education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY

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MEMORANDUM

MARKS: 200

This memorandum consists of 19 pages.

QUESTION 1: MULTIPLE CHOICE QUESTIONS

(Learning Outcome 3: Assessment Standards 1 – 9)

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

[20]

QUESTION 2: FORCES AND SYSTEMS AND CONTROL

(Learning Outcome 3: Assessment Standards 6 and 8)

2.1 GEARS

2.1.1 CALCULATE THE GEAR RATIO

$$\text{GearRatio} = \frac{\textit{Product of number of teeth of the driven gear}}{\textit{Product of number of teeth of the driving gear}}$$ ✓

$$= \frac{86 \times 70}{35 \times 43}$$

$$= 4:1$$ ✓ (2)

2.1.2 CALCULATE THE OUTPUT SPEED OF THE SPINDLE

$$\frac{\textit{Speed of Driver}}{\textit{Speed of Driven}} = \frac{\textit{Product of number of teeth of the driven gears}}{\textit{Product of number of teeth of the driving gear}}$$ ✓

$$\frac{840}{N_{spindle}} = \frac{86 \times 70}{35 \times 43}$$

$$N_{spindle} = \frac{840}{4}$$

$$N_{spindle} = 210\ rpm$$ ✓ (2)

2.1.3 CALCULATE THE SPINDLE TORQUE

$$P = \frac{2\pi NT}{60}$$

$$T = \frac{P \times 60}{2\pi N}$$ ✓

$$= \frac{5\ 000 \times 60}{2\pi \times 210}$$

$$= 227{,}36\ Nm$$ ✓ (2)

2.1.4 Yes, it is suitable for the gear train because both the spindle speed and torque are higher than the desired/required one. ✓✓ (2)

2.2 LEVERS

2.2.1 CALCULATE THE EFFORT TO LIFT THE HANDLE OF THE WHEELBARROW

Taking moments about the fulcrum

$$\sum of\ \ clockwise\ moments = \sum of\ \ the\ anti - clowise\ moments$$ ✓

$$1000 \times 0{,}5 = E \times 1{,}5$$ ✓✓

$$E = 333{,}33\ N$$ ✓ (4)

2.2.2 CALCULATE THE MECHANICAL ADVANTAGE (MA)

$$Mechanical\ \ Advantage\ (MA) = \frac{Load}{Effort}$$

$$MA = \frac{1000}{333{,}33}$$ ✓

$$= 3$$ ✓ (2)

2.2.3 CALCULATE THE WORK DONE

$$Work\ done = Load \text{ x } distance$$

$$= 333{,}3 \text{ x } 0{,}2$$ ✓

$$= 66{,}67\ Joule$$ ✓ (2)

2.2.4 CALCULATE THE POWER

$$Power = \frac{Work\,done}{time}$$

$$= \frac{66{,}67}{3}$$ ✓

$$= 22{,}22\ W$$ ✓ (2)

2.2.5
- Less effort is used because the efficiency is high. ✓
- The system is having a leverage advantage of 3:1 ✓
- A small force (effort) equal to (one third) was required to lift the load. ✓ (3)

2.3 STRESS AND STRAIN (YOUNG'S MODULUS)

2.3.1 CALCULATE THE TOTAL LENGTH

$$Total\ Length = 350 + 150$$ ✓

$$= 500\ mm\ or\ 0{,}5\ m$$ ✓ (2)

2.3.2 CALCULATE THE STRESS AT SECTION A AND SECTION B

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

(6

$$= \frac{\pi \times 0{,}05^2}{4}$$ ✓

$$= 1{,}96 \times 10^{-3}\ m^2$$

$$\sigma_A = \frac{F}{A_A}$$

$$= \frac{150 \times 10^3}{1{,}96 \times 10^{-3}}$$

$$= 76{,}53 \times 10^6\ Pa$$ ✓

$$= 76{,}53\ MPa$$ ✓

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

$$= \frac{\pi \times 0{,}04^2}{4}$$

$$= 1{,}26 \times 10^{-3}\ m^2$$ ✓

$$\sigma_B = \frac{F}{A_B}$$

$$= \frac{150 \times 10^3}{1{,}26 \times 10^{-3}\ m^2}$$ ✓

$$= 119{,}05 \times 10^6\ Pa$$

$$= 119{,}05\ MPa$$ ✓ (6)

