basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2018

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 21 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1	A ✓	(1)
1.2	C ✓	(1)
1.3	A ✓	(1)
1.4	B ✓	(1)
1.5	D ✓	(1)
1.6	A ✓	(1)

TOTAL QUESTION 1: [6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Angle grinder: (Before using)**

- The safety guard must be in place before starting. ✓
- Protective shields must be placed around the object being grinded to protect the people around. ✓
- Use the correct grinding disc for the job. ✓
- Make sure that there are no cracks in the disc before you start. ✓
- Protective clothing and eye protection are essential. ✓
- Check electrical outlets and cord/plugs for any damages. ✓
- Ensure that lockable switch is disengaged. ✓
- Ensure that the disc and the nut are well secured. ✓
- Ensure that the removable handle is secured. ✓

(Any 2 x 1) (2)

2.2 **Welding goggles:**

- To protect your eyes against sparks ✓
- To protect your eyes against heat ✓
- To be able to see where to weld ✓
- To protect your eyes from UV rays ✓

(Any 2 x 1) (2)

2.3 **PPE for Hydraulic Press:**

- Overall ✓
- Safety shoes / boots✓
- Safety goggle ✓
- Leather gloves ✓
- Face shield ✓

(Any 2 x 1) (2)

2.4 **Workshop layouts:**

- Process layout ✓
- Product layout ✓ (2)

2.5 **Employer's responsibility regarding first-aid:**

- Provision of first-aid equipment ✓
- First aid training ✓
- First-aid services by qualified personnel ✓
- Any first aid procedures / treatment ✓
- Display first aid safety signs ✓
- First aid personnel must be identified by means of arm bands or relevant personal signage ✓

(Any 2 x 1) (2)

TOTAL QUESTION 2: [10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **Bending test:**

- Ductility ✓✓
- Malleability ✓✓
- Brittleness ✓✓
- Flexibility ✓✓

(Any 1 x 2) (2)

3.2 **Heat-treatment:**

3.2.1 **Annealing:**

- To relieve internal stresses ✓
- To soften the steel ✓
- To make the steel ductile ✓
- To refine the grain structure of the steel ✓
- To reduce the brittleness of the steel ✓

(Any 2 x 1) (2)

3.2.2 **Case hardening:**

- To require a wear resistant surface ✓ and it must be tough enough internally ✓ at the core to withstand the applied loads.
- Hard case ✓ and tough core. ✓

(Any 1 x 2) (2)

3.3 **Tempering process:**

- To reduce ✓ the brittleness ✓ caused by the hardening process.
- Relieve ✓ strain ✓ caused during hardening process.
- Increase ✓ the toughness of the steel. ✓

(Any 1 x 2) (2)

3.4 **Factors for heat-treatment processes:**

- Heating temperature / Carbon content ✓
- Soaking (Time period at temperature) / Size of the work piece ✓
- Cooling rate / Quenching rate ✓ (3)

3.5 **Hardening of steel:**

- Steel is heated to 30 – 50°C above the higher critical temperature. (AC_3) ✓
- It is then kept at that temperature to ensure (soaking) that the whole structure is Austenite. ✓
- The steel is then rapidly cooled by quenching it in clean water, brine or oil. ✓ (3)

TOTAL QUESTION 3: [14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

TOTAL QUESTION 4: [14]

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

5.1 **Advantages of using the tailstock to cut an external taper:**

- Long an accurate taper can be cut. ✓
- The automatic feed can be used which result in a good finish. ✓ (2)

5.2 **Calculate the compound slide set-over:**

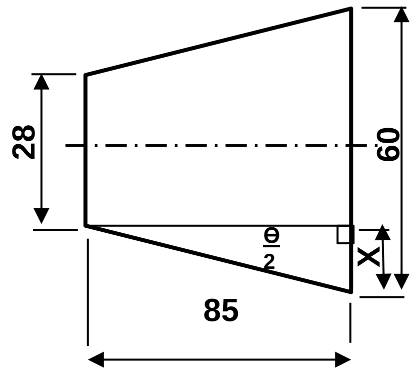
$$\text{Tan}\frac{\theta}{2} = \frac{D-d}{2L} \quad ✓$$

$$\text{Tan}\frac{\theta}{2} = \frac{60-28}{2\times 85} \quad ✓✓$$

$$= 0,188$$

$$\frac{\theta}{2} = 10,66^{\circ} \quad ✓✓$$

OR



$$X = \frac{D-d}{2} \quad ✓$$

$$= \frac{60-28}{2} \quad ✓$$

$$= 16\,\text{mm} \quad ✓$$

$$\text{Tan}\frac{\theta}{2} = \frac{16}{85} \quad ✓$$

$$\frac{\theta}{2} = 10,66^{\circ} \quad ✓$$

(5)

