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 14 pages.

ANSWER SHEET

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

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

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QUESTION 2: TOOLS AND EQUIPMENT

2.1 **Cylinder leakage test:**

2.1.1 Cylinder Leakage Test ✓ (1)

2.1.2 **Procedure for cylinder leakage test:**

- Run the engine until normal operating temperature. ✓
- Remove the spark plug from cylinder number three. ✓
- Install cylinder leakage tester to the spark plug hole of cylinder number three. ✓
- Remove the oil filler cap, radiator filler cap as well as the air filter. ✓
- Turn the crankshaft pulley until piston number three is at TDC (Power stroke) ✓
- Apply air pressure to cylinder. ✓
- Listen at the carburettor for a hissing noise. (Inlet valve is leaking) ✓
- Listen at the exhaust pipe for a hissing noise. (exhaust valve is leaking) ✓
- Listen at the dipstick for a hissing noise. (Piston rings are worn) ✓
- Listen at the oil filler hole for a hissing noise. (Piston rings are worn) ✓
- Look for bubbles in the radiator water, if so the cylinder head gasket is blown or the cylinder block is cracked. ✓ (11)

[50% (6 marks) will be credited for the steps related to any type of test other than that mentioned in 2.1.1]

2.2 **Spring tester:**

- Squareness/Roundness ✓ or (specifications of length and pressure) (2)
- Correct tension✓

2.3 Computer Numerical Control✓ (1)

2.4 **Metal arc gas shielded:**

2.4.1 **Advantages**

- Can weld in any position. ✓
- Higher disposition rate. ✓
- Less operator skill required. ✓
- Long welds can be made without stops and starts. ✓
- Minimal post-weld cleaning / no slag removal is required. ✓
- Causes less deformation ✓
- Gives better finish ✓
- Faster than arc welding ✓

Easy operation ✓ **Any 3 X 1** (3)

2.4.2 **Gasses**
- Argon ✓ and CO_2 ✓ (2)

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QUESTION 3: MATERIALS

3.1 **Carbon fibre:**
- It gives a smooth finish✓
- Light in weight✓
- Resistant to corrosion✓
- Easy to mould✓
- Its tough✓
- It's strong ✓ **Any 2 X 1** (2)

3.2 **Stiffness of materials:**
Material B is the stiffer✓
Reason: Material B is more resistant to a bending deformation✓✓ (3)

3.3 **Non-ferrous alloys:**

3.3.1 A non-ferrous alloy is a metal that has a combination of two or more non-ferrous metals. ✓✓ (2)

3.3.2 **Examples:**
- Brass✓
- Bronze✓
- White metal✓
- Duralumin✓
- Solder✓
- Silver solder✓ **Any 3 X 1** (3)

3.4 **Composite:**

3.4.1 **Thermosetting plastics**
- Teflon✓
- Nylon✓ (2)

3.4.2 **Properties of Teflon and nylon to support choice:**
- High friction resistance✓
- Light in weight✓
- Easy to work with✓
- Provides a smooth finish✓
- Needs no lubrication ✓
- No/low maintenance ✓
- Corrosion free ✓
- Poor conductor of electricity ✓ **Any 4 X 1** (4)

3.5 **Soft solder**
Lead ✓ and tin ✓or Antimony (2)

3.6 **Silver solder**
High melting point ✓
Resistant to corrosion✓ (2)

good conductor
give a strong bead
used to join a variety of materials

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QUESTION 4: SAFETY, TERMINOLOGY AND JOINING METHODS

4.1 **Hydraulic press:**

- Make sure the object is firmly secured. ✓
- Make sure pins holding the beam is fitted properly. ✓
- Check pins for wear. ✓
- Check for oil leaks. ✓
- Make sure the area around the press is clean and free from oil. ✓
- Release pressure after operation ✓
- Personal safety ✓
- Safety guards ✓ (4)

Any 4 X 1

4.2 **Gas cylinders:**

- Store oxygen and acetylene separately.✓
- Store full and empty cylinders apart. ✓
- Keep cylinders in a cool place away from heat. ✓
- Place cylinders in an upright position. ✓
- Don't drop cylinders. ✓
- Cylinder heads must be on. ✓
- Keep cylinders away from oil or grease. ✓
- Don't hammer on cylinders. ✓
- Secure cylinders properly. ✓
- Do not transport in horizontal position ✓ **Any 4 X 1** (4)

