basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2019

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 20 pages.

QUESTION 1: MULTIPLE-CHOICE (Generic)

1.1 B ✓ (1)

1.2 C ✓ (1)

1.3 A ✓ (1)

1.4 C ✓ (1)

1.5 A ✓ (1)

1.6 C ✓ (1)
[6]

QUESTION 2: SAFETY (Generic)

2.1 **Machine safety rule:**

- Know how to switch the machine off / emergency stop. ✓
- Wear personal protective equipment (PPE). ✓
- Know how to use the machine. ✓
- Ensure that all guards are in place. ✓
- No tools lying on the machine. ✓
- Work piece is properly secured. ✓
- Check the condition of the machine. ✓
- Follow manufacture's specifications before operating a machine. ✓
- Operator must have authorization to working on a machine. ✓
- Make sure the machine is not locked out. ✓
- Ensure that the machine setup is correct and safe. ✓
- Ensure that the machine area is clean and safe. ✓

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

2.2 **Drill press safety precautions:**

- To prevent injuries. ✓
- To improve accuracy. ✓
- To prevent work piece rotating/moving. ✓
- To prevent the drill bit from breaking. ✓

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

2.3 **Hydraulic press safety rules:**

- Make sure the press is in a good working condition. ✓
- Take notice of the pre-determined maximum pressure of the hydraulic press. ✓
- Make sure the area around the press is clean and free of oil, grease and water. ✓
- Ensure that the platform is rigid and square to the cylinder. ✓
- Ensure that suitable jigs and prescribed equipment is available. ✓

- Check hydraulic pipes for leaks or cracks. ✓
- Check supporting pins are not worn out and fitted properly. ✓
- Check fluid levels. ✓
- Compressive force must be applied at 90° to the object. ✓
- Check cable and pulleys on the platform if equipped. ✓
- Correct PPE. ✓
- Pressure gauge must be checked and calibrated. ✓
- Ensure that all guards are in place. ✓

(Any 2 x 1) (2)

2.4 **Reasons for wearing surgical gloves:**

- To prevent HIV/AIDS or any blood related infections being transmitted.✓
- To prevent contamination of the open wounds. ✓ (2)

2.5 **Safe handling of portable electrical equipment:**

- Ensure the electrical cord and plug, are in a good condition. ✓
- Ensure all safety guards are in place. ✓
- Ensure that the correct attachments (drill bits, blades etc.) are fixed in the correct way. ✓
- Do not force the machine/equipment. ✓
- Operate according to manufacturer instructions. ✓
- Avoid contact with water. ✓
- Keep the cable away from heat, oil, sharp edges and moving parts. ✓
- Make sure that the wires don't wrap around each other. ✓
- Avoid dropping the machine. ✓
- Check the condition of the equipment. ✓

(Any 2 x 1) (2)

2.6 **Responsibility of employer:**

- Provide and maintain working systems, work area, equipment and tools in a safe condition. ✓
- Eliminate or reduce any potential hazard. ✓
- Produce, handle, store and transport goods safely. ✓
- Ensure that every person employed complies with the requirements of this OHS Act. ✓
- Enforce measures if necessary in the interest of health and safety. ✓
- Appoint a person who is trained and who have the authority to ensure that the employee takes precautionary measures. ✓
- Inform employees of the hazards to his health and safety attached to any duty or work situation. ✓
- Provide first aid equipment. ✓

(Any 1 x 1) (1)

2.7 **Responsibility of employee:**

- Pay attention to their own and other people's health and safety. ✓
- Co-operate with the employer regarding the OHS Act. ✓
- Carry out a lawful order given to them. ✓
- Report any situation that is unsafe or unhealthy. ✓
- Report all incidents and accidents. ✓
- Not to interfere with any safety equipment or misuse such equipment.✓
- Obey all safety rules. ✓

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

QUESTION 3: MATERIAL (Generic)

3.1 **Filing test:**

- Use the right ✓ filing skills. ✓
- File on the tip or edge ✓✓ of the metal.
- By applying chalk ✓ to the file surface. ✓

(Any 1 x 2) (2)

3.2 **Purpose of heat treatment of steel:**

Heat treatment of steel is done to change ✓ the properties/grain structure ✓ of steel. (2)

