basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: FITTING AND MACHINING

NOVEMBER 2025

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 27 pages.

Instructions to marker: Mechanical Technology – Fitting and Machining

1. **General marking instructions:**

1.1 During marking of multiple-choice questions, only ONE possible answer can be accepted. If the candidate indicated two or more responses, ONLY the first response will be recognised /acknowledged and marked according to marking guideline.

1.2 Where the number of responses of the candidate exceeds the required number stated in the question, only the first required number of responses will be accepted. E.g. if the question states, 'Name THREE …' and the candidate stated four different responses, ONLY the first three will be accepted. The remaining responses must be ignored with a line drawn through it.

1.3 When the question clearly indicates what is expected of the candidate:

(a) If the candidate is required to describe a process step by step (e.g., a process in four steps), only the first four responses should be considered.
(b) However, if the candidate is required to explain a process, it should be noted that the response may be lengthy and not necessarily well organized. In such cases, the marker must evaluate the entire response to determine whether the candidate has explained the required outcome satisfactorily and allocate marks on merit.

1.4 If question numbering of sub-questions is not correct according to question paper sequence, the responses can be accepted if a sequence pattern can be identified or followed.

1.5 Attention must be given to mark allocation in questions where two (2) marks were allocated to one response, e.g. (**Any 1 x 2**).

1.6 ONE tick must be allocated for each mark awarded and no global marking is allowed.

1.7 Unanswered and incorrect responses of questions must be indicated with a cross (X).

1.8 All blank pages in an ANSWER BOOK must be crossed out to indicate that the pages have been seen by the marker.

1.9 Attention must be given to questions where the candidate did not complete the answer and continued answer(s) on subsequent pages in the answer book. Continue marking such answers and award marks, if applicable. If a question is answered twice, mark the first response.

1.10 During calculation marking, pay attention to the position of the tick mark(s) in the marking guideline.

1.11 If a candidate skipped a step where a tick mark is allocated in the marking guideline and the final answer is correct, the total amount of tick marks must be indicated by the marker to indicate full marks awarded for the question correctly answered so that the examination assistants can verify marks awarded.

1.12 If the unit required for calculations is specified in the question, the final answer can be considered correct without explicitly stating the unit, provided that the numerical value matches the unit specified or used in the question.

1.13 If an incorrect unit is stated in the candidate's answer during calculations, the answer will be marked incorrect even if the value itself is correct.

1.14 Attention must be given to calculation type questions when different methods are used by candidates to obtain the correct answer. Consider answers where candidates have rounded off in sub-questions and it affects the final answer.

1.15 Attention must be given to special marking instructions to the marker which are stated for specific questions in the marking guideline.

1.16 A red line must be drawn by the marker to indicate the end of each question.

1.17 Marks of sub-questions must be indicated in the outside margins of the ANSWER BOOK pages and NOT in the inside margins.

1.18 When sub-question marks are allocated in the outside margins they must be in line with the sub-question and NOT be circled.

1.19 The total marks awarded for the question must be written on the red line drawn by the marker and circled to clearly indicate the marks awarded for that particular question.

1.20 Marker must transfer marks to cover page and ensure correctness of transfer.

1.21 Markers should familiarise themselves with the question and answer before evaluating the responses of candidates.

1.22 Always interpret the responses of the candidates within the context of the question.

1.23 Mark what the candidate wrote and do not make assumptions about or predict intended responses.

1.24 Accept incorrect spelling in answers unless the spelling changes the meaning of the answer.

1.25 Pencil work is normally acknowledged as rough work and should not be considered/marked.

1.26 As a rule, marks are not awarded for formulas that are found in the attached formula sheet. If a formula was correctly manipulated, then only can a mark be awarded. Marks will also be awarded for correct formulas given by candidates if the particular formula is not found in formula sheet. Marks are awarded for correct substitution.

1.27 Incorrect values from previous calculations substituted at the right place in the formula will be awarded marks.

1.28 Markers must pay attention to calculations where an incorrect answer from a previous step was correctly substituted in the next calculation. In such cases, they must write "*sub*" next to the tick mark on the script to indicate that the mark was awarded for correct substitution only.

