



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

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MEMORANDUM

MARKS: 200

This memorandum consists of 15 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS**(Learning Outcome 3: Assessment Standard 1 – 9)**

- | | | |
|------|-----|-------------|
| 1.1 | D✓ | (1) |
| 1.2 | A✓ | (1) |
| 1.3 | D ✓ | (1) |
| 1.4 | D✓ | (1) |
| 1.5 | B✓ | (1) |
| 1.6 | C ✓ | (1) |
| 1.7 | A ✓ | (1) |
| 1.8 | C✓ | (1) |
| 1.9 | D ✓ | (1) |
| 1.10 | A ✓ | (1) |
| 1.11 | D ✓ | (1) |
| 1.12 | B ✓ | (1) |
| 1.13 | B ✓ | (1) |
| 1.14 | C ✓ | (1) |
| 1.15 | A ✓ | (1) |
| 1.16 | C ✓ | (1) |
| 1.17 | D ✓ | (1) |
| 1.18 | A ✓ | (1) |
| 1.19 | C ✓ | (1) |
| 1.20 | D ✓ | (1) |
| | | [20] |

QUESTION 2: FORCES AND SYSTEMS AND CONTROL**(Learning Outcome 3: Assessment Standard 6 and 8)****2.1 Stress and strain**

2.1.1 Compression Stress ✓ (1)

2.1.2 Stress in material

$$\begin{aligned}
 A &= \frac{\pi(D^2 - d^2)}{4} && \checkmark \\
 &= \frac{\pi(0,04^2 - 0,03^2)}{4} && \checkmark \\
 &= 0,55 \times 10^{-3} \text{ m}^2 && \checkmark \\
 \sigma &= \frac{F}{A} && \checkmark \\
 &= \frac{23 \times 10^3}{0,55 \times 10^{-3}} && \checkmark \\
 &= 41,84 \text{ MPa} && \checkmark \quad (5)
 \end{aligned}$$

2.1.3 Shortening of bush

$$\begin{aligned}
 \varepsilon &= \frac{\sigma}{E} && \checkmark \\
 &= \frac{41,82 \times 10^6}{90 \times 10^9} && \checkmark \\
 &= 0,46 \times 10^{-3} && \\
 \Delta l &= \sigma l \times \varepsilon && \checkmark \\
 &= 80 \times (0,46 \times 10^{-3}) && \checkmark \\
 &= 36,8 \times 10^{-3} \text{ mm} && \checkmark \quad (5)
 \end{aligned}$$

2.2 Hydraulic**2.2.1 Fluid pressure**

$$A_p = \frac{\pi D_p^2}{4}$$

$$= \frac{\pi \times 0,038^2}{4}$$

$$= 1,13 \times 10^{-3} \text{ m}^2$$

✓

$$p = \frac{F_p}{A_p}$$

$$= \frac{200}{1,13 \times 10^{-3}}$$

$$= 0,18 \text{ MPa or } 176348,9674 \text{ Pa}$$

✓

✓ (3)

2.2.2 Diameter of ram

$$A_r = \frac{F_r}{p}$$

$$= \frac{23 \times 10^3}{0,18 \times 10^6}$$

$$= 0,13 \text{ m}^2$$

✓

✓

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

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

$$D = \sqrt{\frac{4(0,13)}{\pi}}$$

$$= 0,41 \text{ m or } 0,4075 \text{ m}$$

$$= 410 \text{ mm or } 407,5 \text{ mm}$$

✓

✓ (4)

2.3 Gear Drive**2.3.1 Rotation of motor**

$$\begin{aligned}
 N_E &= \frac{80 \times 40 \times 90}{30 \times 20} \\
 &= \frac{288000}{600} \\
 &= 480 \text{ r/min}
 \end{aligned}$$

√
√ (2)

2.3.2 Advantages

- No slip occurs
 - It is much stronger
 - More accurate
 - Last longer
- √
√
√
√ (Any TWO correct answers) √ (2)

2.4 Belt Drive**2.4.1 Diameter of driven pulley**

$$\begin{aligned}
 D_{DN} &= \frac{N_{DR} \times D_{DR}}{N_{DN}} \\
 &= \frac{710 \times 420}{220} \\
 &= 1355,5 \text{ mm}
 \end{aligned}$$

√
√
√ (3)

