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 14 pages.

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

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

QUESTION 2: FORCES AND SYSTEMS AND CONTROL
(Learning Outcome 3: Assessment Standards 6 and 8)

2.1 GEARS

2.1.1

$$\begin{aligned} \textit{Pitch circle diameter} &= \textit{module} \times \textit{number of teeth} \\ &= 4 \times 60 \quad \surd \\ &= 240\ mm \quad \surd \end{aligned}$$

√ (3)

2.1.2

$$\begin{aligned} \textit{Addendum} &= \textit{module} \quad \surd \\ &= 4\ mm \quad \surd \end{aligned}$$

(2)

2.1.3

$$\begin{aligned} \textit{Clearance} &= 0{,}25 \times \textit{module} \quad \surd \\ &= 0{,}25 \times 4 \quad \textit{or} \quad = 0{,}157 \times 4 \quad \surd \\ &= 1\ mm \qquad\qquad = 0{,}628\ mm \quad \surd \end{aligned}$$

(3)

2.1.4

$$\begin{aligned} \textit{Dedendum} &= 1{,}25 \times \textit{module} \quad \surd \\ &= 1{,}25 \times 4 \quad \textit{or} \quad = 1{,}157 \times 4 \quad \surd \\ &= 5\ mm \qquad\qquad = 4{,}628\ mm \quad \surd \end{aligned}$$

(3)

2.1.5

$$\begin{aligned} \textit{Outside diameter} &= PCD + 2 \times \textit{module} \quad \surd \\ &= 240 + 2(4) \quad \surd \\ &= 248\ mm \quad \surd \end{aligned}$$

(3)

2.2 Cutting tool

A Trailing angle √
B Leading angle √
C Clearance angle √
D Helix angle √ (4)

2.3 Friction clutch

$$Torque = \mu WnR \quad \surd$$

$$R = \frac{Torque}{\mu Wn}$$

$$= \frac{245}{0{,}35 \times 2{,}5 \times 10^{3\times} \times 2} \quad \surd$$

$$= 0{,}14m \quad \surd$$

$$but\ D_{effective} = 2 \times R$$

$$D_{effective} = 2 \times 0{,}14 \quad \surd$$

$$= 0{,}28m$$

$$= 280mm \quad \surd \qquad (5)$$

2.4 Levers

2.4.1

$$Effort \times 0.6 = (200 \times 10) \times 0.2 \quad \surd$$

$$Effort \times 0.6 = 400 \quad \surd$$

$$Effort = \frac{400}{0.6} \quad \surd$$

$$= 666.667N \quad \surd \qquad (4)$$

2.4.2

$$Mechanical\ Advantage = \frac{Load}{Effort} \quad \surd$$

$$= \frac{2000}{666{,}667} \quad \surd$$

$$= 2.999\ or\ 3 \quad \surd \qquad (3)$$

2.5 Stress and strain

2.5.1 Total area of the rivets:

$$A_{total} = \frac{\pi D^2}{4} \times 2 \quad \surd$$

$$= \frac{\pi (0.012)^2}{4} \times 2 \quad \surd\surd$$

$$= 0{,}23 \times 10^{-3}\, m^2 \quad \surd\surd$$

(5)

2.5.2 Stress in one rivet

$$Stress = \frac{Load}{Area} \div 2 \quad \surd\surd$$

$$Stress = \frac{80 \times 10^3}{0{,}23 \times 10^{-3}} \div 2 \quad \surd$$

$$= 347{,}83 \times 10^6 \div 2 \quad \surd$$

$$= 173{,}83 MPa \quad \surd$$

(5)

2.6 Belt drives

2.6.1

$$\frac{D_{Driven}}{D_{Driver}} = \frac{N_{Driver}}{N_{Driven}} \quad \surd$$

$$D_{Driven} = \frac{N_{Driver} \times D_{Driver}}{N_{Driven}} \quad \surd$$

$$D_{Driven} = \frac{7{,}2 \times 0{,}6}{10} \quad \surd$$

$$= 0{,}432m$$

$$= 432mm \quad \surd$$

(4)

