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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2025

MECHANICAL TECHNOLOGY: FITTING AND MACHINING MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 21 pages.



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SECTION A: COMPULSORY**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)**

- | | | |
|-----|-----|-------------|
| 1.1 | A ✓ | (1) |
| 1.2 | C ✓ | (1) |
| 1.3 | C ✓ | (1) |
| 1.4 | B ✓ | (1) |
| 1.5 | A ✓ | (1) |
| 1.6 | D ✓ | (1) |
| | | (6 X 1) (6) |

QUESTION 2: SAFETY (GENERIC)**2.1 Safety precautions**

- See that all guards are in place. ✓
 - Make sure that no oil, grease, or obstacles are around the machine. ✓
 - Select the right blade for the material to be cut. ✓
 - Do not adjust guides while the machine is running. ✓
 - All materials must be clamped properly before cutting is started. ✓
 - Long pieces of material must be supported at the end. ✓
 - Always stop machine when you leave it unattended. ✓
- (Any 2 x 1) (2)

2.2 Responsibilities of the employees

- Pay attention to their own and other people's health and safety. ✓
 - Co-operate with the employer regarding the OHS Act. ✓
 - Carry out a lawful order given to them. ✓
 - Report any situation that is unsafe or unhealthy. ✓
 - Report all incidents and accidents. ✓
 - Not to interfere with any safety equipment or misuse such equipment
 - Obey all safety rules. ✓
- (Any 2 x 1) (2)

2.3 Bench grinder

- Use safety goggles at all times when grinding metal. ✓
 - Do not adjust the tool rest while the wheel is in motion. ✓
 - Do not force the workpiece onto or bump it against the emery wheel.
 - Keep fingers away from revolving wheel, especially when grinding small pieces. ✓
 - Grind only on the front surface and never on the sides of an emery wheel. ✓
- (Any 2 x 1) (2)



2.4 Advantages of 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 labor is possible. ✓
- Less total inspection is required. ✓
- Less total floor space is needed per unit of production. ✓

(Any 2 x 1) (2)

2.5 Categories of OHS

- Actions ✓
- Conditions ✓

(2)
[10]



QUESTION 3: MATERIALS (GENERIC)**3.1 Testing materials**

- Sound test ✓
- Bending test ✓
- Filling test ✓
- Machining test
- Hardness test
- Spark test

(Any 3 x 1) (3)

3.2 Carbon groups

- Low carbon steel ✓ 0,15–0,3% ✓
- Medium carbon steel ✓ 0,3–0,75% ✓
- High carbon steel ✓ 0,75–1,7% ✓

(6)

3.3 Purpose of normalizing

- To relieve the internal stresses ✓ produced by machining, forging or welding. ✓

(2)

3.4 Tempering process for steel

- Heat the steel to a temperature below the critical temperature. ✓
- Soak it at that temperature for a period. ✓
- Quench / cool in an appropriate quenching agent. (water, brine, or oil) ✓

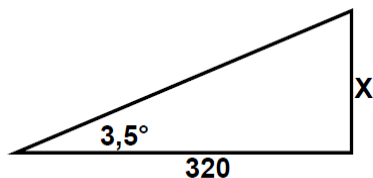
(3)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTION (SPECIFIC)

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

[14]

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)**5.1 Tailstock set over**

$$\tan \frac{\theta}{2} = \frac{X}{320} \checkmark$$

$$X = \tan 3,5^\circ \times 320 \checkmark$$

$$= 19,57 \text{ mm} \checkmark \quad (3)$$

5.2 Keyway

5.2.1 Parallel key OR Pratt and Whitney key OR feather key $\checkmark$ (1)

5.2.2 Length = $1,5 \times D$

Diameter = $\frac{126}{1,5} \checkmark$

= 84 mm $\checkmark$ (2)

5.2.3 Thickness = $\frac{D}{6}$

= $\frac{84}{6} \checkmark$

= 14 mm $\checkmark$ (2)

5.2.4 Width = $\frac{D}{4}$

= $\frac{84}{4} \checkmark$

= 21 mm $\checkmark$ (2)