5.3 **Centre gauge:**

- To measure the form and angle of the screw cutting tool angle while grinding the tool ✓
- To set the screw cutting tool square/perpendicular to the axis of the work piece ✓ (2)

5.4 **Parallel key:**
Length:

$$\text{Length} = 1,5 \times \text{diameter} \quad ✓$$

$$= 1,5 \times 42 \quad ✓$$

$$= 63\ \text{mm} \quad ✓$$

(3)

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

- Deeper cuts can be made as the cutting pressure on the cutter is lower than down 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 quicker/course feed can be used. ✓
- The strain on the cutter and arbour will be less. ✓
- Vibration is limited ✓
- Good finish ✓
- Low noise level ✓

(Any 2 x 1) (2)

5.6 **Disadvantage of down-cut milling:**

- Vibration in the arbour is unavoidable. ✓
- A fine feed must be used. ✓
- When milling a material with hard scale the milling cutter will be damaged. ✓
- Process takes time because of slower feed. ✓
- Noisy process. ✓
- Bad finish because of vibration. ✓

(Any 2 x 1) (2)

5.7 **Methods of centring a milling cutter:**

- Square and ruler method. ✓
- Set-over method by milling machine dial. ✓
- Dial indicator method ✓
- Using reference points on digital read out equipment ✓

(Any 2 x 1) (2)

TOTAL QUESTION 5: **[18]**

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 **Spur gear:**
Chordal tooth thickness:

$t_c = Tm\sin\frac{90^\circ}{T}$ ✓ or $t_c = PCD\sin\frac{90^\circ}{T}$ ✓

$= 50 \times 3\sin\frac{90^\circ}{50}$ ✓ or $= 150\sin\frac{90^\circ}{50}$ ✓

$= 50 \times 3(0{,}03141)$ ✓ or $= 150 \times 0{,}03141$ ✓

$= 4{,}71\ mm$ ✓ or $= 4{,}71\ mm$ ✓ (4)

6.2 **Calculate simple indexing:**

$\text{Simple Indexing} = \frac{40}{N}$

$= \frac{40}{13}$ ✓

$= 3\frac{1}{13}$ ✓

$= 3\frac{1}{13} \times \frac{3}{3}$

$= 3\frac{3}{39}$ ✓

✓
3 full turns and 3 holes in a 39 hole circle (4)

6.3 **Differential indexing:**

6.3.1 **Indexing required:**

$$\text{Indexing} = \frac{40}{n} = \frac{40}{127}$$

$$= \frac{40}{A} = \frac{40}{125} \div \frac{5}{5} \quad ✓$$

$$= \frac{8}{25} \quad ✓$$

Indexing = 8 holes on the 25 hole circle ✓ (3)

6.3.2 **Change gears required:**

$$\frac{Dr}{Dn} = \frac{A-n}{A} \times \frac{40}{1} \quad ✓$$

$$= \frac{125-127}{125} \times \frac{40}{1} \quad ✓$$

$$= \frac{2}{125} \times \frac{40}{1}$$

$$= \frac{-80}{125} \div \frac{5}{5} \quad ✓$$

$$= \frac{-16}{25} \times \frac{4}{4}$$

$$= \frac{-64}{100} \quad ✓ ✓$$

(5)

6.3.3 **Direction of rotation of index plate:**
The index plate will turn the opposite ✓ direction as the index crank handle. (1)

