basic education

Department:
Basic Education
**REPUBLIC OF SOUTH AFRICA**

# SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

## MECHANICAL TECHNOLOGY: FITTING AND MACHINING

## 2019

## MARKING GUIDELINES

**MARKS: 200**

**These marking guidelines consist of 17 pages.**

## QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 B ✓ (1)

1.2 B ✓ (1)

1.3 A ✓ (1)

1.4 A ✓ (1)

1.5 D ✓ (1)

1.6 B ✓ (1)
**[6]**

## QUESTION 2: SAFETY (GENERIC)

2.1 **Angle grinder:**
- Do not use excessive force while grinding ✓
- Ensure that the sparks do not endanger co-workers ✓
- Keep hands clear from grinding disc ✓
- Maintain a firm grip on the angle grinder ✓

**(Any 2 x 1)** (2)

2.2 **Welding goggles:**
- To protect your eyes from the spatter ✓
- To protect your eyes from the harmful rays ✓
- To ensure proper vision of the process ✓

**(Any 2 x 1)** (2)

2.3 **PPE – Bench grinder:**
- Overall ✓
- Safety goggles ✓
- Safety shoes ✓

**(Any 2 x 1)** (2)

2.4 **Process and product workshop layout:**
- The product layout ensures that the machines are arranged in the sequence of the manufacturing process of a product. ✓
- The process layout is based on the type of manufacturing process needed in the making of the product. ✓ (2)

2.5 **Employer's responsibility – equipment:**
- They must provide and maintain equipment ✓
- Ensure that the equipment is safe to use by employees ✓
- Provide safe storage for equipment ✓
- Provide proper training of employees in the use of the equipment ✓
- Enforce safety measures ✓

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

## QUESTION 3: MATERIALS (GENERIC)

3.1 **Tests to distinguish between metals:**

- Bending test: ✓ hit with hammer✓
- Filing test ✓file material(colour and ease) ✓
- Machining test ✓ machine material (type of shaving, ease and colour) ✓
- Sound ✓ drop on floor(high or low frequency) ✓ (8)

3.2 **Heat-treatment:**

3.2.1 **Tempering:**
After hardening, the steel must be tempered

- To relieve ✓ the strains ✓ induced.
- To reduce ✓ brittleness. ✓

**(Any 1 x 2)** (2)

3.2.2 **Normalising:**

- To relieve ✓ the internal stresses ✓ produced by forging and machining. (2)

3.2.3 **Hardening:**

- To produce extremely hard steel ✓ to enable it to resist wear and tear ✓ or to use as cutting tools. (2)

**[14]**

## QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

4.1 D ✓ (1)

4.2 B ✓ (1)

4.3 B ✓ (1)

4.4 C ✓ (1)

4.5 B ✓ (1)

4.6 B ✓ (1)

4.7 C ✓ (1)

4.8 A ✓ (1)

4.9 C ✓ (1)

4.10 B ✓ (1)

4.11 B ✓ (1)

4.12 D ✓ (1)

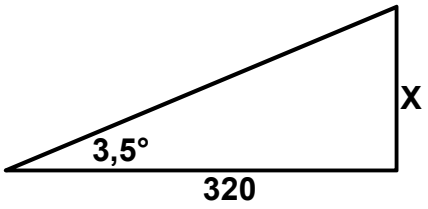
4.13 A ✓ (1)

4.14 A ✓ (1)

**[14]**

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

5.1 **Calculate the tailstock set-over:**




$$\text{Tan}\theta = \frac{X}{320} \quad \checkmark$$
$$x = \text{Tan}\,3{,}5° \times 320 \quad \checkmark$$
$$= 19{,}57 \text{ mm} \quad \checkmark$$

(3)

5.2 **Methods to cut multiple-start threads:**

- By moving the tool with the compound-slide ✓
- By turning the change-gears ✓
- By using a driving plate with accurately cut slots ✓
- By using a graduated driving plate ✓

**(Any 3 x 1)** (3)

5.3 **Parallel key:**

5.3.1 **Width:**

$$\text{Width} = \frac{D}{4}$$
$$= \frac{48}{4} \quad \checkmark$$
$$= 12 \text{ mm} \quad \checkmark$$

(2)