5.3 Milling processes

Up-cut milling advantages

- Heavier cuts can be taken $\checkmark$
- Hard steels can be cut.
- Life of a milling cutter is extended.
- A coarse feed can be used.
- Strain on the cutter and arbor will be less.
- Heavier cuts can be taken

(Any 1 x 1) (1)

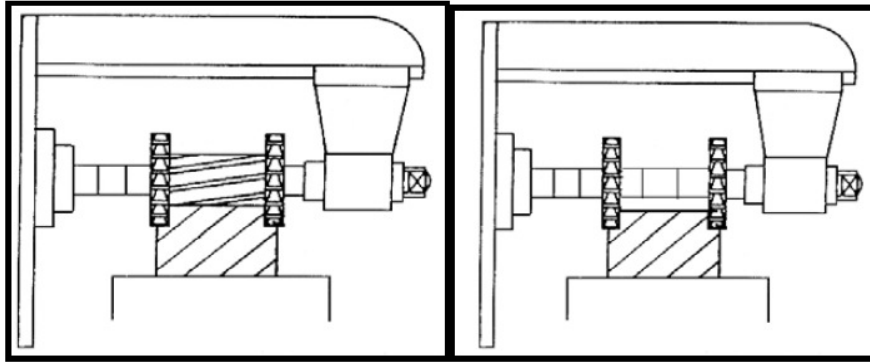


Down-cut milling advantages

- Deeper cuts can be taken ✓
- A finer finish is obtained
- Less vibration is experienced

(Any 1 x 1) (2)

5.4 Difference between gang milling and straddle milling.



Gang milling

Straddle milling

Correct drawing	2 marks each
Labels	1 mark each

(6)
[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)**6.1 Gear terminology****6.1.1 Dedendum**

$$\begin{array}{ll}
 \text{Dedendum} = 1,25 \times m & \text{OR } \text{Dedendum} = 1,157 \times m \\
 \text{Dedendum} = 1,25 \times 2,5 & \text{Dedendum} = 1,157 \times 2,5 \quad \checkmark \\
 = 3,125 \text{ mm} & = 2,89 \text{ mm} \quad \checkmark
 \end{array}$$

(2)

6.1.2 Pitch circle diameter.

$$\begin{aligned}
 \text{PCD} &= \frac{\text{circular pitch (CP)} \times \text{number of teeth (T)}}{\pi} \\
 &= \frac{(m \times \pi) \times T}{\pi} \\
 &= \frac{7,85 \times 25}{\pi} \\
 &= 62,5 \text{ mm}
 \end{aligned}$$

OR

$$\begin{aligned}
 \text{PCD} &= m \times T \\
 &= 2,5 \times 25 \quad \checkmark \\
 &= 62,5 \text{ mm} \quad \checkmark
 \end{aligned}$$

(2)

6.1.3 Outside diameter

$$\begin{aligned}
 \text{Outside Diameter} &= \text{PCD} + 2m \\
 &= 62,5 + 2 \times 2,5 \quad \checkmark \\
 &= 67,5 \text{ mm} \quad \checkmark
 \end{aligned}$$

(2)

6.1.4 Circular pitch

$$\begin{aligned}
 \text{Circular Pitch} &= \pi \times m \\
 &= \pi \times 2,5 \quad \checkmark \\
 &= 7,85 \text{ mm} \quad \checkmark
 \end{aligned}$$

(2)



6.2 Spur gear cutting

6.2.1 Simple indexing

$$\text{Indexing} = \frac{40}{A} \checkmark$$

$$= \frac{40}{100} \checkmark$$

$$= \frac{2}{5} \times \frac{5}{5} \checkmark$$

$$= \frac{10}{25} \checkmark$$

Indexing is 10 holes in 25-hole circle ✓

OR

Indexing is 12 holes in 30-hole circle (4)

6.2.2 Change gears

$$\frac{\text{Driver}}{\text{Driven}} = \frac{A-N}{A} \times \frac{40}{1} \checkmark$$

$$= \frac{100-97}{100} \times \frac{40}{1} \checkmark$$

$$= \frac{120}{100} \checkmark$$

$$= \frac{6}{5} \times \frac{8}{8} \checkmark$$

$$= \frac{48}{40} \checkmark$$

Driver has 48 teeth
Driven has 40 teeth

(5)

