These marking guidelines consist of 18 pages.
### QUESTION 1: MULTIPLE-CHOICE QUESTIONS

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<td>1.19</td>
<td>B</td>
<td>(1)</td>
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<tr>
<td>1.20</td>
<td>A</td>
<td>(1)</td>
</tr>
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</table>

Total: [20]
QUESTION 2: SAFETY

2.1 Surface grinder:
- Make sure the sparks are of no danger to co-workers. ✓
- Do not force the material onto the grinding wheel. ✓
- Do not plunge grind. ✓
- Bring the material slowly into contact with the grinding wheel. ✓
- Never clean or adjust the machine while it is in motion. ✓
- Use cutting fluid ✓
- Know where the emergency stop is located ✓
- Stop the machine before any adjustments ✓
- Keep tools clear from moving parts ✓

(Any 3x1) (3)

2.2 Hydraulic press:
- To make sure there is no leakages. ✓
- To make sure that the readings are accurate. ✓
- To make sure the prescribed pressure is not exceeded. ✓

(2)

2.3 MIG/MAGS welding:
- Working area must be well ventilated. ✓
- Make sure electrical parts are properly insulated. ✓
- Make sure the inert gas cylinder is fixed in an upright position. ✓
- Make sure the terminals are connected correctly to the right outlet points. ✓
- The operator should know how to use the equipment. ✓
- The operator must be completely insulated by means of boots, gloves and rubber mats. ✓
- The work area must be partitioned off. ✓
- Use protective equipment. (Overall, gloves, apron, welding helmet etc.) ✓
- Ensure adequate fire precautions. ✓
- See that there is no oil or grease around the machine. ✓
- Ensure that the working area is clean. ✓

(Any 3x1) (3)

2.4 Spring compressor:
- Make certain the compressor is strong enough for the spring ✓
- The compressor must be fitted correctly and firmly. ✓
- Ensure that the spring cannot slip out of position. ✓
- A uniform load must be applied. ✓
- Release the load carefully and also uniformly. ✓
- Do not use wire or ropes to compress the spring. ✓
- Do not hit with a hammer. ✓
- The hookes on the clamps should not be warn ✓
- Clamps must be evenly distributed ✓
- Do not exceed the maximum tension ✓

(Any 2x1) (2)
QUESTION 3: TOOLS AND EQUIPMENT

3.1 Volt and ammeter:
- Voltmeter: connected in parallel to a circuit. ✔
- Ammeter: connected in series to a circuit. ✔

(2)

3.2 Uses of the multimeter:
- Direct current measurement (DC) ✔
- Alternating current measurement (AC) ✔
- Voltage measurement ✔
- Resistance measurement ✔
- Transistor test ✔
- Diode test ✔
- Continuity test ✔
- Temperature ✔
- Battery test ✔

(Any 4x1) (4)

3.3 Compression Test:
- The piston rings are worn out. ✔️
- Worn cylinders. ✔️
- Cracked piston. ✔️

(Any 1x2) (2)

3.4 Tests:

3.4.1 A beam bending test is to investigate the **deflection / bend** ✔️ of beams.

(2)

3.4.2 A cylinder leakage tester is to check whether **gases or air leaks** ✔️ from the cylinders / **valve leak**.

(2)

[12]
QUESTION 4: MATERIALS

4.1 Properties of structures:

4.1.1 Cementite: hard ✓ and brittle ✓ (2)

4.1.2 Ferrite: soft ✓ and ductile ✓ (2)

4.2 Heating process of carbon steel:

4.2.1 Iron-Carbon ✓ Equilibrium ✓ Diagram (2)

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

4.2.3 700 – 800 °C ✓✓ (2)

[13]
QUESTION 5: TERMINOLOGY

5.1 Screw thread terms:

5.1.3: NOTE: Any other corresponding point on the screw thread

5.2 Milling processes:

5.2.1 Up-cut milling

5.2.2 Down-cut milling

5.3 Indexing:

\[ \text{Indexing} = \frac{40}{A} \]

\[ \frac{40}{22} \]

\[ \frac{18}{22} \times \frac{3}{3} \]

\[ \frac{54}{66} \]

✓ ✓ ✓ ✓

1 full turn and 54 holes on the 66-hole circle
5.4 Dividing head:

5.4.1 The sector arm save time and removes the possibility of error in counting the number of holes for each move of the index pin. ✓ ✓ (2)

5.4.2 The index plate is equipped with accurate spaced holes on different-diameter circles. Each circle has a different number of holes. These circles allow the crank handle to be given an accurate part of a turn to obtain the desired spacing. ✓ ✓ (2)