3.3 **Reasons for tempering hardened steel:**

- To reduce ✓ the brittleness ✓ caused by the hardening process.
- To relieve ✓ strain ✓ caused during hardening process.
- To increase ✓ the toughness ✓ of the steel.
- To give hardened work piece a more ✓ fine-grained structure. ✓

(Any 2 x 2) (4)

3.4 **Heat treatment processes on steel:**

3.4.1 **Annealing:**

- The steel is heated to the prescribed temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then cooled very slowly to produce maximum softness. ✓ (3)

3.4.2 **Hardening:**

- The steel is heated slightly higher than the upper critical temperature. (AC_3) ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in rapid cooling medium. ✓ (3)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (Specific)

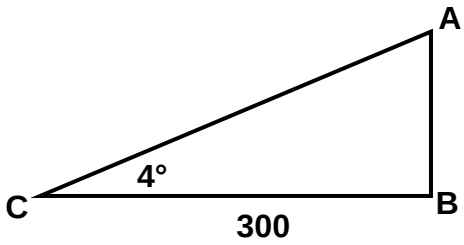
4.1	A ✓	(1)
4.2	D ✓	(1)
4.3	B/A ✓	(1)
4.4	A ✓	(1)
4.5	B/A ✓	(1)
4.6	B ✓	(1)
4.7	B ✓	(1)
4.8	A ✓	(1)
4.9	C ✓	(1)
4.10	B ✓	(1)
4.11	D ✓	(1)
4.12	B ✓	(1)
4.13	A ✓	(1)
4.14	B ✓	(1)

[14]

QUESTION 5: TERMINOLOGY (Lathe and Milling Machine) (Specific)

5.1 **Taper turning:**

5.1.1 **Small diameter:**



$$\text{Tan}\frac{\theta}{2}=\frac{AB}{300} \quad \checkmark$$

$$AB = \text{Tan}4°\times 300$$

$$= 20{,}98\text{ mm} \quad \checkmark$$

$$d = D - 2(AB) \quad \checkmark$$

$$= 200 - 2(20{,}98) \quad \checkmark$$

$$= 158{,}04\text{ mm} \quad \checkmark$$

OR

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

$$\tan 4° = \frac{200-d}{2(300)} \quad \checkmark$$

$$\tan 4°\times 600 = 200 - d \quad \checkmark$$

$$d = 200 - (\tan 4°\times 600) \quad \checkmark$$

$$d = 158{,}04\text{ mm} \quad \checkmark$$

OR

$$d = D - 2AB \quad \checkmark$$

$$= 200 - 2(300\times\tan 4°) \quad \checkmark\checkmark\checkmark$$

$$= 158{,}04\text{ mm} \quad \checkmark$$

(5)

5.1.2 **Setting over of tailstock:**

$$\text{Setting over}: 20{,}98\ \text{mm over } 300\ \text{mm}$$
$$\text{Thus "X" mm over } 400\ \text{mm}$$
$$300\text{"X"} = 20{,}98 \times 400 \quad ✓$$
$$\text{"X"} = \frac{20{,}98 \times 400}{300} \quad ✓$$
$$\text{"X"} = 27{,}97\text{mm} \quad ✓$$

OR

$$\text{Set over} = \frac{L(D-d)}{2l} \quad ✓$$
$$= \frac{400(200-158{,}04)}{2(300)} \quad ✓$$
$$= 27{,}97\ \text{mm} \quad ✓$$

(3)

5.2 **Parallelkey:**

5.2.1 **Width:**

$$\text{Width} = \frac{D}{4}$$
$$= \frac{42}{4} \quad ✓$$
$$= 10{,}5\ \text{mm} \quad ✓$$

(2)

5.2.2 **Thickness:**

$$\text{Thickness} = \frac{D}{6}$$
$$= \frac{42}{6} \quad ✓$$
$$= 7\ \text{mm} \quad ✓$$