6.3 Dovetail calculations

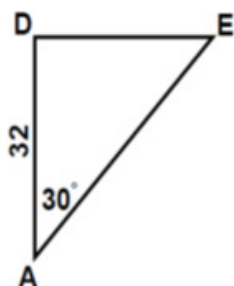
Calculate distance "x" between rollers:

$$X = 120 - 2(DE) + 2(AC) + 2(r)$$

$$Y = 120 - 2(DE)$$

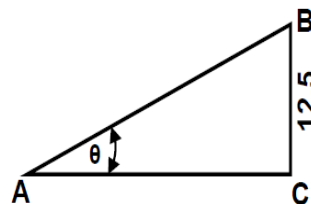
Calculating DE

$$\begin{aligned} \tan \phi &= \frac{DE}{AD} \quad \checkmark \\ DE &= \tan \phi \times AD \quad \checkmark \\ &= \tan 30^\circ \times 32 \quad \checkmark \\ &= 18,48 \text{ mm} \quad \checkmark \end{aligned}$$



Calculating AC

$$\begin{aligned} \tan \phi &= \frac{BC}{AC} \quad \checkmark \\ AC &= \frac{BC}{\tan \phi} \quad \checkmark \\ &= \frac{12,5}{\tan 30^\circ} \quad \checkmark \\ &= 21,65 \text{ mm} \quad \checkmark \end{aligned}$$



Calculating Y

$$\begin{aligned} Y &= 120 - 2(DE) \\ &= 120 - 2(18,48) \quad \checkmark \\ &= 83,04 \text{ mm} \quad \checkmark \end{aligned}$$

Calculating X

$$\begin{aligned} X &= 120 - 2(DE) + 2(AC) + 2(r) \quad \checkmark \\ &= 120 - 2(18,48) + 2(21,65) + 2(12,5) \quad \checkmark \\ &= 83,04 + 43,3 + 25 \\ &= 151,34 \text{ mm} \quad \checkmark \end{aligned}$$

(11)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)**7.1 Difference between hardness and toughness****Hardness**

Material's ability to resist deformation, abrasion, indentation, penetration or scratching and wear ✓✓

Toughness

Material's ability to withstand shock loads without bending or cracking ✓✓ (4)

7.2 Hardness testing

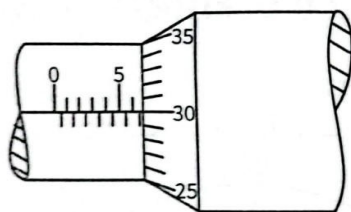
7.2.1 Brinell hardness testing ✓ (1)

7.2.2 Label parts

A – Applied force ✓

B – Indenter or indenter diameter ✓

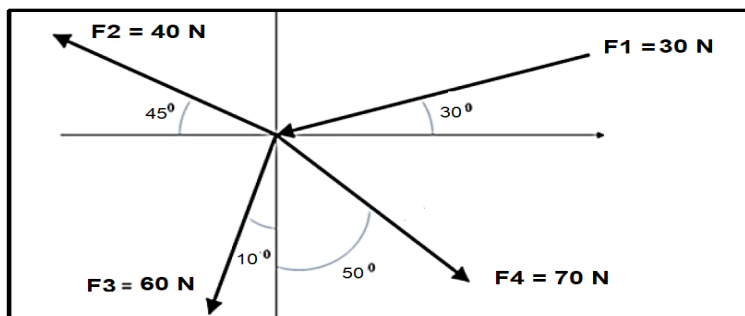
C – Indentation diameter ✓ (3)

7.3 Screw thread micrometer reading

$$\text{Reading} = 6 \text{ mm} + 0,5 \text{ mm} + 0,3 \text{ mm} = 6,80 \text{ mm}$$

Drawing	2 marks
Correct reading	3 marks
6 mm ✓ 0,5 mm ✓ 0,3 mm ✓	

(5)
[13]

QUESTION 8: FORCES (SPECIFIC)**8.1 System of forces****8.1.1 Sum of horizontal components**

$$\begin{aligned}
 \Sigma HC &= -30 \cos 30 - 40 \cos 45 - 60 \cos 80 + 70 \cos 40 \\
 &= -25,98 \checkmark - 28,28 \checkmark - 10,42 \checkmark + 53,62 \checkmark \\
 &= -11,06 \text{ N } \checkmark
 \end{aligned}
 \tag{5}$$

