MECHANICAL TECHNOLOGY: FITTING AND MACHINING

2021

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 25 pages.
QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 B ✓ (1)
1.2 A ✓ (1)
1.3 C ✓ (1)
1.4 C ✓ (1)
1.5 D ✓ (1)
1.6 A ✓ (1) [6]
QUESTION 2: SAFETY (GENERIC)

2.1 First aid basic treatment:
- Examination ✓
- Diagnosis ✓
- Treatment ✓

(3)

2.2 Drill press (Already been switched on):
- Never leave the drill unattended while in motion. ✓
- Switch off the drill when leaving. ✓
- Use a brush or wooden rod to remove chips. ✓
- When reaching around a revolving drill, be careful that your clothes do not get caught in the drill or drill chuck. ✓
- Don't stop a revolving chuck with your hand. ✓
- Don't adjust the drill while working. ✓
- Don't open any guard while in motion. ✓
- Keep hands away from action points. ✓
- Do not force the drill bit into the material. ✓
- Apply cutting fluid if required. ✓

(Any 2 x 1) (2)

2.3 Isolation of electrode holder:
To prevent electric shock. ✓

(1)

2.4 Disadvantages of the process layout:
- Production is not always continuous. ✓
- Transportation costs between process departments may be high. ✓
- Additional time is spent in testing and sorting as the product moves to the different departments. ✓
- Damage to fragile goods may result from extra handling. ✓

(Any 2 x 1) (2)

2.5 Advantages of the product layout:
- Handling of material is limited to a minimum. ✓
- Time period of manufacturing cycle is less. ✓
- Production control is almost automatic. ✓
- Control over operations is easier. ✓
- Greater use of unskilled labour is possible. ✓
- Less total inspection is required. ✓
- Less total floor space is needed per unit of production. ✓
- Reduction in manufacturing costs. ✓

(Any 2 x 1) (2)

[10]
QUESTION 3: MATERIALS (GENERIC)

3.1 Heat-treatment:
- Heat the metal slowly to a certain temperature. ✓
- Soak the metal for a certain period to ensure a uniform temperature. ✓
- Cool the metal at a certain rate to room temperature. ✓

3.2 Quenching mediums:
- Water ✓
- Brine ✓
- Liquid salts ✓
- Oil ✓
- Soluble oil and water ✓
- Sand ✓
- Molten lead ✓
- Air ✓
- Lime ✓

(Any 3 x 1) (3)

3.3 Annealing:
- To relieve internal stresses of the steel ✓
- Soften steel to make machining possible ✓
- Make steel ductile ✓
- Refine grain structure ✓
- Reduce brittleness ✓

(Any 1 x 1) (1)

3.4 Carbon steels:
- Low carbon steel ✓
- Medium carbon steel ✓
- High carbon steel ✓

(3)

3.5 Iron-carbon equilibrium diagram:

A Percentage carbon / carbon content ✓
B Temperature in °C ✓
C AC3 line / Higher critical temperature ✓
D AC1 line / Lower critical temperature ✓

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

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<td>D ✔</td>
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[14]
QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

5.1 Disadvantages of compound slide method:
- The automatic feed of the machine cannot be used. ✓
- Causes poor finish. ✓
- Only short tapers can be cut. ✓
- It causes fatigue in the operator. ✓

(Any 3 x 1) (3)

5.2 Taper calculations:

5.2.1 Diameter of taper:

\[ \tan \frac{\theta}{2} = \frac{D - d}{2 \times l} \]

\[ \tan \frac{10}{2} = \frac{165 - d}{2 \times 210} \]

\[ 420 \tan 5^\circ = 165 - d \]

\[ d = 165 - 36.75 \]

\[ d = 128.25 \text{ mm} \]

(4)

5.2.2 Tailstock set-over:

\[ x = \frac{L (D - d)}{2 \times l} \]

\[ x = \frac{325 (165 - 128.25)}{2 \times 210} \]

\[ x = 28.44 \text{ mm} \]

(3)

5.3 Calculation of parallel key:

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

\[ = \frac{55}{4} \]

\[ = 13.75 \text{ mm} \]

(2)