6.4 **Calculate distance "x" between rollers:**

$$"x" = 150 + 2(AB) - 2(CD) - 2r$$

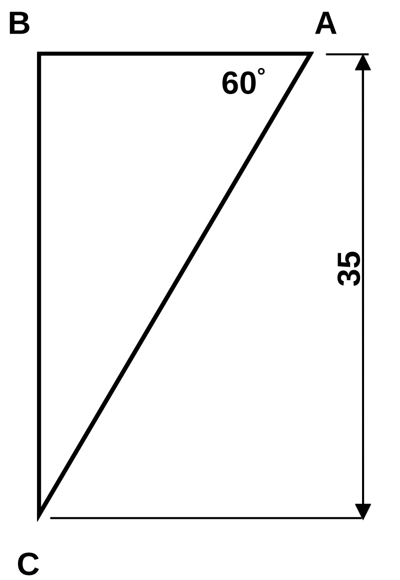
$$\tan\theta = \frac{BC}{AB} \quad ✓$$

$$AB = \frac{BC}{\tan\theta}$$

$$= \frac{35}{\tan 60°} \quad ✓$$

$$= 20{,}207 \text{ mm} \quad ✓$$

$$= 20{,}21 \text{ mm}$$

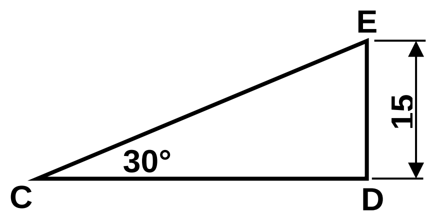


$$\tan\theta = \frac{DE}{CD} \quad ✓$$

$$CD = \frac{15}{\tan\theta} \quad ✓$$

$$= \frac{15}{\tan 30°}$$

$$= 25{,}98 \text{ mm} \quad ✓$$



$$"x" = 150 + 2(AB) - 2(CD) - 2r \quad ✓$$

$$= 150 + 2(20{,}21) - 2(25{,}98) - 2(15)$$

$$= 150 + 40{,}42 - 51{,}96 - 30 \quad ✓$$

$$= 108{,}454 \text{ mm}$$

$$= 108{,}45 \text{ mm} \quad ✓$$

(9)

6.5 **Reasons for balancing work piece on a centre lathe:**

- Prevent unnecessary bearing loads ✓
- Prevent excessive vibration ✓
- To obtain a good finish ✓
- To prevent clatter on the gear teeth ✓
- To prevent the spindle from bending ✓

(Any 2 x 1) (2)

TOTAL QUESTION 6: [28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Hardness testers:**

- Brinell-hardness tester ✓
- Rockwell-hardness tester ✓
- Vickers ✓

(Any 2 x 1) (2)

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

7.3 **Tensile test:**
A piece of material is subjected to an increasing axial load ✓ while measuring ✓ the corresponding elongation ✓ of the material. (3)

7.4 **Depth micro-meter:**

Reading = 100 ✓ + 11,00 ✓ + 0,50 ✓ + 0,09 ✓

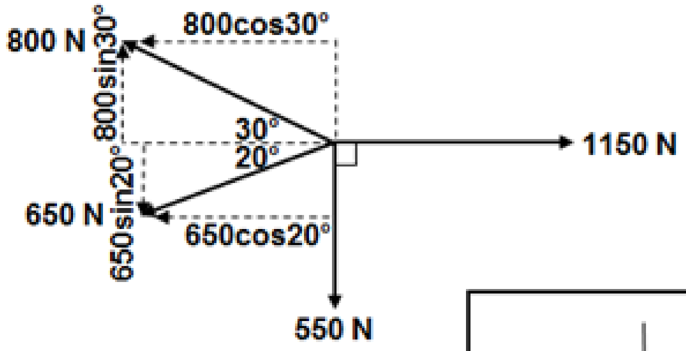
= 111,59 mm ✓ (5)

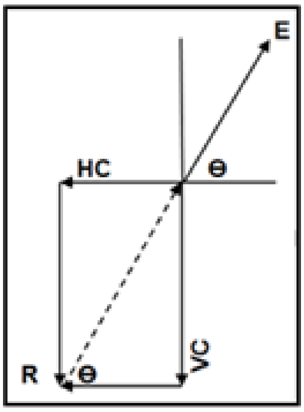
7.5 **Measure depth:**
Vernier calliper ✓ (1)

TOTAL QUESTION 7: [13]

QUESTION 8: FORCES (SPECIFIC)

8.1 **Forces:**





$$HC = 1150 - 800\cos 30° - 650\cos 20° \checkmark$$
$$= 1150 \checkmark - 692{,}82 \checkmark - 610{,}80 \checkmark$$
$$= -153{,}62\ N \checkmark$$

$$VC = 800\sin 30° - 650\sin 20° - 550 \checkmark$$
$$= 400 \checkmark - 222{,}31 \checkmark - 550 \checkmark$$
$$= -372{,}31\ N \checkmark$$