8.1.2 Sum of vertical components

$$\begin{aligned}
 \Sigma VC &= -30 \sin 30 + 40 \sin 45 - 60 \sin 80 - 70 \sin 40 \\
 &= -15 \checkmark + 28,28 \checkmark - 59,09 \checkmark - 45 \checkmark \\
 &= -90,81 \text{ N } \checkmark
 \end{aligned}
 \tag{5}$$

OR

Force	θ	Vertical components		Horizontal components	
30	210	$30 \sin 210$	- 15 ✓	$30 \cos 210$	-25,98 ✓
40	135	$40 \sin 135$	28,28 ✓	$40 \cos 135$	-28,28 ✓
60	260	$60 \sin 260$	-59,09 ✓	$60 \cos 260$	-10,42 ✓
70	320	$70 \sin 320$	-45 ✓	$70 \cos 320$	53,62 ✓
TOTAL		Y	-90,81 N ✓	X	-11,06N ✓

8.1.3 Magnitude of the resultant

$$\begin{aligned}
 R^2 &= X^2 + Y^2 \\
 &= (11,06)^2 + (90,81)^2 \checkmark \\
 &= \sqrt{8368,7797} \\
 R &= 91,48 \text{ N } \checkmark
 \end{aligned}
 \tag{2}$$

8.1.4 Angle and the direction of the resultant

$$\begin{aligned}
 \tan \theta &= \frac{Y}{X} \\
 &= \frac{90,81}{11,06} \checkmark \\
 &= \tan^{-1} (8,21066....) \\
 \theta &= 83,10^\circ \text{ S of W } \checkmark \quad \text{OR} \quad 263,10^\circ
 \end{aligned}
 \tag{2}$$



8.2 Stress and Strain

8.2.1 Diameter of the shaft

$$60 \text{ kN} = 50 \times 10^3$$

$$30 \text{ MPa} = 30 \times 10^6$$

$$\sigma = \frac{F}{A}$$

$$A = \frac{F}{\sigma} \checkmark$$

$$= \frac{60 \times 10^3}{30 \times 10^6} \checkmark$$

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

$$A = \pi r^2$$

$$r^2 = \frac{A}{\pi}$$

$$r = \sqrt{\frac{2 \times 10^{-3}}{\pi}} \checkmark$$

$$= 25 \times 10^{-3}$$

$$D = 50,46 \times 10^{-3} \text{ m}$$

$$= 50,46 \text{ mm} \checkmark$$

(5)

8.2.2 Strain

$$K = \frac{\sigma}{\varepsilon} \checkmark$$

$$\varepsilon = \frac{\sigma}{K}$$

$$= \frac{30 \times 10^6}{90 \times 10^9} \checkmark$$

$$= 3,33 \times 10^{-4} \checkmark$$

(3)

8.2.2 Change in length

$$\varepsilon = \frac{\Delta l}{L} \checkmark$$

$$\Delta L = \varepsilon \times L \checkmark$$

$$= 3,33 \times 10^{-4} \times 2$$

$$= 6,67 \times 10^{-4} \text{ m} \checkmark$$

$$= 0,67 \text{ mm}$$

(3)

8.3 Moments

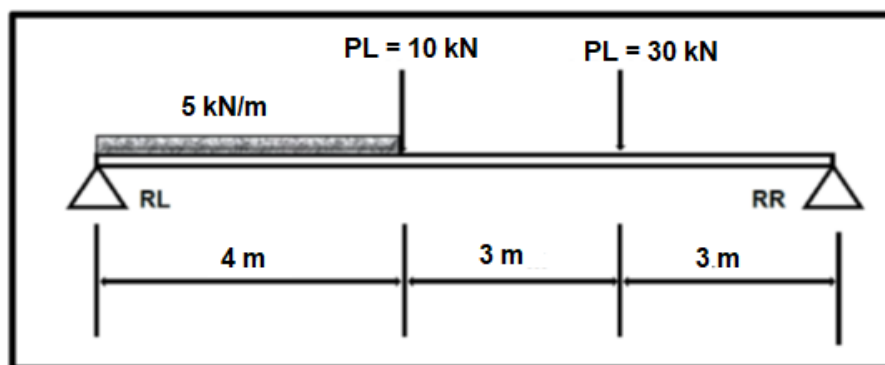


FIGURE 8.3

8.3.1 Uniform Distributed Load

$$\begin{aligned} &5 \text{ kN/m} \times 4 \text{ m} \checkmark \\ &= 20 \text{ kN} \checkmark \end{aligned} \quad (2)$$