4.3 **Cutting feed:**

$$V = \pi DN$$

$$N = \frac{V}{\pi D} \quad ✓$$

$$N = \frac{100}{\pi \times 0{,}12} \quad ✓$$

$$N = 265{,}258\,2385\ rpm \quad ✓$$

$$f = f_1 \times T \times N \quad ✓$$

$$f = 0{,}1 \times 40 \times 265{,}258 \quad ✓$$

$$f = 1061{,}03\ mm/\min \quad ✓$$

(6)

4.4 **Indexing:**

4.4.1

$$\textbf{Indexing} = \frac{\textbf{40}}{\textbf{A}} \quad ✓$$

$$= \frac{\textbf{40}}{\textbf{70}} \quad ✓$$

$$= \frac{\textbf{4}\times\textbf{4}}{\textbf{7}\times\textbf{4}} \text{ or } \frac{4\times6}{7\times6} \text{ or } \frac{4}{7} \quad ✓$$

$$= \frac{\textbf{16}}{\textbf{28}} \textbf{ or } \frac{\textbf{24}}{\textbf{42}} \textbf{ or } \frac{\textbf{28}}{\textbf{49}} \quad ✓$$

16 holes on the 28 – hole cir ✓

24 holes on the 42 - hole circ

28 holes on the 49 - hole circ..

(5)

4.4.2

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

$$\frac{D_r}{D_v} = (70-67)\times\frac{40}{70} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{120}{70} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{12\times4}{7\times4} \quad ✓$$

$$\frac{D_r}{D_v} = \frac{48}{28}$$

No full turn, 16 holes on the 28-hole circle with change gears $\frac{48}{28}$ *or* ✓

No full turn, 24 holes on the 42-hole circle with change gears $\frac{48}{28}$ *or*

No full turn, 28 holes on the 49-hole circle with change gears $\frac{48}{28}$

(5)

4.4.3 Same direction/clockwise/positive ✓ (1)

4.5 **Gear drives:**

4.5.1 Driving gear /electrical motor gear✓ (1)

4.5.2 Clockwise direction✓ (1)

4.5.3 Output/final/driven gear/ washing machine gear✓ (1)

4.5.4 **Gear B**

$N_A \times T_A = N_B \times T_B$ ✓
$1200 \times 30 = N_D \times 22$ ✓
$N_B = 1636\ rpm$ ✓ (3)

4.5.5 **Gear A**

$PCD = m \times T$
$= 3 \times 30$ ✓
$= 90\ mm$ ✓ (2)

4.5.6 **Outside diameter**

$Outside\ diameter\ (OD) = PCD + 2 \times Module$
$= 90 + (2 \times 3)$ ✓
$= 96\ mm$ ✓ (2)

4.5.7 **Dedendum**

$Dedendum = 1{,}157 \times m$ ✓
$= 1{,}157 \times 3$
$= 3{,}471\ mm$ ✓

OR

$Dedendum = 1{,}25 \times m$ ✓
$= 1{,}25 \times 3$
$= 3{,}75\ mm$ ✓ (2)

4.6 **Weld defects and testing:**

4.6.1 **Causes porous weld:**

- Atmospheric contamination. ✓
- Surface contamination. ✓
- Dirty or wet electrodes. ✓
- Rusted MIG wire. ✓
- Type of welder ✓
- Current too high ✓
- Poor quality material ✓
- Incorrect method ✓
- Dirty welding rods ✓

Any 2 X 1 (2)

4.6.2 **Prevention:**

- Clean the workpiece. ✓
- Use clean, dry electrodes. ✓
- Use correct electrodes including low hydrogen electrodes ✓ **Any 1 X 1** (1)

4.6.3 **Causes of poor fusion:**

- Welding current to low or too fast. ✓
- Welding pool too wide or too large✓
- Wrong joint preparation root gap & chamfering). ✓
- Welding electrode to thick. ✓ **Any 2 X 1** (2)

4.6.4 **Prevention:**

- Use correct current. ✓
- Be sure to melt the sides of the groove. ✓
- Groove must be free of other metals. ✓
- Width of the electrode must be small enough to fit in groove. ✓ **Any 1 X 1** (1)

4.6.5 **Liquid dye penetration test:**

- Clean the weld that needs to be tested. ✓
- The dye is sprayed onto the welded surface.✓
- Allowed dye to penetrate all the cracks. ✓
- Excess dye is cleaned away with a cleaning agent. ✓
- Allowed surface to dry. ✓
- Spray a developer onto the surface to bring out the dye trapped in cracks. ✓
- The dye will show all the surface defects ✓ (7)

