2)
5.4 **Disadvantages of straddle milling:**

- The cutters used place more stress on the machine’s spindle.
- The milling machine works harder due to more than one cutter being used.
- There can be more vibration.
- Poor finishing.

(Total 1 x 1) (1)

5.5 **TWO milling processes:**

**The milling of:**

- Bevels
- Keyways
- Slides
- Chamfers
- Other angles
- Grooves
- Jigs recesses
- Tees
- Dovetail slots
- Surface milling
- Drilling
- Reaming
- Tapping
- Up-cut milling
- Down-cut milling

(Total 2 x 1) (2)

5.6 **Calculate X:**

\[ x = \frac{\text{Diameter of workpiece} - \text{Thickness of cutter}}{2} \]

\[ = \frac{60 - 12}{2} \]

\[ = 48 \]

\[ = \frac{48}{2} \]

\[ = 24 \text{mm} \]

(Any 2 x 1) (3) [18]
QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 Gear calculations:

6.1.1 Module:

\[
\text{Module} = \frac{\text{PCD}}{T} = \frac{165}{110} = 1,5
\]

6.1.2 Outside diameter:

\[
\text{OD} = \text{PCD} + 2(m) = 165 + 2(1,5) = 168 \text{ mm}
\]

\[
\text{OD} = m(T + 2) = 1,5(110 + 2) = 168 \text{ mm}
\]

6.2 Dovetail calculations:

\[
W = 120 + 2(\text{DE})
\]

\[
m = W - [2(\text{AC}) + 2(\text{R})] \quad \text{OR} \quad m = W - 2(\text{AC} + \text{R}) \quad \text{OR} \quad m = W - 2(\text{AC}) - 2(\text{R})
\]

6.2.1 Maximum width distance of dove tail. (W)

Calculate DE:

\[
\tan \alpha = \frac{\text{DE}}{\text{AD}} \quad \tan \beta = \frac{\text{AD}}{\text{DE}}
\]

\[
\text{DE} = \tan \alpha \times \text{AD} = \tan 30^\circ \times 30 = 17,32 \text{ mm}
\]

\[
\text{DE} = \frac{\text{AD}}{\tan 60^\circ} = \frac{30}{\tan 60^\circ} = 17,32 \text{ mm}
\]

\[
W = 120 + 2(\text{DE}) = 120 + 2(17,32) = 154,64 \text{ mm}
\]
6.2.2 **Distance between the rollers. (m)**

**Calculate AC:**

\[
\begin{align*}
\tan \alpha &= \frac{BC}{AC} \\
\tan \theta &= \frac{AC}{BC} \\
AC &= \frac{BC}{\tan \alpha} \\
AC &= \tan \theta \times BC \\
\text{OR} \\
\frac{11}{\tan 30^\circ} &= 19.05 \text{mm} \\
\end{align*}
\]

\[
m = W - [(2(AC) + 2(R)) \\
= 154.64 - [2(19.05) + 2(11)] \\
= 154.64 - (38.10 + 22) \\
= 94.54 \text{ mm} \\
\text{OR} \\
m = W - 2(AC + R) \\
= 154.64 - 2(19.05 + 11) \\
= 154.64 - (38.10 + 22) \\
= 94.54 \text{ mm} \\
\text{OR} \\
m = W - 2(AC) - 2(R) \\
= 154.64 - 2(19.05) - 2(11) \\
= 154.64 - 38.11 - 22 \\
= 94.54 \text{ mm} \\
\]

(6)
6.3 Milling of spur gear:

6.3.1 Indexing:

Indexing = \frac{40}{n} = \frac{40}{163}

= \frac{40}{A} = \frac{40}{160} \checkmark

= \frac{1 \times 6}{4 \times 6}

= \frac{6}{24} \checkmark

Approximate indexing: 6 holes on a 24-hole circle. \checkmark

OR

7 holes on a 28-hole circle. \checkmark

(3)

6.3.2 Change gears:

\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}

= (160 - 163) \times \frac{40}{160} \checkmark

= -3 \times \frac{40}{160} \checkmark

= - \frac{120}{160}

= \frac{12}{16} \times \frac{2}{2} \checkmark \quad \text{OR} \quad \frac{12}{16} \times \frac{4}{4} \checkmark

= \frac{24}{32} \checkmark \quad \text{OR} \quad \frac{48}{64} \checkmark

(5)
6.4 **TWO types of balancing methods:**
- Static balance (stationary balancing)
- Dynamic balance (running balancing)

6.5 **TWO advantages of correct balancing:**
- Prevents vibrations.
- Prevents poor finish / ensure good finish.
- Prevents wear on bearings / components.
- Prevents accidents.
- Improve production.
- Promotes accuracy.
- Prevent damage to workpiece.
- Prevent components from loosening.

