Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

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MECHANICAL TECHNOLOGY MEMORANDUM

MARKS: **200**

This memorandum consists of 14 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

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QUESTION 2: SAFETY

2.1
- The area around the tester must be cordoned off. ✓
- Only one person should be in the confined space. ✓
- The tester should wear safety goggles.
- Make certain that the dial indicator is mounted properly. (Any 2 x 1) (2)

2.2
- Keep the meter dry. ✓
- Keep the meter away from dust and dirt. ✓
- Use and store the meter in environments where the temperature is normal/room temperature.
- Do not drop the meter as it could be damaged and this will affect its operation. (Any 2 x 1) (2)

2.3
- Make certain that the puller is the right one for the job. ✓
- Make certain that the puller is strong enough to remove the bearing or gear. ✓ (2)

2.4
- An operator should be instructed to use a machine safely. ✓
- A workplace must be effectively partitioned off. ✓
- An operator must use protective equipment. ✓
- The insulation of electrical leads must be satisfactory. ✓
- The holder which contains the wire must be completely insulated to prevent accidental contact with current-carrying parts.
- The argon gas cylinder must be fixed in an upright position.

(Any 4 x 1) (4)

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QUESTION 3: TOOLS AND EQUIPMENT

3.1
A − Flow meter ✓
B − Continuous wire feed ✓
C − Welding gun ✓
D − Shielding gas cylinder ✓
E − Regulator ✓ (5)

3.2 Metal Inert Gas ✓ (1)

3.3
- Listen to the carburettor for a hissing noise − inlet valve is leaking. ✓
- Listen to the exhaust pipe for a hissing noise exhaust valve is leaking. ✓
- Listen for a hissing noise in the dipstick hole − piston ring is worn. ✓
- 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 or the cylinder block is cracked. (Any 4 x 1) (4)

3.4
- To test the properties of a tension ✓or compression spring. ✓ (2)

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QUESTION 4: MATERIALS

4.1 Iron ✓ and carbon ✓ (2)

4.2 It is intensely hard and brittle. ✓ (1)

4.3 A − Uniform rise in temperature ✓
B − Uniform drop in temperature ✓
C − Uniform rise in temperature ✓
D − Uniform drop in temperature ✓
E − Halt in temperature drop (Point of recalescence AR_1) ✓
F − Halt in temperature rise (Point of decalescence AC_1) ✓ (6)

4.4
- Because of their air-cooled properties ✓ (1)

4.5
- Forged steel ✓ or
- Cast iron ✓ (1)

4.6
- Case hardening/surface hardening ✓
- Tempering ✓ (2)

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QUESTION 5: TERMINOLOGY

5.1
- Set up the work piece in the centre lathe and turn the part to be threaded to the major diameter of the thread. ✓
- Set the compound slide to 30° to the right and set the cutting tool up accurately in the tool post. ✓
- Set the shift levers to the necessary pitch of the screw thread. ✓
- Start the centre lathe and set the cutting tool at touching point on the work piece. ✓
- Set the dials of the cross feed and compound slide to zero.
- Move the cutting tool to clear the end of the work piece and feed the compound slide 0, 05 mm inwards. ✓
- With the centre lathe revolving, engage the half nuts at the correct line on the threading dial, putting the first cut of the screw thread in progress, whereby the tool will now scrape (scratch) the work piece. ✓
- At the end of the cut, withdraw the cutting tool quickly and disengage the half nut lever and return the carriage to the starting point of the screw thread. ✓
- Stop the centre lathe and check the screw-thread pitch with a screw thread pitch gauge. ✓
- Repeat the process until the required depth is reached. ✓ (9)

5.2 5.2.1 Calculate the Simple Indexing:
For Simple Indexing we use N = 86 as given
Therefor Indexing = $\frac{40}{86}$
$= \frac{20}{43}$ ✓

No full turns and 20 holes in a 43 hole circle. ✓ (2)