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QUESTION 5: MAINTENANCE AND TURBINES

5.1 **Lubrication:**

5.1.1 **Properties**

- Viscosity must be correct. ✓
- It must resist oxidation. ✓
- It must avoid foaming. ✓
- Resist carbon forming. ✓
- It must prevent corrosion **or** rust✓.
- It must resist extreme pressures. ✓
- Pour point ✓
- Resistance to temperature change ✓ **Any 5 X 1** (5)

5.1.2 Viscosity of oil refers to the resistance of oil to flow./ thickness of oil ✓✓ (2)

5.1.3 **EP Oils**

- Manual gearbox✓
- Final drive or differential✓
- Heavy duty machinery **Any 2 X 1** (2)

5.1.4 Society of Automotive Engineers ✓ (1)

5.1.5 **Cutting Fluid**

- Acts as lubricant ✓
- Prevents chips from sticking ✓
- Improves quality of finish ✓
- Keeps the work piece cool ✓
- Keeps the cutting tool cool ✓
- Gives the cutting tool a longer life span ✓
- Wash away/remove chips/swarfs **Any 4 x 1** (4)

5.1.6 **Gear Lubrication**

COLUMN A	COLUMN B	
Engine	SAE 20W50	B✓
Gearbox	Extreme pressure oil (EP 90)	D✓
Differential	Extreme pressure oil (EP 90)	D✓
Power steering	Hydraulic oil	A✓ (4)

5.1.7 **Automatic transmission Fluid**

- Transmitting power via torque converter ✓
- Acting as hydraulic fluid via servo cylinder ✓
- Acts as a heat-transfer medium ✓
- Acts as lubricant for gears and bearings ✓ **Any 2 X 1** (2)

5.2 **Blower:**

5.2.1 Roots blower ✓ (1)

5.2.2 1. Inlet ✓
2. Outlet ✓
3. Rotors ✓ (3)

5.2.3 **Operation**

- The engine drives the rotors by means of gears or chain ✓
- Air is trapped between the rotor and aluminium casing. ✓
- This 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)

5.3 **Superchargers**

- To fill the cylinder with air pressure higher than atmospheric pressure. ✓
- To increase the compression pressure in the cylinder. ✓
- To increase volumetric efficiency of the engine. ✓
- No lag in relation to turbo charger ✓
- Obtain more power ✓ **Any 3 X 1** (3)
-

5.4 **Superchargers and turbochargers**

- Supercharger is mechanically driven by gears or a belt. ✓
- Turbocharger is driven by the exhaust gases. ✓ (2)

5.5 **Steam turbine uses**

- To drive generators to generate electricity. ✓
- To operate ships. ✓
- To operate pumps ✓ **Any 2 X 1** (2)

5.6 **Advantages of steam turbines**

- It is compact. ✓
- No lubrication is required. ✓
- Steam 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 engines. ✓
- Low maintenance ✓ **Any 4 X 1** (4)

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QUESTION 6: FORCES AND SYSTEMS AND CONTROL

6.1 Hydraulics:

6.1.1 Fluid pressure:

$$A_B = \frac{\pi D^2}{4} \quad \checkmark$$

$$A_B = \frac{\pi(0,2)^2}{4} \quad \checkmark$$

$$A_B = 31,41593\times10^{-3}\,m^2 \quad \checkmark$$

$$P = \frac{F_B}{A_B} \quad \checkmark$$

$$P = \frac{15\times10^3}{31,41593\times10^{-3}} \quad \checkmark$$

$$= 477464,8293\,Pa$$

$$= 0,48\ MPa \quad \checkmark$$

(6)

6.1.2 Force F on piston A:

$$A_A = \frac{\pi D^2}{4} \quad \checkmark$$

$$A_A = \frac{\pi\times(0,075)^2}{4} \quad \checkmark$$

$$A_A = 4,4178\times10^{-3}m^2 \quad \checkmark$$

$$P_A = P_B$$

$$P_A = \frac{F_A}{A_A} \quad \checkmark$$

$$F_A = P_A \times A_A \quad \checkmark$$

$$F_A = \left(0,48\times10^6\right)\left(4,42\times10^{-3}\right)$$

$$F_A = 2,10935\ kN \quad \checkmark$$

$$= 2,11\ kN$$

$$or\ \frac{F_1}{A_1} = \frac{F_2}{A_2} \quad \checkmark\checkmark$$

$$F_1 = \frac{F_2 \times A_1}{A_2} \quad \checkmark$$

$$= \frac{15\times10^3\times4,4178\times10^{-3}}{31,41593\times10^{-3}} \quad \checkmark\checkmark$$

$$= 2,1093\ kN \quad \checkmark$$

$$= 2,11\ kN$$

(6)

