



Province of the
EASTERN CAPE
EDUCATION

Iphondo leMpuma Kapa: Isebe leMfundo
Provinsie van die Oos Kaap: Departement van Onderwys
Porafensie Ya Kapa Botjhabela: Lefapha la Thuto

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2024

MECHANICAL TECHNOLOGY: FITTING AND MACHINING MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 16 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 A ✓ (1)
- 1.6 D ✓ (1)
- [6]**

QUESTION 2: SAFETY (GENERIC)**2.1 Gas cylinder safety precautions:**

- Always store and use gas cylinders in an upright position. ✓
- Never stack cylinders on top of one another. ✓
- Do not bang or work on the cylinders. ✓
- Never allow cylinders to fall. ✓
- No oil and grease should come into contact with gas cylinders or fittings. ✓
- Keep the caps on the cylinders for protection. ✓ (Any 2 x 1) (2)

2.2 Employers' responsibility regarding safety:

- Provide and maintain working systems, work area, equipment and tools in a safe condition. ✓
- Eliminate or reduce any hazard or potential hazard. ✓
- Produce, handle, store and transport goods safely. ✓
- Ensure that every person employed complies with the requirements of this Act. ✓
- Enforce measures, if necessary, in the interest of health and safety. ✓
- Appoint a person who is trained and who have the authority to ensure that employee take precautionary measures. ✓ (Any 2 x 1) (2)

2.3 Safety precautions before switching on the angle grinder:

- Make sure that there are no cracks or chips on the disc. ✓
- Make sure that there are no flammable materials nearby. ✓
- Ensure that guards are in place. ✓
- Wear the appropriate PPE especially eye protection. ✓ (Any 2 x 1) (2)

2.4 Welding goggles:

- To protect your eyes against sparks. ✓
- To protect your eyes against heat. ✓
- To see where to weld. ✓ (Any 2 x 1) (2)

2.5 Disadvantages of 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)

[10]

QUESTION 3: MATERIALS (GENERIC)**3.1 Reason to cut from the unmarked end:**

- Marking does not get lost ✓
- Be able to identify the material ✓

(Any 1 x 1) (1)

3.2 Heat-treatment processes properties:

	PROCESS	PROPERTY
3.2.1	Hardening	Very hard, high tensile strength and brittle ✓
3.2.2	Tempering	Tough, hard ✓
3.2.3	Annealing	Soft, ductile, low tensile strength ✓
3.2.4	Normalising	Tough and machinable ✓

(4)

3.3 Heat-treatment process steps:

- Heat the metal slowly to a temperature below the critical temperature. ✓
- Soak it at that temperature for a period. ✓
- Quench / cool in an appropriate quenching medium. ✓

(3)

3.4 Quenching media:

- Water ✓
- Brine ✓
- Oil ✓

(3)

3.5 Types of tests:

3.5.1 Filing test ✓

(1)

3.5.2 Spark test ✓

(1)

3.5.3 Bending test ✓

(1)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

- | | | |
|------|-----|-------------|
| 4.1 | A ✓ | (1) |
| 4.2 | D ✓ | (1) |
| 4.3 | C ✓ | (1) |
| 4.4 | C ✓ | (1) |
| 4.5 | B ✓ | (1) |
| 4.6 | A ✓ | (1) |
| 4.7 | C ✓ | (1) |
| 4.8 | B ✓ | (1) |
| 4.9 | C ✓ | (1) |
| 4.10 | D ✓ | (1) |
| 4.11 | A ✓ | (1) |
| 4.12 | C ✓ | (1) |
| 4.13 | B ✓ | (1) |
| 4.14 | D ✓ | (1) |
| | | [14] |

QUESTION 4: MULTIPLE CHOICE QUESTION (SPECIFIC)

4.1 B ✓

4.2 A ✓

4.3 A ✓

4.4 C ✓

4.5 C ✓

4.6 C ✓

4.7 D ✓

4.8 D ✓

4.9 C ✓

4.10 B ✓

4.11 B ✓

4.12 D ✓

4.13 A ✓

4.14 D ✓

[14]