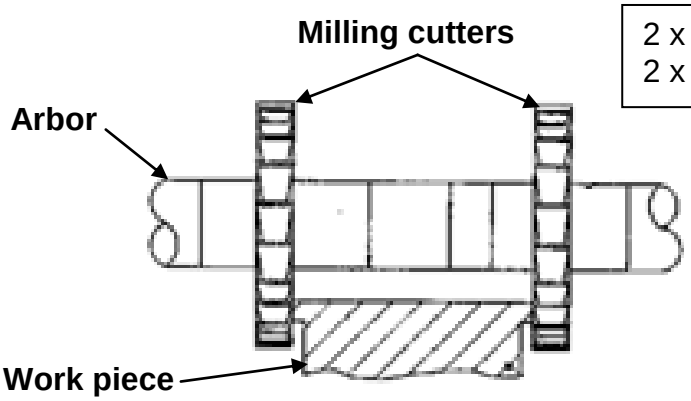
(2)

5.3 **Advantages of down cut milling:**

- A better finish is obtained. ✓
- Friction is reduced. ✓
- High speed cutting is possible. ✓
- Less power required. ✓
- Coolant is carried down to the teeth to where it is required. ✓
- Tends to force the work piece onto the machine table there for deeper cuts can be made. ✓
- Less vibration. ✓

(Any 2 x 1) (2)

5.4 **Straddle milling:**



2 x ✓ for drawing
2 x ✓ for any 2 labels

(4)
[18]

QUESTION 6: TERMINOLOGY (Indexing) (Specific)

6.1 **Spur gear terminology:**

6.1.1 **Module:**

$$\text{Module} = \frac{\text{PCD}}{\text{T}}$$
$$= \frac{126}{42} \quad ✓$$
$$= 3 \quad ✓$$

(2)

6.1.2 **Working depth:**

$$\text{WD} = 2 \times \text{m} \quad ✓$$
$$= 2 \times 3$$
$$= 6\text{mm} \quad ✓$$

(2)

6.1.3 **Cutting depth:**

$$\text{Cutting depth} = 2{,}157 \times \text{m} \qquad = 2{,}25 \times \text{m}$$
$$= 2{,}157 \times 3 \quad ✓ \qquad \text{or} \qquad = 2{,}25 \times 3 \quad ✓$$
$$= 6{,}47\text{mm} \quad ✓ \qquad = 6{,}75\text{mm} \quad ✓$$

(2)

6.2 **Angular indexing:**

$$\text{Indexing} = \frac{\text{n}}{9^\circ} = \frac{34^\circ}{9^\circ} \quad ✓$$
$$= 3\frac{7}{9} \times \frac{6}{6} \quad ✓$$
$$= 3\frac{42}{54} \quad ✓$$

3 full turns and 42 holes on the 54 hole circle. ✓ (4)

6.3 **Indexing:**

6.3.1 **Differential indexing:**

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

$$= \frac{40}{121} \quad \notin \text{ not possible}$$

$$\text{Chosen divisions} = \frac{40}{A}$$

$$= \frac{40}{120} \quad ✓$$

$$= \frac{1}{3} \times \frac{8}{8} \quad ✓$$

$$= \frac{8}{24} \quad ✓ ✓$$

No full turns, 8 holes on the 24 hole circle. ✓
OR
No full turns, 10 holes on the 30 hole circle.✓
OR
No full turns, 13 holes on the 39 hole circle. ✓
OR
No full turns, 14 holes on the 42 hole circle. ✓
OR
No full turns, 17 holes on the 51 hole circle. ✓
OR
No full turns, 18 holes on the 54 hole circle. ✓
OR
No full turns, 19 holes on the 57 hole circle. ✓
OR
No full turns, 22 holes on the 66 hole circle. ✓ (5)

6.3.2 **Change gears:**

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

$$= \frac{120 - 121}{120} \times \frac{40}{1} \quad ✓$$

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

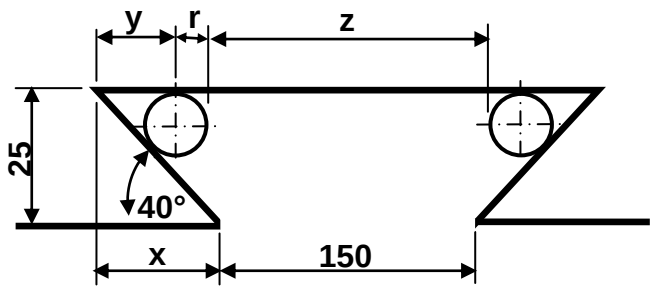
$$= \frac{-40}{120}$$

$$= \frac{-1}{3} \times \frac{24}{24} \quad ✓$$

$$\frac{Dr}{Dn} = \frac{24}{72} \quad ✓ ✓$$

(5)