(Any 2 x 1)
QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 Function of a screw-thread micrometer:
The screw-thread micrometer is specifically designed to measure ✓ the pitch diameter ✓ of a screw thread.  

7.2 Brinell labelled drawing:

7.3 Types of forces:
- Tensile force ✓
- Compressive force ✓
- Shear force ✓
- Torsional force ✓
- Gravitational force ✓
- Normal Force ✓
- Frictional Force ✓
- Reaction Force ✓

(Any 2 x 1)  

7.4 ISO-Metric screw-thread:

7.4.1 A – Root/Root land ✓
B – Pitch diameter / Effective diameter / Mean diameter ✓
C – Crest diameter / Major diameter / Outside diameter / Basic diameter ✓

7.4.2 Pitch diameter:
Dp = Dn – (0,866 x P)
Dp = 12 – (0,866 x 1,75) ✓
Dp = 12 – 1,52  
Dp = 10,48 mm ✓

[13]
QUESTION 8: FORCES (SPECIFIC)

8.1 Forces:

8.1.1 Horizontal component:

\[ \Sigma HC = 25\cos90^\circ + 40\cos0^\circ + 55\cos70^\circ - 120\cos30^\circ \]

\[ \Sigma HC = 0 + 40 + 18,81 - 103,92 \]

\[ \Sigma HC = -45,11N \] \hspace{1cm}(4)

8.1.2 Vertical component:

\[ \Sigma VC = 25\sin90^\circ - 40\sin0^\circ - 55\sin70^\circ - 120\sin30^\circ \]

\[ \Sigma VC = 25 - 0 - 51,68 - 60 \]

\[ \Sigma VC = -86,68N \] \hspace{1cm}(4)

OR

\[ \begin{align*}
\text{Force} & \quad \theta & \quad 8.1.1 \Sigma HC/x = F\cos\theta & \quad 8.1.2 \Sigma VC/y = F\sin\theta \\
25N & \quad 90^\circ & HC = 25\cos90^\circ & 0N & VC = 25\sin90^\circ & 25N \checkmark \\
40N & \quad 0^\circ & HC = 40\cos0^\circ & 40N \checkmark & VC = 40\sin0^\circ & 0N \\
55N & \quad 290^\circ & HC = 55\cos290^\circ & 18,81N \checkmark & VC = 55\sin290^\circ & -51,68N \checkmark \\
120N & \quad 210^\circ & HC = 120\cos210^\circ & -103,92N \checkmark & VC = 120\sin210^\circ & -60N \checkmark \\
\text{Total} & & \Sigma HC = -45,11N \checkmark & & \Sigma VC = -86,68N \checkmark 
\end{align*} \]

8.1.3 Resultant:

\[ R^2 = VC^2 + HC^2 \]

\[ R = \sqrt{(-86,68)^2 + (-45,11)^2} \checkmark \]

\[ R = \sqrt{9549,24} \]

\[ R = 97,72N \checkmark \] \hspace{1cm}(2)
8.1.4 **Angle and direction of resultant:**

**Angle:**

\[
\tan \theta = \frac{VC}{HC}
\]

\[
\theta = \tan^{-1}\left(\frac{-86,68}{-45,11}\right) \checkmark
\]

\[
\theta = \tan^{-1}(1,92)
\]

\[
\theta = 62,5^\circ \checkmark
\]

**OR**

\[
\tan \theta = \frac{HC}{VC}
\]

\[
\theta = \tan^{-1}\left(\frac{-45,11}{-86,68}\right) \checkmark
\]

\[
\theta = \tan^{-1}(0,52)
\]

\[
\theta = 27,49^\circ \checkmark
\]

**Direction:**

R = 97,72N 62,5° South of West \checkmark

**OR**

R = 97,72N 27,5° West of South \checkmark

(3)

8.2 **UDL Beam:**

8.2.1 **Distributed load:**

Uniform distributed load:

\[
7 \times 12 = 84 \text{ N} \checkmark
\]

(1)

8.2.2 **Reaction in support A:**

**Take moments about B:**

\[
(75 \times 12,5) + (84 \times 5,5) + (55 \times 0) = (A \times 14)
\]

\[
937,5 + 462 + 0 = 14A
\]

\[
A = \frac{1399,5}{14} \checkmark
\]

\[
A = 99,96 \text{N} \checkmark
\]

(5)
8.2.3 Reaction in support B:
Take moments about A:

\[(B \times 14) = (75 \times 1,5) + (84 \times 8,5) + (55 \times 14)\]

\[14B = 112,5 + 714 + 770\]

\[B = \frac{1596,5}{14} \checkmark\]

\[B = 114,04N \checkmark\]