5.4.3 The index pin can be set in the crank handle so that it can be dropped into calculated hole and lock the crank the hole circles. ✓ ✓ (2)

5.4.4 Ratio between worm and worm gear: 40:1 ✓ ✓ (2)

5.5 Gear terminology:

5.5.1 The pitch-circle diameter 'PCD'

\[
\text{Module}(m) = \frac{\text{PCD}}{T} \quad ✓
\]

\[
\text{PCD} = m \times T \quad ✓
\]

\[
= 3 \times 94 \quad ✓
\]

\[
\text{PCD} = 282\ mm \quad ✓
\] (3)

5.5.2 The outside diameter:

\[
\text{Outside diameter} = \text{PCD} + 2m \quad ✓
\]

\[
\text{OD} = 282 + 2(3) \quad ✓
\]

\[
\text{OD} = 288\ mm \quad ✓
\] (2)

5.5.3 The dedendum:

\[
\text{Dedendum} b = 1,157 m \quad \text{or} \quad b = 1,25 m \quad ✓
\]

\[
= 1,157 \times 3 \quad b = 1,25 \times 3 \quad ✓
\]

\[
= 3,47 \ mm \quad b = 3,75 \ mm \quad ✓
\] (2)

5.5.4 The cutting depth:

\[
\text{Cutting depth} = 2,157 \times m \quad \text{or} \quad \text{Cutting depth} = 2,25 \times m \quad ✓
\]

\[
= 2,157 \times 3 \quad = 2,25 \times 3 \quad ✓
\]

\[
= 6,47 \ mm \quad = 6,75 \ mm \quad ✓
\] (2)

[30]
QUESTION 6: JOINING METHODS

6.1 Causes of undercutting:
• Current setting is too high ✓
• Current setting is too low ✓
• Faulty electrode manipulation ✓
• Arc length is too long ✓
• Welding speed is too fast ✓
• Incorrect electrode size ✓

(Any 2x1) (2)

6.2 Prevention of slag inclusion:
• Chip off the slag from the previous weld runs before doing any further welding. ✓✓
• Increase the current setting. ✓✓
• Ensure that the joint is properly cleaned before any welding is done. ✓✓
• Ensure constant current flow. ✓✓
• Arc length must be shorter ✓✓
• Use dry electrodes

(Any 1x2) (2)

6.3 Liquid dye penetrant test:
• Dye is sprayed onto the clean surface to be inspected ✓
• Allow a short time for the dye to penetrate, then remove excess dye with a solvent ✓
• Wash surface with water and allow to dry ✓
• When the surface is dry spray a developer on the surface to bring out the colour in the dye which is trapped in the cracks or pin holes ✓

(4)

6.4 Advantages of using a MIGS/MAGS welding:
• Operator needs less skills ✓
• Continuous welds can be done without replacing electrodes ✓
• Less cleaning of weld, (No slag to be removed) ✓
• It is a quicker process ✓
• Thin material can be welded easily ✓
• Can weld in any position ✓
• Create a better finish ✓
• High deposition rate ✓
• Less distortion ✓

(Any 3x1) (3)

6.5 Gas flow meter:
Control the flow of rate of shielding gas ✓ and measure the flow rate. ✓

(2)
6.6 **MIGS/MAGS welding process:**
A = Melted welding pool / Parent metal / Weld metal / Weld ✓
B = Contact nozzle / Weld pistol / gun ✓
C = Gas shroud / Weld pistol / gun ✓
D = Shielding gas ✓
E = Earth clamp / Skelm / Earth cable ✓

6.7 **Shielding gas in MIGS/MAGS:**
- To control the welding arc ✓ ✓
- Shield the molten pool from atmospheric gases ✓ ✓

(Any 1x2) (2)

6.8 **Earth cable:**
- To complete the circuit ✓ ✓
- To maintain constant current ✓ ✓
- To prevent electric shock ✓ ✓

(Any 1x2) (2)

6.9 **THREE types of gasses used for MIGS/MAGS welding:**
- Argon ✓
- Teral ✓
- CO₂ ✓
- Helium ✓
- Gas mixture ✓

(Any 3x1) (3)

[25]
QUESTION 7: FORCES

7.1

\[ \sum HC = 300 \cos 50° - 200 \cos 30° + 400 \\
= 192.84 + 419.63N \checkmark \\
\]

\[ \sum VC = 200 \sin 30° - 100 + 300 \sin 50° \\
= 100 - 100 + 229.81 \checkmark \\
= 229.81N \checkmark \\
\]

\[ OR \]