6.4 **Calculate distance Z between rollers:**

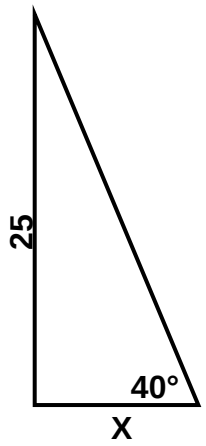


$$z = 150 + 2x - 2(y + r)$$

$$\text{Tan}\,40° = \frac{25}{x} \quad ✓$$

$$x = \frac{25}{\text{Tan}40°}$$

$$= 29{,}79\,\text{mm} \quad ✓$$



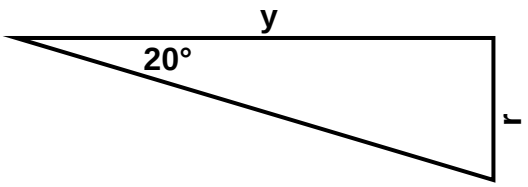
$$r = \frac{d}{2}$$

$$= \frac{10}{2} \quad ✓$$

OR

$$= 5\,\text{mm}$$

$$\text{Tan}20° = \frac{r}{y} \quad ✓$$



$$y = \frac{5}{\text{Tan}20°}$$

$$= 13{,}74\ \text{mm} \quad ✓$$

$$z = 150 + 2x - 2(y + r) \quad ✓$$

$$= 150 + 2(29{,}79) - 2(13{,}74 + 5) \quad ✓$$

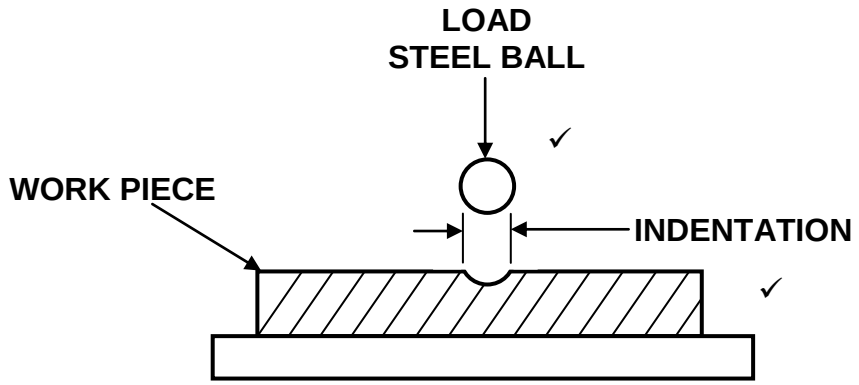
$$= 150 + 59{,}58 - 37{,}48$$

$$= 172{,}1\ \text{mm} \quad ✓$$

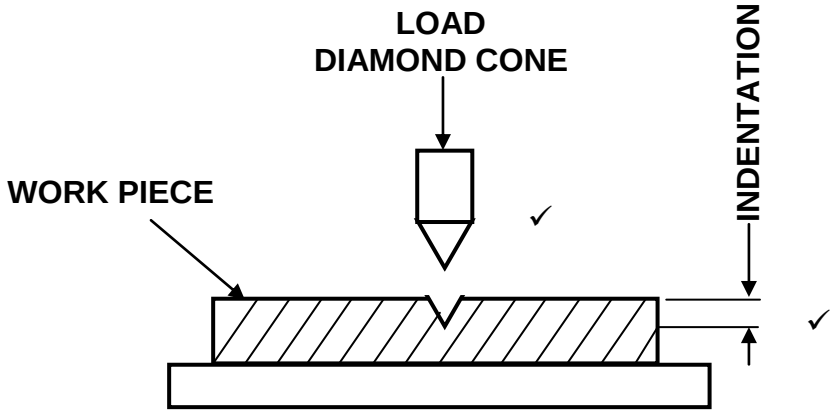
(8)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (Specific)

7.1 **Brinell tester:**



Rockwell hardness tester:



(4)

7.2 **Tensile test:**

- Tensile strength ✓
- Elasticity ✓
- Ductility ✓
- Plasticity ✓

(Any 2 x 1) (2)