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

\[ = \frac{55}{6} \]

\[ = 9.17 \text{ mm} \]

(2)
5.3.3  
Lenght = 1.5 \times \text{diameter of shaft} 
= 1.5 \times 55 \checkmark 
= 82.5 \text{ mm} \checkmark 

5.4  
**Advantages of up-cut milling:**
- Heavier cuts can be taken. \checkmark 
- When hard steels are cut, the total cutting pressure is absorbed by the material at the back of the edge. \checkmark 
- When milling material with a hard scale, the cut is started under the scale where material is softer, extending the life of the cutter. \checkmark 
- A courser feed can be used. \checkmark 
- The strain on the cutter and arbor is less. \checkmark 
- Less vibration experienced on machine. \checkmark 

(Any 2 x 1)  
(2)

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

6.1 Gear calculations:

6.1.1 Number of teeth:

\[
\text{Module} = \frac{\text{PCD}}{T}, \quad T = \frac{\text{PCD}}{m} \quad \checkmark \\
= \frac{136}{4} \quad = 34 \text{ teeth} \quad \checkmark
\]

(2)

6.1.2 Dedendum:

\[
\text{Dedendum} = 1,157(m) \quad = 1,25(m) \quad = 1,157 \times 4 \quad \checkmark \quad \text{OR} \quad = 1,25 \times 4 \quad \checkmark \quad = 4,63 \text{ mm} \quad \checkmark \quad = 5 \text{ mm} \quad \checkmark
\]

(2)

6.1.3 Outside diameter:

\[
\text{OD} = \text{PCD} + 2(m) \quad = m(T + 2) \quad = 136 + 2(4) \quad \checkmark \quad \text{OR} \quad = 4(34 + 2) \quad \checkmark \quad = 144 \text{ mm} \quad \checkmark \quad = 144 \text{ mm} \quad \checkmark
\]

(2)

6.1.4 Circular pitch:

\[
\text{CP} = m \times \pi \quad = 4 \times \pi \quad \checkmark \quad = 12,57 \text{ mm} \quad \checkmark
\]

(2)
6.2 **Dove tail calculations:**

\[ w = 190 - 2(DE) \]

\[ M = w + 2 \left( AC \right) + 2 \left( R \right) \quad \text{or} \quad M = w + 2 \left( AC + R \right) \]

6.2.1 **Minimum width of dove tail (w):**

**Calculate DE:**

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

\[ DE = AD \tan \alpha \quad \text{OR} \quad \tan 60^\circ = \frac{38}{ED} \]

\[ = 38 \tan 30^\circ \quad \checkmark \]

\[ = 21.94 \text{ mm} \quad \checkmark \]

\[ w = 190 - 2(DE) \quad \checkmark \]

\[ = 190 - 2(21.94) \quad \checkmark \]

\[ = 190 - 43.88 \]

\[ = 146.12 \text{ mm} \quad \checkmark \] (6)

6.2.2 **Distance over the rollers (M):**

**Calculate AC:**

\[ \tan \alpha = \frac{BC}{AC} \quad \checkmark \]

\[ \tan \theta = \frac{CA}{BC} \quad \checkmark \]

\[ AC = \frac{BC}{\tan \alpha} \quad \checkmark \quad \text{OR} \quad CA = BC \tan \theta \quad \checkmark \]

\[ = \frac{15}{\tan 30^\circ} \]

\[ = 25.98 \text{ mm} \quad \checkmark \]

\[ M = w + 2 \left( AC \right) + 2 \left( R \right) \quad \checkmark \]

\[ = 146.12 + 2(25.98) + 2(15) \quad \checkmark \]

\[ = 146.12 + 51.96 + 30 \quad \checkmark \]

\[ = 228.08 \text{ mm} \quad \checkmark \] (6)
6.3 Milling of spur gear:

6.3.1 Indexing:

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

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

\[
= \frac{40}{160} \checkmark
\]

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

\[
= \frac{6}{24} \checkmark
\]

Approximate indexing:

No full turns and 6 holes on a 24-hole circle \( \checkmark \)

OR

No full turns and 7 holes on a 28-hole circle \( \checkmark \) \( (3) \)