1.29 If during the calculations of a candidate, the formula that appear on the formula page was not indicated correctly but calculations and steps were done correctly, full marks may be awarded.

1.30 If, during a candidate's calculations, the formula from the formula sheet was transferred incorrectly, no marks should be awarded for the values substituted in that calculation, as it renders the solution mathematically incorrect.

2. **Specific marking instructions:**

2.1 In Questions 9.3 and 9.4, the answers must be in context of the subject.

QUESTION 1: MULTIPLE-CHOICE (GENERIC)

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

QUESTION 2: SAFETY (GENERIC)

2.1 **Examination procedures:**

- Breathing irregularities. ✓
- Abnormal position of limbs that indicate breakages. ✓
- Any visible signs of bleeding. ✓
- Level of consciousness. ✓

(Any 2 x 1) (2)

2.2 **Arc welding safety:**

- An operator must be adequately trained. ✓
- A workplace must be effectively partitioned off. ✓
- An operator uses protective equipment. ✓
- Ensure that all equipment is in safe working conditions. ✓
- Keep proper housekeeping to avoid fire hazards and electric shocks. ✓

(Any 2 x 1) (2)

2.3 **Portable angle grinder (PPE excluded):**

- Safety guard must be in place. ✓
- Protective shields must be placed around the area where grinding is taking place. ✓
- Use the correct disc. ✓
- Ensure the grinder is in good and safe working order.
- Make sure there are no cracks on the disc. ✓
- Ensure the lockable switch is in the off position. ✓
- Check electrical cables for any defects. ✓
- Ensure that the surrounding area is dry. ✓
- Ensure the grinder is in good and safe working order. ✓
- Ensure the disc is securely fastened. ✓
- Clamp work piece firmly. ✓

(Any 2 x 1) (2)

2.4 **Handling gas cylinders:**

- Never stack cylinders on top of one another. ✓
- Cylinders must not be stored in direct sunlight. ✓
- Chain/handle cylinders in upright position. ✓
- Valve guards must be on cylinders. ✓
- Don't work or bang on cylinders. ✓
- Never allow cylinders to fall. ✓
- Do not allow oil or grease to come into contact with oxygen fittings. ✓
- Do not interfere with the structure (no modification) of the gas cylinders. ✓
- Store full and empty cylinders separately. ✓
- Store acetylene and oxygen cylinders separately. ✓
- Keep cylinders away from flammable substances. ✓
- Do not drag/roll cylinders. ✓
- Cylinders' valves should be closed properly. ✓

(Any 2 x 1) (2)

2.5 **Disadvantage of product layout:**

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

(Any 1 x 1) (1)

2.6 **Employee responsibilities:**

- Take reasonable care of the health and safety of himself and others. ✓
- To cooperate with employer to comply with any duty or responsibility. ✓
- Carry out any lawful order to him/her as to obey the health and safety rules. ✓
- Report any unsafe conditions. ✓
- Report any unhealthy conditions. ✓
- Report any incident immediately. ✓
- Report any injury immediately if possible. ✓

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

QUESTION 3: MATERIALS (GENERIC)

3.1 **Bend test:**

3.1.1 Bends easily ✓ (1)

3.1.2
- Hard to bend ✓
- It will snap/break easily ✓
- Tends to crack/fracture easily✓

(Any 1 x 1) (1)

3.2 **Heat treatment:**

To change the properties ✓ of metals. (1)

3.3 **Quenching media:**

- Water ✓
- Brine (salt and water) ✓
- Oil ✓
- Molten metal salts ✓
- Nitrogen ✓
- Air ✓
- Sand ✓
- Molten lead ✓
- Ash ✓

(Any 3 x 1) (3)

3.4 **Sound test:**

- Tap with a hammer ✓
- Drop on the floor ✓ (2)

3.5 **Purpose of case hardening:**
It is to produce a hard case ✓ over a tough core. ✓ (2)

3.6 **Case hardening methods:**
- Carburising ✓
- Nitriding ✓
- Cyaniding ✓

(Any 2 x 1) (2)