7.3 **Depth micro-meter reading:**

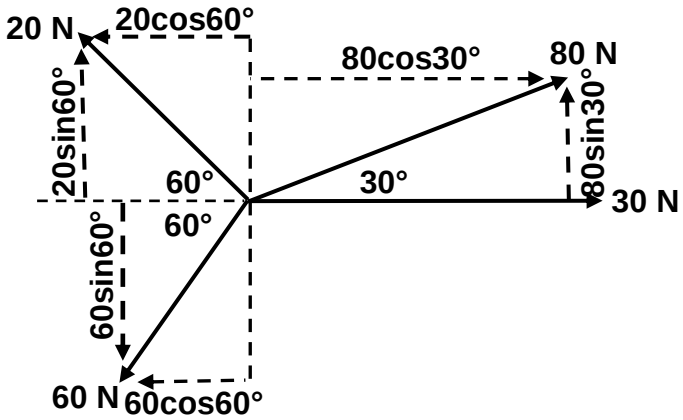
50,00 ✓
16,00 ✓
0,00 ✓
0,33 ✓
66,33 mm ✓ (5)

7.4 Screw thread ✓ micro meter ✓ (2)

[13]

QUESTION 8: FORCES (Specific)

8.1 **Equilibrant:**



$$\sum HC = 30 + 80\cos30° - 20\cos60° - 60\cos60°$$

✓ ✓ ✓ ✓

$$= 30 + 69{,}28 - 10 - 30$$

$$= 59{,}28 \text{ N} \checkmark$$

$$\sum VC = 20\sin60° + 80\sin30° - 60\sin60°$$

✓ ✓ ✓

$$= 17{,}32 + 40 - 51{,}96$$

$$= 5{,}36 \text{ N} \checkmark$$

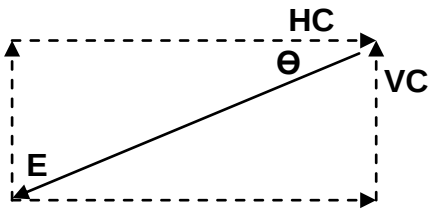
OR

HC	Magnitudes	VC	Magnitudes
30	30 ✓	20sin60°	17,32 ✓
80cos30°	69,28 ✓	80sin30°	40 ✓
-20cos60°	-10 ✓	-60sin60°	-51,96 ✓
-60cos60°	-30 ✓		
TOTAL	59,28 N ✓	**TOTAL**	5,36 N ✓

$$E^2 = HC^2 + VC^2$$

$$E = \sqrt{59{,}28^2 + 5{,}36^2} \checkmark$$

$$E = 59{,}52 \text{ N} \checkmark$$



$$\text{Tan}\theta = \frac{VC}{HC}$$

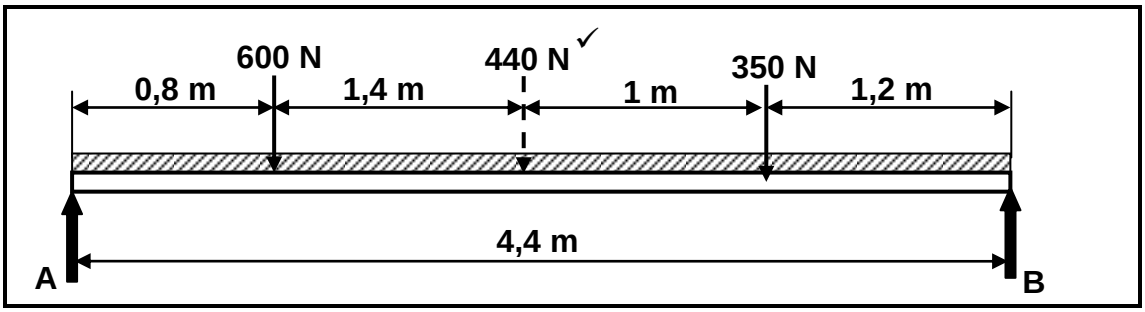
$$= \frac{5{,}36}{59{,}28} \checkmark$$

$$\theta = 5{,}17° \checkmark$$

E = 59,52 N at 5,17° (South from West) or
E = 59,52 N at 84,83° (West from South) or
E = 59,52 N at a bearing of 264,83° ✓

(14)

8.2 **Moments:**



Distributed load:

$= 100\,\text{N/m} \times 4{,}4\,\text{m}$

$= 440\,\text{N}$ ✓

Calculate A:

Moments about B:

$\sum \text{RHM} = \Sigma \text{LHM}$

$(A \times 4{,}4) = (350 \times 1{,}2) + (440 \times 2{,}2) + (600 \times 3{,}6)$ ✓

$\frac{4{,}4A}{4{,}4} = \frac{3548}{4{,}4}$ ✓

$A = 806{,}36\,\text{N}$ ✓

Calculate B:

Moments about A.