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)**5.1 Included angle:**

$$\tan \frac{\theta}{2} = \frac{D-d}{2l} \quad \checkmark$$

$$\tan \frac{\theta}{2} = \frac{40 - 31,6}{2 \times 60} \quad \checkmark$$

$$\frac{\theta}{2} = \tan^{-1}(0,07)$$

$$\frac{\theta}{2} = 4^\circ \quad \checkmark$$

$$\theta = 8^\circ \quad \checkmark \quad (4)$$

5.2 Keyway

$$\begin{aligned} 5.2.1 \quad \text{Width} &= \frac{D}{4} \\ &= \frac{48}{4} \quad \checkmark \\ &= 12 \text{ mm} \quad \checkmark \end{aligned} \quad (2)$$

$$\begin{aligned} 5.2.2 \quad \text{Thickness} &= \frac{D}{6} \\ &= \frac{48}{6} \quad \checkmark \\ &= 8 \text{ mm} \quad \checkmark \end{aligned} \quad (2)$$

$$\begin{aligned} 5.2.3 \quad \text{Length} &= 1,5 \times D \\ &= 1,5 \times 48 \quad \checkmark \\ &= 72 \text{ mm} \quad \checkmark \end{aligned} \quad (2)$$

5.2.4 Distance between cutter and engineering square

$$\begin{aligned} \chi &= \frac{\text{diameter of workpiece} - \text{thickness of cutter}}{2} \quad \checkmark \\ &= \frac{48 - 12}{2} \quad \checkmark \\ &= 18 \text{ mm} \quad \checkmark \end{aligned} \quad (3)$$

5.3 Labels A–E:A – Workpiece \checkmark B – Keyway \checkmark C – Steel ruler \checkmark D – Cutter \checkmark E – Engineering square \checkmark (5)
[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

- 6.1 Index plate enables one revolution of the crank to be further subdivided into fractions of a revolution, especially where the fraction is the factor of 40. ✓✓ (2)

6.2 Gear terminology

$$\begin{aligned}
 6.2.1 \quad M &= \frac{PCD}{T} \\
 &= \frac{108}{36} \quad \checkmark \\
 &= 3 \text{ mm} \quad \checkmark
 \end{aligned}
 \quad (2)$$

$$\begin{aligned}
 6.2.2 \quad OD &= PCD + 2 \text{ (m)} \\
 &= 108 + 2 \text{ (3)} \quad \checkmark \\
 &= 114 \text{ mm} \quad \checkmark
 \end{aligned}
 \quad (2)$$

6.3 Spur gear cutting**6.3.1 Simple indexing**

$$\begin{aligned}
 \text{Indexing} &= \frac{40}{A} \quad \checkmark \\
 &= \frac{40}{120} \quad \checkmark \\
 &= \frac{1}{3} \times \frac{8}{8} \\
 &= \frac{8}{24}
 \end{aligned}$$

Indexing is 8 holes in 24-hole circle ✓ (3)

6.3.2 Change gears

$$\begin{aligned}
 \frac{\text{Driver}}{\text{Driven}} &= \frac{A-N}{A} \times \frac{40}{1} \quad \checkmark \\
 &= \frac{120-129}{120} \times \frac{40}{1} \quad \checkmark \\
 &= \frac{-3}{1} \times \frac{24}{24} \\
 &= \frac{-72}{24} \quad \checkmark
 \end{aligned}$$

Driver has 72 teeth ✓

Driven has 24 teeth ✓

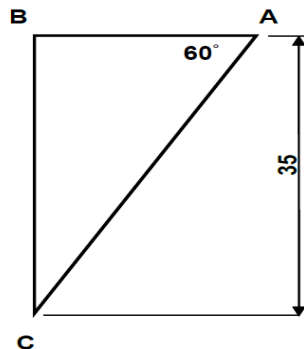
(5)

- 6.3.3 Index plate rotates in the opposite direction than the crank arm. ✓ (1)

6.4 Dovetail calculations

Calculate distance "X" between rollers:

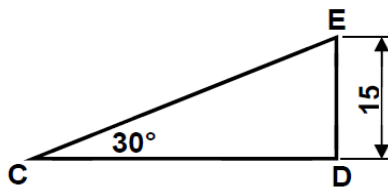
$$X = 150 + 2(AB) - 2(CD) - 2(r)$$



$$\tan \theta = \frac{BC}{AB} \quad \checkmark$$

$$\tan 60^\circ = \frac{35}{AB} \quad \checkmark$$

$$\begin{aligned} AB &= \frac{35}{\tan 60} \\ &= 20,21 \text{ mm} \quad \checkmark \end{aligned}$$



$$\tan \frac{\theta}{2} = \frac{DE}{CD} \quad \checkmark$$

$$\tan 30^\circ = \frac{15}{CD} \quad \checkmark$$

$$\begin{aligned} CD &= \frac{15}{\tan 30} \\ &= 25,98 \text{ mm} \quad \checkmark \end{aligned}$$

$$\begin{aligned} X &= 150 + 2(AB) - 2(CD) - 2(r) \quad \checkmark \\ &= 150 + 2(20,21) - 2(25,98) - 2(15) \quad \checkmark \\ &= 150 + 40,42 - 51,96 - 30 \\ &= 108,46 \text{ mm} \quad \checkmark \end{aligned} \tag{9}$$

6.5 Balancing methods

- Static balancing \checkmark
- Dynamic balancing \checkmark (2)

6.6 Balancing advantages:

- Prevents vibration ✓
- Prevents poor finish / ensure good finish ✓
- Prevents wear on bearings / components ✓
- Prevents accidents ✓
- Improve production ✓
- Promotes accuracy ✓
- Prevents damage to workpiece ✓
- Prevents components from loosening ✓

(Any 2 x 1) (2)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)**7.1 Brinell and Rockwell hardness testers****Brinell hardness tester:**

- The Brinell hardness test involves indenting the test material with a piece of hardened steel or carbide ball of 10 mm. The diameter of the indentation left in the test material is measured with a low-powered microscope. ✓✓

Rockwell hardness tester:

- Rockwell hardness test method involves indenting the test material with a diamond cone or hardened steel-ball indenter. ✓✓

(4)

7.2 ONE function of a moment tester:

- To determine the reactions on either side of simply loaded beam. ✓
- To illustrate the concept of the triangle of forces. ✓

(Any 1 x 1) (1)

7.3 Precision measuring instruments:

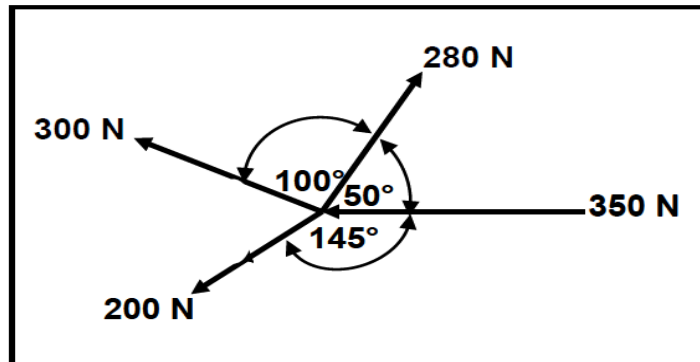
- Outside micrometer ✓
- Inside micrometer ✓
- Depth micrometer ✓

(3)

7.4 Micrometer reading

$$\begin{array}{ccccccc} \checkmark & \checkmark & & \checkmark & & \checkmark & \\ 100 & + & 11,00 & + & 0,50 & + & 0,09 \\ = & 111,59 & \text{mm} & \checkmark & & & \end{array}$$

(5)
[13]

QUESTION 8: FORCES (SPECIFIC)**8.1 System of forces**

8.1.1 Sum of horizontal components:

$$\begin{aligned}
 \sum HC &= -350 \cos 0 + 280 \cos 50 - 300 \cos 30 - 200 \cos 35 \\
 &= -350 \checkmark + 179,98 \checkmark - 251,81 \checkmark - 163,83 \checkmark \\
 &= -593,66 \text{ N } \checkmark
 \end{aligned}
 \tag{5}$$