2.6.2

$$T_2 \times 2{,}5 = 300 \quad \surd$$

$$T_2 = \frac{300}{2.5} \quad \surd$$

$$= 120N \quad \surd$$

$$\therefore P = (T_1 - T_2)\pi DN$$

$$= (300 - 120)\pi \times 0{,}6 \times 7{,}2 \quad \surd$$

$$= 2442{,}902W \quad \surd$$

$$= 2{,}443kW \quad \surd$$

(6)

[50]

QUESTION 3: TOOLS AND EQUIPMENT
(Learning Outcome 3: Assessment Standards 2)

3.1 Operating rules for all multi-meter

Check that the measuring leads are inserted into the correct sockets for the measurement you wish to perform √
Turn the function switch to the desired function. (Volt, Amps, Ohms) √
If you do not know what size of reading to expect, it is good practice to always first switch to the highest range in that function. √
Connect the meter's measuring lead probes to the correct points in the circuit to be tested. √
When using an analog meter, if there is only a small deflection of the pointer across the scale, it is always difficult to read. Always interpret the reading and then check that there is not a lower range in that function to switch to. This will magnify the scale and so give a more accurate reading√

Any FOUR (4x1=4) (4)

3.2 **Metal Arc Gas Shielded welding (MAGS)** √√ (2)

Or

Metal Inert Gas Shielded welding (MIGS) √√

3.3 Spring tester:

- Place the valve spring in the tension gauge, pull the tension lever down. √
- Note the load applied on the lever on the tension gauge, also note the height of the spring. √
- Compare the load and height to the manufacturer's specifications, if the height of the spring is lower, then it has lost its tension. It must be replaced. √
- When the valves are assembled measure the height of the spring and compare to specification √ (4)

3.4 Cylinder leakage tester:

Check radiator for air bubbles. √
This indicates the cylinder is leaking into the water jacket. √
Listen for air coming out at the carburetor or air cleaner. √
This indicates that the inlet valve is leaking √
Listen for air escaping through the exhaust pipe or tail pipe. √
This indicates that the exhaust valve is leaking. √
Check for air escaping through the oil filler cap. √
This indicates a crankcase leakage; the cause may be the result of worn or broken rings, worn piston and worn cylinder. √
If there is a high leakage next to each cylinder. √
This indicates the cylinder head gasket is leaking or cracked. √

Any THREE (3x2=6) (6)

3.5 Brinell Hardness tester:

Turn the adjustable air regulator valve clockwise until the desired load is indicated on the gauge √
Check the load reading when making the initial test of a series and adjust the regulator valve if necessary so that the desired load is indicated on the gauge √
Place the test piece on the anvil. Turn the hand-wheel until the gap is sufficient to allow the specimen to be inserted into the machine √
Pull out the load and unload plunger on the left side of the machine. √
Read the Brinell impression with a microscope and obtain the Brinell hardness number from the hardness table (4)

[20]

QUESTION 4: MATERIALS
(Learning Outcome 3: Assessment Standard 3)

4.1 Stainless steel

4.1.1 It has a high gloss when polished √
It is strong √
Easily machined √
Weldable with stainless steel rod √
Any TWO (2x1=2) (2)

4.1.2 It is lighter and thus √
Cheaper than the solid bar √ (2)

4.1.3 Mild steel could rust √
Needs painting for a good appearance √ (2)

4.2 Road wheels

With heat treatment steel becomes tougher and √
Harder than aluminium √ (2)

4.3 Key

4.3.1 High carbon steel and stainless steel
√√ (2)

4.3.2 Properties:
- Can be machined
- Can be welded
- Has high tensile strength
- Greater resistance to wear
- Ductility is low Any TWO (2x1=2) (2)

4.4 Bolt cutter

Jaws - Resistance against denting and wear
- Can be heat treated √√

Strap - Because of high tensile strength √√ (4)

4.5 Nylon gears

4.5.1 **Properties**
- Good resistance to wear √
- Has low frictional properties √
- Has a fairly high melting point √