2.4.2 Width of belt

$$\begin{aligned}
 \frac{T_1}{T_2} &= 2,5 \\
 \therefore T_1 &= 2,5 T_2 \\
 \text{Power} &= \frac{(T_1 - T_2) \pi D n}{60} \\
 8 \times 10^3 &= \frac{(2,5 T_2 - T_2) \times 0,42 \times 710}{60} \\
 \therefore T_2 &= 341,6 \text{ N} \\
 T_1 &= 2,5 T_2 \\
 &= 2,5 \times 341,6 \\
 &= 854 \text{ N} \\
 \text{Tensile force is } 4 \text{ N per mm belt width.} \\
 \therefore \text{Width} &= \frac{854}{4} \\
 &= 213,5 \text{ mm}
 \end{aligned}$$

√
√
√
√
√
√
√
√ (6)

2.5 Gear Teeth

- 2.5.1 Pitch circle diameter = Module x Number of teeth
 $= 4 \times 60$
 $= 240 \text{ mm}$ $\sqrt{\quad}$
 $\sqrt{\quad}$ (2)
- 2.5.2 Addendum = Module
 $= 4 \text{ mm}$ $\sqrt{\quad}$
 $\sqrt{\quad}$ (2)
- 2.5.3 Clearance = 0,25 x module or 0,157 x module
 $= 0,25 \times 4$ or $0,157 \times 4$
 $= 1 \text{ mm}$ or $0,628 \text{ mm}$ $\sqrt{\quad}$
 $\sqrt{\quad}$ (2)
- 2.5.4 Dedendum = 1,25 x module or 0,157 x module
 $= 1,25 \times 4$ or $1,157 \times 4$
 $= 5 \text{ mm}$ or $4,628 \text{ mm}$ $\sqrt{\quad}$
 $\sqrt{\quad}$ (2)
- 2.5.5 Outside diameter = PCD + 2 module
 $= 240 + 2(4)$
 $= 248 \text{ mm}$ $\sqrt{\quad}$
 $\sqrt{\quad}$ (2)

2.6 Square thread cutting tool

- A** = Trailing/Following angle, **B** = Leading angle $\sqrt{\quad}$
 $\sqrt{\quad}$ (4)
C = Clearance angle, **D** = Helix angle

2.7 Clutches**2.7 Friction clutch**

$$T = \mu W n R$$

$$R = \frac{T}{\mu W n}$$

$$R = \frac{245}{0,35 \times 2500 \times 2}$$

$$R = \frac{245}{1750}$$

$$R = 0,14 \text{ m}$$

$$D = 2R$$

$$D = 2(0,14)$$

$$D = 0,28 \text{ m}$$

$$D = 280 \text{ mm}$$

$\sqrt{\quad}$ (5)
[50]

QUESTION 3: TOOLS AND EQUIPMENT**(Learning Outcome 3: Assessment Standard 2)****3.1 Brinell hardness tester**

- | | | | |
|----|------------------------|---|-----|
| 1. | Test piece | √ | |
| 2. | Load | √ | |
| 3. | Hardened steel ball | √ | |
| 4. | Diameter of impression | √ | (4) |

3.2 Tensile test

- | | | |
|---|---|-----|
| To determine, | √ | |
| the yield stress, | √ | |
| the ultimate tensile stress, | √ | |
| the percentage elongation of a piece of material. | √ | (4) |

3.3 Wet compression test

- | | | |
|---|---|-----|
| • To determine worn rings | √ | |
| • To determine worn piston | √ | |
| • To check if there is a difference in readings between the dry test and the wet test | √ | |
| • To verify if there is a need for performing the cylinder leakage test | √ | (4) |

3.4.1	Gas analyzer	√√	(2)
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3.4.2	Carbon Monoxide (CO) and Carbon Dioxide (CO ₂) and water (H ₂ O)	√√	(2)
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3.5 Torsion

Torsion is the twisting action in a member caused by two opposing moments along the longitudinal axis of a member .	√	
	√	(2)

3.6	Is to investigate the deflection of the beam to see if the beam will withstand the required force (Testing for rigidity)	√√	(2)
			[20]

QUESTION 4: MATERIALS**(Learning outcome 3: Assessment standard 3)****4.1 Tin snips**

4.1.1 High carbon steel or Tool steel √ (1)

4.1.2 • They resist wear √
• It has high tensile strength √ (2)

4.1.3 • To prevent rust √ (1)

4.2 Ferrous alloys

They are alloys that contain iron √

examples

• Low, medium and high carbon steels,
• stainless steel,
• chromium steel
• manganese steel
• vanadium steel
• titanium
• tungsten steel (Any TWO correct answers) √ √ (3)