8.3.2 Taking moments about RL

$$\begin{aligned} \sum \text{CWM} &= \sum \text{ACWM} \\ (20 \times 2) + (10 \times 4) + (30 \times 7) &= (\text{RR} \times 10) \checkmark \\ \frac{40 + 40 + 210}{10} &= \frac{10 \text{ RR}}{10} \checkmark \\ \text{RR} &= 29 \text{ kN} \checkmark \end{aligned} \quad (3)$$

8.3.3 Taking moments about RR

$$\begin{aligned} \sum \text{CWM} &= \sum \text{ACWM} \\ (30 \times 3) + (10 \times 6) + (20 \times 8) &= (\text{RL} \times 10) \checkmark \\ \frac{90 + 60 + 160}{10} &= \frac{10 \text{ RL}}{10} \checkmark \\ \text{RL} &= 31 \text{ kN} \checkmark \end{aligned} \quad (3)$$

[33]

QUESTION 9: MAINTENANCE**9.1 Preventative maintenance sub-groups**

- Planned or scheduled maintenance ✓
- Condition based maintenance ✓ (2)

9.2 Chain drive maintenance

- Cleaning uncovered chain drives ✓
- Check sprocket teeth and link plate wear ✓
- Lubricating chain drives (manually or automatically) ✓
- Checking the functioning of tensioning devices (idler sprocket)
- Inspect chains regularly for elongation and record results (Any 3 x 1) (3)

9.3 Cutting fluid maintenance

- Check that there is sufficient flow of cutting fluid to the cutting tool ✓
- Ensure that the sump is topped up from time to time ✓
- Remove metal cutting from the machine's splash tray. ✓
- Avoid contamination of the cutting fluid by draining and regularly replacing it. (Any 3 x 1) (3)

9.4 Viscosity

Viscosity is the resistance of a fluid to flow. ✓✓ (2)

9.5 Advantageous characteristics for using nylon

- Toughness ✓
- Hard-wearing ✓
- Needs little or no maintenance
- Needs no lubrication
- It is cheap
- It is light
- Can absorb shock
- Resistant to chemicals
- Endures high temperatures (Any 2 x 1) (2)

9.6 Uses of Materials**9.6.1 Teflon**

- Orthopaedic and prosthetic appliances ✓
- Hearing aids
- Joints
- Upholstery
- Corrosion resistant mechanical parts (taps and bearings)
- Electrical insulation
- Non-stick coatings for cooking utensils (Any 1 x 1) (1)

9.6.2 **Glass fibre**

Motor vehicle bodies ✓

Boats

Transparent roofing sheets

Petrol tanks

Swimming pools

Furniture

Fruit and salad bowls

Ornaments

Fishing rods

(1)

9.7 **True or False**

9.7.1 True ✓

(1)

9.7.2 False ✓

(1)

9.7.3 False ✓

(1)

9.7.4 True ✓

(1)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)**10.1 Pitch of screw thread**

- The pitch is the axial distance measured from any given point on the screw thread ✓ to a corresponding point on an adjacent thread. ✓ (2)

10.2 Square thread terminology

- A – Crest/outside diameter ✓
- B – Effective/mean diameter or pitch diameter ✓
- C – Pitch ✓
- D – Helix angle ✓
- E – Cutting tool ✓ (5)