Any TWO (2x1=2) (2)

4.5.2 **Nylon fibre:**
- It has good resistance to wear √
- It is hard √
- It has resistance to chemical attack √

Any TWO (2x1=2) (2)
[20]

QUESTION 5: SAFETY, TERMINOLOGY AND JOINING METHODS
(Learning Outcome 3: Assessment Standards 1, 4 and 5)

5.1 Metal Arc Gas Shield welding

Advantages of Metal Arc Gas Shield welding:

- Can weld in any position √
- High deposition rate √
- Less operator skill required √
- Long welds can be made without stops and starts √
- Minimal post weld cleaning is required √ (5)

5.2 Milling

5.2.1 **Advantages of up cutting milling**

- A coarse feed may be used √
- Less vibration is experienced √
- Less strain on the cutter and arbor √

Any TWO (2x1=2) (2)

5.2.2 **Advantages of down cutting milling**

- Deeper cut can be taken because the force of the cutter is downwards, √
- Finer finish is obtained √

Any TWO (2x1=2) (2)

5.3 Cutters

- **Arbor cutters** √
- e.g. plain, side, staggered-tooth, metal slitting saw and form cutters √√
- **Shank cutters** √
- e.g. end mills, T-slot, Woodruff key seat and fly cutter √√ (6)

5.4 Characteristics of a good cutter

- High abrasive resistance √
- Red hardness i.e. the hardness of the cutting edge must not be affected by heat generated by machining process. √
- Edge toughness √ (3)

5.5 Incomplete penetration

Causes:

- Current too low √
- Electrode too large √
- Joint preparation incorrect √
- Weld speed too fast √

Any THREE (3x1=3) (3)

Cures/Prevention

- Use correct current √
- Proper electrode should be used √
- Joint should prepared properly √
- Correct speed should be used √

Any THREE (3x1=3) (3)

5.6 Joining methods

Destructive tests	**Non destructive tests**
Free bend test √	Liquid dye penetrant test √
Nick break test √	X-ray test √
Guided bend test √	Ultrasonic test √

(6)

5.7 Cutting speed:

$$V = \pi DN$$ √

$$N = \frac{V}{\pi D}$$ √

$$N = \frac{30}{\pi \times 0,1}$$ √

$$N = 95,49\,\text{rpm}$$

$$f = f \;\; \times T \times N$$ √

$$f = 0,06 \times 16 \times 95,493$$ √

$$f = 91,67\,\text{mm/min}$$ √ (6)

5.8 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*

5.8.1 Indexing:

$$Indexing = \frac{40}{n} = \frac{40}{50} \quad \surd$$

$$= \frac{40}{48} \div \frac{2}{2} \quad \surd$$

$$= \frac{20}{24} \quad \surd \surd$$

No full terms and 20 holes on a 24 hole circle. (4)

5.8.2 Change gears:

$$\frac{D_r}{D_v} = (A-n)\times\frac{40}{A} \quad \surd$$

$$=(48-50)\times\frac{40}{48} \quad \surd$$

$$=\frac{-80}{48}\div\frac{2}{2} \quad \surd$$

$$=\frac{-40}{24} \quad \surd$$

(4)

5.8.3 Plate direction – turns in the opposite direction √√ (2)

5.9 Beam bending tester

- Make sure the object to be tested is firmly secured √
- Make sure that all the holding devices is fitted properly √
- Check components of the tester for wear √
- Check for leaks at the hydraulic pump including hoses(if using hydraulic system) √
- Area around tester should be clean and free from grease and oil. √

Any FOUR (4x1=4) (4)

[50]

QUESTION 6: MAINTENANCE AND TURBINES
(Learning Outcome 3: Assessment Standards 7 and 9)

6.1 Properties of oil

6.1.1 Fluidity is the ease with which the oil flows through oil channels and spread over bearing surfaces. The viscosity of oil is determined by viscosimeter. It takes into account the temperature and the time, a specified amount of oil takes to flow through a hole of a specified diameter √√ (2)

