basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

2023

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 25 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 C ✓ (1)

1.2 A ✓ (1)

1.3 A ✓ (1)

1.4 C ✓ (1)

1.5 B ✓ (1)

1.6 A ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Safety rule after the work procedures:**
Switch off the machine. ✓ (1)

2.2 **Space between the tool rest and the emery wheel:**
- To prevent the work piece from jamming between the wheel and tool rest. ✓
- Prevents the wheel from being damaged. ✓
- Prevents the work piece from being damaged. ✓
- Prevent injury. ✓

(Any 2 x 1) (2)

2.3 **Workshop layouts:**

2.3.1 Process layout. ✓ (1)

2.3.2 Product layout. ✓ (1)

2.4 **Hydraulic press:**
- Safety goggles ✓
- Safety gloves ✓
- Safety shoes ✓
- Overall ✓

(Any 1 x 1) (1)

2.5 **Safety guard on the portable angle grinder:**
- To protect one against sparks/metal particles. ✓
- To protect one from a breaking disc. ✓
- To protect your hand from coming into contact with the disc. ✓

(Any 1 x 1) (1)

2.6 **Shearing/Guillotine machine:**
- Follow the manufactures recommendations. ✓
- Keep hands away from action points. ✓
- Do not exceed the maximum material thickness. ✓
- Ensure that all guards are in place and secure. ✓
- Report defects immediately. ✓

(Any 1 x 1) (1)

2.7 **Storing gas cylinders:**

- Upright position ✓
- Stored at 20°C / cool area ✓
- Empty cylinders stored separately from full cylinder. ✓
- Never store cylinders on top of each other. ✓
- Oxygen cylinders separate from fuel cylinders. ✓
- Secure gas cylinders. ✓
- Ensure that cylinders are properly closed. ✓
- Stored away from sparks / flammable material/ electrical switches. ✓
- Stored in a well-ventilated area. ✓
- Safety signs should be displayed. ✓
- Keep cylinders clearly labelled (Full/Empty). ✓

(Any 2 x 1) (2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **Purpose of tempering:**

- To relieve ✓ strain / brittleness. ✓
- To increase ✓ the toughness of the steel. ✓
- To refine ✓ grain structure. ✓

(Any 1 x 2) (2)

3.2 **Heat treatment processes:**

3.2.1 **Case hardening:**

- To obtain a wear-resistant surface ✓ and at the same time be tough enough internally at the core ✓ to withstand the applied loads.
- For a hard case ✓over a tough core. ✓

(Any 1 x 2) (2)

3.2.2 **Annealing:**

- To relieve ✓ internal stresses. ✓
- To soften ✓ steel. ✓
- Facilitate ✓ the machining processes. ✓
- Increase ✓ the steel's ductility. ✓
- Reduce ✓ brittleness. ✓

(Any 1 x 2) (2)

3.3 **Spark test:**

- Hold steel against grinding wheel. ✓
- Observe the spark pattern to identify the type of steel. ✓ (2)

3.4 **Tests:**

3.4.1 **Filing test:**
File on the tip or near the edge ✓ of the material. The bite will determine the hardness. ✓ (2)

3.4.2 **Bend test:**

- Metal is subjected to deformation by bending. ✓
- Observe the rupture of the metal. ✓ (2)

3.5 **Sound test on steel:**

3.5.1 **Low carbon steel (LCS):**
Dull (low pitch)✓ sound. (1)

3.5.2 **High carbon steel (HCS):**
Loud and clear (high pitch) ✓ sound. (1)
[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

QUESTION 5: TERMINOLOGY (LATHE AND MILLING MACHINE) (SPECIFIC)

Screw-cutting dial:

5.1 A. Lead screw ✓
B. Dial ✓
C. Worm wheel / worm gear ✓ (3)

5.2 **Taper:**

5.2.1 **Length of taper:**

$$\text{Tan}\frac{\theta}{2} = \frac{\text{D} - \text{d}}{2 \times \text{L}}$$

$$\text{Tan}\,5{,}5° \overset{\checkmark}{=} \frac{\text{D} - \text{d}}{2 \times \text{L}}$$

$$\text{L} = \frac{\text{D} - \text{d}}{2 \times \text{Tan}\,5{,}5°} \checkmark$$

$$\text{L} = \frac{65 - 45}{2 \times \text{Tan}\,5{,}5°} \checkmark$$

$$\text{L} = 103{,}85 \text{ mm} \checkmark$$

(4)