2.3.3 **CALCULATE THE STRAIN INDUCED IN SECTION A AND B**

$$\varepsilon_A = \frac{\sigma_A}{E}$$
$$= \frac{76,53 \times 10^6}{80 \times 10^9}$$
$$= 0,96 \times 10^{-3}$$ ✓

$$\varepsilon_B = \frac{\sigma_B}{E}$$
$$= \frac{119,05 \times 10^6}{80 \times 10^9}$$ ✓
$$= 1,49 \times 10^{-3}$$ (2)

2.3.4 **CALCULATE THE TOTAL FINAL LENGTH OF THE PIN**

$$\varepsilon_A = \frac{\Delta L_A}{OL_A}$$
$$\Delta L_A = \varepsilon_A \times OL_A$$
$$= 0.96 \times 10^{-3} \times 350$$
$$= 0,34\ mm$$ ✓ ✓

$$\varepsilon_B = \frac{\Delta L_B}{OL_B}$$
$$\Delta L_B = \varepsilon_B \times OL_B$$
$$= 1,49 \times 10^{-3} \times 150$$
$$= 0,22\ mm$$ ✓ ✓

$$Final\ Length = Total\ length + \Delta L_A + \Delta L_B$$
$$= 500 + 0,34 + 0,22$$
$$= 500,56\ mm$$ ✓ (5)

2.3.5 The resistance to strain will be higher and the elongation will therefore be less. ✓ ✓ (2)

2.4 HYDRAULICS

2.4.1 CALCULATE THE PRESSURE APPLIED TO PISTON A

Pressure at piston A = Pressure at piston B

$$Area\ of\ \ piston\ A \ = \frac{\pi d^2}{4}$$ ✓

$$= \frac{\pi(70\times10^{-3})^2}{4}$$

$$= 3{,}85\times10^{-3}\,m^2$$

$$Pressure\ at\ \mathrm{A} \ = \frac{\text{Force at A}}{\text{Area at A}}$$ ✓

$$= \frac{600}{3{,}85\times10^{-3}}$$ ✓ (3)

$$= 155{,}84\ kPa$$

2.4.2 CALCULATE THE DISTANCE 'X' OF PISTON B

NB: volume in cylinder A is equal to the volume in cylinder B.

$$Volume_A = Area_A \times stroke\ length_A$$

$$\mathrm{V_A} = \mathrm{A_A} \times \mathrm{L_A}$$

$$\mathrm{V_A} = 3{,}85\times10^{-3}\times 65\times10^{-3}$$

$$= 0{,}25\times10^{-3}\,\mathrm{m}^3$$ ✓

Note $V_A = V_B$

✓

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

$$A_B = \frac{\pi\times(200\times10^{-3})^2}{4}$$

$$A_B = 31{,}4\times10^{-3}\,m^2$$ ✓

$$V_B = A_B \times L_B$$

$$0{,}25\times10^{-3} = 31{,}4\times10^{-3}\times L_B$$

$$L_B = 7{,}96\times10^{-3}\,m$$

$$= 7{,}96\ mm$$ ✓ (4)

2.4.3 If the length is halved there will be no effect on the system. The ✓ pressure will still be the same throughout the system and the same volume will be reduced, meaning the distance 'x' will still be the ✓✓ same. (3)

2.4.4 **Any two of the following:**

- Hydraulic jack ✓
- Brakes of a motor car ✓
- Clutch of a motor car ✓
- Any other relevant example ✓

(any 2 x 1) (2)

[50]

QUESTION 3: TOOLS AND EQUIPMENT

Learning Outcome 3: Assessment Standard 2)

3.1 BRINELL HARDNESS TEST

1 = Test piece ✓
2 = Load ✓
3 = Hardened steel ball or ball ✓
4 = Diameter of impression or ball diameter or indentation ✓ (4)

3.2 DETERMINING CYLINDER LEAKAGE TEST

Tracing	Causes
Listen at the carburetor for a hissing noise ✓	Inlet valve is leaking ✓
Listen at the exhaust pipe for a hissing noise ✓	Exhaust valve is leaking ✓
Listen for a hissing noise in the dipstick hole ✓	Piston ring is warn
Remove the filler cap on the tappet cover and listen for a hissing noise ✓	Rings are worn ✓
If you see bubbles in the radiator water ✓	The cylinder head gasket is blown ✓

(10)

3.3 PRESSURE TESTER

- It is used to determine the test pressure of a pressure vessel ✓
- If there is a pressure drop after 20-30 minutes it means that there is a leakage in the valves or seams. ✓
- The test is carried out on vessels containing either air or fluids ✓ (3)