Horizontal components ✓	Magnitudes	Vertical components ✓	Magnitudes
1150	1150 N ✓	800Sin30°	400 N ✓
-800Cos30°	-692,82 N ✓	-650Sin20°	– 222,31 N ✓
-650Cos20°	-610,80 N ✓	-550	-550 N ✓
TOTAL	-153,62 N ✓	TOTAL	-372,31 N ✓

$$E^2 = HC^2 + VC^2 \checkmark$$
$$\sqrt{E^2} = \sqrt{153{,}62^2 + 372{,}31^2}$$
$$E = 402{,}76N \checkmark$$

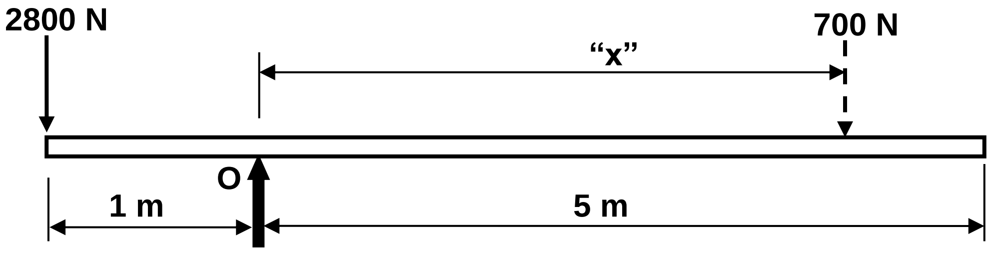
$$\tan\theta = \frac{VC}{HC} \checkmark$$
$$= \frac{372{,}31}{153{,}62}$$
$$\theta = 67{,}58° \checkmark$$

Equilibrant = 402,76 N en 67,58° North from East ✓

(15)

Horizontal Components	Magnitudes	Vertical Components	Magnitudes
1150cos0°	1150N	1150sin0°	0N
800cos150°	-692,82N	800sin150°	400N
650cos200°	-610,80N	650sin200°	-222,31N
550cos270°	0N	550sin270°	-550N
TOTAL:	**-153,62N**	**TOTAL:**	**-372,31N**

8.2 **Moments:**



Calculate "x":
Take moments about O.

$$\sum RHM = \sum LHM$$
$$700 \times "x" = 2800 \times 1 \quad ✓$$
$$700 \times "x" = 2800 \quad ✓$$
$$"x" = \frac{2800}{700} \quad ✓$$
$$"x" = 4\,m \quad ✓$$

(4)

8.3 **Stress and Strain:**

8.3.1 **Type of stress:**
Compressive stress ✓ (1)

8.3.2 **Stress:**

$$A = \frac{\pi(D^2 - d^2)}{4} \quad ✓$$
$$= \frac{\pi(0{,}04^2 - 0{,}03^2)}{4}$$
$$A = 0{,}55 \times 10^{-3}\ m^2 \quad ✓$$

$$\sigma = \frac{F}{A} \quad ✓$$
$$= \frac{50 \times 10^3}{0{,}55 \times 10^{-3}} \quad ✓$$
$$\sigma = 90{,}91 \times 10^6\ Pa$$
$$\sigma = 90{,}91\ MPa \quad ✓$$

(NO UNIT – NO MARK) (5)

8.3.3 **Change in length:**

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

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

$$= \frac{90,91 \times 10^{6}}{90 \times 10^{9}}$$

$$= 1,01 \times 10^{-3} \quad ✓$$

(IF ANY UNIT IS GIVEN – NO MARK)

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

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

$$= (1,01 \times 10^{-3}) \times (80) \quad ✓$$

$$= 0,08 \text{ mm} \quad ✓$$

(5)

8.3.4 **Safety factor:**

$$\text{Safety factor} = \frac{\text{Break stress}}{\text{Safe workingstress}} \quad ✓$$

$$\text{Safe workingstress} = \frac{\text{Break stress}}{\text{Safety factor}}$$

$$= \frac{600 \times 10^{6}}{4} \quad ✓$$

$$= 150 \times 10^{6} \text{ Pa}$$

$$= 150 \text{ MPa} \quad ✓$$

(3)

TOTAL QUESTION 8: [33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Lack of preventative maintenance:**

- Risk of injury or death. ✓
- Financial loss due to damage suffered as a result of part failure and the waste of material. ✓
- Loss of valuable production time. ✓ (3)