5.2.2 **Tailstock set-over:**

$$x = \frac{\text{L}(\text{D} - \text{d})}{2 \times l}$$

$$x = \frac{103{,}85\,(65 - 45)}{2 \times 103{,}85} \checkmark \checkmark$$

$$x = 10 \text{ mm} \checkmark$$

OR

$$x = \frac{\text{D} - \text{d}}{2} \checkmark$$

$$x = \frac{65 - 45}{2} \checkmark$$

$$x = 10 \text{ mm} \checkmark$$

(3)

5.3 **Parallel key:**

Width:

5.3.1

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

$$= \frac{70}{4} \checkmark$$

$$= 17{,}50 \text{ mm} \checkmark$$

(2)

Thickness:

5.3.2 $\text{Thickness} = \frac{D}{6}$

$= \frac{70}{6}$ ✓

$= 11{,}67$ mm ✓ (2)

Length:

5.3.3 Length = 1,5 x diameter of shaft

= 1,5 x 70 ✓

= 105 mm ✓ (2)

5.4 **Mean diameter:**

Mean Diameter = OD – (½ x P)

= 38 – 2 ✓

= 36 mm ✓ (2)

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QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **Cutting gear:**

6.1.1 **Number of teeth:**

$$\text{Module} = \frac{\text{PCD}}{\text{T}}$$

$$\text{Teeth} = \frac{\text{PCD}}{\text{Module}} \checkmark$$

$$= \frac{120}{3} \checkmark$$

$$= 40 \text{ teeth} \checkmark$$

(3)

6.1.2 **Dedendum:**

Dedendum = 1,157(m)
= 1,157 x 3 ✓
= 3,47 mm ✓

OR

= 1,25(m)
= 1,25 x 3 ✓
= 3,75 mm ✓

(2)

6.1.3 **Outside diameter:**

OD = PCD + 2(m)
= 120 + 2(3) ✓
= 126 mm ✓

OR

= m(T + 2)
= 3(40 + 2) ✓
= 126 mm ✓

(2)

6.1.4 **Circular pitch:**

CP = m x π
= 3 x π ✓
= 9,42 mm ✓

(2)

6.2 **Dovetail:**

6.2.1 **Angle θ:**

$$(x)\text{AC} = \frac{166{,}96 - 112{,}32 - 2(10)}{2} \checkmark \checkmark$$
$$= 17{,}32 \text{ mm} \checkmark$$

$$\text{Tan}\alpha = \frac{\text{BC}}{\text{AC}}$$
$$\text{Tan}\alpha = \frac{10}{17{,}32} \checkmark$$
$$\alpha = 30{,}00° \checkmark$$
$$\theta = 30° \times 2$$
$$\theta = 60° \checkmark$$

(6)

6.2.2 **Minimum width (w) distance:**

DE:

$$\text{Tan}\frac{\theta}{2} = \frac{\text{DE}}{\text{AD}} \checkmark$$

DE = tanθ x AD

= tan30° x 32 ✓

= 18,48 mm ✓

OR

$$\text{Tan}\theta = \frac{\text{AD}}{\text{DE}}$$
$$\text{DE} = \frac{\text{AD}}{\text{Tan}\theta} \checkmark$$
$$= \frac{32}{\text{Tan}60°} \checkmark$$
$$= 18{,}48 \text{ mm} \checkmark$$

w = 166,96 – 2(DE) ✓

= 166,96 – 2(18,48) ✓

= 166,96 – 36,96

= 130 mm ✓

(6)

6.3 **Milling of spur gear:**

6.3.1 **Indexing:**

$$\text{Indexing} = \frac{40}{N}$$
$$= \frac{40}{140} \quad ✓$$
$$= \frac{2}{7} \times \frac{4}{4}$$
$$= \frac{8}{28} \quad ✓$$