8.1.2 Sum of vertical components:

$$\begin{aligned}
 \sum VC &= -350 \sin 0 + 280 \sin 50 - 300 \sin 30 - 200 \sin 35 \\
 &= 0 + 214,49 \checkmark - 150 \checkmark - 114,72 \checkmark \\
 &= 249,77 \text{ N } \checkmark
 \end{aligned}$$

OR

Force	θ	Vertical components		Horizontal components	
350	180	$350 \sin 180$	0	$350 \cos 180$	-350
280	50	$280 \sin 50$	214,49	$280 \cos 50$	179,98
300	150	$300 \sin 150$	150	$300 \cos 150$	-259,81
200	215	$200 \sin 215$	-114,72	$200 \cos 215$	-163,83
TOTAL		Y	249,77 N	X	-593,66 N

(4)

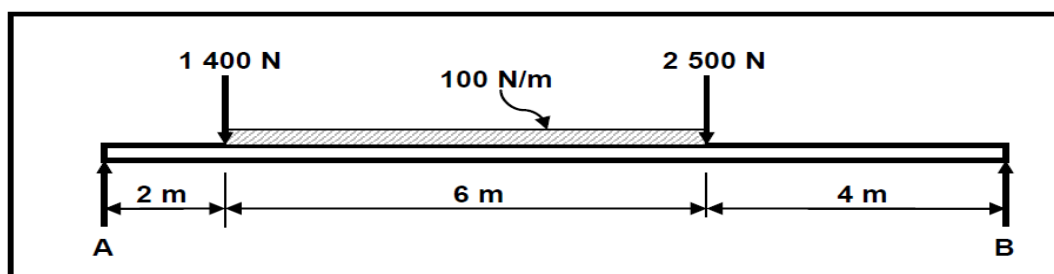
8.1.3 Magnitude of the resultant:

$$\begin{aligned}
 R^2 &= X^2 + Y^2 \\
 &= (593,66)^2 + (249,77)^2 \checkmark \\
 &= \sqrt{414\,817,25} \\
 R &= 644,06 \text{ N } \checkmark
 \end{aligned}
 \tag{2}$$

8.1.4 Angle and the direction of the resultant:

$$\begin{aligned}
 \tan \theta &= \frac{Y}{X} \checkmark \\
 &= \frac{249,77}{593,66} \checkmark \\
 &= \tan^{-1}(0,4207 \dots) \\
 \theta &= 22,82^\circ \text{ N of W } \checkmark \quad \text{OR} \quad 157,82^\circ
 \end{aligned}
 \tag{3}$$

8.2 UDL BEAM



8.2.1 Uniform distributed load

$$6 \times 100 \checkmark$$

$$= 600 \text{ N} \checkmark$$

(2)

8.2.2 Calculate A

Taking moments about B

$$\sum \text{CWM} = \sum \text{ACWM}$$

$$(2\,500 \times 4) + (600 \times 7) + (1\,400 \times 10) = (A \times 12) \checkmark$$

$$\frac{10\,000 + 4\,200 + 14\,000}{12} = \frac{A}{1} \checkmark$$

$$A = 2\,350 \text{ N} \checkmark$$

(3)

8.2.3 Calculate B

Taking moments about A

$$\sum \text{CWM} = \sum \text{ACWM}$$

$$(1\,400 \times 2) + (600 \times 5) + (2\,500 \times 8) = (B \times 12) \checkmark$$

$$\frac{2\,800 + 3\,000 + 20\,000}{12} = \frac{B}{1} \checkmark$$

$$B = 2\,150 \text{ N} \checkmark$$

(3)