4.3 Hammer head

4.3.1 Medium carbon steel √ (1)

4.3.2 • Very tough √
• High tensile strength √ (2)

4.4 Tensile definition

The ability of a material to withstand pulling forces or tension forces √√ (2)

4.5 Tensile strength

Material B has the lowest tensile strength because it **deforms easily** √
under tension or is the most deformed material. √ (2)

4.6 Electric plug

- 4.6.1 Nylon
- It has resistance to wear
 - It is a good insulator
 - It has low frictional properties. (Any TWO correct answers) (2)
- 4.6.2 Bronze
- Strong
 - Tough
 - Corrosion resistance
 - Good conductor of electricity (Any TWO correct answers) (2)

4.7 Properties of Carbon Fibre

- Stiff and strong
 - Low density
 - Light weight
 - Resistant to corrosion (Any TWO: 1 x 2) (2)
- [20]**

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS**5.1 Torsion tester**

- Use safety goggles ✓
- Make sure the workpiece is properly tightened. ✓
- Be careful for metal particles coming off after the metal fractures. ✓
- Do not hold the test piece with your hands; it may be hot, use pliers. ✓ (4)

5.2 MIG welder

- The welding area must be kept clean and tidy. ✓
- Operator must use protective equipment ✓
- Make sure that the main cable insulation is not damaged when welding. ✓
- Gas bottle must be well secured with a chain ✓
- Welding area must have effective ventilation ✓
- Welding must not be carried out in areas of explosive and flammable liquids. ✓
- Use a fume extractor for toxic fumes given off when welding galvanized or zinc coated material (Any FOUR correct answers) ✓ (4)

5.3 Helical cutter

- Uses less power ✓
- Vibration experience by machine is less ✓
- Longer life span for the cutter ✓
- Deeper cuts may be taken ✓
- Wider cutters may be used (Any FOUR correct answers) ✓ (4)

5.4 Dividing head

To divide the circumference of a circular work into equally spaced dimension. ✓✓ (2)

5.5 Indexing

Hole circles											
Side 1	24	25	28	30	34	37	38	39	41	42	43
Side 2	46	47	49	51	53	54	57	58	59	62	66

Standard change gears										
24 x 2	28	32	40	44	48	56	64	72	86	100

5.5.1 Indexing

$$\begin{aligned}
 \text{Indexing} &= \frac{40}{n} = \frac{40}{160} && \checkmark \\
 &= \frac{1}{4} \times \frac{7}{7} \text{ or } \frac{1}{4} \times \frac{6}{6} && \checkmark \\
 &= \frac{7}{28} \text{ or } \frac{6}{24} && \checkmark
 \end{aligned}$$

7 holes on a 28-hole circle or 6 holes on a 24-hole circle $\checkmark\checkmark$ (5)

5.5.2 Change gears

$$\begin{aligned}
 \frac{D_r}{D_v} &= (A - n) \times \frac{40}{A} \\
 &= (160 - 163) \times \frac{40}{160} && \checkmark \\
 &= \frac{-3 \times 40}{160} && \checkmark \\
 &= \frac{-120}{160} && \checkmark \\
 &= \frac{-3}{4} \times \frac{8}{8} && \checkmark \\
 &= \frac{-24}{32}
 \end{aligned}$$

Drive gear is 24 and the driven gear is 32 \checkmark (5)

5.5.3 The index plate rotates in the opposite direction to the crank handle (-)

$\checkmark\checkmark$ (2)

5.6 Cutting speed

$$V = \pi DN \quad \checkmark$$

$$N = \frac{V}{\pi D} \quad \checkmark$$

$$N = \frac{200}{\pi \times 0,2} \quad \checkmark$$

$$N = 318.31 \text{ rpm}$$

$$f = f \times T \times N \quad \checkmark$$

$$f = 0,1 \times 20 \times 318.31 \quad \checkmark$$

$$f = 636.62 \text{ mm/min} \quad \checkmark \quad (6)$$

5.7 Dividing head

1. Plunger \checkmark
2. Index plate \checkmark
3. 40-teeth worm wheel \checkmark
4. Single start worm \checkmark
5. Sector arm \checkmark (5)