8.3.1 Resistance area:

\[\sigma = \frac{F}{A}\]

\[A = \frac{F}{\sigma} \checkmark\]

\[A = \frac{85 \times 10^3}{36 \times 10^6} \checkmark\]

\[A = 2,36 \times 10^{-3}m^2 \checkmark\]

8.3.2 Change in length:

\[E = \frac{\sigma}{\varepsilon}\]

\[\varepsilon = \frac{\sigma}{E} \checkmark\]

\[\varepsilon = 36 \times 10^6 \checkmark\]

\[\varepsilon = 90 \times 10^5 \checkmark\]

\[\varepsilon = 4 \times 10^{-4} \checkmark\]

\[\varepsilon = \frac{\Delta L}{L}\]

\[\Delta L = \varepsilon \times L \checkmark\]

\[\Delta L = 4 \times 10^{-4} \times 0,12 \checkmark\]

\[\Delta L = 4,8 \times 10^{-5}m\]

\[\Delta L = (4,8 \times 10^{-5}) \times 1000\]

\[\Delta L = 0,048 mm \checkmark\]
QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 Failure to conduct preventative maintenance:
- Risk of injury or death. ✓
- Financial loss due to damage suffered as a result of part failure. ✓
- Loss of valuable production time. ✓
- Equipment failure. ✓
- Damage to material or project. ✓

(Any 3 x 1) (3)

9.2 Mechanical drives:
- Belt drives ✓
- Gear drives ✓
- Chain drives ✓
- Hydrostatic drives ✓
- Hydraulic drives ✓
- Cable drives ✓
- Pneumatic drive ✓

(Any 3 x 1) (3)

9.3 Enhance the strength of glass fibre:
Polyester resin ✓

(1)

9.4 Properties:

9.4.1 Bakelite:
- Stiff ✓
- Strong ✓
- Hard / wear resistant ✓
- Chemical resistance ✓
- Thermo hardened ✓
- Water resistant ✓
- Electrical isolation ✓
- Heat resistant ✓
- Machinable ✓
- Brittleness ✓

(Any 2 x 1) (2)

9.4.2 Carbon fibre:
- Good fatigue resistance ✓
- Heat resistance ✓
- Tough ✓
- Strong ✓
- Semi rigid ✓
- Good chemical resistance ✓
- Light weight ✓
- Water resistant ✓
- Flexible ✓

(Any 2 x 1) (2)
9.5 **Manufacturing of PVC:**
- Oil ✓
- Salt ✓
- Coal ✓

(Any 1 x 1)  (1)

9.6 **Ways to conduct preventive maintenance:**
- Inspection ✓
- Measuring ✓
- Cleaning ✓
- Lubricating ✓
- Adjusting of parts ✓
- Replacing of parts ✓
- Tests ✓

(Any 3 x 1)  (3)

9.7 **Main types of plastic composites:**
- Thermoplastic ✓
- Thermosetting plastic / Thermo-hardened ✓

(2)

9.8 **Non-stick coatings for frying pans:**
- Teflon ✓

(1) [18]
QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 Screw thread terminology:

10.1.1 Lead:
It is the distance ✓ that the point (nut/bolt) on a screw thread will move / advance ✓ along the axis, ✓ when turned through one complete revolution / turn. ✓ (4)

10.1.2 Helix angle:
It is the angle that the thread makes with a line perpendicular / 90° ✓ to the axis of the screw thread. ✓ (2)

10.2 Square Thread:

10.2.1 Pitch:

\[
\text{Pitch} = \frac{\text{Lead}}{\text{Number of starts}}
\]

\[
= \frac{42}{2} ✓
\]

\[
= 21 \text{ mm ✓}
\]

(3)

10.2.2 Pitch diameter:

\[
\text{PD} = \text{OD} - \frac{P}{2}
\]

\[
= 90 - \frac{21}{2} ✓
\]

\[
= 79.50 \text{ mm ✓}
\]

(2)
10.2.3 **Helix angle of the thread:**

\[
\tan \theta = \frac{\text{Lead}}{\pi \times D_m} \\
\tan \theta = \frac{42}{\pi \times 79,50} \checkmark \\
\tan \theta = 0,168163713 \\
\theta = \tan^{-1} 0,168163713 \\
= 9,55^\circ \text{ or } 9^\circ 33' \checkmark
\]

(3)

10.2.4 **Leading tool angle:**

Leading tool angle = 90° - (helix angle + clearance angle)

\[
= 90^\circ - (9,55^\circ + 3^\circ) \checkmark \\
= 77,45^\circ \text{ or } 77^\circ 27' \checkmark
\]