CYLINDER LEAKAGE TESTER

- It is used to determine any leak through air intake valve, an exhaust valve, head or block and excessive leakage of the piston rings. ✓
- If the tester shows a pressure drop after 20-30 minutes, it means that there is a leakage in the cylinder. ✓
- This test is carried out only on internal combustion engines. ✓ (3)

[20]

QUESTION 4: MATERIALS

(Learning Outcome 3: Assessment Standard 3)

4.1 A **NON-FERROUS ALLOY** is a metal that has a combination of two or more ✓ non-ferrous metals, which are melted together to form one alloy ✓ (2)

4.2 ALLOYS

4.2.1

Aluminium Bronze		
Composition	**Properties**	**Uses**
Consists of copper and aluminium ✓	Any one of the following: • Ductile✓ • Malleable ✓ • Corrosion resistant ✓ • Tough ✓ • Hard ✓	Any one of the following: • General engineering ✓ • Ship building ✓ • Pipe lines ✓ • Taps and valves ✓ • Cooking utensils✓

(3)

4.2.2

Duralumin		
Consists of copper manganese magnesium and aluminium ✓	Any one of the following: • Very strong ✓ • Light ✓ • Hardens with age✓	Any one of the following: • Forging ✓ • Stamping ✓ • Bars ✓ • Sheets ✓ • Tubes ✓ • Rivets ✓

(3)

4.2.3

Carbon fibres		
Produced from polymere PAN (Polyacrylonitrile) ✓	Any one of the following: • Low density ✓ • Light weight ✓ • Resistant to corrosion✓ • Stiffest and strongest reinforcing fibre ✓	Any one of the following: • Airplane body ✓ • Racing car bodies✓ • Canopies of light drive vehicles(LDV) ✓

(3)

4.3 NYLON PROPERTIES

- Needs no lubrication ✓
- Shock resistant ✓
- No maintenance ✓
- Very light in weight ✓
- Easy to machine ✓

(Any 3 x 1) (3)

4.4 Polyvinylchloride (PVC)

- Highly versatile polymer ✓
- Can be plasticised to make it soft, flexible for flooring, medical products and good electrical insulator ✓
- Unplasticised PVC has good chemical resistance and weather resistance. It is stiff, hard, tough, lightweight, has a wide colour range, needs to be stabilised for outdoor use and building applications ✓
- Excellent electrical insulation properties ✓
- Good impact and weatherproof attributes ✓
- Rigid but flexible ✓
- Corrosion resistance ✓

(Any 3 x 1) (3)

4.5 TEFLON USES

- Gears ✓
- Bearings ✓
- Pipe connections ✓
- Crankshaft thrust washers ✓
- Vice jaws ✓
- Bushes for steering columns ✓
- Control linkages / arm ✓
- Medical appliances ✓
- Nonstick coatings ✓
- Electrical insulation ✓
- Upholstery ✓

(Any 3 x 1) (3)
[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS

(Learning Outcome 3: Assessment Standards 1, 4 and 5)

5.1 HYDRAULIC PRESS SAFETY

- Make sure the object to be pressed is firmly secured ✓
- Make sure that the pins holding the lower beam is fitted properly ✓
- Check pins for wear ✓
- Check for leaks at the hydraulic pump ram and including the hose ✓
- Check that the cable to lift the beam is in good order ✓
- Make sure area around the press is clean and free from oil and grease ✓

(Any 3 x 1) (3)

5.2 ARC WELDING SAFETY

- During arc welding the whole body should be protected against infra-red and ultra-violet rays given off when arc welding ✓
- Because ultra-violet rays can cause blindness and skin cancer, the complete head must be protected ✓
- A welder should wear a welding hood fitted with the filter lens. Under the hood the welder should wear safety goggles as a protection against splattering and chipping when the hood is raised ✓
- Wear flameproof gauntlet, gloves, flameproof apron or leather, asbestos or other non-flammable materials, because of hot sparks ✓
- Do not use gloves to carry hot metal; use a pair of pliers ✓
- Use fire-resistant leggings and safety boots to protect legs and feet ✓

(Any 3 x 1) (3)