Approximate indexing: 8 holes on a 28-hole circle ✓

OR

12 holes on a 42-hole circle ✓

OR

14 holes on a 49-hole circle ✓ (3)

6.3.2 **Change gears:**

$$\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}$$
$$\frac{Dr}{Dn} = (140 - 137) \times \frac{40}{140} \quad ✓$$
$$= 3 \times \frac{40}{140}$$
$$= \frac{120}{140}$$
$$= \frac{6}{7} \times \frac{4}{4} ✓ \quad \textbf{OR} \quad \frac{6}{7} \times \frac{8}{8} ✓$$
$$\frac{Dr}{Dn} = \frac{24}{28} ✓ ✓ \quad \textbf{OR} \quad \frac{48}{56} ✓ ✓$$

(4)
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QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Hardness indenters:**

7.1.1 **Rockwell hardness tester:**
- Diamond cone / Pyramid ✓
- Hardened steel-ball indenter ✓

(Any 1 x 1) (1)

7.1.2 **Brinell hardness tester:**
Hardened carbide steel-ball indenter ✓ (1)

7.2 **Label Rockwell tester:**
A. Hardness indicator meter ✓
B. Platform ✓
C. Platform height adjuster ✓
D. Activating knob ✓ (4)

7.3 **Identify screw thread:**

7.3.1 Metric ✓ (1)

7.3.2 Crest diameter/Outside diameter/Major diameter/Nominal diameter ✓ (1)

7.3.3 Pitch ✓ (1)

7.4 **Screw thread micrometer:**

A. Adjustable anvil / Spindle ✓
B. Lock ✓
C. Barrel / Sleeve ✓
D. Ratchet / Ratchet stop ✓ (4)

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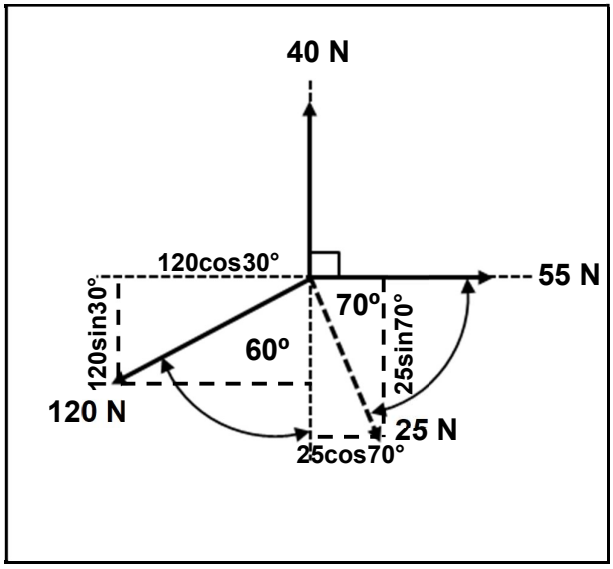
QUESTION 8: FORCES (SPECIFIC)

8.1 **System of forces:**



8.1.1 **Horizontal component:**

$$\sum HC = 55\cos 0° + 40\cos 90° - 120\cos 30° + 25\cos 70°$$

$$\sum HC = \overset{\checkmark}{55} + \overset{\checkmark}{0} - \overset{\checkmark}{103,92} + \overset{\checkmark}{8,55}$$

$$\sum HC = -40,37 \text{ N} \checkmark$$ (4)

8.1.2 **Vertical component:**

$$\sum VC = 55\sin 0° + 40\sin 90° - 120\sin 30° - 25\sin 70°$$

$$\sum VC = 0 + \overset{\checkmark}{40} - \overset{\checkmark}{60} - \overset{\checkmark}{23,49}$$

$$\sum VC = -43,49 \text{ N} \checkmark$$ (4)