5.3.2 **Thickness:**

$$\text{Thickness} = \frac{D}{6}$$
$$= \frac{48}{6} \quad \checkmark$$
$$= 8 \text{ mm} \quad \checkmark$$

(2)

5.4 **Advantages for using the compound slide method to cut an external V-thread on the centre lathe:**

- No unnecessary burden on tool because cutting action takes place on one side of the tool. ✓
- The force on the tool is evenly distributed along the cutting action. ✓
- The thread can be cut at a fairly fast speed because only the cutting edge need to be at centre height and a side rake may be ground. ✓
- By lightly restricting the movement of the apron hand wheel, the non-cutting edge of the tool can be made to polish the side of the thread. ✓

**(Any 2 x 1)** (2)

5.5 **Milling processes:**

5.5.1 **Advantages of down-cut milling:**

- Deeper cuts can be taken, as the force of the cutter is downwards. ✓
- Finer finish is obtained. ✓
- Less vibration. ✓

**(Any 1 x 1)** (1)

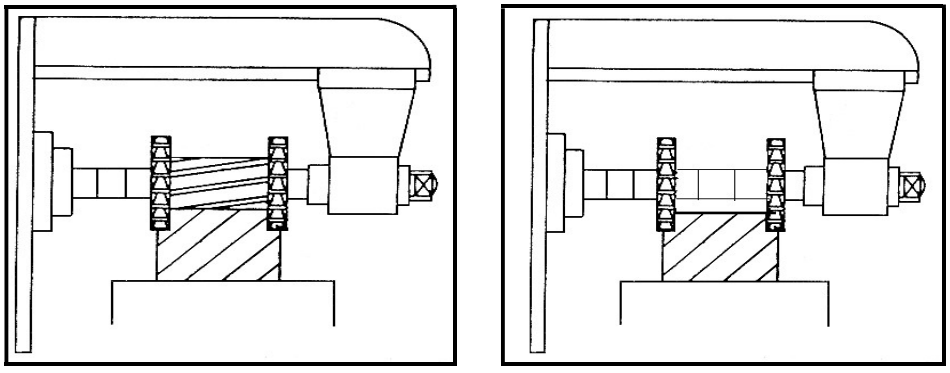
5.5.2 **Advantages of up-cut milling:**

- The process enables hard steel to be cut, because the total cutting pressure is absorbed by the material at the back of the edge. ✓
- Metal with hard scale, such as castings or forgings, the cut is started under the scale where the material is softer which extends the life of the cutter. ✓
- A coarser feed can be used. ✓
- The strain on the cutter and arbor will be less. ✓

**(Any 1 x 1)** (1)

5.6 **Gang milling and straddle milling:**

✓ ✓



**Gang milling** ✓ **Straddle milling** ✓

(4)
**[18]**

## QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **Spur gear:**

6.1.1 **Number of teeth:**

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

$$\text{Teeth} = \frac{\text{PCD}}{\text{m}} \quad ✓$$

$$= \frac{99}{3}$$

$$= 33 \text{ teeth} \quad ✓$$

(2)

6.1.2 **Outside diameter:**

$$\text{OD} = \text{PCD} + 2a \quad ✓$$

$$= 99 + 2(3) \quad ✓$$

$$= 105 \text{ mm}$$

or

$$= m(T + 2) \quad ✓$$

$$= 3(33 + 2)$$

$$= 105 \text{ mm} \quad ✓$$

(2)

6.1.3 **Cutting depth:**

$$\text{Cutting depth} = 2{,}157m \quad ✓$$

$$= 2{,}157 \times 3 \quad ✓$$

$$= 6{,}47 \text{ mm}$$

or

$$= 2{,}25m \quad ✓$$

$$= 2{,}25 \times 3$$

$$= 6{,}75 \text{ mm} \quad ✓$$

(2)

6.1.4 **Addendum:**

$$\text{Addendum} = m$$

$$= 3 \text{ mm} \quad ✓$$

(1)

6.1.5 **Dedendum:**

$$\text{Dedendum} = 1{,}157m \quad ✓$$

$$= 1{,}157 \times 3$$

$$= 3{,}47 \text{ mm} \quad ✓$$

or

$$= 1{,}25m \quad ✓$$

$$= 1{,}25 \times 3$$

$$= 3{,}75 \text{ mm} \quad ✓$$

(2)

