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 20 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. ✓
- Grinding disc fitted will not turn faster than the manufactures recommendation. ✓
- Make sure that there is no cracks or chips on the grinding disc
- Safety guard must be in place. ✓
- PPE must be worn. ✓
- Beware of lockable switches in the on position when the machine is plugged in and switched on. ✓
- Check for defective cables. ✓
- Secure work piece properly. ✓
- Grinding angle to be away from body to prevent sparks directly on clothing. ✓
- Make sure disc does not wobble during cutting. ✓

(Any 2 x 1) (2)

2.2 **Welding goggles:**

- To protect your eyes from the spatter / sparks. ✓
- To protect your eyes from the harmful rays / UV rays. ✓
- To ensure proper vision of the process. ✓

(Any 2 x 1) (2)

2.3 **PPE – Bench grinder:**

- Overall ✓
- Safety goggles / face shield ✓
- 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/ OHS acts and Regulations. ✓
- Employer must provide proper personal protective equipment (PPE) for the specific machines. ✓

(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) ✓
- Spark test. ✓ Shape and colour of sparks. ✓

(Any 4 x 2) (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. ✓✓ (2)

3.2.3 **Hardening:**

- To produce extremely hard steel. ✓✓
- To enable it to resist wear and tear. ✓✓

(Any 1 x 2) (2)
[14]

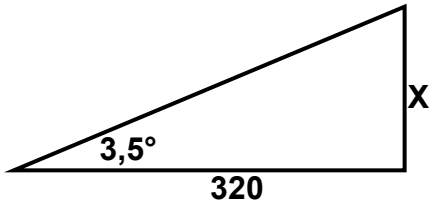
QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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:**



$$\text{Tan}\,\theta = \frac{X}{320} \quad ✓$$

$$x = \text{Tan}\,3{,}5° \times 320 \quad ✓$$

$$= 19{,}57 \text{ mm} \quad ✓$$

(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:**

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

$$= \frac{48}{4} \quad ✓$$

$$= 12 \text{ mm} \quad ✓$$

(2)

5.3.2 **Thickness:**

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

$$= \frac{48}{6} \quad ✓$$

$$= 8 \text{ mm} \quad ✓$$

(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)

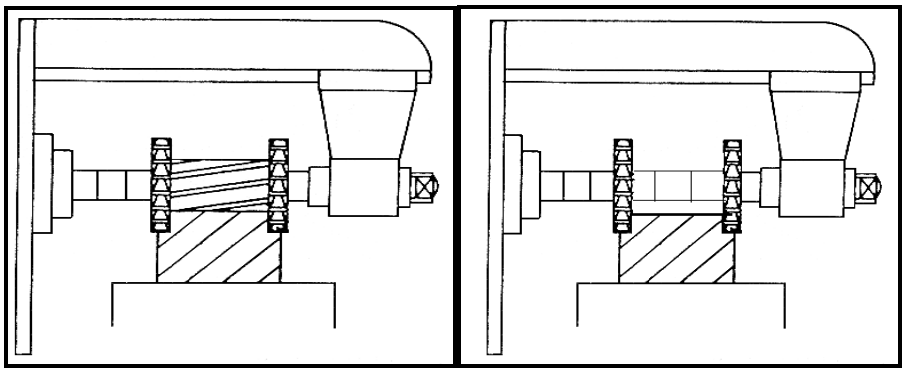
5.5.2 **Advantages of up-cut milling:**

- 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:**

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

$$= 99 + 2(3) \quad ✓$$

$$= 105 \text{ mm} \quad ✓$$

or

$$= m(T + 2)$$

$$= 3(33 + 2) \quad ✓$$

$$= 105 \text{ mm} \quad ✓$$

(2)

6.1.3 **Cutting depth:**

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

$$= 2{,}157 \times 3 \quad ✓$$

$$= 6{,}47 \text{ mm} \quad ✓$$

or

$$= 2{,}25m$$

$$= 2{,}25 \times 3 \quad ✓$$

$$= 6{,}75 \text{ mm} \quad ✓$$

(2)

6.1.4 **Addendum:**

$$\text{Addendum} = m$$

$$= 3 \text{ mm} \quad ✓$$

(1)

6.1.5 **Dedendum:**

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

$$= 1{,}157 \times 3 \quad ✓$$

$$= 3{,}47 \text{ mm} \quad ✓$$

or

$$= 1{,}25m$$

$$= 1{,}25 \times 3 \quad ✓$$

$$= 3{,}75 \text{ mm} \quad ✓$$

(2)

6.1.6 **Circular pitch:**

$$\text{CP} = m \times \pi$$

$$= 3 \times \pi \quad ✓$$

$$= 9{,}42 \text{ mm} \quad ✓$$

or

$$\text{CP} = \frac{\text{PCD}}{\text{T}} \times \pi$$

$$= \frac{99}{33} \times \pi \quad ✓$$

$$= 9{,}42 \text{ mm} \quad ✓$$

(2)

