basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

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MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 23 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1	B ✓	(1)
1.2	B ✓	(1)
1.3	C ✓	(1)
1.4	C ✓	(1)
1.5	A ✓	(1)
1.6	B ✓	(1)
		[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Vital functions:**

- Breathing ✓
- Heart rate / pulse ✓
- State of consciousness ✓

(Any 2 x 1) (2)

2.2 **Safety glasses during grinding:**

- To prevent any injuries to the operator's eyes. ✓
- To protect eyes from sparks and debris. ✓
- To prevent blindness due to injury. ✓

(Any 1 x 1) (1)

2.3 **Type of guards:**

- Fixed guard ✓
- Automatic sweep-away ✓
- Self-adjusting / automatic guard ✓
- Electronic presence sensing device ✓
- Two-hand control device. ✓

(Any 2 x 1) (2)

2.4 **Precautions *before* gas welding operations can be undertaken:**

- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment (PPE). ✓
- Ensure that fire equipment is at hand. ✓
- Ensure that the equipment is in a safe working condition. ✓
- Ensure the gas equipment is set-up correctly. ✓
- Ensure the area is well ventilated. ✓
- Ensure that the working area is safe. ✓

(Any 3 x 1) (3)

2.5 **TWO disadvantages of the product layout:**

- Lack of flexibility. ✓
- Optimum use of equipment is not possible. ✓ (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **THREE properties:**

- Toughness ✓
- Hardness / Wear resistance ✓
- Softness ✓
- Case hardness ✓
- Ductility ✓
- Malleability ✓
- Elasticity ✓
- Brittleness ✓
- Strength ✓

(Any 3 x 1) (3)

3.2 **Heat treatment processes:**

3.2.1 **Tempering:**

- It consists of heating the hardened steel ✓ to a temperature below its critical temperature (colour chart). ✓
- Soaking it at this temperature for a period of time, ✓
- Quenching/cooling it rapidly in water, brine or oil. ✓ (4)

3.2.2 **Hardening:**

- The steel is heated slightly higher than the upper critical temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in water, brine or oil. ✓ (3)

3.3 **Examples of case-hardening:**

- Bearing cases ✓
- Bearing ball ✓
- Bearing needles ✓
- Crankshafts ✓
- Gears ✓
- Camshafts ✓
- Cylinder sleeves ✓
- Hammer head ✓
- Jack Hammer drill bits ✓

(Any 2 x 1) (2)

3.4 **Why steels are cooled down in still air away from draughts:**
This prevents sudden cooling of localised spots, ✓ which might cause distortion/cracks. ✓ (2)
[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

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

5.1 **TWO advantages of cutting using the tailstock set-over method:**

- Long tapers can be cut. ✓
- The automatic feed can be used. ✓
- Good finish is obtained ✓

(Any 2 x 1) (2)

5.2 **Big diameter of taper:**

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

$$D = \text{Tan}\frac{\theta}{2}(2 \times l) + d \quad ✓$$

$$= \text{Tan}\frac{8^\circ}{2}(2 \times 290) + 42 \quad ✓$$

$$= \text{Tan}4^\circ(580) + 42 \quad ✓$$

$$D = 82{,}56 \text{ mm} \quad ✓$$

(4)

5.3 **Calculation of parallel key:**

5.3.1

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

$$= \frac{65}{4} \quad ✓$$

$$= 16{,}25 \text{ mm} \quad ✓$$

(2)

5.3.2

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

$$= \frac{65}{6} \quad ✓$$

$$= 10{,}83 \text{ mm} \quad ✓$$

(2)

5.3.3

$$\text{Length} = 1{,}5 \times \text{diameter of shaft}$$

$$= 1{,}5 \times 65 \quad ✓$$

$$= 97{,}5 \text{ mm} \quad ✓$$

(2)

5.4 **Disadvantages of straddle milling:**

- The cutters used place more stress on the machine's spindle. ✓
- The milling machine works harder due to more than one cutter being used. ✓
- There can be more vibration. ✓
- Poor finishing. ✓

(Any 1 x 1) (1)

5.5 **TWO milling processes:**

The milling of:

- Bevels ✓
- Keyways ✓
- Slides ✓
- Chamfers ✓
- Other angles ✓
- Grooves ✓
- Jigs recesses ✓
- Tees ✓
- Dovetail slots ✓
- Surface milling ✓
- Drilling ✓
- Reaming ✓
- Tapping ✓
- Up-cut milling ✓
- Down-cut milling ✓

(Any 2 x 1) (2)