6.1.3 **Distance 'X':**

$$V_B = V_A \quad ✓$$

$$A_B \times X = A_A \times L_A \quad ✓$$

$$X = \frac{A_A \times L_A}{A_B} \quad ✓$$

$$X = \frac{(4{,}42\times10^{-3})(0{,}12)}{31{,}41\times10^{-3}} \quad ✓$$

$$X = 16{,}87499773\ mm/stroke \quad ✓$$

$$X = 16{,}87499773\times16$$

$$X = 269{,}99\ mm \quad ✓$$

$$= 270\ mm$$

(6)

6.2 **Stress and strain:**

6.2.1 **Side length:**

$$\sigma = \frac{F}{A} \quad ✓$$

$$A = \frac{F}{\sigma} \quad ✓$$

$$A = \frac{30\times10^{3}}{6\times10^{6}} \quad ✓$$

$$A = 5\times10^{-3}m^2$$

$$A = L^2 \quad ✓$$

$$L = \sqrt{A} \quad ✓$$

$$L = \sqrt{5\times10^{-3}m^2} \quad ✓$$

$$L = 0{,}0707106\,m$$

$$L = 70{,}71\ mm \quad ✓$$

(8)

6.2.2 **Strain:**

$$E = \frac{\sigma}{\varepsilon} \quad ✓$$

$$\varepsilon = \frac{\sigma}{E} \quad ✓$$

$$\varepsilon = \frac{6\times10^{6}}{90\times10^{9}} \quad ✓$$

$$\varepsilon = 0{,}06667\times10^{-3} \quad ✓$$

$$= 6{,}67\times10^{-5}$$

(4)

6.2.3 **Change in length:**

$$\varepsilon = \frac{\Delta \ell}{o\ell} \quad \checkmark$$
$$\Delta \ell = \varepsilon \times o\ell$$
$$\Delta \ell = 6{,}67 \times 10^{-5} \times 200 \quad \checkmark$$
$$= 0{,}013\,\text{mm} \quad \checkmark \qquad (3)$$

6.3 **Belt drives:**

6.3.1 **Rotational frequency of the driven pulley**

$$(D_{DN} + t) \times N_{DN} = (D_{DR} + t) \times N_{DR} \quad \checkmark$$
$$N_{DN} = \frac{(D_{DR} + t) \times N_{DR}}{(D_{DN} + t)} \quad \checkmark$$
$$= \frac{(475+12) \times 1440}{(180+12)} \quad \checkmark$$
$$= \frac{487 \times 1440}{192} \quad \checkmark$$
$$= 3652{,}5\,rpm \quad \checkmark$$

Or

$$N_1 D_1 = N_2 D_2 \quad \checkmark$$
$$N2 = \frac{N_1 D_1}{D_2} \quad \checkmark$$
$$= \frac{475 \times 1440}{180} \quad \checkmark$$
$$= 3800\,\text{rpm} \quad \checkmark \qquad (5)$$

6.3.2 **Belt speed:**

$$V = \frac{\pi (D+t) \times N}{60} \quad \checkmark$$
$$= \frac{\pi\,(0.475 + 0{,}012) \times 1440}{60} \quad \checkmark$$
$$= 36{,}72\,m.s^{-1} \quad \checkmark \qquad (3)$$

6.4 **Clutches:**

6.4.1 **The maximum torque transmitted:**

$$T = \mu W n R$$
$$T = 0{,}3 \times 4 \times 10^3 \times 2 \times \frac{0{,}28}{2} \quad \checkmark$$
$$= 0{,}3 \times 4 \times 10^3 \times 2 \times 0{,}14 \quad \checkmark\checkmark$$
$$= 336 Nm \quad \checkmark$$
$$\checkmark \qquad (5)$$

6.4.2 **Power transmitted at 3500 rpm in kW:**

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

$$P = \frac{2\pi \times 3500 \times 336}{60} \quad \checkmark\checkmark$$

$$P = 123{,}15\,kW \quad \checkmark$$

(4)
[50]

TOTAL: 200