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

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

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

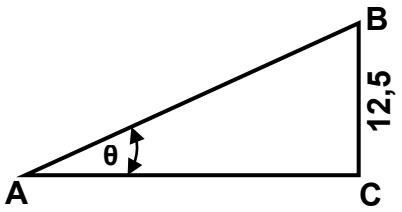
Calculate AC:

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

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

$$= \frac{12,5}{\text{Tan } 30°}$$

$$= 21,65 \text{ mm} \quad ✓$$



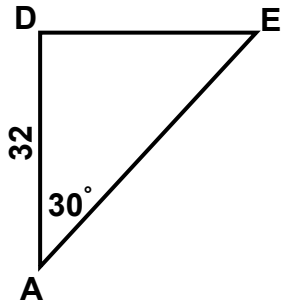
Calculate DE:

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

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

$$= \text{Tan}30° \times 32$$

$$= 18,48 \text{ mm} \quad ✓$$



Calculate 'Y':

$$Y = 180 - 2(DE) \quad ✓$$

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

$$= 143,04 \text{ mm} \quad ✓$$

Calculate 'X':

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

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

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

$$= 211,34 \text{ mm} \quad ✓$$

(Any other correct method is also acceptable.) (11)

6.3 **Differential indexing :**

6.3.1 **Indexing required:**

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

$$= \frac{40}{120} \div \frac{5}{5} \quad (\text{approximate})$$

$$= \frac{8}{24} \quad \checkmark$$

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 holes on a 66 hole circle ✓ (2)

6.3.2 **Change gears required:**

$$\frac{Dr}{Dn} = \frac{A-N}{A} \times \frac{40}{1}$$

$$= \frac{120-119}{120} \times \frac{40}{1} \quad \checkmark$$

$$= \frac{1}{120} \times \frac{40}{1}$$

$$= \frac{40}{120}$$

$$= \frac{4}{12} \times \frac{6}{6}$$

$$\frac{Dr}{Dn} = \frac{24}{72} \quad \checkmark \checkmark$$ (3)

6.3.3 **Direction of rotation of index plate:**

- Same direction ✓
- Clockwise ✓
- Positive ✓

(Any 1 x 1) (1)

[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

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

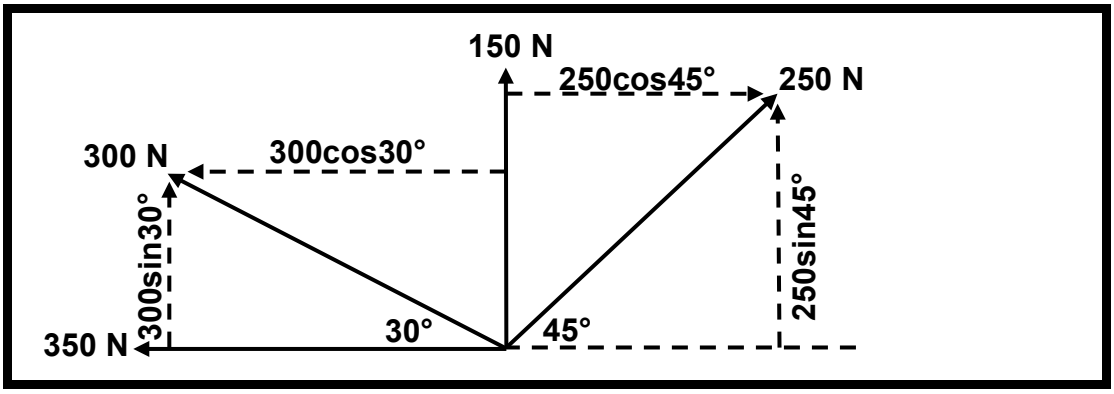
7.2 **Moment tester:**
To determine the reactions ✓ on either side ✓ of a simply loaded beam. (2)

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

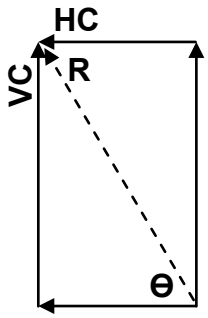
7.4 **Depth-micrometer:**
✓ ✓ ✓
66,64 mm (3)
[13]

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)

OR

HC (x)		VC (y)	
250cos45°	176,78N ✓	250sin45°	176,78N ✓
150cos90°	0N	150sin90°	150N ✓
300cos150°	-259,81N ✓	300sin150°	150N ✓
350cos180°	-350N ✓	350sin180°	0N
ΣHC	-433,03N ✓	ΣVC	476,78N ✓

(4) (4)

(13)

$R^2 = HC^2 + VC^2$ ✓

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

$R = 644{,}08\,N$ ✓

(2)