$\sum \text{LHM} = \Sigma \text{RHM}$

$(B \times 4{,}4) = (600 \times 0{,}8) + (440 \times 2{,}2) + (350 \times 3{,}2)$ ✓

$\frac{4{,}4B}{4{,}4} = \frac{2568}{4{,}4}$ ✓

$B = 583{,}64\,\text{N}$ ✓ (8)

8.3 **Stress-strain:**

8.3.1 Compressive stress ✓ (1)

8.3.2 **Stress:**

$$A = \frac{\pi\left(D^2 - d^2\right)}{4}$$

$$= \frac{\pi\left(0{,}04^2 - 0{,}025^2\right)}{4} \quad ✓$$

$$A = 0{,}77 \times 10^{-3}\,m^2 \quad ✓$$

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

$$= \frac{600}{0{,}77 \times 10^{-3}} \quad ✓$$

$$\sigma = 779220{,}78\ Pa \text{ or}$$

$$= 0{,}78 \times 10^{6}\ Pa \text{ or} \quad ✓$$

$$= 0{,}78\,MPa$$

(4)

8.3.3 **Change in length:**

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

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

$$= \frac{0{,}78 \times 10^{6}}{90 \times 10^{9}} \quad ✓$$

$$\varepsilon = 8{,}66 \times 10^{-6} \quad ✓$$

$$\varepsilon = \frac{\Delta l}{ol}$$

$$\Delta l = \varepsilon \times ol \quad ✓$$

$$= \left(8{,}67 \times 10^{-6}\right) \times (100) \quad ✓$$

$$= 0{,}87 \times 10^{-3}\ mm \quad ✓$$

(6)

[33]

QUESTION 9: MAINTENANCE (Specific)

9.1 **Types of maintenance:**

- Preventative ✓
- Predictive ✓
- Reliable centred ✓ (3)

9.2 **Malfunctioning of belt drives:**

- Lubrication between belt and pulley causing belt slip. ✓
- Pulleys not properly secured to shafts. ✓
- Incorrect pulley alignment. ✓
- Overloading the system. ✓
- Incorrect belt tension. ✓
- Worn belts. ✓
- Faulty/damaged tensioner pulley. ✓
- Lack of maintenance. ✓

(Any 2 x 1) (2)

9.3 **Replace the chain on a chain drive system:**

- Release the tension on the chain and remove from sprocket. ✓
- Check the condition and alignment of the sprockets. ✓
- Fit the new specified chain and lubricate. ✓
- Apply adequate tension to the chain. ✓
- Check for proper operation. ✓ (5)

9.4 **Wear on a gear drive system:**

- Check and replenish of lubrication levels. ✓
- Ensuring the gears are properly secured to shafts. ✓
- Cleaning and replacement of oil filters. ✓
- Reporting excessive noise, wear, vibration and overheating for expert attention. ✓

(Any 2 x 1) (2)

9.5 **Material:**

9.5.1 **Nylon:**

- Bushes ✓
- Gears ✓
- Pulleys ✓
- Fishing line ✓
- Clothing ✓
- Sails ✓
- Ropes ✓
- Sport equipment ✓
- Powder coating ✓

(Any 1 x 1) (1)

9.5.2 **Glass fibre:**

- Used in boats ✓
- Motor vehicle bodies ✓
- Transparent roof sheets ✓
- Petrol tanks ✓
- Swimming pools ✓
- Furniture ✓
- Fruit and salad bowls ✓
- Ornaments ✓
- Fishing rods ✓
- Sporting equipment ✓

(Any 1 x 1) (1)

9.6 **Thermoplastic or Thermo hardened composites:**

9.6.1 **Teflon:**
Thermoplastic ✓ (1)