3.7 **Normalising:**

It is to relieve the internal stresses ✓ caused by machining/forging/welding. ✓ (2)
[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

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

5.1 **Disadvantages of set-over of the tailstock:**

- As the centres are not in line, a correct bearing surface on the centred work piece cannot be allowed for. ✓
- Big cuts cannot be taken. ✓
- Only small angled tapers can be turned. ✓
- This method can only be used for external tapers. ✓
- Can only use a faceplate and a centre, not a chuck. ✓
- The work must be driven by using a dog clamp. ✓
- Only practical when doing mass production. ✓
- Set-over must be recalculated for different lengths but same included angle. ✓

(Any 2 x 1) (2)

5.2 **Taper calculations:**

5.2.1 **Small diameter:**

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

$$\tan\frac{6°}{2} = \frac{102 - d}{2\times 510} \checkmark \checkmark$$

$$1020 \times \tan 3° = 102 - d$$

$$53{,}4559348\ 7 = 102 - d$$

$$d = 102 - 53{,}4559348\ 7 \checkmark$$

$$d = 48{,}54 \text{ mm} \checkmark$$

OR

$$\tan 3° = \frac{x}{510}$$

$$x = 510 \tan 3° \checkmark$$

$$x = 26{,}72796743 \text{ mm} \checkmark$$

$$d = D - 2x$$

$$d = 102 - 2(26{,}73) \checkmark$$

$$d = 48{,}54 \text{ mm} \checkmark$$

(4)

5.2.2 **Set-over of the tailstock:**

$$\text{Set-over} = \frac{L(D-d)}{2\times l}$$

$$= \frac{670(102-48{,}54)}{2\times 510} \checkmark \checkmark$$

$$= 35{,}12 \text{ mm} \checkmark$$

OR

$$\text{Tan}\frac{\theta}{2} = \frac{X}{L}$$

$$\text{Tan}\frac{6°}{2} = \frac{X}{670} \checkmark$$

$$670 \text{Tan} 3° = X \checkmark$$

$$= 35{,}12 \text{ mm} \checkmark$$

NOTE: X = Set-over

(3)

5.3 **Key ways:**

5.3.1 **Width:**

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

$$= \frac{210}{4} \checkmark$$

$$= 52{,}50 \text{ mm} \checkmark$$ (2)

5.3.2 **Thickness:**

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

$$= \frac{210}{6} \checkmark$$

$$= 35 \text{ mm} \checkmark$$ (2)

5.3.3 **Length:**

$$\text{Length} = 1{,}5 \times \text{diameter of shaft}$$
$$= 1{,}5 \times 210 \checkmark$$
$$= 315 \text{ mm} \checkmark$$ (2)

5.4 **Balancing:**

- Unnecessary bearing load. ✓
- Excessive vibration. ✓
- Work that is not perfectly round.
- Poor finish/surface finish. ✓
- Damage to the work piece. ✓
- Clatter on the gear teeth. ✓
- Tendency to bend the spindle. ✓
- Damage to cutting tool. ✓
- Danger to the operator. ✓

(Any 2 x 1) (2)

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

- Tendency for cutter to lift the work piece. ✓
- Poor finish. ✓
- More vibrations occur on machine. ✓

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

QUESTION 6: TERMINOLOGY (INDEXING) (SPECIFIC)

6.1 Gear terminology:

6.1.1 Circular pitch:

$$CP = m \times \pi$$
$$= 3 \times \pi \ ✓$$
$$= 9{,}42 \text{ mm} \ ✓$$

(2)

6.1.2 Number of teeth:

$$m = \frac{PCD}{T}$$
$$T = \frac{PCD}{m} \ ✓$$
$$T = \frac{240}{3} \ ✓$$
$$T = 80 \text{ teeth} \ ✓$$

OR

$$PCD = \frac{CP \times T}{\pi}$$
$$240 = \frac{9{,}42 \times T}{\pi} \ ✓$$
$$T = \frac{240 \times \pi}{9{,}42} \ ✓$$
$$T = 80 \text{ teeth} \ ✓$$

(3)