 Please turn over

5.3 MILLING MACHINE SAFETY

- Make sure that all guards are in place ✓
- Do not use a machine or come close to its moving parts while wearing loose clothing ✓
- Check that there is no oil or grease on the floor around the machine ✓
- Do not leave spanners or keys on rotary parts ✓
- Never apply a wrench to revolving work ✓
- Always clamp work pieces and holding devices safely and firmly ✓
- Do not use your hands to remove cutting while a machine is in motion ✓
- Never adjust the cutting tool while the machine is running ✓
- Resist the habit of leaning on machinery ✓
- Do not attempt to stop a machine by placing your hand on the chuck while the machine is slowing down ✓
- Give attention to cutting-fluid control before switching on a machine ✓

(Any 4 x 1) (4)

5.4 ULTRASONIC INSPECTION

1 = Initial sound pulse / Welding defect wave ✓
2 = Defect sound echo / Reflection wave ✓
3 = Oscilloscope / Screen ✓
4 = Calibration of screen / Baseline ✓
5 = Search pattern / Zig zag pattern of transducer ✓
6 = Ultrasonic search unit / Ultrasonic transducer ✓
7 = Ultrasonic sound wave / Movement of ultrasonic wave ✓
8 = Defect / Welding defect / Weld ✓ (8)

5.5

	WELD DEFECT/ IDENTITY	**CAUSES/INTERPRET**	**CORRECTION METHOD/EVALUATION**	
5.5.1	Porous weld ✓ ***[If Porous weld and Slag inclusion are swapped around it is acceptable]***	Any one of the following: • speed too fast ✓ • current too low ✓ • insufficient pudding time ✓ • faulty electrode ✓ • high sulphur or other impurities in metal ✓ • impaired base metal ✓ • short arc with exception of low hydrogen and stainless steel ✓	Any one of the following • use correct current ✓ • hold a longer arc ✓ • use low hydrogen electrodes ✓ • check for impurities in base metal ✓ • allow for sufficient puddling time for gases to escape ✓ • weave the weld ✓ • use correct electrode for the job ✓	(3)
5.5.2	Slag inclusion ✓ ***[If Porous weld and Slag inclusion are swapped around it is acceptable]***	Any one of the following: • included angle is too narrow ✓ • rapid chilling ✓ • weld temperature is too low ✓ • high viscosity of molten metal ✓	Any one of the following: • preheat metal ✓ • slag not removed from previous run weld ✓ • increase included angle✓	(3)
5.5.3	Incomplete penetration ✓	Any one of the following: • speed too fast ✓ • joint design faulty ✓ • electrodes too large ✓ • current too low ✓	Any one of the following: • use correct current to obtain desired penetration and weld slowly ✓ • calculate the electrode penetration properly ✓ • select correct electrode according to welding groove ✓ • leave enough free space at the bottom of the weld ✓	(3)
5.5.4	Undercutting ✓	Any one of the following: • faulty electrode manipulation ✓ • current too high ✓ • arc length too long ✓ • speed of weld too fast ✓	Any one of the following: • use a uniform weave in butt welding✓ • do not use a too large electrode ✓ • avoid excessive weaving ✓; current to be moderate and weld slowly ✓ • hold the electrode at a safe distance from the vertical plane when making a horizontal fillet weld ✓	(3)

5.6 CALCULATION OF THE FEED ON A MILLING MACHINE

$$D = \frac{100}{1000}$$ ✓

$$= 0{,}1\text{m}$$

$$V = \pi DN$$ ✓

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

$$= \frac{40}{\pi \times 0{,}1}$$ ✓

$$= 127{,}32\ \text{r / min}$$

$$f = f_1 \times T \times N$$

$$= 1{,}06 \times 18 \times 127{,}32$$ ✓

$$= 137{,}51\ \text{mm / min}$$

$$= 138\ \text{mm / min}$$ ✓ (5)

5.7 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*

5.7.1 **Simple indexing**: Use N = 100

$$\text{Indexing} = \frac{40}{100} = \frac{2}{5} \times \frac{5}{5} = \frac{10}{25}$$ ✓✓✓ (3)

No full turns and 10 holes in a 25 hole circle
Can accept a different hole circle **e.g**.

$$\text{Indexing} = \frac{40}{100} = \frac{2}{5} \times \frac{6}{6} = \frac{12}{30}$$ No full turns and 12 holes in a 30 hole circle

5.7.2 $\text{Change gears} : \frac{Dr}{Dv} = (N - n) \times \frac{40}{N}$

$$= (100 - 103)\, x\, \frac{40}{100}$$ ✓ ✓

$$= \frac{-120}{100}$$ ✓

$$= \frac{-6}{5}\, x\, \frac{8}{8}$$ ✓

$$= \frac{-48}{40}$$ ✓ ✓

[can accept final answer if – is left out] (6)