9.2 **Causes for the malfunctioning of chain drive systems:**

- Lack of or incorrect lubrication ✓
- Lack of maintenance ✓
- Overloading ✓
- Misalignment of sprockets ✓
- Incorrect chain tension ✓
- Contamination of chain drive system such as dust or sand ✓

(Any 2 x 1) (2)

9.3 **Procedures to reduce the physical wear on a belt drive system:**

- Check the belt alignment. ✓
- Checking the belt tension. ✓
- Prevent overloading of the system. ✓
- Keep the pulleys and belt clean. ✓
- Check that all covers are secure. ✓

(Any 2 x 1) (2)

9.4 **Procedures to replace the belt on a belt drive system:**

- Ensure that the machine is switched off ✓
- Release the tension on the belt ✓
- Remove the belt from the pulleys ✓
- Fit the correct size replacement belt onto the pulleys ✓
- Check the pulley alignment ✓
- Apply adequate tension according to specification and lock the system ✓

(Any 5 x 1) (5)

9.5 **Properties of materials:**

9.5.1 **Poly vinyl chloride (PVC):**

- Flexible ✓
- Rubber-like substance ✓
- Makes a dull sound when dropped ✓
- Tough ✓
- Act as an insulator ✓
- It is durable ✓
- Highly resistant to oxidative material ✓
- Oil, water and chemical resistant ✓

(Any 1 x 1) (1)

9.5.2 **Carbon fibre:**

- Strong ✓
- Tough ✓
- Light weight ✓
- Good electrical conductor ✓

(Any 1 x 1) (1)

9.6 **Difference between "Thermoplastic" and "Thermo hardened (thermosetting)" composites:**
Thermoplastics can be reheated and deformed. / Recyclable ✓
Thermo hardened cannot be reheated. / Non-recyclable ✓ (2)

9.7 **Examples of thermo hardened composites:**

- Carbon fibre or (Any application) ✓
- Glass fibre or (Any application) ✓
- Bakelite or (Any application) ✓
- Teflon or (Any application) ✓

(Any 2 x 1) (2)

TOTAL QUESTION 9: [18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Square thread:**

10.1.1 **The lead of the thread:**

$$\text{Lead} = \text{pitch} \times \text{no of starts} \ \checkmark$$
$$= 5 \times 2$$
$$= 10 \text{ mm} \ \checkmark$$

(2)

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

$$\text{Helix angle } \tan\theta = \frac{\text{lead}}{\text{pitch cercumfrence}} \ \checkmark$$
$$= \frac{10}{\pi \times \left(\text{outside dia} - \frac{1}{2}\text{pitch}\right)} \ \checkmark \checkmark$$
$$= \frac{10}{\pi \times (82 - 2,5)} \ \checkmark$$
$$= 0,0400$$
$$\theta = 2,29° / 2°17'24'' \ \checkmark$$

OR

$$\text{Helix angle } \tan\theta = \frac{\text{lead}}{\text{pitch diameter}} \ \checkmark$$
$$= \frac{10}{82 - 2,5} \ \checkmark \checkmark\checkmark$$
$$\theta = 7,17° / 7°10'12'' \ \checkmark$$

(5)

10.1.3 **The leading tool angle:**

$$\text{Leading tool angle} = 90° - (\text{helix angle} + \text{clearance angle}) \ \checkmark$$
$$= 90° - (2,29° + 3°)$$
$$= 84,71° / 84°42'36'' \ \checkmark$$

OR

$$\text{Leading tool angle} = 90° - (\text{helix angle} + \text{clearance angle}) \ \checkmark$$
$$= 90° - (7,17° + 3°)$$
$$= 79,83° / 79°49'48'' \ \checkmark$$

(2)

10.1.4 **The following tool angle:**

$$\begin{aligned}\text{Following tool angle} &= 90° + (\text{helix angle} - \text{clearance angle}) \checkmark \\ &= 90° + (2{,}29° - 3°) \\ &= 89{,}29° / 89°17'24'' \checkmark\end{aligned}$$

OR

$$\begin{aligned}\text{Following tool angle} &= 90° + (\text{helix angle} - \text{clearance angle}) \checkmark \\ &= 90° + (7{,}17° - 3°) \\ &= 94{,}17° / 94°10'12'' \checkmark\end{aligned}$$

(2)