6.1.3 Dedendum:

$$\text{Dedendum} = 1{,}157 \times m$$
$$= 1{,}157 \times 3 \ ✓$$
$$= 3{,}47 \text{ mm} \ ✓$$

OR

$$\text{Dedendum} = 1{,}25 \times m$$
$$= 1{,}25 \times 3 \ ✓$$
$$= 3{,}75 \text{ mm} \ ✓$$

(2)

6.2 Dovetails:

6.2.1 Maximum width distance of dovetail: (W)

Calculate DE or y:

$$\tan \alpha = \frac{DE}{AD}$$
$$DE = \tan \alpha \times AD \ ✓$$
$$= \tan 30° \times 35 \ ✓$$
$$= 20{,}21 \text{ mm} \ ✓$$

OR

$$\tan \theta = \frac{AD}{DE}$$
$$\tan 60° = \frac{35}{DE} \ ✓$$
$$DE = \frac{35}{\tan 60°} \ ✓$$
$$= 20{,}21 \text{ mm} \ ✓$$

$$W = 250 + 2(DE) \ ✓$$
$$= 250 + 2(20{,}21) \ ✓$$
$$= 250 + 40{,}42$$
$$= 290{,}42 \text{ mm} \ ✓$$

(6)

6.2.2 **Distance over the rollers: (M)**

Calculate AC or x:

$$\text{Tan } C\hat{A}B = \frac{BC}{AC}$$

$$AC = \frac{BC}{\text{Tan } C\hat{A}B} \checkmark$$

$$= \frac{8}{\text{Tan } 30^\circ} \checkmark$$

$$= 13{,}86 \text{ mm} \checkmark$$

OR

$$\text{Tan } C\hat{B}A = \frac{AC}{BC}$$

$$AC = \text{Tan } C\hat{B}A \times BC \checkmark$$

$$= \text{Tan } 60^\circ \times 8 \checkmark$$

$$= 13{,}86 \text{ mm} \checkmark$$

M = w + [2(AC) + 2(R)] ✓
= 250 + [2(13,86) + 2(8)] ✓
= 250 + (27,72 + 16)
= 293,72 mm ✓

OR

M = w + 2(AC + R) ✓
= 250 + 2(13,86 + 8) ✓
= 250 + 27,72 + 16
= 293,72 mm ✓

OR

M= w + 2(AC) + 2(R) ✓
= 250 + 2(13,86) + 2(8) ✓
= 250 + 27,72 + 16
= 293,72 mm ✓ (6)

6.3 **Milling of spur gear:**

6.3.1 **Indexing:**

$$\text{Indexing} = \frac{40}{n}$$
$$= \frac{40}{97}$$
$$\text{Indexing} = \frac{40}{A}$$
$$= \frac{40}{100} \checkmark$$
$$= \frac{2}{5} \times \frac{5}{5}$$
$$= \frac{10}{25} \checkmark$$

Approximate indexing:

No full turns and 10 holes on a 25-hole circle ✓

OR

No full turns and 12 holes on a 30-hole circle ✓ (3)

6.3.2 **Change gears:**

$$\frac{Dr}{Dn} = (A - n) \times \frac{40}{A}$$
$$\frac{Dr}{Dn} = (100 - 97) \times \frac{40}{100} \checkmark$$
$$= 3 \times \frac{40}{100} \checkmark$$
$$= \frac{120}{100} \checkmark$$
$$= \frac{12}{10} \times \frac{4}{4}$$
$$\frac{Dr}{Dn} = \frac{48 \checkmark}{40 \checkmark}$$
(5)

6.4 **CNC codes:**
G-codes ✓ (1)
[28]

QUESTION 7: TOOLS AND EQUIPMENT (SPECIFIC)

7.1 **Determine hardness:**

- Resistance to penetration ✓
- Elastic hardness ✓
- Resistance to abrasion ✓

(Any 1 x 1) (1)

7.2 **Label indentation:**

A Material/work piece/test piece ✓
B Indenter/ball ✓
C Applied force/load ✓
D Indentation diameter ✓ (4)