6.3.2 Change gears:

\[
\frac{D_{DR}}{D_{DN}} = (A - n) \times \frac{40}{A}
\]

\[
\frac{D_{DR}}{D_{DN}} = (160 - 163) \times \frac{40}{160} \checkmark
\]

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

\[
= -\frac{120}{160}
\]

\[
= \frac{3 \times 8}{4 \times 8} \checkmark
\]

\[
\frac{D_{DR}}{D_{DN}} = \frac{24}{32} \checkmark
\]

\( (5) \)

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

7.1 Reading:

Reading = 7,90 mm  

(2)

7.2 Brinell hardness test:

- Select the desired load to apply to the specimen. ✓
- The specimen is raised to be in contact with the Brinell ball by turning the hand wheel. ✓
- The load is then applied for about 15 - 30 seconds ✓
- Release the load from the specimen. ✓
- Measure the diameter of the impression. ✓
- Determine the Brinell hardness number. ✓  

(6)

7.3 The tensile tester:

- Yield stress ✓
- Ultimate / maximum tensile stress ✓
- Elongation percentage ✓
- Break stress ✓
- Limit of proportionality ✓
- Elastic limit ✓
- Strain ✓
- Ductility ✓  

(Any 3 x 1)  (3)

7.4 Screw thread micrometer:

Identify:

7.4.1 Screw thread micrometer ✓  

(1)

Function:

7.4.2 Measure the pitch diameter ✓ of a screw thread.  

(1)  [13]
QUESTION 8: FORCES (SPECIFIC)

8.1  Magnitude and direction of the equilibrant:

8.1.1  Sum of the horizontal components (HC):

\[ \sum HC = 280 \cos 45^\circ + 120 \cos 0^\circ - 150 \cos 90^\circ - 250 \cos 30^\circ \]

\[ = 197.99 + 120 - 0 - 216.51 \]

\[ = 101.48 \text{ N} \]

OR

<table>
<thead>
<tr>
<th>Force</th>
<th>HC (x)</th>
<th>Total</th>
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<tr>
<td>120 N</td>
<td>120\cos 0^\circ \checkmark</td>
<td>120 N</td>
</tr>
<tr>
<td>280 N</td>
<td>280\cos 45^\circ \checkmark</td>
<td>197.99 N</td>
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<tr>
<td>250 N</td>
<td>250\cos 210^\circ \checkmark</td>
<td>-216.51 N</td>
</tr>
<tr>
<td>150 N</td>
<td>150\cos 270^\circ</td>
<td>0 N</td>
</tr>
<tr>
<td></td>
<td>Total: 101.48 N \checkmark</td>
<td></td>
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</table>

8.1.2  Sum of the vertical components (VC):

\[ \sum VC = 280 \sin 45^\circ + 120 \sin 0^\circ - 150 \sin 90^\circ - 250 \sin 30^\circ \]

\[ = 197.99 + 0 - 150 - 125 \]

\[ = -77.01 \text{ N} \]

OR

<table>
<thead>
<tr>
<th>Force</th>
<th>VC (y)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 N</td>
<td>120 \sin 0^\circ</td>
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</tr>
<tr>
<td>280 N</td>
<td>280\sin 45^\circ \checkmark</td>
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</tr>
<tr>
<td>250 N</td>
<td>250\sin 210^\circ \checkmark</td>
<td>-125 N</td>
</tr>
<tr>
<td>150 N</td>
<td>150\sin 270^\circ \checkmark</td>
<td>-150 N</td>
</tr>
<tr>
<td></td>
<td>Total: -77.01 N \checkmark</td>
<td></td>
</tr>
</tbody>
</table>

(4)
8.1.3 **Magnitude of the equilibrium force:**

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

\[ E = \sqrt{(77.01)^2 + (101.48)^2} \checkmark \]

\[ = 127.39 \text{ N} \checkmark \]  

(3)

8.1.4 **Direction of the equilibrium force:**

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

\[ \tan \theta = \frac{77.01}{101.48} \]

\[ \theta = 37.19^\circ \checkmark \]

\[ E = 127.39 \text{ N at } 37.19^\circ \text{ N of W} \checkmark \]