5.2.2 Calculate the change gears for the dividing head:
Gear ratio = (N − n) x $\frac{40}{N}$ ✓
Use 86 divisions as given as a hint.
Gear ratio = (86 – 85) x $\frac{20}{43}$ ✓
= 1 x $\frac{20}{43}$ ✓
= $\frac{20}{43}$ ✓

No full turns and 20 holes in a 43 hole circle. ✓ (5)

5.3 It is the operation of milling the opposite sides of a work piece ✓ at the same time, ✓ with two side and face cutters spaced at the correct distance apart ✓ on the milling machine arbor. ✓ (4)

5.4 Gang milling. ✓ It is the use of several milling cutters on one spindle to produce a surface with a required profile ✓ or to mill the face or sides of the work simultaneously. ✓ A combination of milling cutters may be used for plain milling and side milling simultaneously. ✓ (4)

5.5 $\text{Number of turns} = \frac{40}{N}$

$= \frac{40}{114}$

$= \frac{20}{57}$ ✓

There will be no full turns and 20 holes in a 57 hole circle. ✓ (2)

5.6
- Worm shaft ✓
- Worm gear/wheel ✓
- Index plate ✓
- Crank handle ✓ (4)

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QUESTION 6: JOINING METHODS

6.1 The automotive industry ✓ or
The fabrication industry (1)

6.2 Porosity ✓ (1)

6.3 Direct current (DC) ✓ (1)

6.4
- Use a hacksaw and cut both edges through the centre of the weld approximately 6,5 mm deep. ✓
- Place the saw-nicked specimen on two steel supports and use a sledge hammer to break the specimen by striking it in the zone where you made the saw cuts. ✓
- The weld metal exposed in the break should be completely fused, free from slag inclusion and contain no gas pockets greater than 1,6 mm. ✓
- There should not be more than one pore or gas pocket per square centimetre visible. ✓ (4)

6.5
- The liquid dye penetrant is sprayed onto the surface being tested/inspected. ✓
- The liquid is allowed to penetrate for a short time. ✓
- The excess amount of dye is removed with a cleaner. ✓
- The surface is washed with water and allowed to dry. ✓
- After the surface is thoroughly dry, a developer is sprayed on the surface, which brings out the colour in the dye penetrant that has penetrated into any cracks or pin holes. ✓
- Should the dye penetrant not come up; it means that the welded joint is good. ✓

OR

- The fluorescent liquid penetrant is sprayed onto the surface being tested/inspected. ✓
- After a short time, the excess fluorescent liquid is removed with a cleaner and the surface is washed and dried.
- A black-light source (ultraviolet light) is then brought up to the surface.
- Areas where the fluorescent liquid has penetrated will show up clearly under the ultraviolet light. (6)

6.6 6.6.1 **Incomplete penetration: Causes**
- Faulty joint design ✓
- Welding speed to rapid ✓
- Insufficient welding current or nozzle size
- To large an electrode or filler rod (Any 2 x 1) (2)

6.6.2 **Undercutting: Causes**

- Current too high or nozzle too large ✓
- Incorrect manipulation ✓
- Arc length too long
- Welding speed too rapid (Any 2 x 1) (2)

6.6.3 **Slag inclusion: Causes**

- Joint design continues to narrow ✓
- High viscosity of molten metal ✓
- Rapid chilling
- Too low a weld temperature (Any 2 x 1) (2)

6.7 A − Gas shroud ✓
B − Goose neck ✓
C − Wire ✓
D − Trigger ✓ (4)

6.8
- Mixture of argon and CO_2. ✓
- Tirrell (Any 1 x 1) (1)