5.6 **Calculate X:**

$$x = \frac{\text{Diameter of workpiece} - \text{Thickness of cutter}}{2} \checkmark$$

$$= \frac{60 - 12}{2} \checkmark$$

$$= \frac{48}{2}$$

$$= 24\text{ mm} \checkmark$$

(3)
[18]

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **Gear calculations:**

6.1.1 **Module:**

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

$$= \frac{165}{110} \checkmark$$

$$= 1{,}5 \checkmark$$

(2)

6.1.2 **Outside diameter:**

OD = PCD +2(m)
= 165 + 2(1,5) ✓
= 168 mm ✓

OR

OD = m(T + 2)
= 1,5(110 + 2) ✓
= 168 mm ✓

(2)

6.2 **Dovetail calculations:**
W = 120 + 2(DE)
m = W – [2(AC) + 2(R)] **OR** m = W – 2(AC + R) **OR** m = W – 2(AC) – 2(R)

6.2.1 **Maximum width distance of dove tail. (W)**

Calculate DE:

$$\text{Tan}\alpha = \frac{\text{DE}}{\text{AD}}$$

$$\text{DE} = \tan\alpha \times \text{AD} \checkmark$$

$$= \tan 30° \times 30 \checkmark$$

$$= 17{,}32\,\text{mm} \checkmark$$

OR

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

$$\text{DE} = \frac{\text{AD}}{\text{Tan}60°} \checkmark$$

$$= \frac{30}{\text{Tan}60°} \checkmark$$

$$= 17{,}32\,\text{mm} \checkmark$$

W = 120 + 2(DE) ✓
= 120 + 2(17,32) ✓
= 120 + 34,64
= 154,64 mm ✓

(6)

6.2.2 **Distance between the rollers. (m)**

Calculate AC:

$\text{Tan}\alpha = \frac{BC}{AC}$

$AC = \frac{BC}{\text{Tan}\alpha}$ ✓

$= \frac{11}{\text{Tan}30^o}$ ✓

$= 19{,}05\,mm$ ✓

OR

$\text{Tan}\theta = \frac{AC}{BC}$

$AC = \text{Tan}\theta \times BC$ ✓

$= \text{Tan}60^o \times 11$ ✓

$= 19{,}05\,mm$ ✓

m = W – [(2(AC) + 2(R)] ✓
= 154,64 – [2(19,05) + 2(11)] ✓
= 154,64 – (38,10 + 22)
= 94,54 mm ✓

OR

m = W – 2(AC + R) ✓
= 154,64 – 2(19,05 + 11) ✓
= 154,64 – (38,10 + 22)
= 94,54 mm ✓

OR

m = W – 2(AC) – 2(R) ✓
= 154,64 – 2(19,05) – 2(11) ✓
= 154,64 – 38,11 – 22
= 94,54 mm ✓

(6)

6.3 **Milling of spur gear:**

6.3.1 **Indexing:**

$$\text{Indexing} = \frac{40}{n} = \frac{40}{163}$$

$$= \frac{40}{A} = \frac{40}{160} \checkmark$$

$$= \frac{1}{4} \times \frac{6}{6}$$

$$= \frac{6}{24} \checkmark$$

Approximate indexing: 6 holes on a 24-hole circle. ✓

OR

7 holes on a 28-hole circle. ✓

(3)

6.3.2 **Change gears:**

$$\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}$$

$$= (160 - 163) \times \frac{40}{160} \checkmark$$

$$= -3 \times \frac{40}{160} \checkmark$$

$$= \frac{-120}{160}$$

$$= \frac{12}{16} \times \frac{2}{2} \checkmark \quad \textbf{OR} \quad \frac{12}{16} \times \frac{4}{4} \checkmark$$

$$= \frac{24 \checkmark}{32 \checkmark} \quad \textbf{OR} \quad \frac{48 \checkmark}{64 \checkmark}$$

(5)

6.4 **TWO types of balancing methods:**

- Static balance (stationary balancing) ✓
- Dynamic balance (running balancing) ✓ (2)