8.3 Stress and strain

8.3.1 Stress

$$20 \text{ mm} = 0,02 \text{ m}$$

$$50 \text{ kN} = 50 \times 10^3$$

$$\begin{aligned} A &= \pi r^2 \\ &= \pi (0,01)^2 \checkmark \\ &= 3,14 \times 10^{-4} \text{ m}^2 \checkmark \end{aligned}$$

$$\begin{aligned} \sigma &= \frac{F}{A} \checkmark \\ &= \frac{50 \times 10^3}{3,14 \times 10^{-4}} \checkmark \\ &= 1,59 \times 10^8 \text{ Pa} \checkmark \end{aligned}$$

$$\text{OR } 159,15 \text{ MPa} \quad (5)$$

8.3.2 Strain

$$\begin{aligned}\varepsilon &= \frac{\Delta l}{L} \checkmark \\ &= \frac{605 - 600}{600} \checkmark \\ &= 8,33 \times 10^{-3} \checkmark\end{aligned}\quad (3)$$

8.3.3 Young's modulus of elasticity

$$\begin{aligned}K &= \frac{\sigma}{\varepsilon} \checkmark \\ &= \frac{1,59 \times 10^8}{8,33 \times 10^{-3}} \checkmark \\ &= 1,91 \times 10^{10} \text{ Pa} \checkmark \quad \text{OR} \quad 19,1 \text{ GPa}\end{aligned}\quad (3)$$

[33]

QUESTION 9: MAINTENANCE

9.1 Failure to do maintenance:

- Risk of possible injury or death e.g. brake failure ✓
 - Financial loss due to damages caused by part failure ✓
 - Loss of production time ✓
- (3)

9.2 Coefficient of friction factors:

- Contact pressure ✓
 - Surface roughness ✓
 - Temperature ✓
 - Sliding velocity ✓
 - Type of lubricant ✓
 - Type of material ✓
- (Any 3 x 1) (3)

9.3 Cutting fluid:

- To reduce friction ✓
 - Remove metal chips ✓
 - Take away chips, cool cutting tool and prevent rust ✓
- (Any 1 x 1) (1)

9.4 Preventative maintenance:

9.4.1 V-belt drive:

- Checking for wear and tear on belt ✓
 - Checking belt alignment ✓
 - Checking the tension setting ✓
 - Checking tensioning devices, for example jockey ✓
- (Any 2 x 1) (2)

9.4.2 Gear drive:

- Checking and replenishment of lubrication levels ✓
 - Ensuring that gears are properly secured to shafts ✓
 - Cleaning and replacement of oil filters ✓
 - Reporting excessive noise and wear, vibration and overheating for expect attention ✓
- (Any 2 x 1) (2)

- 9.5 **Reasons for using glass fibre to manufacture motor vehicle bodies:**
- Durable and strong ✓
 - Can be cut and drilled ✓
 - Can be polished to fine finish ✓
 - Can be coloured ✓
 - Fire resistance ✓
 - Low maintenance ✓
 - Weather resistant ✓
 - Lightweight ✓
 - Corrosion resistance ✓
 - Chemical resistance ✓
- (Any 2 x 1) (2)
- 9.6 **Element used to enhance the strength of a glass fibre.**
- Polyester resins ✓
- (1)
- 9.7 **Thermo-hardened or a thermoplastic composite:**
- 9.7.1 Thermoplastic ✓ (1)
- 9.7.2 Thermo-hardened ✓ (1)
- 9.7.3 Thermo-hardened ✓ (1)
- 9.7.4 Thermoplastic ✓ (1)
- [18]**

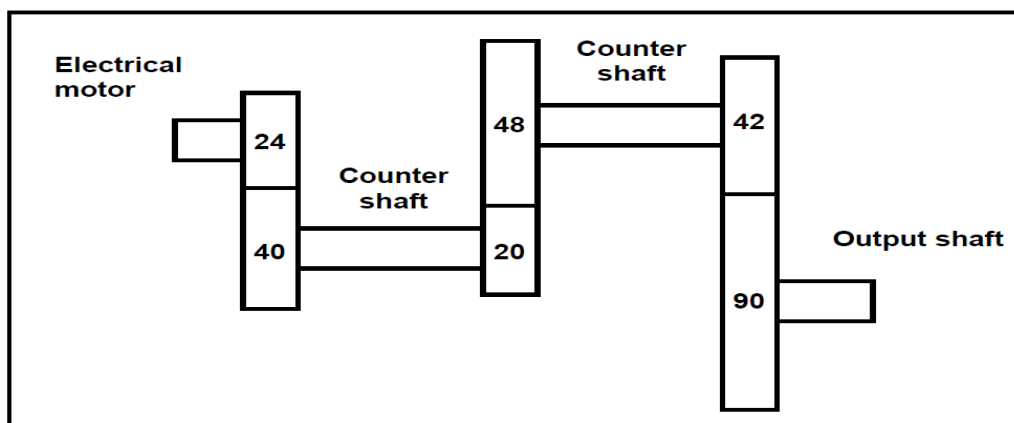
QUESTION 10: JOINING METHODS (SPECIFIC)