6.9 To avoid porosity, because the weld zone must be 'shielded' or protected from the atmosphere. ✓ (1)

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QUESTION 7: FORCES

7.1 7.1.1 Diameter:

$$\text{Stress} = \frac{FORCE}{AREA}$$

$$204 \times 10^6 = \frac{100\ X\ 10^3}{AREA}\ \checkmark$$

$$\text{AREA} = \frac{100\ X\ 10^3}{204\ X\ 10^6}\ \checkmark$$

$$\frac{\pi D^2}{4} = 0{,}00049\ \checkmark$$

$$D = 0{,}0249 \text{ mm}\ \checkmark \quad (4)$$

7.1.2 Young's Modulus = $\frac{Stress}{Strain}$

$$\text{Strain} = \frac{Stress}{Young's\ Modulus}\ \checkmark$$

$$\text{Strain} = \frac{204\ x\ 10^6}{210\ x\ 10^9}\ \checkmark$$

Strain = 0,000971 ✓ (3)

7.1.3 Change in length:

$$\text{Strain} = \frac{Change\ in\ Length}{Original\ Length}$$

Change in Length = Strain x Original Length ✓

= 0,000971 x 110 ✓

= 0,1068 ✓ (3)

7.1.4 **Type of stress**

Compressive stress ✓ (1)

7.1.5 **Influence**

The pin will shorten ✓
New length = 109,89 mm ✓ (2)

7.1.6 **Brass**

Brass = softer ✓
Change in length will be bigger. ✓
Pin will shorten even more than mild steel. ✓ (3)

7.2 **FORCE/STRESS**

X:	**75 Cos 45°**	**53,03**	**Y:**	**75 Sin 45°**	**53,03**
	40 Cos 60°	**-20**		**40 Sin 60°**	**34,64**
	80 Cos 30°	**-36,25**		**80 Sin 60°**	**-69,28**
	X =	**-36,25**		**Y =**	**18,39**

X- Components: 75 Cos 45° − 40 Cos 60° − 80 Cos 30° ✓
= -36,25 N ✓
Y-Components: 75 Sin 45° + 40 Sin 60° − 80 Sin 60° ✓
= 18,39 N ✓

$R^2 = X^2 + Y^2$
$= -36,25^2 + 18,39^2$ ✓
R = 40,6 N ✓ (6)

7.3 7.3.1 RL: M(RR x 12) = (4 x 4) + (18 x 5,5) + (3 x 9) ✓

= 16 + 99 + 27

$R\ R = \frac{142}{12}$

RR = 11,83 N ✓

RR: (RL x 12) = (3 x 3) + (18x 6,5) + (4 x 8) ✓

= 9 + 117 + 32

$RL = \frac{158}{12}$

RL = 13,17 N ✓ (4)

7.3.2 BMA: (13,17 x 4) = 52,68 N ✓

BMB: (13,17 x 7) – (4 x 3) = 80,19 N ✓

BMC: (13,17 x 9) – (4 x 5) – (18 x 3 x 3,5) ✓ = 35,53 N ✓ (4)

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QUESTION 8: MAINTENANCE

8.1 Properties of good lubricating oils:
- Oxidation resistant ✓
- Corrosion resistant ✓
- Foam resistant ✓
- Carbon resistant (4)

8.2
- Formation of acids or lacquer may be left by the combustion of fuel. ✓
- It loses its viscosity after a while due to heat. ✓
- Metal particles in oil due to metal and metal contact. ✓ (3)

8.3
- Cutting fluid should be applied to the cutting tool in order for it to reach all the areas ✓that need cooling and lubricating. ✓
- The cutting fluid is recycled as a pump circulates it from the machine's splash tray and sump back to the spout. ✓ (3)

8.4
- Transmitting power ✓ − in the torque converter. ✓
- Acting as hydraulic fluid ✓ − transmitting hydrostatic energy to move components. ✓

OR

- Acting as a heat transfer medium ✓ − transfer heat from within the transmission to the outside and to assist in cooling it down. ✓
- Acting as a lubricant ✓ − for gears and bearings. ✓ (4)

8.5
- Extreme pressure gear oil. ✓ (1)

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QUESTION 9: SYSTEMS AND CONTROL

9.1 9.1.1 Belt Drive:
Calculate the mass of the belt.
Mass per meter = Area x Length x Density