6.1.6 **Circular pitch:**

$$CP = m \times \pi$$

$$= 3 \times \pi \quad ✓$$

$$= 9{,}42 \text{ mm} \quad ✓$$

(2)

6.2 **Calculate distances 'Y and X':**

$$Y = 180 - 2(DE)$$

$$X = 180 - 2\,(DE) + 2(AC) + 2(rad)$$

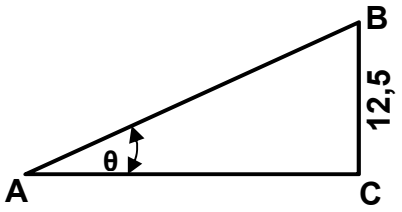
**Calculate AC:**

$$\text{Tan}\,\theta = \frac{BC}{AC} \quad \checkmark$$

$$AC = \frac{BC}{\text{Tan}\,\theta} \quad \checkmark$$

$$= \frac{12,5}{\text{Tan}\,30°}$$

$$= 21,65 \text{ mm} \quad \checkmark$$



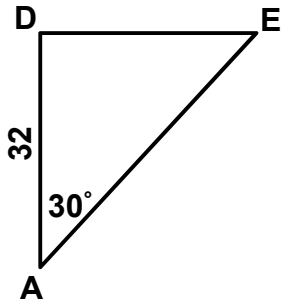

**Calculate DE:**

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

$$DE = \text{Tan}\,\theta \times AD \quad \checkmark$$

$$= \text{Tan}30° \times 32$$

$$= 18,48 \text{ mm} \quad \checkmark$$




**Calculate 'Y':**

$$Y = 180 - 2(DE) \quad \checkmark$$

$$= 180 - 2(18,48)$$

$$= 143,05 \text{ mm} \quad \checkmark$$

**Calculate 'X':**

$$X = 180 - 2(DE) + 2(AC) + 2(rad) \quad \checkmark$$

$$= 143,04 + 2(21,65) + 2(12,5) \quad \checkmark$$

$$= 143,04 + 43,3 + 25$$

$$= 211,34 \text{ mm} \quad \checkmark$$

(11)

6.3 **Differential indexing :**

6.3.1 **Indexing required:**

$$\text{Indexing} = \frac{40}{n}$$
$$= \frac{40}{120} \div \frac{5}{5} \quad (\text{approximate})$$
$$= \frac{8}{24} \quad ✓$$

Approximate indexing: 8 holes on a 24 hole circle ✓
or
10 holes on a 30 hole circle ✓
or
13 holes on a 39 hole circle ✓
or
14 holes on a 42 hole circle ✓
or
18 holes on a 54 hole circle ✓
or
22 gate on a 66 hole circle ✓ (2)

6.3.2 **Change gears required:**

$$\frac{Dr}{Dn} = \frac{A-N}{A} \times \frac{40}{1}$$
$$= \frac{120-119}{120} \times \frac{40}{1} \quad ✓$$
$$= \frac{1}{120} \times \frac{40}{1}$$
$$= \frac{40}{120}$$
$$= \frac{4}{12} \times \frac{6}{6}$$
$$\frac{Dr}{Dn} = \frac{24}{72} \quad ✓ \quad ✓$$

(3)

6.3.3 **Direction of rotation of index plate:**
The index plate will rotate in the same ✓ direction as the index crank. (1)

**[28]**

## QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Rockwell hardness tester:**
A – Test piece / Work piece ✓
B – Diamond cone ✓
C – Load ✓
D – Indentation ✓ (4)

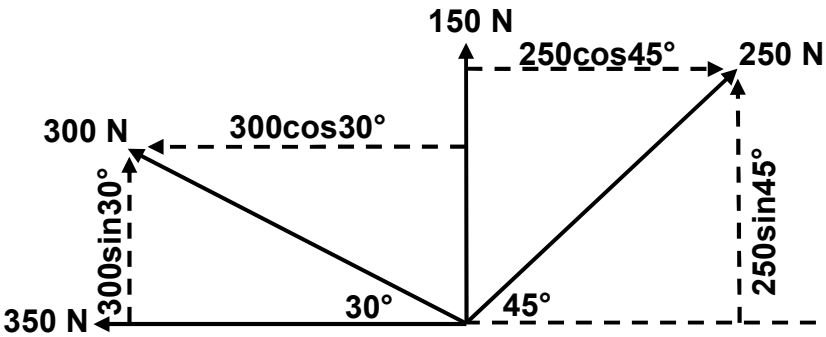
7.2 **Moment tester:**
To determine the reactions ✓ on either side ✓ of a simply loaded beam. (2)