(3)
8.2 Magnitudes of the reactions in supports A and B:

Calculate A:  
Take moments about B:

\[ \sum_{\text{CWM}} = \sum_{\text{ACM}} \]
\[ A \times 6 = (285 \times 2,7) + (165 \times 4,2) + (345 \times 5,4) \checkmark \]
\[ A \times 6 = 769,5 + 693 + 1863 \checkmark \]
\[ A \times 6 = 3325,5 \]
\[ A = \frac{3325,5}{6} \checkmark \]
\[ A = 554,25 \text{ N} \checkmark \]

Calculate B:  
Take moments about A:

\[ \sum_{\text{CWM}} = \sum_{\text{ACM}} \]
\[ (345 \times 0,6) + (165 \times 1,8) + (285 \times 3,3) = 6 \times B \checkmark \]
\[ 207 + 297 + 940,5 = 6 \times B \checkmark \]
\[ 1444,5 = 6 \times B \]
\[ \frac{1444,5}{6} = B \checkmark \]
\[ B = 240,75 \text{ N} = B \checkmark \]

(8)
8.3 Stress and Strain:

8.3.1 The resistance area of the bush:

\[ A = \frac{\pi (D^2 - d^2)}{4} \]

\[ A = \frac{\pi (0.058^2 - 0.042^2)}{4} \]

\[ A = 1.26 \times 10^{-3} \text{ m}^2 \]

(2)

8.3.2 The stress in the material:

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

\[ = \frac{50 \times 10^3}{1.26 \times 10^{-3}} \]

\[ = 39682539.68 \text{ Pa} \]

\[ = 39.68 \text{ MPa} \]

(3)

8.3.3 Strain:

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

\[ = \frac{0.975}{68} \]

\[ = 14.34 \times 10^{-3} \]

(If any unit indicated, then NO mark for final answer)

(3)

8.3.4 Young’s modulus:

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

\[ = \frac{39.68 \times 10^6}{14.34 \times 10^{-3}} \]

\[ = 2.77 \times 10^9 \text{ Pa} \]

\[ = 2.77 \text{ GPa} \]

(3)
QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 Lack of preventative maintenance:
- Risk of injury or death. ✓
- Financial loss. ✓
- Damage to parts. ✓
- Loss of production time. ✓

(Any 2 x 1) (2)

9.2 Malfunctioning of chain drives:
- Uncovered chain drives not cleaned. ✓
- Tensioning device is not working efficiently. ✓
- Chain is not inspected regularly for elongation. ✓
- Chain drive is not aligned. ✓
- Wear and tear of chain. ✓
- Wear of sprocket teeth. ✓
- Lack of lubrication. ✓
- Chain drive has been overloaded. ✓

(Any 2 x 1) (2)

9.3 Wear on a gear drive system:
- Checking and replacement of lubrication levels. ✓
- Ensuring that gears are properly secured to shaft. ✓
- Cleaning and replacement of oil filter. ✓
- Reporting excessive noise, wear, vibration and overheating for expert attention. ✓
- Cleaning of gears regularly. ✓

(Any 2 x 1) (2)

9.4 Property of materials:

9.4.1 Polyvinyl chloride (PVC):
- Can be re-heated and re-shaped ✓
- Flexible ✓
- Rubber like substance and makes a dull sound when dropped. ✓
- Can be modified to suit most applications. ✓
- Can be welded (plastic welding). ✓
- Can be bonded with an adhesive. ✓
- Weather resistant ✓
- Water proof ✓
- Easy to work with. ✓
- Light weight ✓
- Recyclable ✓
- Corrosion resistant ✓

(Any 2 x 1) (2)
9.4.2 **Carbon fibre:**
- Cannot be re-heated and re-shaped ✓
- Tough and strong material. ✓
- Light weight ✓
- Weather resistant ✓
- Heat resistant ✓
- Enhance strength of plastic by entrenchment. ✓
- Highly electrically conductive ✓

(Any 2 x 1) (2)

9.4.3 **Bakelite:**
- Electrically non-conductor (electrical insulator) ✓
- Heat resistant ✓
- Well moulded into specific shapes ✓
- Weather resistant ✓
- Cannot be re-heated and re-shaped ✓