= (Thickness x width) x Length x Density
= (0,01 x 0,165) x 1 x (0,75 x 10^{-3}) ✓
= 1 650 x 750 ✓
= 1,24 kg/m ✓ (3)

9.1.2 Calculate the belt speed
Belt speed = $\frac{\pi(D+t)\,x\,N}{60}$
= $\frac{\pi(\,0{,}265+\,0{,}165\,)\,X\,N}{60}$ ✓ or $\frac{3{,}142\,x\,0{,}43\,x\,1795}{60}$
= $\frac{2425{,}152}{60}$ ✓
= 40,4 m/s ✓ (3)

9.1.3 Calculate the power to drive the belt system.
Power = $\frac{2\pi N\,T}{60}$

But T = F x r

= 350 N x 0,133 ✓
= 46,55 Nm ✓

Power = $\frac{2\,x\,\pi\,x\,\,1795\,\,x\,\,46{,}55}{60}$ ✓

= $\frac{525{,}22\ \mathrm{W}}{60}$
= 8,746 kW ✓ (4)

9.2 9.2.1 Calculate the diameter of Piston A:
First we have to calculate the volume of cylinder B.
V_B = Area B x Stroke length B

= $\frac{\pi x D^2 B}{4}$ x L_B ✓

= $\frac{\pi x (0,195)^2}{4}$ x 0,012 ✓

= 35,84 x 10^{-5} m³ ✓

But $V_A = V_B$

A_A x 0,04 = 35,84 x 10^{-5} ✓

$A_A = \frac{35,84 X 10^{-5}}{0,04}$ ✓

A_A = 0,00896

A_A = 89,6 10^{-4} m^2 ✓

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

$D^2 = \frac{89,6 X 10^{-4} X 4}{\pi}$ ✓

$= \sqrt{0,0114}$ ✓

D^2 = 0,106 m or 106 mm ✓ (9)

9.2.2 Calculate the pressure exerted on Piston A.
Pressure at A = $\frac{F_A}{A_A}$

$P_A = \frac{600}{89,6 X 10^{-4}}$ ✓

= 66 964,28 Pa

= 66,97 kPa ✓ (2)

9.2.3 Calculate the force exerted on Piston B:
Note that Pressure at A = Pressure at B

$P_B = P_A$

$P_B = \frac{F_B}{A_B}$ ✓

F_B = 66,97 x 10^3 x $\frac{\pi X 0,195^2}{}$ ✓

= 66,97 x10^3 x 29,8 x 10^{-3} ✓

= 2 000,13 N

= 2 kN ✓ (4)

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QUESTION 10: TURBINES

10.1
- Reaction turbines ✓
- Impulse turbines ✓ (2)

10.2
- Non-condensing turbines (or back-pressure) turbines ✓ (1)

10.3
- It uses an isentropic process in which the entropy of the steam entering the turbine is equal to the entropy of the steam leaving the turbine. ✓
- The interior of the turbine has several blades or buckets. ✓
- One set of stationary blades is connected to the casing and one set of rotating blades is connected to the shaft. ✓
- To maximise the turbine efficiency, the steam is expanded, so generating work, in a number of stages. ✓
- These stages are characterised by how the energy is extracted from them and are known as impulse or reaction turbines. ✓ (5)

10.4
- Flowing water is directed onto the blades of a turbine runner, creating a force. ✓
- Since the runner is spinning, the force acts over a distance. ✓
- Energy is transferred from the water flow to the turbine. ✓ (3)

10.5
- It is a dynamic compressor in which air or gas is compressed by the mechanical action of impellers which are spun using the kinetic movement of air, ✓ imparting velocity and pressure to the flowing medium. ✓ (2)

10.6
- It increases horsepower. ✓ (1)

10.7
A − Compressor housing ✓
B − Turbine housing ✓
C − Turbine exhaust gas outlet ✓
D − Turbine wheel ✓
E − Turbine exhaust inlet ✓
F − Compressor air discharge ✓ (6)

[20]

TOTAL: 200