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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

NOVEMBER 2023

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 23 pages.

QUESTION 1: MULTIPLE-CHOICE (GENERIC)

1.1	B ✓	(1)
1.2	A ✓	(1)
1.3	C ✓	(1)
1.4	C ✓	(1)
1.5	A ✓	(1)
1.6	B ✓	(1)
		[6]

QUESTION 2: SAFETY (GENERIC)**2.1 Examination checks:**

- Severe bleeding ✓
- Internal bleeding ✓
- Head injuries ✓
- Neck injuries ✓
- Fractures ✓
- Vital signs ✓
- Physical abnormalities ✓

(Any 2 x 1) (2)**2.2 Safety devices on the power-driven guillotine:**

- Finger protectors / Fixed guards / Blade guard ✓
- Rear view mirrors ✓
- Rear light curtains ✓
- Automatic sweep-away ✓
- Revolving warning lights ✓
- Two-hand / dual control device ✓
- Additional emergency buttons ✓
- Self-adjusting guards ✓
- Covered footswitch ✓

(Any 2 x 1) (2)**2.3 Grinding wheel:**

- The wheel should be rated above the speed of the motor. ✓
- Check for cracks on the grinding wheel. ✓
- Check for chips on the grinding wheel. ✓
- Check that the arbor hole is the correct size. ✓
- Must not be contaminated by oil/fluids or grease. ✓
- Correct size of the wheel. ✓
- Correct type of wheel for the material. ✓

(Any 2 x 1) (2)**2.4 Gas welding equipment – safety devices:**

- Valve guard ✓
- Flash back arrestor ✓
- Pressure regulator ✓
- C-clamps on hoses/Parallel hose clips ✓
- Acetylene spindle key must always be in place. ✓
- Cylinder valves. ✓

(Any 2 x 1) (2)

2.5 **Advantages of process layout of machines are:**

- High machine utilisation. ✓
- Better supervision. ✓
- Less interruption in the flow of work. ✓
- Lower equipment costs. ✓
- Better control of total manufacturing costs. ✓
- Greater flexibility. ✓

(Any 2 x 1)

(2)

[10]

QUESTION 3: MATERIALS (GENERIC)**3.1 Colour code of metal:**

- To identify the type of metal. ✓
- To identify carbon content especially after the metal was stored. ✓
- To identify the profile/size of the metal. ✓

(Any 1 x 1) (1)**3.2 Tests to determine properties of steel:****3.2.1 Sound test:**

- Hardness ✓
- Softness ✓

(Any 1 x 1) (1)**3.2.2 Bending test:**

- Ductility ✓
- Bend strength ✓
- Fracture strength ✓
- Resistance to fracture
- Brittleness ✓
- Elasticity ✓
- Plasticity ✓
- Flexibility ✓

(Any 1 x 1) (1)**3.2.3 Machining test:**

- Hardness ✓
- Strength ✓

(Any 1 x 1) (1)**3.3 Reasons metal soaked during heat treatment:**

- To ensure uniform heat distribution ✓ throughout the metal. ✓
- To achieve a uniform grain structure ✓ after cooling the metal. ✓

(Any 1 x 2) (2)**3.4 Case hardening:**

- Carburising ✓
- Nitriding ✓
- Cyaniding ✓

(Any 2 x 1) (2)**3.5 Annealing process:**

Heating the steel slightly above AC_3 , (upper critical temperature) ✓ soaking it for a required time/period ✓ and then slow cooling ✓ back to room temperature.

(3)

3.6 **Rapid quenching mediums:**

- Brine/Salt water ✓
- Water ✓
- Nitrogen ✓
- Oil ✓

(Any 2 x 1) (2)

3.7 **Heat treatment process:**

Tempering ✓

(1)

[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

4.1	B ✓	(1)
4.2	B ✓	(1)
4.3	C ✓	(1)
4.4	B ✓	(1)
4.5	C ✓	(1)
4.6	B ✓	(1)
4.7	B ✓	(1)
4.8	A or D ✓	(1)
4.9	C ✓	(1)
4.10	C ✓	(1)
4.11	B ✓	(1)
4.12	D ✓	(1)
4.13	A ✓	(1)
4.14	A ✓	(1)
		[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**5.1 Compression tester:****5.1.1 Function of the compression tester:**

- It measures the pressure created ✓ when the piston is at top dead centre on the compression stroke. ✓
- It is used to determine the condition of the piston rings ✓ after a wet compression test. ✓

(Any 1 x 2) (2)**5.1.2 Reasons for low compression:**

- Worn cylinders ✓
- Worn piston rings ✓
- Worn piston ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Leaking cylinder head gasket ✓
- Cracked cylinder head ✓
- Cracked piston / Damaged piston. ✓
- Piston ring groove worn out and not holding pressure. ✓
- Insufficient volumetric efficiency. ✓
- Cracked cylinder sleeve. ✓

(Any 1 x 1) (1)**5.1.3 Card-type compression tester:**

- The compression tester automatically records ✓ the readings on the card in the tester. ✓
- To eliminate the human error ✓ that can be made when taking the readings, ✓ in terms of estimations.