6.1.2 POUR POINT: Some oil will become thick and not pour at all at low temperature. Additives are added to the oil to keep it fluid at low temperature for engine lubrication that is during cold weather starting and initial operation √√ (2)

6.1.3 FOAM RESISTANT: The rotary motion of the crankshaft causes a churning movement in the engine crankcase causing oil to foam. Anti-foaming oil additives are used to prevent foaming √√ (2)

6.2 Lubricating oil

- 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)

6.3 Bearings

6.3.1 **Uses of bearings:**

- It is used to reduce friction between two parts one rotating and one stationary. √
- A bearing also acts as a support for rotating shafts. √
- Bearing provides smooth movement and reduces wear √ (3)

6.3.2 **Causes of overheating:**

- Lubrication is insufficient. √
- Lubrication in the housing is excessive. √
- Oil foams. √
- Liquefaction of the grease. √
- Poor properties of the lubricant. √
- Raceway turning in the housing or on the shaft. √
- Bearing clearance inadequate. √
- Too high operating speed, it creates excessive heat. √
- Insufficient cooling condition. √
- Abrasive dirt in the bearing. √

Any THREE (3x1=3) (3)

6.3.3 **Advantages of anti-friction bearings:**

- Bearing noise indicates that the bearing is failing not is the case of friction bearings. √
- Can take both radial and thrust loads. √
- Ball and roller bearing has less clearance than the journal bearing. √
- Ball and roller bearings are pre-packed with grease to provide maintenance free installation. √
- High overloads for a short period can be achieved with ball and roller bearings. √

Any THREE (3x1=3) (3)

6.3.4 **Disadvantages of anti-friction bearing**:

- Not quite in operation at high speeds as compared to split bearing. √
- Cannot be repaired, must be replaced. √ (2)

6.4 Turbines

6.4.1 **Basic operation of the steam turbine**

- Kinetic energy is the steam which is converted to mechanical energy to cause rotation. (mechanical energy)
- Steam at very high temperature and pressure is directed to the turbine. √
- Nozzles are used to direct the pressure onto the blades.
- The blades are attached to the turbine and shaft causing it rotate. √
- This is mechanical energy created by the impulse and the reaction effort of the steam jet √ (5)

6.4.2 **Advantages of steam turbines**

- It is compact. √
- No lubrication is required. √
- Turbine speeds can be more accurately regulated. √
- A variety of fuels can be used to obtain steam. √
- Steam turbines are more economical. √
- Higher speeds can be obtained as compared to internal combustion engine. √

Any Four (4x1=4) (4)

6.4.3 **Disadvantages of steam turbines**

- Needs a large area for fuel storage. √
- Cooling towers are used to regulate steam to reduce the usage of water √ (2)

6.5 Gas turbines

6.5.1 Operation of gas turbine

- The gas turbine is purely a rotating machine and is thus mechanically driven. It consists of a compressor and a turbine, and the varied rotors of the compressor, √
- The turbine is mounted on a common shaft, as the shaft revolves at its high speed, the compressor draws in air, raises its pressure and delivers it to the combustor, or rings of combustors into which fuel is pumped. √
- The fuel burns continuously except on start-up when it has to be ignited initially after the engine has been run up electrically to self sustaining speed. √
- The burning gases expand very rapidly. √
- The only way the gases can escape from the combustor is via guide vanes to the turbine. √
- The turbine is forced to rotate and supplies the power. √ (6)

6.5.2 Advantages of gas turbines

- High power output from a given weight of engine. √
- The torque output characteristic permits a notable simplification of the transmission system. √
- Smooth vibration less running due to absence of reciprocating parts. √
- No rubbing parts such as piston so that internal friction and wear are almost eliminated. √
- Easy starting. √
- Can use wide range of fuels and does not require expensive anti-knock additives. √
- Low lubricating oil consumption. √
- No water cooling system needed. √
- Non-poisonous exhaust giving very little trouble with pollution. √
- Requires little routine maintenance √

Any THREE (3x1=3) (3)

[40]

TOTAL: 200