10.3 Square Thread Calculations:

$$\begin{aligned}
 10.3.1 \quad \text{Lead} &= \text{Pitch} \times \text{number of starts} \\
 &= 6 \times 3 \checkmark \\
 &= 18 \text{ mm} \checkmark \quad (2)
 \end{aligned}$$

$$\begin{aligned}
 10.3.2 \quad \text{Mean diameter} &= \text{OD} - \frac{1}{2} \text{ pitch} \\
 &= 78 - \frac{1}{2} (6) \checkmark \\
 &= 75 \text{ mm} \checkmark \quad (2)
 \end{aligned}$$

$$\begin{aligned}
 10.3.3 \quad \text{Helix angle: } \tan \theta &= \frac{\text{lead}}{\text{pitch circumference}} \\
 \tan \theta &= \frac{18}{\pi \times 75} \checkmark \checkmark \\
 \theta &= \tan^{-1}(0,0763...) \\
 \theta &= 4,37^\circ \checkmark \quad (3)
 \end{aligned}$$

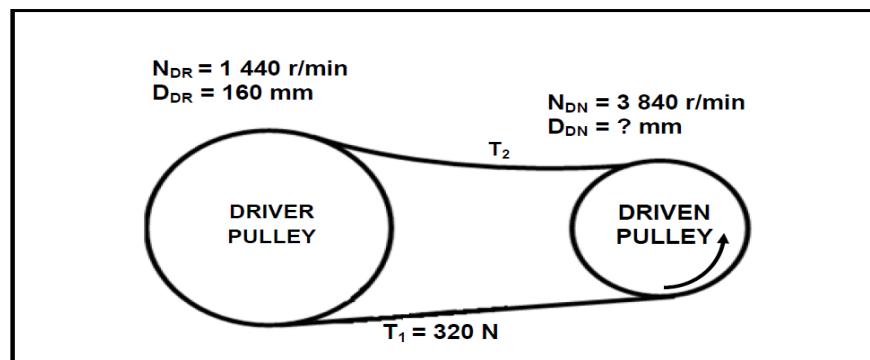
$$\begin{aligned}
 10.3.4 \quad \text{Leading tool angle} &= 90^\circ - (\text{helix} + \text{clearance angle}) \\
 &= 90^\circ - (4,37^\circ + 3^\circ) \checkmark \\
 &= 82,63^\circ \checkmark \quad (2)
 \end{aligned}$$

$$\begin{aligned}
 10.3.5 \quad \text{Following tool angle} &= 90^\circ + (\text{helix} - \text{clearance angle}) \\
 &= 90^\circ + (4,37^\circ - 3^\circ) \checkmark \\
 &= 91,37^\circ \checkmark \quad (2)
 \end{aligned}$$

[18]

QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)**11.1 Function of a belt**

- Transfer motion from pulley **A** ✓ to pulley **B**. ✓ (2)

11.2 Belt drives:**11.2.1 Diameter of the driven pulley**

$$N_{DN} \times D_{DN} = N_{DR} \times D_{DR} \quad \checkmark$$

$$D_{DN} = \frac{N_{DR} \times D_{DR}}{N_{DN}} \quad \checkmark$$

$$D_{DN} = \frac{1440 \times 0,16}{3840}$$

$$D_{DN} = 0,06 \text{ m} \quad \checkmark$$

$$= 60 \text{ mm}$$

(3)

11.2.2 Power transmitted

$$\frac{T_1}{T_2} = 2,5 \quad \checkmark$$

$$T_2 = \frac{320}{2,5} \quad \checkmark$$

$$T_2 = 128 \text{ N} \quad \checkmark$$

$$P = \frac{(T_1 - T_2) \times D_{DN}}{60} \quad \checkmark$$

$$P = \frac{(320 - 128) \times 0,16 \times 1440}{60} \quad \checkmark$$

$$P = 2316,23 \text{ Watt} \quad \checkmark$$

(5)

NOTE: If driven diameter and speed is used to calculate power, mark correct, i.e. 2 316,23 Watt.