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

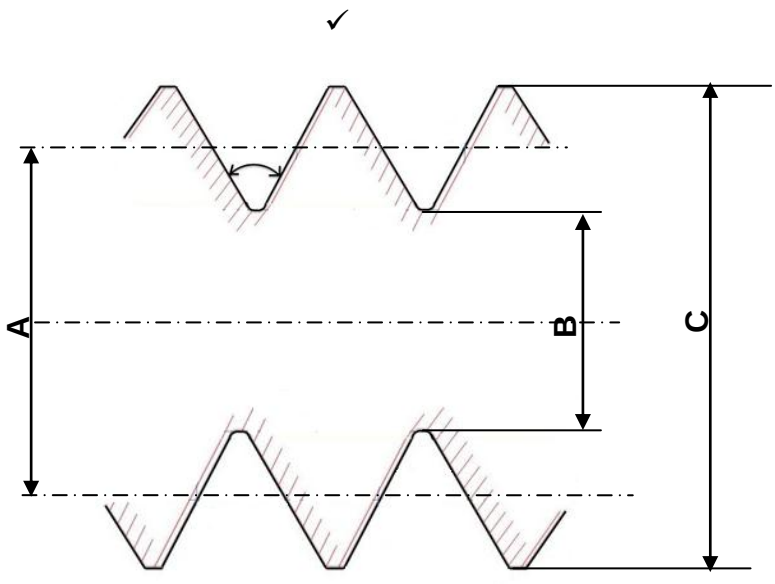
9.7 **Coefficient of friction:**

- Contact pressure ✓
- Surface roughness ✓
- Temperature ✓
- Sliding velocity ✓
- Type (amount) of lubricant ✓
- Type of material ✓

(Any 2 x 1) (2)
[18]

QUESTION 10: JOINING METHODS (Specific)

10.1 **Screw thread diameters:**



A = Pitch diameter/Effective diameter ✓
B = Minor diameter/Root diameter ✓
C = Major diameter/Crest diameter/Outside diameter/Nominal diameter/Basic diameter ✓ (4)

10.2 **Lead of a screw thread:**
The lead is the distance a thread ✓ will move axially ✓ in one full revolution.✓ (3)

10.3 **Square screw thread:**

10.3.1 **Screw thread lead:**

$$\text{Lead} = \text{pitch} \times \text{no of starts}$$
$$= 4 \times 3 \quad ✓$$
$$= 12\,\text{mm} \quad ✓$$ (2)

10.3.2 **Mean/pitch circumference:**

$$\text{Mean/pitch circumference} = \pi\left(\text{OD} - \frac{P}{2}\right) \quad ✓$$
$$= \pi\left(68 - \frac{4}{2}\right) \quad ✓$$
$$= 207{,}35\ \text{mm} \quad ✓$$ (3)

10.3.3 **Helix angle:**

$$\text{Helix angle } \tan\theta = \frac{\text{lead}}{\text{mean/pitch circumference}}$$

$$= \frac{12}{207,35} \quad ✓$$

$$\theta = 3,31° \quad ✓ \quad (2)$$

10.3.4 **Leading angle:**

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

$$= 90° - (3,31° + 3°) \quad ✓$$

$$= 83,69° \quad ✓ \quad (2)$$

10.3.5 **Following angle:**

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

$$= 90° + (3,31° - 3°) \quad ✓$$

$$= 90,31° \quad ✓ \quad (2)$$

[18]

QUESTION 11: SYSTEMS AND CONTROL (Drive Systems) (Specific)

11.1 **Advantages of a gear drive:**

- Compact assembly ✓
- More power can be transmitted/Stronger ✓
- No slip occurs ✓
- Less maintenance ✓

(Any 2 x 1) (2)