7.3 **Depth of screw thread:**

$$\begin{aligned}\text{Depth of screw thread} &= 0{,}613 \times \text{Pitch (P)}\\ &= 0{,}613 \times 2{,}5 \quad ✓\\ &= 1{,}53\text{ mm} \quad ✓\end{aligned}$$

(2)

7.4 **Label screw thread micrometer:**

A. Frame ✓
B. Lock ✓
C. Thimble ✓
D. Ratchet ✓ (4)

7.5 **Depth micrometer reading:**

Reading = 7,00 + 0,46 = 7,46 mm ✓ ✓ (2)

[13]

QUESTION 8: FORCES (SPECIFIC)

8.1.1 **∑ Horizontal component:**

$$\sum HC = 75\cos0° + 120\cos30° - 150\cos60° - 45\cos90°$$

$$\sum HC = 75 + 103{,}92 \checkmark - 75 \checkmark - 0 \checkmark$$

$$\sum HC = 103{,}92 \text{ N} \checkmark$$

∑ Vertical component:

$$\sum VC = 75\sin0° + 120\sin30° + 150\sin60° - 45\sin90°$$

$$\sum VC = 0 + 60 \checkmark + 129{,}90 \checkmark - 45 \checkmark$$

$$\sum VC = 144{,}90 \text{ N} \checkmark$$

OR

Force	***θ***	**∑HC/x = Fcosθ**		**∑VC/y = Fsinθ**	
75 N	0º	HC = 75cos0°	75 N ✓	VC = 75sin0°	0 N
120 N	30º	HC = 120cos30°	103,92 N ✓	VC = 120sin30°	60 N ✓
150 N	120º	HC = 150cos120°	-75 N ✓	VC = 150sin120°	129,90 N ✓
45 N	270º	HC = 45cos270°	0 N	VC = 45sin270°	-45 N ✓
		Total	**103,92 N** ✓		**144,90 N** ✓

(8)

8.1.2 **Resultant:**

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

$$\sqrt{R^2} = \sqrt{(144{,}9)^2 + (103{,}92)^2} \checkmark$$

$$R = 178{,}31 \text{ N} \checkmark$$

(2)

8.1.3 **Angle of resultant:**
Angle:

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

$$\theta = \tan^{-1}\left(\frac{144{,}90}{103{,}92}\right) \checkmark$$

$$\theta = 54{,}35^\circ \checkmark \quad \textbf{OR} \quad 54^\circ 21' \checkmark$$

OR

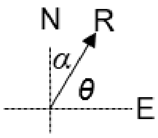
$$\tan\alpha = \frac{HC}{VC}$$

$$\tan\alpha = \tan^{-1}\left(\frac{103{,}92}{144{,}90}\right) \checkmark$$

$$\alpha = 35{,}65^\circ \checkmark \quad \textbf{OR} \quad 35^\circ 39' \checkmark$$

Angle and direction:

Direction:
$R = 178{,}31\text{ N} \quad 54{,}35^\circ$ N from E ✓
OR
$R = 178{,}31\text{ N} \quad 35{,}65^\circ$ E from N ✓



(3)

8.2 **Calculations, UDL and supports A and B:**

8.2.1 **UDL:**

UDL = 14 N/m × 12 m ✓
UDL = 168 N ✓ (2)

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

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

$$\overset{\checkmark}{(155 \times 12)} + \overset{\checkmark}{(168 \times 6)} + \overset{\checkmark}{(90 \times 1{,}5)} = (A \times 12)$$

$$1860 + 1008 + 135 = 12A$$

$$A = \frac{3003}{12}$$

$$A = 250{,}25 \text{ N } \checkmark$$

Reaction in support B:
Take moments about A:

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

$$(B \times 12) = \overset{\checkmark}{(90 \times 10{,}5)} + \overset{\checkmark}{(168 \times 6)} + (155 \times 0)$$

$$12B = 945 + 1008 + 0$$

$$B = \frac{1953}{12}$$

$$B = 162{,}75 \text{ N } \checkmark$$

(7)

8.3 **Label A–C:**
A. Limit of proportionality ✓
B. Elastic limit ✓
C. Maximum stress ✓ (3)