OR

Force	θ	∑VC/y = Fsinθ		∑HC/x = Fcosθ	
55N	0º	VC = 55sin0º	0 N	HC = 55cos0º	55 N ✓
40N	90º	VC = 40sin90º	40N ✓	HC = 40cos90º	0 N
120N	210º	VC = 120sin210º	-60 N ✓	HC = 120cos210º	-103,92 N✓
25N	290º	VC = 25sin290º	-23,49 N ✓	HC = 25cos290º	8,55 N ✓
		Total	**-43,49 N** ✓		**-40,37 N** ✓

(8)

8.1.3 **Resultant:**

$$R^2 = VC^2 + HC^2$$

$$\sqrt{R^2} = \sqrt{(-43,49)^2 + (-40,37)^2} \checkmark$$

$$R = 59,34 \text{ N} \checkmark$$

(2)

8.1.4 **Angle of resultant:**

$$\tan\theta = \frac{VC}{HC}$$

$$\theta = \tan^{-1}\left(\frac{-43,49}{-40,37}\right) \checkmark$$

$$\theta = \tan^{-1}(1,077)$$

$$\theta = 47,13^\circ \checkmark$$

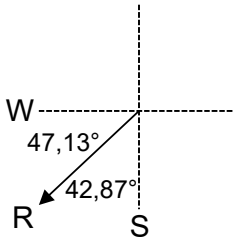
(2)

8.1.5 **Direction of resultant:**

$R = 59,34 \text{ N} \quad 47,13^\circ \text{ South of West}$ ✓

OR

$R = 59,34 \text{ N} \quad 42,87^\circ \text{ West of South}$ ✓



OR

At a bearing of 222,87° ✓

(1)

8.2 **UDL beam:**

UDL:

8.2.1 UDL = 10 x 9
= 90 N ✓ (1)

Reaction in support A:

8.2.2 **Moments about B:**
$\sum LHM = \sum RHM$

$$(75 \times 12) + (90 \times 4,5) = (A \times 9)$$
$$900 + 405 = 9A$$
$$A = \frac{1305}{9}$$
$$A = 145 \text{ N} \checkmark$$ (4)

Reaction in support B:

8.2.3 **Moments about A:**
$\sum LHM = \sum RHM$

$$(B \times 9) + (75 \times 3) = (90 \times 4,5) + (60 \times 9)$$
$$9B + 225 = 405 + 540$$
$$9B = 720$$
$$B = \frac{720}{9}$$
$$B = 80 \text{ N} \checkmark$$ (5)

8.3 **Stress:**

8.3.1 **Side length in millimetres:**

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

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

$$L^2 = \frac{45 \times 10^3}{9 \times 10^6} \quad \checkmark$$

$$L = \sqrt{5 \times 10^{-3}} \quad \checkmark$$

$$L = 0{,}07071 \text{ m}$$

$$L = 70{,}71 \text{ mm} \checkmark$$ (4)

8.3.2 **The strain:**

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

$$\varepsilon = \frac{\sigma}{E} \quad \checkmark$$

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

$$\varepsilon = 1 \times 10^{-4} \checkmark$$ (3)

8.3.3 **The original length:**

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

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

$$OL = \frac{0{,}15}{1 \times 10^{-4}} \checkmark$$

$$OL = 1500 \text{ mm} \checkmark$$ (3)

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QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Reasons for conducting maintenance on an operating system:**

- To prevent failure ✓ of particular parts. ✓
- To prevent failure ✓ of whole system. ✓
- To ensure optimal ✓ operation. ✓

(Any 1 x 2) (2)

9.2 **Belts:**

- V belts ✓
- Wedge belts ✓
- Flat belts ✓
- Cogged belts/Toothed belts ✓
- Round belts ✓

(Any 3 x 1) (3)

9.3 **Preventative maintenance procedures:**

- Cleaning uncovered chain drives. ✓
- Check sprocket and link plate wear. ✓
- Refilling reservoirs lubricant or lubricating chains. ✓
- Checking functioning of tensioning devices. ✓
- Inspecting chains regularly for elongation. ✓
- Make sure that drives are properly fitted. ✓

(Any 3 x 1) (3)