<table>
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<th>Magnitudes</th>
<th>Vertical component</th>
<th>Magnitudes</th>
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<td>-200Cos30°</td>
<td>-173,21 N</td>
<td>200Sin30°</td>
<td>100 N</td>
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<tr>
<td>300Cos50°</td>
<td>192,84</td>
<td>300Sin50°</td>
<td>229,81 N</td>
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<td>400 N</td>
<td>400 N</td>
<td>0</td>
<td>0 N</td>
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<tr>
<td>0</td>
<td>0 N</td>
<td>-100</td>
<td>-100 N</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>419,63N</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>229,81 N</strong></td>
</tr>
</tbody>
</table>

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

\[ R = \sqrt{419.63^2 + 229.81^2} \checkmark \]

\[ R = 478.44N \checkmark \]

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

\[ = \frac{229.81}{419.63} \]

\[ \theta = 28.71° \checkmark \]

\[ R = 478.44N \text{ at } 28.71° \text{ north from east} \checkmark \]

(13)
7.2 Stress and Strain:

7.2.1 Stress in the bar:

\[ A = \frac{\pi D^2}{4} \]
\[ = \frac{\pi \times 0.056^2}{4} \]
\[ = 2.46 \times 10^{-3} \text{ m}^2 \]

\[ \sigma = \frac{F}{A} \]
\[ = \frac{40 \times 10^3}{2.46 \times 10^{-3}} \]
\[ = 16260 \text{ Pa} \]
\[ = 16.26 \times 10^6 \text{ Pa} \]
\[ = 16.26 \text{ MPa} \] (5)

7.2.2 Strain:

\[ \varepsilon = \frac{\sigma}{E} \]
\[ = \frac{16.26 \times 10^6}{90 \times 10^9} \]
\[ = 0.18 \times 10^{-3} \] (3)

7.2.3 Change in length:

\[ \varepsilon = \frac{\Delta l}{ol} \]
\[ \Delta l = \varepsilon \times ol \]
\[ = (0.18 \times 10^{-3}) \times 0.85 \]
\[ = 0.15 \times 10^{-3} \text{ m} \]
\[ \text{OR} \]
\[ = 0.15 \text{ mm} \] (3)
7.3 **Moments:**

Calculate A. Moments about B:

\[ \sum \text{RHM} = \sum \text{LHM} \]

\[ (A \times 12) = (960 \times 6) + (750 \times 8) \]

\[ 12A = 5760 + 6000 \]

\[ A = \frac{12}{12} \times 980 \text{ N} \]

Calculate B. Moments about A:

\[ \sum \text{LHM} = \sum \text{RHM} \]

\[ (B \times 12) = (750 \times 4) + (960 \times 6) - (300 \times 12) \]

\[ 12B = 3000 + 5760 + 3600 \]

\[ 12B = \frac{12360}{12} \]

\[ B = 1030 \text{ N} \]
QUESTION 8: MAINTENANCE

8.1  **Pour point:**
The lowest temperature ✓ at which a liquid will flow. ✓ (2)

8.2  **Advantages of cutting fluids:**
- Keep the work piece and cutting tool cool ✓
- It prolongs the life of the cutting tool ✓
- Ensure a better finish ✓
- It washes the cuttings/swarf away ✓
- It protects the machine by making the cutting process easier ✓
- Prevents rust ✓
- It increases the productivity because ✓
- It is possible to cut faster ✓
- It lubricates the machine ✓

(Any 3x1) (3)

8.3  **'ATF':**
Automatic transmission fluid ✓✓ (2)

8.4  **Main parts of a clutch:**
Pressure plate ✓ clutch plate ✓ release bearing (Thrust bearing) ✓ (3)

8.5  **Results of a stretched chain:**
- The chain weakens ✓
- Generates friction ✓
- Vibration occurs ✓
- Becomes noisy ✓
- Derails easily ✓
- Tends to break easily ✓

(Any 3x1) (3)

8.6  **Causes of belt slip:**
- Incorrect tension (loose) ✓
- Oil on the contact surfaces ✓
- Worn belts ✓
- Incorrect pulley alignment ✓
- Overloading ✓
- Not the correct size ✓

(Any 2x1) (2)
QUESTION 9: SYSTEM AND CONTROLS

9.1 Gear drives:

9.1.1 Rotation frequency of the output shaft:

\[ N_F = \frac{T_A \times T_C \times T_E}{T_B \times T_D \times T_F} \]
\[ N_A = \frac{T_A \times T_C \times T_E}{T_B \times T_D \times T_F} \]
\[ N_P = \frac{30 \times 20 \times 50}{40 \times 60 \times 70} \times 2300 \]
\[ = 410,71 \text{ r/min} \]  