- 10.1 **Most common screw thread used in South Africa**
 • Metric screw thread ✓ (1)
- 10.2 **Included angle of screw threads:**
- 10.2.1 V-screw thread 60° ✓ (1)
- 10.2.2 Square screw thread 90° ✓ (1)
- 10.3 **M24 x 2,5**
 • 2,5 is the thread pitch ✓ (1)
- 10.4 **Square thread calculations:**
- 10.4.1 Lead = Pitch x number of starts
 $= 5 \times 2$ ✓
 $= 10 \text{ mm}$ ✓ (2)
- 10.4.2 Pitch diameter = OD – $\frac{1}{2}$ pitch
 $= 82 - \frac{1}{2}(5)$ ✓
 $= 79,5 \text{ mm}$ ✓ (2)
- 10.4.3 Helix angle: $\tan \theta = \frac{\text{lead}}{\text{pitch circumference}}$ ✓
 $\tan \theta = \frac{10}{\pi \times 79,5}$ ✓✓
 $\theta = \tan^{-1}(0,04)$
 $\theta = 2,29^\circ$ ✓ (4)
- 10.4.4 Leading tool angle = $90^\circ - (\text{helix} + \text{clearance angle})$
 $= 90^\circ - (2,29^\circ + 3^\circ)$ ✓
 $= 84,71^\circ$ ✓ (2)
- 10.4.5 Following tool angle = $90^\circ + (\text{helix} - \text{clearance angle})$
 $= 90^\circ + (2,29^\circ - 3^\circ)$ ✓
 $= 89,29^\circ$ ✓ (2)
- 10.5 A multi-start thread allows for a faster travel or movement and is more efficient compared to single-start thread. ✓✓ (2)

[18]

QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)**11.1 Factors to determine the use of gear drives:**

- Where high levels of torque and power have to be transmitted ✓
- Where direction of power transmission has to change ✓
- Where there are restricted spaces ✓
- Where varying rotating speeds are needed ✓ (Any 2 x 1) (2)

11.2 Gear drives:**11.2.1 Rotation frequency of the output:**

$$\frac{N_{\text{input}}}{N_{\text{output}}} = \frac{\text{Product of the driven}}{\text{Product of the drivers}} \quad \checkmark$$

$$\frac{1440 \checkmark}{N_{\text{output}}} = \frac{40 \times 48 \times 90 \checkmark}{24 \times 20 \times 42}$$

$$N_{\text{output}} = \frac{1\,440 \times 24 \times 20 \times 42}{40 \times 48 \times 90}$$

$$= 168 \text{ r/min} \quad \checkmark \quad (4)$$

11.2.2 Velocity ratio

$$\text{VR} = \frac{N_{\text{input}}}{N_{\text{output}}}$$

$$= \frac{1\,440 \checkmark}{168}$$

$$= 8,6 : 1 \quad \checkmark$$

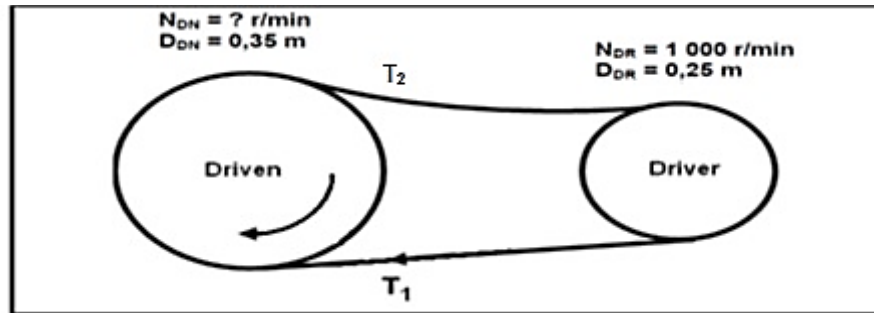
OR

$$\text{Gear ratio} = \frac{\text{Product of the driven}}{\text{Product of the drivers}}$$