6.5 **TWO advantages of correct balancing:**

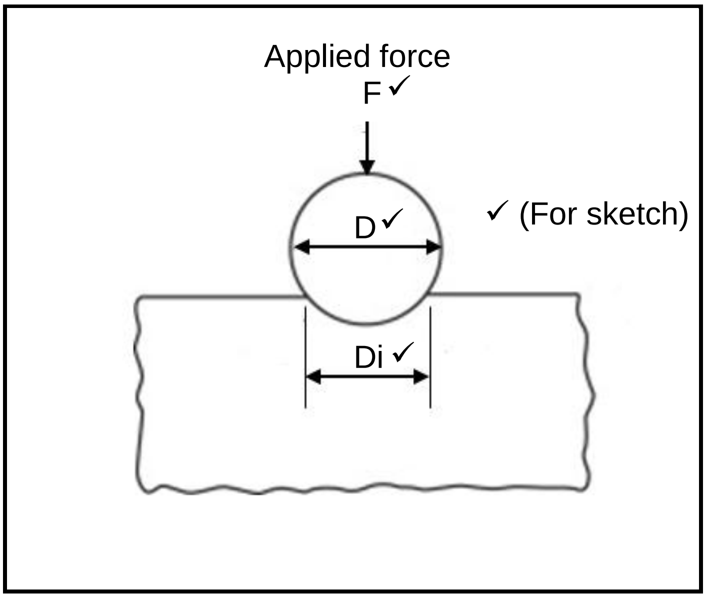
- Prevents vibrations. ✓
- Prevents poor finish / ensure good finish. ✓
- Prevents wear on bearings / components. ✓
- Prevents accidents. ✓
- Improve production. ✓
- Promotes accuracy. ✓
- Prevent damage to workpiece. ✓
- Prevent components from loosening. ✓

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

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Function of a screw-thread micrometer:**
The screw-thread micrometer is specifically designed to measure ✓ the pitch diameter ✓ of a screw thread. (2)

7.2 **Brinell labelled drawing:**



Di - Indentation

D - Indenter diameter

(4)

7.3 **Types of forces:**
- Tensile force ✓
- Compressive force ✓
- Shear force ✓
- Torsional force ✓
- Gravitational force ✓
- Normal Force ✓
- Frictional Force ✓
- Reaction Force ✓

(Any 2 x 1) (2)

7.4 **ISO-Metric screw-thread:**

7.4.1 A – Root/Root land ✓
B – Pitch diameter / Effective diameter / Mean diameter ✓
C – Crest diameter / Major diameter / Outside diameter / Basic diameter ✓ (3)

7.4.2 **Pitch diameter:**
Dp = Dn – (0,866 x P)

Dp = 12 – (0,866 x 1,75) ✓

Dp = 12 – 1,52

Dp = 10,48 mm ✓ (2)

[13]

QUESTION 8: FORCES (SPECIFIC)

8.1 **Forces:**

8.1.1 **Horizontal component:**

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

$$\sum HC = 0 + \overset{\checkmark}{40} + \overset{\checkmark}{18,81} - \overset{\checkmark}{103,92}$$

$$\sum HC = -45,11\text{N} \checkmark$$

(4)

8.1.2 **Vertical component:**

$$\sum VC = 25\sin 90^\circ - 40\sin 0^\circ - 55\sin 70^\circ - 120\sin 30^\circ$$

$$\sum VC = \overset{\checkmark}{25} - 0 - \overset{\checkmark}{51,68} - \overset{\checkmark}{60}$$

$$\sum VC = -86,68\text{N} \checkmark$$

(4)

OR

Force	***θ***	8.1.1 **∑HC/x = Fcosθ**		8.1.2 **∑VC/y = Fsinθ**	
25N	90º	HC = 25cos90°	0N	VC = 25sin90°	25N ✓
40N	0º	HC = 40cos0°	40N ✓	VC = 40sin0°	0N
55N	290º	HC = 55cos290°	18,81N ✓	VC = 55sin290°	-51,68N ✓
120N	210º	HC = 120cos210°	-103,92N ✓	VC = 120sin210°	-60N ✓
		Total	**-45,11N** ✓		**-86,68N** ✓

(8)

8.1.3 **Resultant:**

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

$$R = \sqrt{(-86,68)^2 + (-45,11)^2} \quad \checkmark$$

$$R = \sqrt{9549,24}$$

$$R = 97,72\text{N} \quad \checkmark$$

(2)

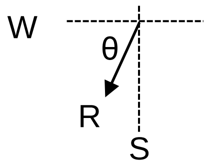
8.1.4 **Angle and direction of resultant:**
Angle:

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

$$\theta = \tan^{-1}\left(\frac{-86,68}{-45,11}\right) \checkmark$$

$$\theta = \tan^{-1}(1,92)$$

$$\theta = 62,5^\circ \checkmark$$



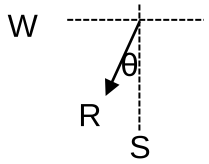
OR

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

$$\theta = \tan^{-1}\left(\frac{-45,11}{-86,68}\right) \checkmark$$

$$\theta = \tan^{-1}(0,52)$$

$$\theta = 27,49^\circ \checkmark$$



Direction:
$R = 97,72N$ $62,5^\circ$ South of West ✓

OR

$R = 97,72N$ $27,5^\circ$ West of South ✓ (3)