8.4 **Stress calculations:**

8.4.1 **Diameter:**

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

$$A = \frac{\pi\ (0{,}045)^2}{4}\ \checkmark$$

$$A = 1{,}590431281 \times 10^{-3}\ m^2\ \checkmark\ \textbf{OR}\ \ 0{,}001590431281\, m^2\ \checkmark$$

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

$$F = A \times \sigma\ \ \checkmark$$

$$F = (1{,}59043128\ 1 \times 10^{-3}) \times (28{,}56\ \times 10^{6})\ \ \checkmark$$

$$F = 45422{,}72\ \ N\ \ \checkmark$$

(5)

8.4.2 **The original length:**

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

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

$$\Delta L = 350 \times 0{,}0003\ \checkmark$$

$$\Delta L = 0{,}11\ \ mm\ \checkmark$$

(3)
[33]

QUESTION 9: MAINTENANCE (SPECIFIC)

9.1 **Thermoplastic definition:**

9.1.1 Reheated/Heated/Melted ✓ (1)

9.1.2 Shaped/made/reformed/moulded ✓ (1)

9.1.3 recycled ✓ (1)

9.1.4 heated ✓ (1)

9.2 **Reason for conducting adjustments:**

- To prevent faults ✓ from occurring.
- Ensure operations are at optimal level. ✓

(Any 1 x 1) (1)

9.3 **Thermo-hardened composites materials:**

- Carbon fibre ✓
- Glass fibre/Fibre glass ✓
- Bakelite ✓
- Epoxy ✓
- Silicone ✓
- Vulcanized rubber ✓

(Any 3 x 1) (3)

9.4 **Thermoplastic composites materials:**

- Nylon ✓
- Teflon ✓
- PVC ✓
- Vesconite ✓ (4)

9.5 **Preventative maintenance procedures:**

- Cleaning uncovered chain drives. ✓
- Check sprocket for wear. ✓
- Check link plates/chain for wear. ✓
- Ensure sufficient lubrication of chains. ✓
- Checking functioning of tensioning devices. ✓
- Inspecting chains regularly for elongation. ✓
- Check the alignment. ✓

(Any 3 x 1) (3)

9.6 **Type of composite material:**

9.6.1
- Nylon/Polyurethane ✓
- Vesconite ✓
- Teflon ✓

(Any 1 x 1) (1)

9.6.2 Teflon ✓ (1)

9.6.3 Bakelite ✓ (1)
[18]

QUESTION 10: JOINING METHODS (SPECIFIC)

10.1 **Screw thread terminology:**

10.1.1 Metric ✓ (1)

10.1.2 Major-/Crest-/Basic-/Nominal-/Outside diameter ✓ (1)

10.1.3 Pitch ✓ (1)

10.2 **Square thread:**

10.2.1 **Pitch diameter:**

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

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

$$= \frac{36}{2} \checkmark$$

$$= 18 \text{ mm} \checkmark$$

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

$$= 70 - \frac{18}{2} \checkmark$$

$$= 61 \text{ mm} \checkmark$$

(5)

10.2.2 **Helix angle of the thread:**

$$\text{Tan } \theta = \frac{\text{Lead}}{\pi \text{ PD}}$$

$$\text{Tan } \theta = \frac{36}{\pi \times 61} \checkmark$$

$$\theta = \tan^{-1}(0{,}18785501\ 48) \checkmark$$

$$= 10{,}64^\circ \checkmark \textbf{ OR } 10^\circ 38' \checkmark$$

(3)

10.2.3 **Leading angle:**

Leading angle = 90° – (helix angle + clearance angle)
= 90° – (10,64° + 3°) ✓
= 76,36° ✓ **OR** 76° 22' ✓ (2)

10.2.4 **Following angle:**

Following angle = 90° + (helix angle – clearance)

= 90° + (10,64° – 3°) ✓

= 97,64° ✓ **OR** 97° 38' ✓ (2)

10.3 **V-thread terminology:**

A - Root ✓
B - Pitch ✓
C - Minor diameter/Root diameter/Core diameter ✓ (3)