(2)

10.2.5 **Following tool angle:**

Following tool angle = 90° + (helix angle - clearance angle)

\[
= 90^\circ + (9,55^\circ - 3^\circ) \checkmark \\
= 96,55^\circ \text{ or } 96^\circ 33' \checkmark 
\]

(2) [18]
QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 Hydraulic calculations:

11.1.1 The fluid pressure in the hydraulic system in MPa:

\[ A(\text{Ram}) = \frac{\pi d^2}{4} \]

\[ A = \frac{\pi (0.25)^2}{4} \checkmark \]

\[ A = 0.049 \text{ m}^2 \text{ OR } 4.91 \times 10^{-2} \text{ m}^2 \checkmark \]

\[ p = \frac{F}{A} \]

\[ p = \frac{34000}{0.049} \checkmark \]

\[ p = 693877.55 \text{ Pa} \]

\[ p = 0.69 \text{ MPa} \checkmark \]
11.1.2 **Diameter of the plunger:**

\[
P = \frac{F}{A} \quad \quad \quad \quad F_1 = \frac{F_2}{A_1} \quad \quad \quad \quad \quad \quad F_1 = \frac{F_2}{A_2}
\]

\[
A = \frac{F}{P}
\]

\[
A = \frac{215}{693877,55} \quad \checkmark
\]

\[
A = 0,309852 \times 10^{-3} \text{ m}^2 \quad \checkmark \quad \text{OR} \quad \frac{215}{d^2} = \frac{34000}{250^2} \quad \checkmark
\]

\[
A = \frac{\pi d^2}{4}
\]

\[
d = \sqrt{\frac{4 \times A}{\pi}} \quad \checkmark
\]

\[
d = \sqrt{\frac{4(0,309852 \times 10^{-3})}{\pi}} \quad \checkmark
\]

\[
d = 0,019862422 \text{ m} \quad \checkmark
\]

\[
d = 19,86 \text{ mm} \quad \checkmark
\]

\[
(5)
\]

11.2 **Hydraulic filters:**
- Pressure line filter \( \checkmark \)
- Return line filter \( \checkmark \)

\[
(2)
\]

11.3 **Hydraulic symbols:**

11.3.1 Reservoir \( \checkmark \) \( (1) \)

11.3.2 Directional control valve / Non-return valve / One way valve \( \checkmark \) \( (1) \)
11.4 Belt drive:

11.4.1 The rotational frequency in r/sec:

\[ N_{Dn} = \frac{N_{Dr} \times D_{Dr}}{D_{Dn}} \]

\[ N_{Dn} = \frac{1330 \times 0.15}{0.32} \]

\[ N_{Dn} = 623.44 \text{ r/min} \]

\[ N_{Dn} = 10.39 \text{ r/sec} \]  \( \checkmark \)  \( (3) \)

11.4.2 Power transmitted in Watt:

\[ P = \frac{(T_1 - T_2) \pi D_{N_1}}{60} \]

\[ P = (175 - 130) \pi \times 0.32 \times 10.39 \]

\[ P = 470.03 \text{ Watt} \]  \( \checkmark \)

OR

\[ P = \frac{(T_1 - T_2) \pi D_{N_1}}{60} \]

\[ P = \frac{(175 - 130) \pi \times 0.15 \times 1330}{60} \]

\[ P = 470.06 \text{ Watt} \]  \( \checkmark \)  \( (4) \)
11.5 **Gear drive:**

11.5.1 **Identify gear drive:**
Compound gear drives system ✓

11.5.2 **Rotational frequency of the input shaft \( N_A \):**

\[
\frac{N_{\text{input}}}{N_{\text{output}}} = \frac{\text{Product of teeth on driven gears}}{\text{Product of teeth on driver gears}}
\]

\[
\frac{N_A}{N_F} = \frac{T_B \times T_D \times T_E}{T_A \times T_C \times T_E} ✓
\]

\[
N_A = 40 \times 50 \times 80 ✓
\]

\[
625 \times 20 \times 35 \times 25 ✓
\]

\[
N_A = \frac{40 \times 50 \times 80 \times 625}{20 \times 35 \times 25}
\]

\[
N_A = 5714,29 \text{ r / min} ✓
\]

11.6 **Torque on the lathe spindle:**

Torque \( (T) \) = Force \( \times \) Radius

✓ ✓

\[
T = 250 \times 0,025
\]

\[
T = 6,25 \text{ Nm. ✓}
\]

\[ (3) \text{ [28]} \]

**TOTAL:** 200