8.2 **UDL Beam:**

8.2.1 **Distributed load:**
Uniform distributed load:
7 x 12 = 84 N ✓ (1)

8.2.2 **Reaction in support A:**
Take moments about B:

$$\overset{\checkmark}{(75\times12,5)}+\overset{\checkmark}{(84\times5,5)}+\overset{\checkmark}{(55\times0)}=(A\times14)$$

$$937,5+462+0=14A$$

$$A=\frac{1399,5}{14} \checkmark$$

$$A=99,96N \checkmark$$ (5)

8.2.3 **Reaction in support B:**
Take moments about A:

$$(B \times 14) = (75 \times 1{,}5)\checkmark + (84 \times 8{,}5)\checkmark + (55 \times 14)\checkmark$$

$$14B = 112{,}5 + 714 + 770$$

$$B = \frac{1596{,}5}{14} \checkmark$$

$$B = 114{,}04 N \checkmark$$

(5)

8.3.1 **Resistance area:**

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

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

$$A = \frac{85 \times 10^3}{36 \times 10^6} \checkmark$$

$$A = 2{,}36 \times 10^{-3} m^2 \checkmark$$

(3)

8.3.2 **Change in length:**

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

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

$$\varepsilon = \frac{36 \times 10^6}{90 \times 10^9} \checkmark$$

$$\varepsilon = 4 \times 10^{-4} \checkmark$$

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

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

$$\Delta L = 4 \times 10^{-4} \times 0{,}12 \checkmark$$

$$\Delta L = 4{,}8 \times 10^{-5} m$$

$$\Delta L = (4{,}8 \times 10^{-5}) \times 1000$$

$$\Delta L = 0{,}048 \text{ mm} \checkmark$$

(6)
[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Failure to conduct preventative maintenance:**

- Risk of injury or death. ✓
- Financial loss due to damage suffered as a result of part failure. ✓
- Loss of valuable production time. ✓
- Equipment failure. ✓
- Damage to material or project. ✓

(Any 3 x 1) (3)

9.2 **Mechanical drives:**

- Belt drives ✓
- Gear drives ✓
- Chain drives ✓
- Hydrostatic drives ✓
- Hydraulic drives ✓
- Cable drives ✓
- Pneumatic drive ✓

(Any 3 x 1) (3)

9.3 **Enhance the strength of glass fibre:**
Polyester resin ✓ (1)

9.4 **Properties:**

9.4.1 **Bakelite:**

- Stiff ✓
- Strong ✓
- Hard / wear resistant ✓
- Chemical resistance ✓
- Thermo hardened ✓
- Water resistant ✓
- Electrical isolation ✓
- Heat resistant ✓
- Machinable ✓
- Brittleness ✓

(Any 2 x 1) (2)

9.4.2 **Carbon fibre:**

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

(Any 2 x 1) (2)

9.5 **Manufacturing of PVC:**

- Oil ✓
- Salt ✓
- Coal ✓

(Any 1 x 1) (1)

9.6 **Ways to conduct preventive maintenance:**

- Inspection ✓
- Measuring ✓
- Cleaning ✓
- Lubricating ✓
- Adjusting of parts ✓
- Replacing of parts ✓
- Tests ✓

(Any 3 x 1) (3)

9.7 **Main types of plastic composites:**

- Thermoplastic ✓
- Thermosetting plastic / Thermo-hardened ✓ (2)

9.8 **Non-stick coatings for frying pans:**

Teflon ✓ (1)

[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Screw thread terminology:**

10.1.1 **Lead:**
It is the distance ✓ that the point (nut/bolt) on a screw thread will move / advance ✓ along the axis, ✓ when turned through one complete revolution / turn. ✓ (4)

10.1.2 **Helix angle:**
It is the angle that the thread makes with a line perpendicular / 90° ✓ to the axis of the screw thread. ✓ (2)

10.2 **Square Thread:**

10.2.1 **Pitch:**

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

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

$$= \frac{42}{2} \checkmark$$

$$= 21\,\text{mm} \checkmark$$

(3)

10.2.2 **Pitch diameter:**

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

$$= 90 - \frac{21}{2} \checkmark$$

$$= 79{,}50\,\text{mm} \checkmark$$

(2)

10.2.3 **Helix angle of the thread:**

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

$$\tan\theta = \frac{42 \checkmark}{\pi \times 79{,}50 \checkmark}$$

$$\tan\theta = 0{,}168163713$$

$$\theta = \tan^{-1} 0{,}168163713$$

$$= 9{,}55^\circ \text{ or } 9^\circ 33' \checkmark$$

(3)