$$= \frac{40 \times 48 \times 90 \checkmark}{24 \times 20 \times 42}$$

$$= 8,6 : 1 \quad \checkmark \quad (2)$$

11.3 Belt-drive system:



11.3.3 Rotation frequency

$$N_A \times D_A = N_B \times D_B$$

$$N_A \times 0,35 = 1\,000 \times 0,25 \checkmark$$

$$N_A = \frac{1\,000 \times 0,25}{0,35} \checkmark$$

$$= 714,29 \text{ r/min} \checkmark$$

(3)

$$11.3.3 \quad \text{Belt speed} = \frac{\pi D N}{60} \checkmark$$

$$= \frac{\pi \times 0,25 \times 1\,000}{60} \checkmark$$

$$= 13,09 \text{ m/s} \checkmark$$

(3)

$$11.3.4 \quad \text{Power} = (T_1 - T_2) V \checkmark$$

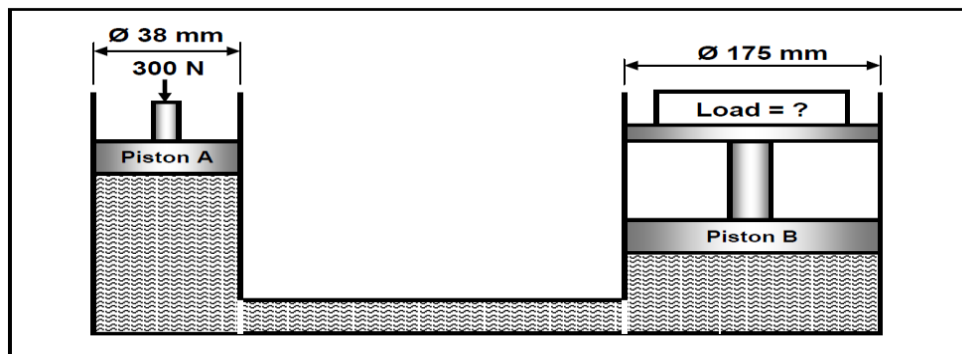
$$= (200 - 90) 13,09 \checkmark$$

$$= 1439,9 \text{ W} \checkmark$$

OR 1,44 kW

(3)

11.4 Hydraulics:



11.4.1 Fluid pressure:

$$38 \text{ mm} = 0,038 \quad r(0,019)$$

$$175 \text{ mm} = 0,175 \quad r(0,0875)$$

$$A_A = \pi r^2$$

$$= \pi (0,019)^2 \checkmark$$

$$= 1,13 \times 10^{-3} \text{ m}^2 \checkmark$$

$$\begin{aligned}
 P &= \frac{F}{A} \checkmark \\
 &= \frac{300}{1,13 \times 10^{-3}} \checkmark \\
 &= 265\,486,72 \text{ Pa} \checkmark \quad \text{OR} \quad 265,49 \text{ kPa} \quad (5)
 \end{aligned}$$

11.4.4 The load that can be lifted by piston B

$$\begin{aligned}
 A_B &= \pi r^2 \\
 &= \pi (0,0875)^2 \checkmark \\
 &= 2,41 \times 10^{-2} \text{ m}^2 \checkmark
 \end{aligned}$$

$$\begin{aligned}
 P &= \frac{F}{A} \checkmark \\
 265\,486,72 &= \frac{\text{load}}{2,41 \times 10^{-2}} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \text{Load} &= 265\,486,72 \times 2,41 \times 10^{-2} \checkmark \\
 &= 6398,22 \text{ N} \checkmark
 \end{aligned}$$

(6)
[28]

TOTAL: 200