7.3 **Tensile tester:**
**Operation**
An increasing ✓ axial tensile force ✓ is exerted onto a piece of material while measuring the corresponding ✓ elongation, ✓ (4)

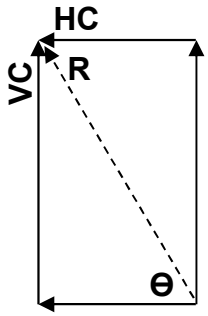
7.4 **Depth-micrometer:**
✓ ✓
50 + 16,00 + 0,5 + 0,14
= 66,64 mm ✓ (3)
**[13]**

## QUESTION 8: FORCES (SPECIFIC)

8.1 **Forces:**




$HC = 250\cos45° - 300\cos30° - 350$ ✓ ✓✓
✓
$= -433,03\ N$




(4)

$VC = 150 + 300\sin30° + 250\sin45°$ ✓✓✓
✓
$= 476,78\ N$

(4)

OR

| HC | Magnitude | VC | Magnitude |
|---|---|---|---|
| 250cos45° ✓ | 176,78 N | 150 ✓ | 150 N |
| -300cos30° ✓ | -259,81 N | 300sin30° ✓ | 150 N |
| -350 ✓ | -350 N | 250sin45° ✓ | 176,78 N |
| ∑HC | -433,03 N ✓ | ∑VC | 476,78 N ✓ |

(4) (4)

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

$\sqrt{R^2} = \sqrt{433,03^2 + 476,78^2}$ ✓

$R = 644,08\ N$ ✓

$\text{Tan}\,\theta = \dfrac{VC}{HC}$

$= \dfrac{476,78}{433,03}$

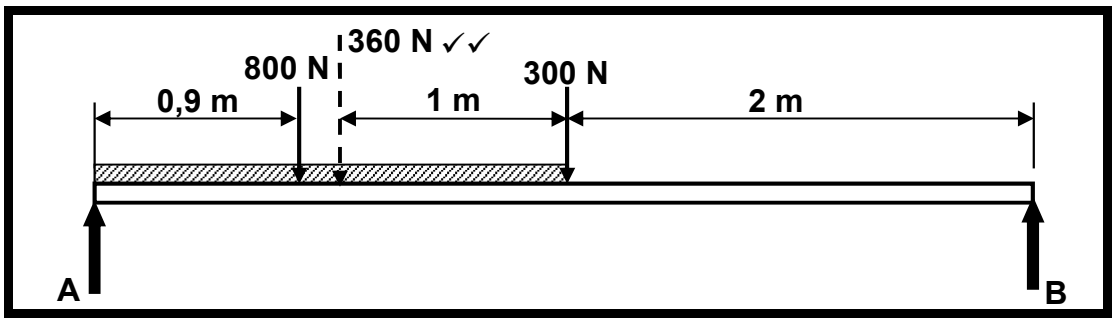
$\theta = 47,75°$ ✓

✓ ✓

Resultant = 644,08 N 47,75° North from West

(13)

8.2 **Moments:**




Calculate A:
Take moments about B.

$$\sum RHM = \sum LHM \quad ✓$$
$$(A \times 4) = (300 \times 2) + (360 \times 3) + (800 \times 3{,}1) \quad ✓$$
$$\frac{4A}{4} = \frac{4160}{4}$$
$$A = 1040\,N \quad ✓$$

Calculate B:
Take moments about A.

$$\sum LHM = \sum RHM \quad ✓$$
$$(B \times 4) = (300 \times 2) + (360 \times 1) + (800 \times 0{,}9) \quad ✓$$
$$\frac{4B}{4} = \frac{1680}{4}$$
$$A = 420\,N \quad ✓$$

(8)