9.4 **Properties:**

9.4.1 **Nylon:**

- Stiff ✓ (when it is short and thick)
- Tough ✓
- Low lubrication ✓
- Light ✓
- Can absorb shock ✓
- Can endure high temperatures ✓
- Non toxic ✓
- Strong ✓
- Hard ✓ (wear resistant)
- Chemical resistance ✓
- Recyclable ✓
- Flexible ✓ (when long and thin)

(Any 2 x 1) (2)

9.4.2 **Fibreglass:**

- Good fatigue resistance ✓
- Heat resistance ✓
- Tough ✓
- Semi rigid ✓
- Can be machined ✓
- Good chemical resistant ✓
- Strong ✓
- Water resistant ✓
- Flexible ✓
- Light weight ✓

(Any 2 x 1) (2)

9.4.3 **PVC:**

- Semi rigid ✓
- Flexible ✓
- Corrosion resistant ✓
- Tough ✓

(Any 2 x 1) (2)

9.5 **Use of each of the following materials:**

9.5.1 **Bakelite:**

- Casings ✓
- Electrical insulators ✓
- Kitchenware ✓
- Jewellery ✓
- Pipe stems ✓
- Toys ✓
- Distributor rotor ✓
- Disc brake systems ✓
- Saucepan handles ✓
- Electrical plugs ✓
- Parts in electrical appliance ✓
- Aircraft components ✓
- Bearings ✓
- Laminated materials ✓

(Any 1 x 1) (1)

9.5.2 **Carbon fibre:**

- Sport equipment ✓
- Bicycle frames ✓
- Surf boards ✓
- Boats ✓
- Compressor/Helicopter blades ✓

(Any 1 x 1) (1)

9.5.3 **Nylon:**

- Bushes ✓
- Gears ✓
- Pulleys ✓
- Ropes ✓

(Any 1 x 1) (1)

9.6 **Vesconite:**

Yes ✓ (1)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Square thread:**

10.1.1 **Pitch diameter:**

$$\text{Lead} = \text{Pitch} \times \text{Number of starts}$$

$$\text{Pitch} = \frac{\text{Lead}}{\text{Number of starts}} \quad \checkmark$$

$$= \frac{46}{2} \quad \checkmark$$

$$= 23 \text{ mm} \checkmark$$

$$D_p = OD - \frac{P}{2}$$

$$= 85 - \frac{23}{2} \checkmark$$

$$= 73{,}50 \text{ mm} \checkmark$$ (5)

10.1.2 **Helix angle of the thread:**

$$\text{Tan}\,\theta = \frac{\text{Lead}}{\pi \times D_P}$$

$$\text{Tan}\,\theta = \frac{46 \checkmark}{\pi \times 73{,}5} \checkmark$$

$$\theta = \tan^{-1}(0{,}19921435)$$

$$= 11{,}27° \checkmark$$ (3)

10.1.3 **Leading tool angle:**

Leading tool angle = 90° – (helix + clearance angle)

= 90° – (11,27° + 3°) ✓

= 75,73° **OR** 75°43' ✓ (2)

10.1.4 **Following tool angle:**

Following tool angle = 90° + (helix angle – clearance angle)

= 90° + (11,27° – 3°) ✓

= 98,27° **OR** 98°16' ✓ (2)

10.2 **Square thread labels:**

A. Crest diameter/Outside diameter/Major diameter/Nominal diameter ✓
B. Effective diameter/Mean diameter/Pitch Diameter ✓
C. Pitch ✓
D. Helix angle ✓ (4)

10.3 **Cutting tools ground:**

The sides must be ground at an angle conforming to the helix angle ✓ of the square thread with correct clearance angles. ✓ (2)
[18]

QUESTION 11: SYSTEMS AND CONTROL (DRIVE SYSTEMS) (SPECIFIC)

11.1 **Hydraulic:**

11.1.1 **The fluid pressure in Pa:**

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

$$P = \frac{85}{0,25} \quad ✓$$

$$P = 340 \text{ Pa} \quad ✓$$ (2)

11.1.2 **Displacement of the ram:**

$$\text{area} \times I = \text{AREA} \times L$$

$$0,25 \times 0,09 = 2,1 \times L \quad ✓$$

$$L = \frac{0,25 \times 0,09}{2,1} \quad ✓$$

$$L = 0,010714285 \text{ m}$$

$$L = 10,71 \text{ mm} \quad ✓$$ (3)