10.2.4 **Leading tool angle:**

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

= 90° - (9,55° + 3°) ✓

= 77,45° or 77° 27’ ✓

(2)

10.2.5 **Following tool angle:**

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

= 90° + (9,55° - 3°) ✓

= 96,55° or 96° 33’✓

(2)

[18]

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

11.1 **Hydraulic calculations :**

11.1.1 **The fluid pressure in the hydraulic system in MPa:**

$$A(\text{Ram}) = \frac{\pi d^2}{4}$$

$$A = \frac{\pi(0,25)^2}{4} \quad \checkmark$$

$$A = 0,049\ \text{m}^2 \quad \text{OR} \quad 4,91 \times 10^{-2}\ \text{m}^2 \quad \checkmark$$

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

$$p = \frac{34000}{0,049} \quad \checkmark$$

$$p = 693877,55\ \text{Pa}$$

$$p = 0,69\ \text{MPa} \quad \checkmark$$

(4)

11.1.2 **Diameter of the plunger:**

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

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

$$A = \frac{215}{693877{,}55} \checkmark$$

$$A = 0{,}309852 \times 10^{-3}\ m^2 \checkmark$$

$$A = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{4 \times A}{\pi}} \checkmark$$

$$d = \sqrt{\frac{4\left(0{,}309852 \times 10^{-3}\right)}{\pi}} \checkmark$$

$$d = 0{,}019862422\ m$$

$$d = 19{,}86\ mm \checkmark$$

OR

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

$$\frac{F_1}{\frac{\pi d^2}{4}} = \frac{F_2}{\frac{\pi D^2}{4}}$$

$$\frac{215}{d^2} \checkmark = \frac{34000}{250^2} \checkmark$$

$$d^2 \times 34000 = 215 \times 250^2 \checkmark$$

$$d = \sqrt{\frac{215 \times 250^2}{34000}} \checkmark$$

$$d = 19{,}88\ mm \checkmark$$

(5)

11.2 **Hydraulic filters:**

- Pressure line filter ✓
- Return line filter ✓ (2)

11.3 **Hydraulic symbols:**

11.3.1 Reservoir ✓ (1)

11.3.2 Directional control valve / Non-return valve / One way valve ✓ (1)

11.4 **Belt drive:**

11.4.1 **The rotational frequency in r/sec:**

$$N_{Dr} \times D_{Dr} = N_{Dn} \times D_{Dn}$$

$$N_{Dn} = \frac{N_{Dr} \times D_{Dr}}{D_{Dn}} \quad \checkmark$$

$$N_{Dn} = \frac{1330 \times 0{,}15}{0{,}32} \quad \checkmark$$

$$N_{Dn} = \frac{623{,}44 \text{ r/min}}{60}$$

$$N_{Dn} = 10{,}39 \text{ r/sec} \quad \checkmark$$

(3)

11.4.2 **Power transmitted in Watt:**

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

$$P = (175 - \overset{\checkmark}{1}30)\pi \times 0{,}3\overset{\checkmark}{2} \times 10{,}\overset{\checkmark}{3}9$$

$$P = 470{,}03 \text{ Watt} \quad \checkmark$$

OR

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

$$P = \frac{(175 - \overset{\checkmark}{1}30)\pi \times 0{,}1\overset{\checkmark}{5} \times 13\overset{\checkmark}{3}0}{60}$$

$$P = 470{,}06 \text{ Watt} \quad \checkmark$$

(4)

11.5 **Gear drive:**

11.5.1 **Identify gear drive:**
Compound gear drives system ✓ (1)

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

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

$$\frac{N_A}{N_F} = \frac{T_B \times T_D \times T_F}{T_A \times T_C \times T_E} \checkmark$$

$$\frac{N_A}{625} = \frac{40 \times 50 \times 80}{20 \times 35 \times 25} \begin{matrix}\checkmark \\ \checkmark\end{matrix}$$

$$N_A = \frac{40 \times 50 \times 80 \times 625}{20 \times 35 \times 25}$$

$$N_A = 5714{,}29 \text{ r/min} \checkmark$$

(4)

11.6 **Torque on the lathe spindle:**

$$\text{Torque}(T) = \text{Force} \times \text{Radius}$$

$$T = \overset{\checkmark}{250} \times \overset{\checkmark}{0{,}025}$$

$$T = 6{,}25 \text{ Nm.} \checkmark$$

(3)
[28]

TOTAL: 200