10.2 **Measurements of a screw thread :**

10.2.1 Metric screw thread ✓ (1)

10.2.2 Crest / Major / External / Basic / Nominal / Outside diameter ✓ (1)

10.2.3 Pitch ✓ (1)

10.3 **Angles of a square thread cutting tool:**
A – Helix angle ✓
B – Clearance angle ✓
C – Leading tool angle ✓
D – Following tool angle ✓ (4)

TOTAL QUESTION 10: [18]

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

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

- Silent operation ✓
- Less expensive ✓
- Drive can take place over a longer distance ✓
- No lubrication needed ✓

(Any 2 x 1) (2)

11.2 **Hydraulics:**

11.2.1 **Fluid pressure:**

$$A_A = \frac{\pi d^2}{4} \quad ✓$$
$$= \frac{\pi(0{,}032)^2}{4}$$
$$= 0{,}8 \times 10^{-3}\ m^2 \quad ✓$$

$$p = \frac{F_A}{A_A} \quad ✓$$
$$= \frac{120}{0{,}8 \times 10^{-3}}$$
$$= 0{,}1492 \times 10^6\ Pa$$
$$= 0{,}15\ MPa \quad or \quad 149207{,}76\ \ Pa \quad ✓$$

(NO UNIT – NO MARK) (4)

11.2.2 **Diameter of the ram:**

$$p = \frac{F_A}{A_A} \quad ✓$$
$$A_B = \frac{F_B}{p}$$
$$= \frac{18 \times 10^3}{0{,}15 \times 10^6} \quad ✓$$
$$= 0{,}12\ m^2 \quad ✓$$

OR

$$\frac{F_B}{A_B} = \frac{F_A}{A_A} \quad ✓$$
$$A_B = \frac{A_A \times F_B}{F_A}$$
$$= \frac{(0{,}8 \times 10^{-3}) \times (18 \times 10^3)}{120} \quad ✓$$
$$= 0{,}12\ m^2 \quad ✓$$

$$A_B = \frac{\pi d^2}{4} \quad ✓$$
$$d = \sqrt{\frac{4A}{\pi}}$$
$$= \sqrt{\frac{4 \times 0{,}12}{\pi}} \quad ✓$$
$$= 0{,}39088\ m \quad ✓$$
$$= 390{,}88\ mm$$

(6)

11.3 **Hydraulic symbols: One-way valve**

 ✓

(1)

11.4 **Belt drives:**
Rotation frequency of the drive pulley:

$$N_{DR}D_{DR} = N_{DN}D_{DN}$$ ✓

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

$$= \frac{80 \times 240}{75}$$ ✓

$$= 256 \text{ r/min}$$ ✓

(4)

11.5 **Gear drives:**

11.5.1 **Rotation frequency of the output:**

$$\frac{N_A}{N_D} = \frac{\text{Product of Driven gears}}{\text{Product of Driver gears}}$$

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

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

$$= \frac{20 \times 25 \times 3000}{35 \times 30}$$ ✓ ✓

$$N_D = \frac{1428{,}57 \text{ r/min}}{60}$$ ✓

$$= 23{,}81 \text{ r/sec}$$ ✓

OR

$$N_B \times T_B = N_A \times T_A$$ ✓

$$N_B = \frac{N_A \times T_A}{T_B}$$

$$= \frac{3000 \times 20}{35}$$

$$= 1714{,}29 \text{r/min}$$ ✓

$$N_B = N_C = 1714{,}29 \text{r/min}$$

$$N_D \times T_D = N_C \times T_C$$ ✓

$$N_D = \frac{N_C \times T_C}{T_D}$$

$$= \frac{1714{,}29 \times 25}{30}$$ ✓

$$= \frac{1428{,}57 \text{r/min}}{60}$$ ✓

$$= 23{,}81 \text{r/sec}$$ ✓

(6)

11.5.2 **Gear ratio:**

$$\text{Gear ratio} = \frac{\text{Product of the number of teeth on driven gears}}{\text{Product of the number of teeth on driver gears}} \checkmark$$

$$= \frac{35}{20} \times \frac{30}{25} \checkmark$$

$$= 2{,}1 : 1 \checkmark$$

(3)

11.6 **Work done:**

$$\text{Work done} = F \times s \checkmark$$

$$= 250 \times 15$$

$$= 3750 \text{ Joule or N.m} \checkmark$$

(2)

TOTAL QUESTION 11: [28]

TOTAL: 200