5.8 Liquid/dye penetrate test

- Clean the surface to be tested. \checkmark
- A liquid dye penetrant is sprayed onto the clean surface. \checkmark
- Allow a short time for the dye to penetrate the welded joint. \checkmark
- Remove the excess dye on the welded joint using a cloth. \checkmark
- Wash the surface and allow it to dry thoroughly. \checkmark
- Spray a developer on the surface which brings out the color in the dye penetrant, that has penetrated the cracks or pin holes. \checkmark
- Should the liquid dye come out of the welded joint, it means there are flaws in the joint. \checkmark (7)

5.9 Incomplete penetration

Causes:

- Current too low \checkmark
 - Electrode too large \checkmark
 - Joint preparation incorrect \checkmark
 - Weld speed too fast \checkmark (3)
- (Any THREE correct answers)

Cures/Prevention

- Use correct current \checkmark
 - Proper electrode should be used \checkmark
 - Joint should be prepared properly \checkmark
 - Correct speed should be used \checkmark (3)
- (Any THREE correct answers)

[50]

QUESTION 6: MAINTENANCE AND TURBINES**(Learning Outcome 3: Assessment Standard 7 and 9)****6.1 Lubricating oil**

- 6.1.1 Label – timing chain
1. Timing chain ✓
 2. Camshaft pulley ✓
 3. Chain guide ✓
 4. Crankshaft pulley ✓
 5. Tensioner ✓ (5)
- 6.1.2 Needs of lubricating oil
- Viscosity must be correct. ✓
 - It must resist oxidation. ✓
 - It must prevent rust. ✓
 - It must avoid foaming. ✓
 - Resist carbon forming. ✓
 - It must prevent corrosion. ✓
 - It must resist extreme pressures (Any FOUR correct answers) ✓ (4)
- 6.1.3 Reasons for oil change
- Formation of gum, acids and lacquer may be left by the combustion of the fuel. ✓
 - Loses its viscosity after a while due to heat. ✓
 - Metal particles due to metal and metal contact ✓ (3)

6.2 Oils

- 6.2.1 SE - The letter 'S' Spark Ignition Engines ✓ (1)
- 6.2.2 CE - The letter 'C' Compression Ignition Engine ✓ (1)
- 6.2.3 SAE 20W50 - Society of Automotive Engineers. Multi grade oil ✓✓ (2)
- 6.2.4 ATF - Automatic transmission fluid ✓ (1)

6.3 Cutting fluid

- Carry away the heat generated by machining process. ✓
- Acts as a lubricant. ✓
- Prevents the chips from sticking and fusing to the cutter teeth. ✓
- Improve quality of the finish of machined surface. ✓
- To obtain a higher cutting speed. ✓
- It gives the cutting tool a longer lifespan. ✓
- Does not rust the machine. (Any FOUR correct answers) ✓ (4)

6.4 Properties of grease

- It must be water resistant, it must not mix ✓
- Rust/corrosion resistant ✓
- Good for load pressure ✓
- High melting point ✓
- Low freezing point (Any THREE correct answers) ✓ (3)

6.5 Superchargers**6.5.1 Purpose:**

- The supercharger fills the cylinder with an increased pressure that is higher than atmospheric pressure. ✓
 - The compression pressure in the cylinder is increased. ✓
 - The volumetric efficiency of the engine is increased. ✓
- (Any TWO correct answers) (2)

6.5.2 Examples:

- Used in racing cars. ✓
- Four-stroke Compression Ignition engines in heavy vehicles. ✓
- Earth moving equipment ✓
- Aircraft engine to overcome loss of power owing to height above sea level. (Any THREE correct answers) ✓ (3)

6.5.3 Advantages:

- More power is obtained compared to a similar vehicle without supercharger. ✓
 - Supercharged engines are more economical per given kilowatt output. ✓
 - Less fuel is used compared to engine mass. ✓
 - Power loss is eliminated above sea level ✓ (3)
- (Any THREE correct answers)

6.6 Turbocharger

- A turbocharger is driven by the exhaust gasses of the engine and therefore there is no power loss. ✓✓
- The turbocharger is generally cheaper. (Any ONE correct answer) ✓✓ (2)

6.7 Steam turbines

- It is compact ✓
- No lubrication is required ✓
- Steam turbine speed can be more accurately regulated ✓
- A variety of fuels can be used to obtain steam ✓
- More economical (Any THREE correct answers) ✓ (3)

6.8 Gas turbines

- Easy starting ✓
 - High power output from the given weight of engine ✓
 - No rubbing parts such piston so that internal friction and wear are almost eliminated. ✓
 - No water cooling system needed ✓
 - Requires little routine maintenance (Any THREE correct answers) ✓ (3)
- [40]**

TOTAL: 200