5.7.3 **Meaning of + and – signs**

+: The index plate is rotating in the same direction as the index crank handle ✓
+: Because more teeth are required the index plate turns in the same direction as the crank handle ✓
+: This will compensate (deduct) the teeth ✓

-: The index plate is rotating in the opposite direction as the index crank handle ✓
-: Because fewer teeth are required the index plate turns in the opposite direction as the crank handle. ✓
-: The negative rotation will compensate for the addition of teeth. ✓ (6)

[50]

QUESTION 6: TURBINES AND MAINTENANCE

(Learning Outcome 3: Assessment Standards 7 and 9)

6.1 NEEDS OF LUBRICATING OIL

- Viscosity must be correct ✓
- It must resist corrosion ✓
- It must prevent rust ✓
- It must avoid forming scum ✓
- Resist carbon scum forming ✓
- Must prevent oxidation ✓
- Must resist extreme pressures and temperatures ✓

(any 4 x 1) (4)

6.2 POUR POINT refers to the lowest temperature at which oil will flow. ✓✓ (2)

6.3 CUTTING FLUIDS

- 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 machine surface ✓
- To keep the work piece cool ✓
- To keep the cutting tool cool ✓
- To obtain a higher cutting speed ✓
- It gives the cutting tool a longer lifespan ✓
- Does not rust the machine ✓
- Helps to wash away the chips of the metal being removed from the work piece, thus keeping the cutting edge of the cutting tool clean ✓

(any 4 x 1) (4)

6.4 Draining and filling gearbox oil procedure

- It is advisable to drain the gearbox oil immediately after the car has been driven, that is when the oil is warm. Oil will flow freely ✓
- Locate the filler plug on the side of the gearbox casing and wipe the plug and area around it clean. Place tray under the gearbox ✓
- Ensure that the spanner fits snugly around the filler plug ✓
- Loosen plug ✓
- Remove the filler plug ✓
- Remove the drain plug well fitting spanner in the base of the gearbox ✓
- Allow oil to drain out of the gearbox into the drain pan ✓
- Clean the drain plug and make sure to fit a new sealing washer ✓
- Replace the drain plug and make sure it is tight ✓
- Refill the gearbox with the recommended oil to the base of the filler plug ✓
- Allow excess oil to trickle out and refit the filler plug ✓ (10)

6.5 Blower

6.5.1 Roots blower ✓ (1)

6.5.2 **Labels**

1 Inlet ✓
2 Rotor ✓
3 Casing ✓
4 Outlet ✓ (4)

6.5.3 **Operation**

- When the engine runs, the rotor rotates. ✓
- Air is trapped between the rotor and aluminium casing ✓
- This compressed air is carried around the outside of the rotor and is pushed into a decreasing volume ✓
- This raises the pressure of the air with the rotational speed of the rotors ✓
- The air is forced into the inlet manifold and then fed into the cylinders ✓ (5)

6.6 SUPERCHARGER

6.6.1 **Advantages of a supercharger**

- 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

(Any 2 x 1) (2)

6.6.2 Disadvantages of supercharger

- A small amount of power is lost in order to drive the supercharger because it uses the engine power to drive it ✓
- Higher fuel consumption if the power generated is not fully used, as in the case of passenger vehicles ✓
- Due to the compression of the air this results in an increase in air temperature causing a decrease in the density of the inlet charge. ✓
- The lifespan of the engine is decreased because of higher cylinder pressure, which increases the load on the engine components ✓

(Any 2 x 1 = (2)

6.7 Operation of the turbo-charger

- The energy at which the exhaust gases rush out of the exhaust is wasted ✓
- This hot expanding gases from the engine is routed in the direction of the turbine wheel through a scroll-like housing, in such a manner as to enable the wheel to spin at very high speed ✓
- The gases are then channeled out of the housing and wheel assembly into the normal exhaust system ✓
- As the turbine wheel spins, it turns a common shaft, which in turn spins the other fan called the impeller ✓
- The impeller and its scroll housing acts as a compressor drawing air or air and fuel mixture in through the inlet compressing and delivering it through the output and the induction passage then into the cylinders under pressure ✓
- This boosted pressure delivered to the cylinders increases the volumetric efficiency of the engine as well as the engine performance ✓ (6)

[40]

TOTAL: 200