[18]

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

11.1 **Hydraulic systems:**

11.1.1 **Area ram:**

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

$$A = \frac{\pi (0,1)^2}{4} \checkmark$$

$$A = 7,85 \times 10^{-3}\ m^2 \checkmark$$

(2)

11.1.2 **Mass lifted:**

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

$$F = P \times A \checkmark$$

$$F = (6,36 \times 10^6) \times (7,85 \times 10^{-3}) \checkmark$$

$$F = 49926\ N \checkmark$$

$$Mass = \frac{49926}{10} \checkmark$$

$$Mass = 4992,60\ kg \checkmark$$

OR

$$Mass = \frac{49926}{9,81} \checkmark$$

$$Mass = 5089,30\ kg \checkmark$$

(5)

11.2 **Components in hydraulic system:**

- Motor ✓
- Pump ✓
- Filter ✓
- Pressure gauges ✓
- Non-return valves/check valves/Direction control valve ✓
- Reservoir ✓
- Pipes ✓
- Bleeding valve ✓
- Levers ✓
- Actuator ✓
- Accumulator ✓
- Flow control valve ✓
- Pressure relief valve ✓
- Lubricator ✓

(Any 2 x 1) (2)

11.3 **Hydraulic pump designs:**

- Radial pump ✓
- Rotary pump ✓
- Axial pump ✓

(Any 1 x 1) (1)

11.4 **Belt drives:**

11.4.1 **Rotational frequency on the driven pulley in r/s:**

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

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

$$N_{DN} = \frac{22 \times 85}{375} \checkmark$$

$$N_{DN} = 4{,}99 \text{ r/s} \checkmark$$

(3)

11.4. 2 **Power transmitted:**

$$\text{Ratio} = \frac{T_1}{T_2}$$

$$2{,}5 = \frac{450}{T_2} \checkmark$$

$$T_2 = \frac{450}{2{,}5}$$

$$T_2 = 180 \text{ N} \checkmark$$

$$P = (T_1 - T_2)\pi \times D \times N$$

$$P = (450 - \overset{\checkmark}{180}) \times \pi \times 0{,}085 \times 22 \checkmark$$

$$P = 1586{,}19 \text{ W}$$

$$P = 1{,}59 \text{ kW} \checkmark$$

OR

$$P = (T_1 - T_2) \times \pi \times D \times N$$

$$P = (450 \overset{\checkmark}{-} 180) \times \pi \times 0{,}375 \times 4{,}99 \checkmark$$

$$P = 1587{,}25 \text{ W}$$

$$P = 1{,}59 \text{ kW} \checkmark$$

(5)

11.5 **Gear drive:**

11.5.1 **Rotational frequency of the output shaft N_F in r/min:**

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

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

$$\frac{95}{N_F} = \frac{50 \times 70 \times 85}{30 \times 25 \times 60} \checkmark \checkmark$$

$$N_F = \frac{30 \times 25 \times 60 \times 95}{50 \times 70 \times 85} \checkmark$$

$$N_F = \frac{4\,275\,000}{297\,500}$$

$$N_F = 14{,}37 \text{ r/min} \checkmark$$

(4)

11.5.2 **Speed ratio:**

$$\text{Speed ratio} = \frac{N_{input}}{N_{output}}$$

$$\text{Speed ratio} = \frac{95 \checkmark}{14{,}37 \checkmark}$$

$$\text{Speed ratio} = 6{,}61 : 1 \checkmark$$

OR

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

$$\text{Gear ratio} = \frac{50 \times 70 \times 85 \checkmark}{30 \times 25 \times 60 \checkmark}$$

$$\text{Gear ratio} = 6{,}61 : 1 \checkmark$$

(3)

11.6 **Torque:**

$$\text{Torque} = \text{Force} \times \text{Radius}$$

$$\text{Radius} = \frac{\text{Torque}}{\text{Force}} \checkmark$$

$$\text{Radius} = \frac{712,5}{750} \checkmark$$

$$\text{Radius} = 0,95 \text{ m} \checkmark$$

(3)
[28]

TOTAL: 200