11.2 **Hydraulics:**

11.2.1 **Fluid pressure:**

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

$$= \frac{\pi(0,2)^2}{4} \quad ✓$$

$$= 31,42 \times 10^{-3} m^2 \quad ✓$$

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

$$= \frac{15 \times 10^3}{31,42 \times 10^{-3}} \quad ✓ \; ✓$$

$$= 477,40 \times 10^3 \text{ Pa}$$

$$= 477,40 \text{ kPa} \quad ✓ \quad (5)$$

11.2.2 **Distance 'X':**

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

$$= \frac{\pi(0{,}075)^2}{4} \quad \checkmark$$

$$= 4{,}42 \times 10^{-3}\,m^2 \quad \checkmark$$

$$V_B = V_A$$

$$A_B \times L_B = A_A \times L_A \quad \checkmark$$

$$L_B = \frac{A_A \times L_A}{A_B} \quad \checkmark$$

$$= \frac{(4{,}42 \times 10^{-3}) \times (0{,}12)}{(31{,}42 \times 10^{-3})} \quad \checkmark$$

$$= 16{,}88 \times 10^{-3}\ m$$

$$= 16{,}88\ mm \quad \checkmark \qquad (6)$$

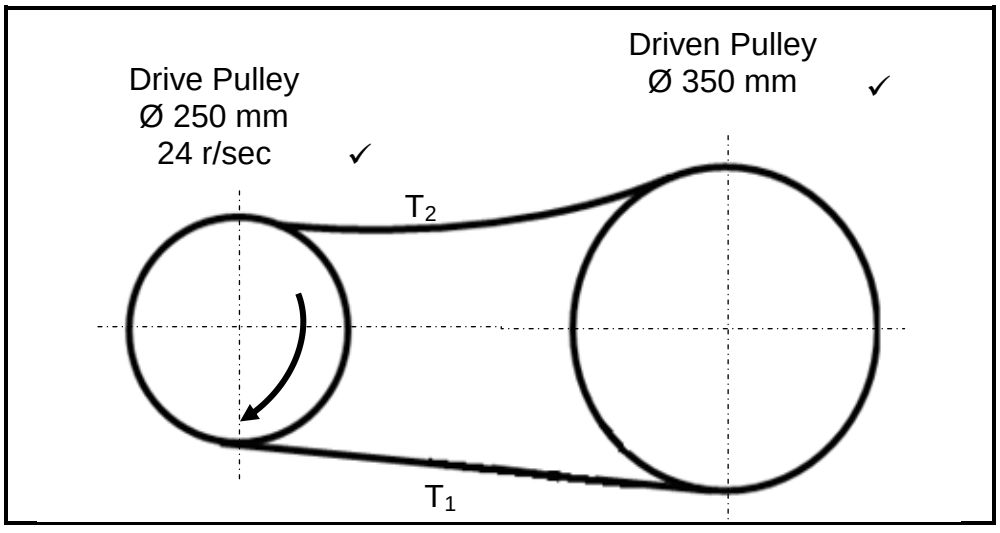
11.3 **Advantages of pneumatics:**

- Compressed air is easy and cheap to generate. ✓
- Leakages are not messy – no oil spills. ✓
- Positive and negative pressure can be generated. ✓
- More compact. ✓
- Easily maintain due to fewer working parts. ✓

(Any 2 x 1) (2)

11.4 **Belt-drive system:**

11.4.1



(2)

11.4.2 **Belt speed:**

$v = \pi Dn$ ✓

$= \pi \times 0,25 \times 24$ ✓

$v = 18,85\ m.s^{-1}$ OR $18,85\ m/s$ ✓ (3)

11.4.3 **Power transmitted:**

$P = (T_1 - T_2)v$ ✓

$= (300 - 120)18,85$ ✓

$= 180 \times 18,85$ ✓

$= 3393\ Watt$

$= 3,39\ kW$ ✓

OR

$P = (T_1 - T_2)\pi Dn$ ✓

$= (300 - 120)\pi \times 0,25 \times 24$ ✓

$= 180 \times 18,85$ ✓

$= 3393\ Watt$

$= 3,39\ kW$ ✓ (4)

11.5 **Gear drive system:**
Number of teeth on gear C:

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

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

$= \frac{80 \times 60 \times 120}{30 \times 40}$ ✓

$= 480\ r/min$ ✓

OR

$N_C \times T_C = N_D \times T_D$

$N_C = \frac{N_D \times T_D}{T_C}$ ✓

$= \frac{120 \times 60}{40}$

$= 180\ r/min$ ✓

$N_A \times T_A = N_B \times T_B$

$N_A = \frac{N_B \times T_B}{T_A}$ ✓

$= \frac{180 \times 80}{30}$

$= 480\ r/min$ ✓ (4)

[28]

TOTAL: 200