(Any 2 x 1) (2)

9.5 **Thermoplastic composites or thermo-hardened (thermosetting) composites:**

9.5.1 **Vesconite:**
Thermoplastic ✓

(1)

9.5.2 **Glass fibre:**
Thermo-hardened/Thermosetting ✓

(1)

9.5.3 **Carbon fibre:**
Thermo-hardened/Thermosetting ✓

(1)

9.6 **Uses of materials.**

9.6.1 **Teflon:**
- Orthopaedic and prosthetic appliances ✓
- Hearing aids ✓
- Joints ✓
- Upholstery ✓
- Mechanical parts (e.g., taps and bearings) ✓
- Electrical insulation ✓
- Non-stick coatings ✓

(Any 1 x 1) (1)
9.6.2 **Carbon fibre:**
- Sporting and leisure equipment like: Tennis rackets, squash rackets, badminton rackets, golf clubs, hockey sticks ✓
- Model airplanes ✓
- Bicycle frames ✓
- Ski’s ✓
- Surf boards ✓
- Boat masts ✓
- Compressor blades ✓
- Self-lubricating gears ✓
- Artificial satellites ✓
- Helicopter blades ✓
- Car bodies
- Airplane parts (fuselage) ✓

(Any 1 x 1) (1)

9.6.3 **Nylon:**
- Bushes ✓
- Gears ✓
- Pulleys ✓
- Fishing line ✓
- Ropes ✓

(Any 1 x 1) (1)
QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 Square Thread:

10.1.1 Mean diameter:

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

\[
\begin{align*}
\text{Pitch} &= \frac{40}{2} \checkmark \\
&= 20 \text{ mm} \checkmark \\
D_m &= OD - \frac{P}{2} \\
&= 85 - \frac{20}{2} \checkmark \\
&= 75 \text{ mm} \checkmark
\end{align*}
\]

10.1.2 Helix angle of the thread:

\[
\tan \theta = \frac{\text{Lead}}{\pi \times D_m}
\]

\[
\begin{align*}
\tan \theta &= \frac{40}{\pi \times 75} \checkmark \\
\theta &= \tan^{-1}(0,169765272) \\
&= 9,63^\circ \text{ or } 9^\circ 38' \checkmark
\end{align*}
\]

10.1.3 Leading tool angle:

Leading tool angle = \(90^\circ \cdot (\text{helix angle} + \text{clearance angle})\)

\[
\begin{align*}
\text{Leading tool angle} &= 90^\circ \cdot (9,63^\circ + 3^\circ) \checkmark \\
&= 77,37^\circ \text{ or } 77^\circ 22' \checkmark
\end{align*}
\]

10.1.4 Following tool angle:

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

\[
\begin{align*}
\text{Following tool angle} &= 90^\circ \cdot (9,63^\circ - 3^\circ) \checkmark \\
&= 96,63^\circ \text{ or } 96^\circ 38' \checkmark
\end{align*}
\]
10.2 **Screw thread label:**
A. Pitch diameter/mean/effective ✓
B. Helix angle ✓
C. Pitch / Lead ✓
D. Root/Root length ✓

10.3 **Uses of square thread:**
- Vice screws ✓
- Brake screws ✓
- Lead screws of lathe machines ✓
- Scissor jacks ✓
- Milling machine table feed screws ✓
- Hydraulic jacks (Adjustable top) ✓

(Any 2 x 1) (2) [18]
QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 Hydraulic calculations:

11.1.1 The fluid pressure in MPa:

Area:

\[ A = \frac{\pi D_A^2}{4} = \frac{\pi (0.025)^2}{4} = 0.49 \times 10^{-3} \text{ m}^2 \quad \text{OR} \quad 4.9 \times 10^{-4} \text{ m}^2 \]

