These marking guidelines consist of 21 pages.
QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 A ✓
1.2 C ✓
1.3 A ✓
1.4 B ✓
1.5 D ✓
1.6 A ✓

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. ✓

(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 ✓

(Any 2 x 1) (2)

2.3 PPE for Hydraulic Press:
- Overall ✓
- Safety shoes / boots ✓
- Safety goggle ✓
- Leather gloves ✓
- 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 / treatment ✓
- 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 ✓✓
- Britleness ✓✓
- 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 require 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. (AC3) ✓
- 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)

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**TOTAL QUESTION 4: 14**
QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

5.1 Advantages of using the tailstock to cut an external taper:
- Long an accurate taper can be cut. ✓
- The automatic feed can be used which result in a good finish. ✓

(2)

5.2 Calculate the compound slide set-over:

\[ \tan \frac{\theta}{2} = \frac{D - d}{2L} \]
\[ \tan \frac{\theta}{2} = \frac{60 - 28}{2 \times 85} \]
\[ = 0,188 \]
\[ \frac{\theta}{2} = 10,66^\circ \]

OR

\[ X = \frac{D - d}{2} \]
\[ = \frac{60 - 28}{2} \]
\[ = 16 \text{ mm} \]

(5)

5.3 Centre gauge:
- To measure the form and angle of the screw cutting tool angle while grinding the tool ✓
- To set the screw cutting tool square/perpendicular to the axis of the work piece ✓

(2)

5.4 Parallel key:
Length:
Length = 1,5 \times \text{diameter} ✓
\[ = 1,5 \times 42 \]
\[ = 63 \text{ mm} \]

(3)

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5.5 **Advantages of up-cut milling:**
- Deeper cuts can be made as the cutting pressure on the cutter is lower than down cut milling. ✓
- The process enables hard steel to be cut, because the total cutting pressure is absorbed by the material at the back of the edge. ✓
- Metal with hard scale, such as castings or forgings, the cut is started under the scale where the material is softer which extends the life of the cutter. ✓
- A quicker/course feed can be used. ✓
- The strain on the cutter and arbour will be less. ✓
- Vibration is limited ✓
- Good finish ✓
- Low noise level ✓

(Any 2 x 1) (2)

5.6 **Disadvantage of down-cut milling:**
- Vibration in the arbour is unavoidable. ✓
- A fine feed must be used. ✓
- When milling a material with hard scale the milling cutter will be damaged. ✓
- Process takes time because of slower feed. ✓
- Noisy process. ✓
- Bad finish because of vibration. ✓

(Any 2 x 1) (2)

5.7 **Methods of centring a milling cutter:**
- Square and ruler method. ✓
- Set-over method by milling machine dial. ✓
- Dial indicator method ✓
- Using reference points on digital read out equipment ✓

(Any 2 x 1) (2)

TOTAL QUESTION 5: [18]
QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 Spur gear:
Chordal tooth thickness:
\[ t_c = T \sin \frac{90^\circ}{T} \checkmark \quad t_c = PCD \sin \frac{90^\circ}{T} \checkmark \]
\[ = 50 \times 3 \sin \frac{90^\circ}{50} \checkmark \quad \text{or} \quad = 150 \sin \frac{90^\circ}{50} \checkmark \]
\[ = 50 \times 3(0.03141) \checkmark \quad = 150 \times 0.03141 \checkmark \]
\[ = 4.71 \text{ mm} \checkmark \quad = 4.71 \text{ mm} \checkmark \]

(4)

6.2 Calculate simple indexing:

Simple Indexing = \( \frac{40}{N} \)
\[ = \frac{40}{13} \checkmark \]
\[ = 3 \frac{1}{13} \checkmark \]
\[ = 3 \frac{1}{13} \times 3 \checkmark \]
\[ = 3 \frac{3}{39} \checkmark \]

3 full turns and 3 holes in a 39 hole circle

(4)
6.3 Differential indexing:

6.3.1 Indexing required:

Indexing \[ \frac{40}{n} = \frac{40}{127} \]

\[ = \frac{40}{A} \quad \frac{5}{125} \]

\[ = \frac{8}{25} \]

Indexing = 8 holes on the 25 hole circle

(3)

6.3.2 Change gears required:

\[ \frac{D_r}{A_n} = \frac{40}{1} \]

\[ = \frac{125 \times 40}{125 \times 1} \]

\[ = \frac{2 \times 40}{125 \times 1} \]

\[ = \frac{-80}{125} \times \frac{5}{5} \]

\[ = \frac{-16}{25} \times \frac{4}{4} \]

\[ = \frac{-64}{100} \]

(5)

6.3.3 Direction of rotation of index plate:

The index plate will turn the opposite direction as the index crank handle.