## 8.3 Stress and Strain:

### 8.3.1 Diameter of the shaft:

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

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

$$= \frac{40 \times 10^3}{20 \times 10^6}$$

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

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

$$D = \sqrt{\frac{4A}{\pi}} \quad \checkmark$$

$$D = \sqrt{\frac{4\left(2 \times 10^{-3}\right)}{\pi}} \quad \checkmark$$

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

$$D = 50{,}46\ mm \quad \checkmark$$

(5)

### 8.3.2 Strain:

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

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

$$= \frac{20 \times 10^6}{90 \times 10^9} \quad \checkmark$$

$$= 0{,}22 \times 10^{-3} \quad \checkmark$$

(4)

### 8.3.3 Change in length:

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

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

$$= \left(0{,}22 \times 10^{-3}\right) \times (2) \quad \checkmark$$

$$= 0{,}44 \times 10^{-3}\ m$$

$$= 0{,}44\ mm \quad \checkmark$$

(3)

**[33]**

## QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Preventative maintenance:**

- To prevent injury or death.(e.g. Brake failure) ✓
- To prevent financial loss due to damage suffered as a result of part failure. ✓
- To prevent loss of production time. ✓

**(Any 2 x 1)** (2)

9.2 **Preventative maintenance procedures on gear drive systems:**

- Check and replenish lubrication levels. ✓
- Ensure that the gears are properly secured to the shafts. ✓
- Clean and replace oil filters. ✓
- Report excessive noise and wear, vibration and overheating for expert attention. ✓

**(Any 2 x 1)** (2)

9.3 **Causes for the malfunctioning of belt drive systems:**

- Incorrect belt tension. ✓
- Misalignment of the pulleys. ✓
- Dirt on the contact surfaces between the belt and the pulley. ✓
- Lubricant on the contact surfaces between the belt and the pulley. ✓
- Overloading the drive system. ✓

**(Any 2 x 1)** (2)

9.4 **Procedures to reduce the wear on a chain drive system:**

- Ensure sufficient lubrication. ✓
- Accurate alignment of the sprockets. ✓
- Keep the chain drive components clean. ✓
- Maintain the correct chain tension in the system. ✓

**(Any 2 x 1)** (2)

9.5 **Properties of materials:**

9.5.1 **Fibre glass:**

- High strength ✓
- Light weight ✓
- Water resistant ✓
- UV-resistant ✓

**(Any 2 x 1)** (2)

9.5.2 **Vesconite:**

- Low friction. ✓
- Easily machined. ✓
- High load carrying capacity. ✓
- Self-lubricating. ✓
- Cost-effective. ✓
- Performs well in unhygienic, dirty and un-lubricated environments. ✓
- Ensures long life together with low maintenance. ✓

**(Any 2 x 1)** (2)

9.5.3 **Carbon fibre:**

- High strength ✓
- Light weight ✓
- Water resistant ✓
- UV-resistant ✓
- Self-lubricating ✓

**(Any 2 x 1)** (2)

9.6 **'Thermoplastic' composites or 'Thermo hardened' (thermosetting) composites:**

9.6.1 **Teflon:**
Thermoplastic ✓ (1)

9.6.2 **Bakelite:**
Thermo hardened ✓ (1)

9.6.3 **Polyvinyl chloride (PVC):**
Thermoplastic ✓ (1)

9.7 **Higher coefficient of friction:**
Rubber ✓ (1)
**[18]**

**QUESTION 10: JOINING METHODS (SPECIFIC)**

10.1 **Calculations on square threads:**

10.1.1 **The pitch diameter:**

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

$$P = \frac{\text{Lead}}{\text{Number of starts}} \quad ✓$$

$$= \frac{30}{3}$$

$$= 10 \text{ mm} \quad ✓$$

$$\text{Pitch diameter} = OD - \left(\frac{P}{2}\right) \quad ✓$$

$$= 75 - \left(\frac{10}{2}\right)$$

$$= 70 \text{ mm} \quad ✓$$

(4)

10.1.2 **The helix angle of the thread:**

$$\text{Helix angle } \tan\theta = \frac{\text{lead}}{\pi \times \text{pitch diameter}} \quad ✓$$

$$= \frac{30}{\pi \times 70} \quad ✓✓$$

$$\theta = 7{,}77°$$

$$\theta = 7°46' \quad ✓$$

(4)