11.3 Speed ratio

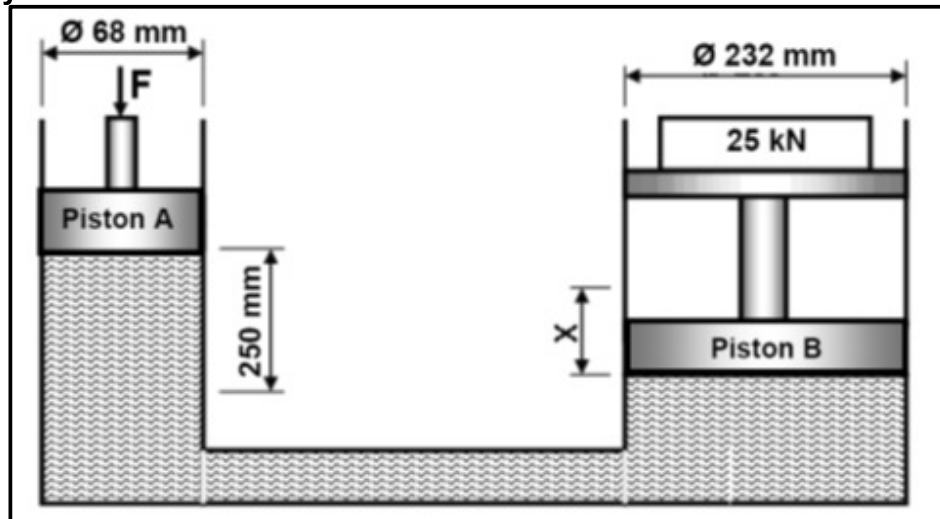
$$\text{Speed ratio} = \frac{\text{Driven}}{\text{Driver}} \checkmark$$

$$= \frac{60}{15} \checkmark$$

$$= 4 : 1 \checkmark$$

(3)

11.4 Hydraulics:



11.4.1 Fluid pressure

$$A_B = \frac{\pi D^2}{4}$$

$$A_B = \frac{\pi (0,232)^2}{4} \checkmark$$

$$A_B = 42,27327 \times 10^{-3} \text{ m}^2 \checkmark$$

$$P = \frac{F_B}{A_B} \checkmark$$

$$P = \frac{25 \times 10^3}{42,27 \times 10^{-3}} \checkmark$$

$$= 591\,390,25 \text{ Pa}$$

$$= 0,59 \text{ MPa} \checkmark$$

(5)

11.4.2 Force F on piston A

$$A_A = \frac{\pi D^2}{4}$$

$$A_A = \frac{\pi \times (0,068)^2}{4} \quad \checkmark$$

$$A_A = 3,631\,683 \times 10^{-3} \text{ m}^2$$

$$P_A = P_B \quad \checkmark$$

$$P_A = \frac{F_A}{A_A}$$

$$F_A = P_A \times A_A \quad \checkmark$$

$$F_A = (0,59 \times 10^6) (3,63 \times 10^{-3}) \quad \checkmark$$

$$F_A = 2\,147,74 \text{ N}$$

$$F_A = 2,15 \text{ kN} \quad \checkmark$$

OR

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \quad \checkmark$$

$$F_1 = \frac{F_2 \times A_1}{A_2} \quad \checkmark$$

$$= \frac{25 \times 10^3 \times 3,63 \times 10^{-3}}{42,27 \times 10^{-3}} \quad \checkmark$$

$$= 2\,147,7 \text{ N} \quad \checkmark$$

$$= 2,15 \text{ kN} \quad \checkmark$$

(5)

11.4.3 Distance X

$$V_B = V_A \quad \checkmark$$

$$A_B \times X = A_A \times L_A$$

$$X = \frac{A_A \times L_A}{A_B} \quad \checkmark$$

$$X = \frac{(3,63 \times 10^{-3}) (0,25)}{42,27 \times 10^{-3}} \quad \checkmark$$

$$X = 21,48 \text{ mm/stroke}$$

$$\text{for 10 strokes} = 21,48 \times 10 \quad \checkmark$$

$$= 214,8 \text{ mm}$$

$$\text{Movement of piston B} = 214,8 \text{ mm} \quad \checkmark$$



ORWork done at _B = Work done at _A

$$F_B \times d_B = F_A \times d_A \quad \checkmark$$

$$d_B = \frac{F_A \times d_A}{F_B} \quad \checkmark$$

$$d_B = \frac{2147,7 \times 0,25}{25000} \quad \checkmark$$

$$d_B = 21,48 \text{ mm/stroke} \quad \checkmark$$

$$\text{for 10 strokes} = 21,48 \times 10 \quad \checkmark$$

$$= 214,8 \text{ mm}$$

$$\text{Movement of piston B} = 214,8 \text{ mm} \quad \checkmark$$

(5)

[28]**TOTAL: 200**