Pressure:

\[ P = \frac{F}{A} = \frac{1.32 \times 10^3}{0.49 \times 10^{-3}} = 2.69 \times 10^6 \text{ Pa} = 2.69 \text{ MPa} \]
11.1.2 The diameter of piston B:

\[
P_B = P_A
\]

\[
\frac{F_B}{A_B} = \frac{F_A}{A_A}
\]

\[
\frac{6.45 \times 10^3}{A_B} = \frac{1.32 \times 10^3}{0.49 \times 10^{-3}} \checkmark
\]

\[
\frac{6.45 \times 10^3}{A_B} = 2.69 \times 10^6
\]

\[
A_B = \frac{6.45 \times 10^3}{2.69 \times 10^6} \checkmark
\]

\[
A_B = 2.40 \times 10^{-3} \checkmark
\]

\[
A_B = \frac{\pi D_B^2}{4}
\]

\[
D_B = \sqrt{\frac{4A_B}{\pi}} \checkmark
\]

\[
= \sqrt{\frac{4(2.40 \times 10^{-3})}{\pi}} \checkmark
\]

\[
= 0.05528 \text{ m}
\]

\[
= 55.28 \text{ mm} \checkmark
\]

(6)

11.2 Advantages of chain drive system over belt drive systems:

- No slipping or creep occurs. \checkmark
- Higher efficiency. \checkmark
- Longer life span. \checkmark
- Does not generate heat. \checkmark
- Does not undergo the same degrading effects of what time has on belts. \checkmark
- Much stronger. \checkmark
- Faster speeds can be obtained. \checkmark

(Any 2 x 1) (2)
11.3 Functions of hydraulic reservoir:
- A fluid storage tank. ✓
- Promotes air separation from the fluid. ✓
- Support for the pump and electric motor. ✓
- Promotes heat dispersion. ✓
- Acts as a base plate for mounting control equipment. ✓
- It allows for expansion or contraction of the hydraulic system. ✓

(Any 2 x 1) (2)

11.4 Application for hydraulic systems:
- Machine tools ✓
- Clutch systems ✓
- Brake systems ✓
- Aircraft ✓
- Jacks ✓
- Missiles ✓
- Ships ✓
- Earth moving equipment ✓
- Punch machines ✓
- Turbines ✓
- Tractor lifts ✓
- Car lifts ✓
- Machine vices ✓
- Jaws of life ✓
- Trains ✓

(Any 1 x 1) (1)

11.5 Belt drive:

11.5.1 Rotational frequency:
\[ N_{DR} \times D_{DR} = N_{DN} \times D_{DN} \]
\[ N_{DR} \times 95 = 85 \times 255 \ ✓ \]
\[ N_{DR} = \frac{85 \times 255}{95} \ ✓ \]
\[ N_{DR} = 228,16 \text{ r/min} \]

OR
\[ N_{DR} = 3,8 \text{ r/sec} \ ✓ \] (3)
11.5.2 **Speed ratio:**

\[ \text{Speed ratio} = \frac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}} \]

\[ \text{Speed ratio} = \frac{255}{95} \checkmark \]

\[ \text{Speed ratio} = 2,68 : 1 \checkmark \]

OR

\[ \text{Speed ratio} = \frac{\text{Frequency of driven pulley}}{\text{Frequency of driver pulley}} \]

\[ \text{Speed ratio} = \frac{228}{85} \checkmark \]

\[ \text{Speed ratio} = 2,68 : 1 \checkmark \] (3)
11.6 Gear drive:

11.6.1 Rotation frequency:

\[ N_f = \frac{T_A \times T_C \times T_E \times N_A}{T_B \times T_D \times T_F} \]

\[ = \frac{30 \times 20 \times 50 \times 2500}{40 \times 60 \times 70} \checkmark \]

\[ = 446.43 \text{ r/min} \]

OR

\[ = 7.44 \text{ r/sec} \checkmark \]

\[ (4) \]

11.6.2 Gear ratio:

\[ \text{Gear Ratio} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}} \]

\[ = \frac{4 \times 60 \times 70}{30 \times 20 \times 50} \checkmark \]

\[ = 5.6 : 1 \checkmark \]

OR

\[ \text{Speed ratio} = \frac{N_{\text{input}}}{N_{\text{output}}} \]

\[ = \frac{2500}{446.43} \checkmark \]

\[ = 5.6:1 \checkmark \]

\[ (3) \]

[28]

TOTAL: 200