10.1.3 **The leading tool angle:**

$$\text{Leading tool angle} = 90° - (\text{helix} + \text{clearance angle}) \quad ✓$$
$$= 90° - (7°46' + 3°)$$
$$= 79°14' \quad ✓$$

(2)

10.1.4 **The following tool angle:**

$$\text{Following tool angle} = 90° + (\text{helix - clearance angle}) \quad ✓$$
$$= 90° + (7°46' - 3°)$$
$$= 94°46' \quad ✓$$

(2)

10.2 **Measurements of a screw thread:**

10.2.1 Metric screw thread ✓ (1)

10.2.2 Crest diameter / Outside diameter ✓ (1)

10.2.3 Pitch ✓ (1)

10.3 **Angles of a square thread cutting tool:**

10.3.1 A = Helix angle ✓ (1)

10.3.2 B = Leading tool angle ✓ (1)

10.3.3 C = Following tool angle ✓ (1)

**[18]**

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

11.1 **Advantages of a chain drive system compared to a belt drive system:**

- Chain drives are stronger ✓
- No slip occurs ✓ (2)

11.2 **Hydraulic system:**

11.2.1 **Fluid pressure:**

$$A_A = \frac{\pi D_A^{\,2}}{4} \quad \checkmark$$
$$= \frac{\pi \times 0{,}022^2}{4}$$
$$= 0{,}38 \times 10^{-3}\ m^2 \quad \checkmark$$

$$p = \frac{F_A}{A_A} \quad \checkmark$$
$$= \frac{250}{0{,}38 \times 10^{-3}}$$
$$= 0{,}66 \times 10^6\ Pa \text{ or } 657665{,}05\ Pa \quad \checkmark$$
$$= 0{,}66\ MPa$$ (4)

11.2.2 **Load on piston B:**

$$A_B = \frac{\pi D_B^{\,2}}{4} \quad \checkmark$$
$$= \frac{\pi \times 0{,}248^2}{4}$$
$$= 48{,}31 \times 10^{-3}\ m^2 \quad \checkmark$$

$$p = \frac{F}{A} \quad \checkmark$$
$$F_B = p \times A_B \quad \checkmark$$
$$= \left(0{,}66 \times 10^6\right) \times \left(48{,}31 \times 10^{-3}\right) \quad \checkmark$$
$$= 31884{,}6\ N$$
$$= 31{,}88\ kN \quad \checkmark$$ (6)

11.3 **Purpose of a filter in a hydraulic system:**

- The purpose of the filter is to retain, ✓ by some porous medium, the insoluble contaminates ✓ from the fluid.
- Strain and filter ✓ the oil of contaminates. ✓

**(Any 1 x 2)** (2)

11.4 **V-belt drive system – Power transmitted:**

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

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

$$= \frac{440}{2,5} \quad \checkmark$$

$$= 176 \text{ N}$$

$$P = (T_1 - T_2)\, v \quad \checkmark$$

$$= (440 - 176)\, 10 \quad \checkmark$$

$$= 2640 \text{ Watt}$$

$$= 2,64 \text{ kW} \quad \checkmark$$

(5)

11.5 **Gear system:**

11.5.1 **The number of teeth on the idler gear:**

$$T_B \times N_B = T_C \times N_C \quad \checkmark$$

$$T_B = \frac{T_C \times N_C}{N_B} \quad \checkmark$$

$$= \frac{80 \times 260}{800}$$

$$= 26 \text{ teeth} \quad \checkmark$$

(3)

11.5.2 **The rotation frequency of the driver gear:**

$$T_A \times N_A = T_C \times N_C \quad \checkmark$$

$$T_A = \frac{T_C \times N_C}{N_A} \quad \checkmark$$

$$= \frac{80 \times 260}{60}$$

$$= 346,67 \text{ r/min} \quad \checkmark$$

(3)

11.6 **Chain drive system – Gear ratio (GR):**

$$GR = \frac{DN}{DR} \quad \checkmark$$

$$= \frac{32}{48} \quad \checkmark$$

$$= 0,67 : 1 \quad \checkmark$$

(3)
**[28]**

**TOTAL: 200**