11.1.3 **Force exerted by the ram:**

$$\frac{F}{A} = \frac{f}{a}$$

$$F = \frac{f \times A}{a} \quad ✓$$

$$F = \frac{85 \times 2,1}{0,25} \quad ✓$$

$$F = 714 \text{ N} \quad ✓$$

OR

$$P_B = \frac{F_B}{A_B}$$

$$F_B = P_B \times A_B \quad ✓$$

$$F_B = 340 \times 2,1 \quad ✓$$

$$F_B = 714 \text{ N} \quad ✓$$ (3)

11.2 **Types of hydraulic pumps:**

- Radial pump ✓
- Rotary pump ✓ (2)

11.3 **Hydraulic valve:**

- Directional control valve ✓
- Non-return valve/check valve ✓
- One-way valve ✓
- Pressure relief/release valve ✓

(Any 1 x 1) (1)

11.4 **Belt drive:**

11.4.1 **Diameter of the driven pulley:**

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

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

$$D_{DN} = \frac{2700 \times 210}{1000} \quad \checkmark$$

$$D_{DN} = 567 \text{ mm} \quad \checkmark$$ (3)

11.4.2 **Power transmitted in kW:**

$$P = \frac{(T_1 - T_2)\ \pi\ D\ N}{60}$$

$$P = \frac{(400)\pi \times 0,21 \times 2700}{60} \quad (\checkmark\ \checkmark\ \checkmark)$$

$$P = 11875,22 \text{ Watt}$$

$$P = 11,88 \text{ kW} \checkmark$$

OR

$$P = \frac{(T_1 - T_2)\ \pi\ d\ n}{60}$$

$$P = \frac{(400)\pi \times 0,567 \times 1000}{60} \quad (\checkmark\ \checkmark\ \checkmark)$$

$$P = 11875,22 \text{ Watt}$$

$$P = 11,88 \text{ kW} \checkmark$$

OR

$$P = 2\pi NT$$

$$P = 2 \times \pi \frac{1000}{60} \times FR$$

$$P = 2 \times \pi \frac{1000}{60} \times 400 \times 0,2835 \quad (\checkmark\ \checkmark\ \checkmark)$$

$$P = 11875,22 \text{ Watt}$$

$$P = 11,88 \text{ kW} \checkmark$$

OR

$$P = 2\pi NT$$

$$P = 2 \times \pi \frac{2700}{60} \times FR$$

$$P = 2 \times \pi \frac{2700}{60} \times 400 \times 0,105 \quad (\checkmark\ \checkmark\ \checkmark)$$

$$P = 11875,22 \text{ Watt}$$

$$P = 11,88 \text{ kW} \checkmark$$

(4)

11.5 **Gear drive:**

11.5.1 **Rotational frequency of the input shaft N_A:**

$$\frac{N_{input}}{N_{output}} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driving gears}}$$

$$\frac{N_A}{N_D} = \frac{T_B \times T_D}{T_A \times T_C}$$

$$\frac{N_A}{800} = \frac{22 \times 40}{40 \times 18} \quad ✓$$

$$N_A = \frac{22 \times 40 \times 800}{40 \times 18} \quad ✓$$

$$N_A = 977{,}78 \text{ r/min} \quad ✓$$

$$N_A = 16{,}30 \text{ r/sec} \quad ✓$$

(4)

11.5.2 **Speed ratio:**

$$\text{Speed ratio} = \frac{N_{input}}{N_{output}}$$

$$\text{Speed ratio} = \frac{977{,}78}{800} \quad ✓ \quad ✓$$

$$\text{Speed ratio} = 1{,}22 : 1 \quad ✓$$

(3)

11.6 **Torque:**

$$P = 2\pi NT$$

$$T = \frac{P}{2 \times \pi \times N} \quad ✓$$

$$T = \frac{11000}{2 \times \pi \times 5} \quad ✓$$

$$T = 350{,}14 \text{ Nm} \quad ✓$$

(3)
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TOTAL: 200