(1)
6.4 **Calculate distance “x” between rollers:**

"x" = 150 + 2(AB) − 2(CD) − 2r

\[
\tan \phi = \frac{BC}{AB} \checkmark
\]
\[
AB = \frac{BC}{\tan \phi} = \frac{35}{\tan 60^\circ} \checkmark
\]
\[
= 20.207 \text{ mm} \checkmark
\]
\[
= 20.21 \text{ mm} \checkmark
\]

\[
\tan \phi = \frac{DE}{CD} \checkmark
\]
\[
CD = \frac{DE}{\tan \phi} = \frac{15}{\tan \phi} \checkmark
\]
\[
= \frac{15}{\tan 30^\circ}
\]
\[
= 25.98 \text{ mm} \checkmark
\]

"x" = 150 + 2(AB) − 2(CD) − 2r

\[
= 150 + 2(20.21) − 2(25.98) − 2(15) \checkmark
\]
\[
= 108.454 \text{ mm} \checkmark
\]
\[
= 108.45 \text{ mm} \checkmark
\]

6.5 **Reasons for balancing work piece on a centre lathe:**

- Prevent unnecessary bearing loads ✓
- Prevent excessive vibration ✓
- To obtain a good finish ✓
- To prevent clatter on the gear teeth ✓
- To prevent the spindle from bending ✓

(Any 2 x 1) (2)

**TOTAL QUESTION 6:** [28]
QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Hardness testers:**
- Brinell-hardness tester ✓
- Rockwell-hardness tester ✓
- Vickers ✓

*(Any 2 x 1)*  

7.2 **Moment tester:**
To determine the reactions ✓ on either side of a simply loaded beam. ✓

7.3 **Tensile test:**
A piece of material is subjected to an increasing axial load ✓ while measuring ✓ the corresponding elongation ✓ of the material.

7.4 **Depth micro-meter:**
✓ ✓ ✓ ✓
Reading = 100 + 11,00 + 0,50 + 0,09 ✓
= 111,59 mm

7.5 **Measure depth:**
Vernier calliper ✓

TOTAL QUESTION 7: [13]
QUESTION 8: FORCES (SPECIFIC)

8.1 Forces:

\[
\begin{align*}
\text{Horizontal Components} & \quad \text{Magnitudes} & \quad \text{Vertical Components} & \quad \text{Magnitudes} \\
1150 \cos 0^\circ & \quad 1150 \text{N} & \quad 800 \sin 30^\circ & \quad 400 \text{N} \\
-800 \cos 30^\circ & \quad -692.82 \text{N} & \quad -650 \sin 20^\circ & \quad -222.31 \text{N} \\
-650 \cos 20^\circ & \quad -610.80 \text{N} & \quad -550 & \quad -550 \text{N} \\
550 \cos 270^\circ & \quad 0 \text{N} & \quad 550 \sin 270^\circ & \quad 0 \text{N} \\
\text{TOTAL:} & \quad -153.62 \text{N} & \quad \text{TOTAL:} & \quad -372.31 \text{N}
\end{align*}
\]

\[
\begin{align*}
E^2 &= HC^2 + VC^2 \\
E &= \sqrt{153.62^2 + 372.31^2} \\
\tan \Theta &= \frac{VC}{HC} \\
\Theta &= 67.58^\circ \\
\text{Equilibrant} &= 402.76 \text{ N en 67.58}\text{ N}\text{ North from East}
\end{align*}
\]
8.2 Moments:

Calculate “x”:
Take moments about O.

\[ \sum RHM = \sum LHM \]
\[ 700 \times "x" = 2800 \times 1 \] ✓
\[ 700 \times "x" = 2800 \]  ✓
\[ "x" = \frac{2800}{700} \]  ✓
\[ "x" = 4 \text{ m} \]  ✓

\[ \sum = \sum \]

\[ (4) \]

8.3 Stress and Strain:

8.3.1 Type of stress:
Compressive stress ✓

8.3.2 Stress:
\[ A = \frac{H(d^2 - d'^2)}{4} \]  ✓
\[ = \frac{H(0.04^2 - 0.03^2)}{4} \]
\[ A = 0.55 \times 10^{-3} \text{ m}^2 \]  ✓
\[ \sigma = \frac{F}{A} \]  ✓
\[ = \frac{50 \times 10^3}{0.55 \times 10^{-3}} \]  ✓
\[ \sigma = 90.91 \times 10^6 \text{ Pa} \]
\[ \sigma = 90.91 \text{ MPa} \]  ✓

(NO UNIT – NO MARK)

\[ (5) \]
8.3.3 Change in length:

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

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

\[ = \frac{90,91 \times 10^6}{90 \times 10^9} \]

\[ = 1,01 \times 10^{-3} \]

(If any unit is given – no mark)

\[ \varepsilon \Delta L \]

\[ \Delta L = \varepsilon L \]

\[ = (1,01 \times 10^{-3}) \times (80) \]

\[ = 0,08 \text{ mm} \]

(5)

8.3.4 Safety factor:

\[ \text{Safety factor} = \frac{\text{Break stress}}{\text{Safe working stress}} \]

\[ \text{Safe working stress} = \frac{\text{Break stress}}{\text{Safety factor}} \]

\[ = \frac{600 \times 10^6}{4} \]

\[ = 150 \times 10^6 \text{ Pa} \]

\[ = 150 \text{ MPa} \]

(3)

TOTAL QUESTION 8: [33]
QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 Lack of preventative maintenance:
- Risk of injury or death. ✓
- Financial loss due to damage suffered as a result of part failure and the waste of material. ✓
- Loss of valuable production time. ✓

9.2 Causes for the malfunctioning of chain drive systems:
- Lack of or incorrect lubrication ✓
- Lack of maintenance ✓
- Overloading ✓
- Misalignment of sprockets ✓
- Incorrect chain tension ✓
- Contamination of chain drive system such as dust or sand ✓

(Any 2 x 1) (2)

9.3 Procedures to reduce the physical wear on a belt drive system:
- Check the belt alignment. ✓
- Checking the belt tension. ✓
- Prevent overloading of the system. ✓
- Keep the pulleys and belt clean. ✓
- Check that all covers are secure. ✓

(Any 2 x 1) (2)

9.4 Procedures to replace the belt on a belt drive system:
- Ensure that the machine is switched off ✓
- Release the tension on the belt ✓
- Remove the belt from the pulleys ✓
- Fit the correct size replacement belt onto the pulleys ✓
- Check the pulley alignment ✓
- Apply adequate tension according to specification and lock the system ✓

(Any 5 x 1) (5)
9.5 Properties of materials:

9.5.1 Poly vinyl chloride (PVC):
- Flexible ✓
- Rubber-like substance ✓
- Makes a dull sound when dropped ✓
- Tough ✓
- Act as an insulator ✓
- It is durable ✓
- Highly resistant to oxidative material ✓
- Oil, water and chemical resistant ✓

(Any 1 x 1) (1)

9.5.2 Carbon fibre:
- Strong ✓
- Tough ✓
- Light weight ✓
- Good electrical conductor ✓

(Any 1 x 1) (1)

9.6 Difference between “Thermoplastic” and “Thermo hardened (thermosetting)” composites:
Thermoplastics can be reheated and deformed. / Recyclable ✓
Thermo hardened cannot be reheated. / Non-recyclable ✓

(2)

9.7 Examples of thermo hardened composites:
- Carbon fibre or (Any application) ✓
- Glass fibre or (Any application) ✓
- Bakelite or (Any application) ✓
- Teflon or (Any application) ✓

(Any 2 x 1) (2)

TOTAL QUESTION 9: [18]
QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 Square thread:

10.1.1 The lead of the thread:

\[
\text{Lead} = \text{pitch} \times \text{no of starts} = 5 \times 2 = 10 \text{ mm}
\]

10.1.2 The helix angle of the thread:

\[
\text{Helix angle } \tan \Phi = \frac{\text{lead}}{\text{pitch diameter}} = \frac{10}{82 - 2.5} = 0.0400 \Rightarrow \Phi = 2.29^\circ / 2^\circ 17' 24''
\]

OR

\[
\text{Helix angle } \tan \Phi = \frac{\text{lead}}{\text{pitch diameter}} = \frac{10}{82 - 2.5} = 0.0400 \Rightarrow \Phi = 7.17^\circ / 7^\circ 10' 12''
\]

10.1.3 The leading tool angle:

\[
\text{Leading tool angle} = 90^\circ - (\text{helix angle + clearance angle}) = 90^\circ - (2.29^\circ + 3^\circ) = 84.71^\circ / 84^\circ 42' 36''
\]

OR

\[
\text{Leading tool angle} = 90^\circ - (\text{helix angle + clearance angle}) = 90^\circ - (7.17^\circ + 3^\circ) = 79.83^\circ / 79^\circ 49' 48''
\]
10.1.4 **The following tool angle:**

\[
\text{Following tool angle} = 90^\circ + (\text{helix angle} - \text{clearance angle})
\]

\[
= 90^\circ + (2.29^\circ - 3^\circ)
\]

\[
= 89.29^\circ / 89^\circ 17'24"
\]