$\text{Tan}\,\Phi = \frac{VC}{HC}$ ✓

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

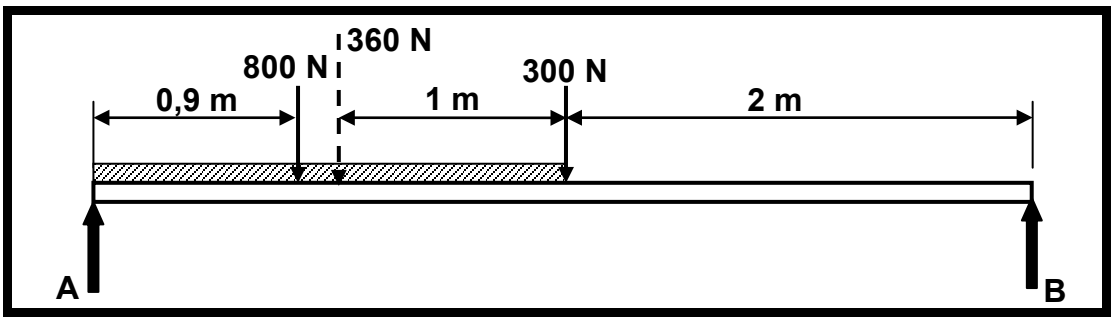
$\Phi = 47{,}75°$ ✓

(2)

✓

Resultant = 644,08 N 47,75° North from West **or** (Bearing 312,25°) (1) (13)

8.2 **Moments:**



Calculate A:
Take moments about B.

$\sum RHM = \sum LHM$

$(A \times 4) = (300 \times 2) + (360 \times 3) + (800 \times 3{,}1)$ ✓ ✓ ✓

$\frac{4A}{4} = \frac{4160}{4}$

$A = 1040\,N$ ✓

Calculate B:
Take moments about A.

$\sum LHM = \sum RHM$

$(B \times 4) = (300 \times 2) + (360 \times 1) + (800 \times 0{,}9)$ ✓ ✓ ✓

$\frac{4B}{4} = \frac{1680}{4}$

$B = 420\,N$ ✓

(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:

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

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

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

$$= 0{,}44 \times 10^{-3}\,m \quad \text{of} \quad = 0{,}44\,mm \quad \checkmark$$

(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. ✓
- Incorrect size belt. ✓
- 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. ✓
- Lack of maintenance. ✓

(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. ✓
- Regular maintenance. ✓

(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:**

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

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

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

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

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

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

$$= 70 \text{ mm} \quad \checkmark$$

(4)

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

$$\text{Helix angle} \quad \tan \Phi = \frac{\text{lead}}{\Pi \times \text{pitch diameter}} \quad \checkmark$$

$$= \frac{30}{\Pi \times 70} \quad \checkmark$$

$$\Phi = 7{,}77° \quad \text{or} \quad \Phi = 7°46' \quad \checkmark \quad \checkmark$$

(4)

10.1.3 **The leading tool angle:**

$$\text{Leading tool angle} = 90° - (\text{helix} + \text{clearance angle})$$

$$= 90° - (7°46' + 3°) \quad \checkmark$$

$$= 79°14' \quad \checkmark$$

OR

$$\text{Leading tool angle} = 90° - (\text{helix} + \text{clearance angle})$$

$$= 90° - (7{,}77° + 3°) \quad \checkmark$$

$$= 79{,}23° \quad \checkmark$$

(2)

10.1.4 **The following tool angle:**

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

OR

$$\text{Following tool angle} = 90° + (\text{helix - clearance angle})$$
$$= 90° + (7{,}77° - 3°) \quad ✓$$
$$= 94{,}77° \quad ✓$$ (2)

10.2 **Measurements of a screw thread:**

10.2.1 Metric screw thread ✓ (1)

10.2.2 Crest diameter / Outside diameter / 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. ✓
- Faster speeds can be obtained as with belt drives. ✓

(Any 2 x 1) (2)

11.2 **Hydraulic system:**

11.2.1 **Fluid pressure:**

$$A_A = \frac{\pi D_A^2}{4} \quad \checkmark$$

$$= \frac{\pi \times 0{,}022^2}{4}$$

$$= 0{,}38 \times 10^{-3}\ m^2 \quad \checkmark$$

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

$$= \frac{250}{0{,}38 \times 10^{-3}} \quad \checkmark$$

$$= 0{,}66 \times 10^6\ Pa \quad \text{or} \quad 657665{,}05\ Pa \quad \text{or} \quad 0{,}66\ MPa \quad \checkmark$$ (4)

11.2.2 **Load on piston B:**

$$A_B = \frac{\pi D_B^2}{4} \quad \checkmark$$

$$= \frac{\pi \times 0{,}248^2}{4}$$

$$= 48{,}31 \times 10^{-3}\ m^2 \quad \checkmark$$

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

$$F_B = p \times A_B \quad \checkmark$$

$$= \left(0{,}66 \times 10^6\right) \times \left(48{,}31 \times 10^{-3}\right) \quad \checkmark$$

$$= 31884{,}6\ N \quad \text{or} \quad 31{,}88\ kN \quad \checkmark$$ (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.
- Filter ✓ the oil of contaminates. ✓

(Any 1 x 2) (2)

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

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

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

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

$$= 176 \text{ N} \quad \checkmark$$

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

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

$$= 2640 \text{ Watt} \quad \text{or} \quad = 2,64 \text{ kW} \quad \checkmark$$ (5)

11.5 **Gear system:**

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

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

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

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

$$= 26 \text{ teeth} \quad \checkmark$$ (3)

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

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

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

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

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