9.1.2 Velocity Ratio:

\[ VR = \frac{N_{\text{INPUT}}}{N_{\text{OUTPUT}}} \]
\[ = \frac{2300}{410,71} \]
\[ = 5,6:1 \]
\[ = 1:0,178 \]

9.2 Belt Drives:

9.2.1 Rotation frequency of the driven pulley:

\[ V = \pi D n \]
\[ n = \frac{V}{\pi D} \]
\[ = \frac{32}{\pi \times (0,26)} \]
\[ n_{r/min} = 39,18 \times 60 \]
\[ n_{r/min} = 2350,6 \text{ r/min} \]

9.2.2 Tensile force in the tight side:

\[ \frac{T_1}{T_2} = 2,5 \]
\[ T_1 = 2,5 \times T_2 \]
\[ = 2,5 \times 140 \]
\[ = 350 N \]

9.2.3 Power transmitted:

\[ P = (T_1 - T_2) \nu \]
\[ P = (350 - 140) \times 32 \]
\[ = 6720 \text{ Watts} \]
9.3 **Hydraulics:**

9.3.1 **Fluid pressure:**

\[ A_A = \frac{\pi D^2}{4} \]
\[ = \frac{\pi 0.02^2}{4} \]
\[ = 0.31 \times 10^{-3} \text{ m}^2 \]

\[ p_A = \frac{F}{A_A} \]
\[ = \frac{300}{0.31 \times 10^{-3}} \text{ Pa} \]
\[ = 967741.94 \text{ Pa} \]
\[ = 0.97 \times 10^6 \text{ Pa} \]
\[ = 0.97 \text{ MPa} \]

(4)

9.3.2 **Stroke at piston B:**

\[ A_B = \frac{\pi D^2}{4} \]
\[ = \frac{\pi 0.075^2}{4} \]
\[ = 4.42 \times 10^{-3} \text{ m}^2 \]

\[ A_B \times L_B = A_A \times L_A \]
\[ L_B = \frac{A_A \times L_A}{A_B} \]
\[ = \left( \frac{0.31 \times 10^{-3}}{4.42 \times 10^{-3}} \right) \times 185 \]
\[ = 12.98 \text{ mm} \]

(4)

9.4 **Traction control:**

It prevents the wheels from spinning ✓ ✓

(2)

9.5 **Safety belt:**

Safety belts need to be activated (buckle up) by the driver/passenger ✓ ✓

(2)

[25]
QUESTION 10: TURBINES

10.1 Water turbine:
- Waterwheel ✓
- Pelton ✓
- Turgo ✓
- Michell-Banki ✓
- Jonval turbine ✓
- Reverse overshot waterwheel ✓
- Archimedes’ screw turbine ✓

(Any 1x1) (1)

10.2 Runaway speed of a water turbine:
Runaway speed of a water turbine is its speed at full flow ✓ and with no shaft load ✓

(2)

10.3 Water turbine:

10.3.1 Type of turbine:
- Reaction turbine ✓
- Kaplan turbine ✓

(Any 1x1) (1)

10.3.2 A. Wicket gate ✓
B. Rotor ✓
C. Stator ✓
D. Shaft ✓
E. Water flow ✓
F. Blades ✓

(6)

10.3.3 Advantages of water turbine:
- Water turbine blades continue to turn on cloudy windless days unlike sun and windy system. ✓
- No water is consumed in this process ✓
- More reliable ✓
- Environmentally friendly with no pollution ✓
- More economical than steam turbines ✓
- Can be mounted vertically to take up less space ✓

(Any 3x1) (3)

10.4 Function of turbo and superchargers:
To increase ✓ volumetric efficiency ✓ of an internal combustion engine.

(2)

10.5 Compressor used in a turbocharger:
Centrifugal ✓

(1)

10.6 Turbocharger:
Exhaust gasses ✓

(1)
10.7 **Advantage of a turbocharger:**
- It is driven by exhaust gasses ✓
- No power from engine is used ✓
- Power loss above sea level is eliminated ✓
- More power is developed compared to a similar vehicle without a turbocharger ✓
- Less fuel is used compared to engine mass ✓
- To increase volumetric efficiency ✓

(Any 1x1) (1)

10.8 **Advantage of a steam turbine:**
- It is compact ✓
- No lubrication is needed ✓
- It is more economical ✓
- Converts heat energy into mechanical energy ✓
- Greater thermal efficiency ✓
- Direct drive ✓
- Low maintenance ✓
- High power to weight ratio ✓

(Any 2x1) (2)

[20]

GRAND TOTAL: 200