OR

\[
\text{Following tool angle} = 90^\circ + (\text{helix angle} - \text{clearance angle})
\]

\[
= 90^\circ + (7.17^\circ - 3^\circ)
\]

\[
= 94.17^\circ / 94^\circ 10'12"
\]

10.2 **Measurements of a screw thread:**

10.2.1 Metric screw thread ✓ (1)

10.2.2 Crest / Major / External / Basic / Nominal / Outside diameter ✓ (1)

10.2.3 Pitch ✓ (1)

10.3 **Angles of a square thread cutting tool:**

A – Helix angle ✓

B – Clearance angle ✓

C – Leading tool angle ✓

D – Following tool angle ✓ (4)

**TOTAL QUESTION 10:** [18]
QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 Advantages of a belt drive system compared to a chain drive system:
- Silent operation ✓
- Less expensive ✓
- Drive can take place over a longer distance ✓
- No lubrication needed ✓

(Any 2 x 1) (2)

11.2 Hydraulics:

11.2.1 Fluid pressure:
\[ A_A = \frac{\pi d^2}{4} \]
\[ = \frac{(0.032)^2}{4} \]
\[ = 0.8 \times 10^{-3} \text{ m}^2 \]
\[ p = \frac{F_A}{A_A} \]
\[ = \frac{120}{0.8 \times 10^{-3}} \]
\[ = 0.1492 \times 10^6 \text{ Pa} \]
\[ = 0.15 \text{ MPa or 149207.76 Pa} \] ✓

(NO UNIT – NO MARK) (4)

11.2.2 Diameter of the ram:
\[ p = \frac{F_A}{A_A} \] ✓
\[ F_B = \frac{F_A}{A_A} \] ✓
\[ A_B = \frac{F_B}{p} \]
\[ = \frac{18 \times 10^3}{0.15 \times 10^6} \]
\[ = 0.12 \text{ m}^2 \] ✓
\[ A_B = \frac{A_A \times F_B}{F_A} \]
\[ = \frac{0.12}{120} \]
\[ = 0.12 \text{ m}^2 \] ✓

\[ A_B = \frac{\pi d^2}{4} \] ✓
\[ d = \sqrt[4]{\frac{4A}{\pi}} \]
\[ = \sqrt[4]{4 \times 0.12} \]
\[ = 0.39088 \text{ m} \] ✓
\[ = 390.88 \text{ mm} \]
11.3 **Hydraulic symbols: One-way valve**

![One-way valve symbol]

(1)

11.4 **Belt drives:**

**Rotation frequency of the drive pulley:**

\[
\frac{N_{dr}}{D_{dr}} = \frac{N_{dn}}{D_{dn}} \checkmark
\]

\[
N_{dr} = \frac{N_{dn} \times D_{dn}}{D_{dr}} \checkmark
\]

\[
= \frac{80 \times 240}{75} \checkmark
\]

\[
= 256 \text{ r/min} \checkmark
\]

(4)

11.5 **Gear drives:**

11.5.1 **Rotation frequency of the output:**

\[
N_A = \frac{\text{Product of Driven gears}}{\text{Product of Driver gears}} \checkmark
\]

\[
N_D = \frac{T_A \times T_C}{N_D} \checkmark
\]

\[
N_D = \frac{T_A \times T_C \times N_A}{T_B \times T_D} \checkmark
\]

\[
= \frac{20 \times 25 \times 3000}{35 \times 30} \checkmark
\]

\[
= 1428.57 \text{ r/min} \checkmark
\]

\[
= \frac{1428.57}{60} \checkmark
\]

\[
= 23.81 \text{ r/sec} \checkmark
\]

**OR**

\[
N_B = N_C = 1714.29 \text{ r/min}
\]

\[
N_B = \frac{N_A \times T_A}{T_B} \checkmark
\]

\[
N_B = \frac{3000 \times 20}{35} \checkmark
\]

\[
= 1714.29 \text{ r/min} \checkmark
\]

\[
N_D = \frac{N_C \times T_C}{T_D} \checkmark
\]

\[
= \frac{1714.29 \times 25}{30} \checkmark
\]

\[
= \frac{1428.57 \text{ r/min}}{60} \checkmark
\]

\[
= 23.81 \text{ r/sec} \checkmark
\]

(6)
11.5.2 **Gear ratio:**

\[
\text{Gear ratio} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driver gears}} = \frac{35 \times 30}{20 \times 25} = 2.1 : 1
\]

(3)

11.6 **Work done:**

\[
\text{Work done} = F \times s = 250 \times 15 = 3750 \text{ Joule or N.m}
\]

(2)

**TOTAL QUESTION 11:** [28]

**TOTAL:** 200