(Any 1 x 2) (2)**5.2 Cylinder leakage tester:****5.2.1 Function:**

- To check where the combustion chamber/cylinder leaks gases ✓ during compression stroke. ✓
- To determine the percentage ✓ pressure loss ✓ from the combustion chamber.

(Any 1 x 2) (2)**5.2.2 Gauge A:**

Percentage leakage (%) / Pressure leakage gauge ✓

(1)**5.2.3 Control valve:**

- Used to calibrate the cylinder leakage tester. ✓
- Regulates the air pressure entering the cylinder leakage tester. ✓

(Any 1 x 1) (1)

5.3 Exhaust gas analysis unit of measure:**5.3.1 Carbon dioxide (CO₂):**

Percentage (%) ✓

(1)

5.3.2 Hydrocarbon (HC):

Parts per million (ppm) ✓

(1)

5.4 Reason for removing pick-up hose:

- For auto-zero on the analyser to start at zero. / Calibration of tester to zero. ✓
- For exhaust gases to get out of the hose. ✓

(2)

5.5 OBD-II plug location:

- At the glove compartment (cubby hole). ✓
- Under the dashboard by the driver. ✓
- Behind a trim panel. ✓
- Between the front seats. ✓
- By the ashtray. ✓
- The floor panel. ✓
- In the fuse box. ✓

(Any 2 x 1)

(2)

5.6 Information typed into the diagnostic scanner:

- The vehicle identification number (VIN). ✓
- The make of the vehicle. ✓
- The model of the vehicle. ✓
- The engine type. ✓

(Any 3 x 1)

(3)

5.7 Wheel balancing:

Static ✓

(1)

5.8 Label the bubble gauge:

Gauge 1 - Zero scale/level ✓

Gauge 2 - Castor ✓

Gauge 3 - King pin inclination ✓

Gauge 4 - Camber ✓

(4)

[23]

QUESTION 6: ENGINES (SPECIFIC)**6.1 Crankshaft of a four-cylinder engine:****6.1.1 Label the crank shaft:**

- A – Crank nose/vibration damper mounting ✓
- B – Main journals ✓
- C – Big-end journals / Crankpin journals ✓
- D – Counterweight/Crank web ✓

(4)

6.1.2 Correcting crank shaft imbalance:

- By removing metal/weight from the crank webs. ✓
- By adding metal/weight to the crank webs. ✓

(2)

6.2 Vibration dampers:**6.2.1 Label:**

- A – Friction disc ✓
- B – Crankshaft ✓
- C – Secondary flywheel ✓
- D – Rubber cushion ✓

(4)

6.2.2 Location:

Fitted to the front end/nose of the crankshaft. ✓

(1)

6.2.3 Function:

- To smooth out / absorb/ minimize the engine vibrations. ✓
- To counteract the torsion of the crankshaft. ✓

(Any 1 x 1) (1)**6.3 Engine configurations:**

- Inline / Straight ✓
- V-engine ✓
- W-engine / Double V-engine ✓
- Horizontally opposed engine / Flat engine / Boxer engine ✓
- Radial engine ✓
- X-Engine ✓
- U-engine ✓
- Delta engine ✓
- K-engine ✓
- Opposed-piston engine ✓

(Any 2 x 1) (2)

6.4 Power strokes per revolution:

6.4.1 **Four-cylinder:**
2 ✓ (1)

6.4.2 **Six-cylinder:**
3 ✓ (1)

6.5 Turbo-chargers:

6.5.1 **Type:**
Variable geometry turbo-charger ✓ (1)

6.5.2 **Reason turbocharger boosts:**

- It increases ✓ volumetric efficiency ✓ of the cylinders.
- It increases ✓ the pressure of the air ✓ entering the cylinder.

(Any 1 x 2) (2)

6.5.3 **Influence on the lifespan:**

- The oil supply is clean. ✓
- Use of the correct grading/type of oil. ✓
- The exhaust gas does not become overheated. ✓
- Adopting the proper switch-off procedure. ✓
- Sufficient oil pressure. ✓

(Any 2 x 1) (2)

6.6 Disadvantages of a turbo-charger:

- It requires pressure lubrication for high-speed bearings. ✓
- It requires pressure lubrication to act as a coolant. ✓
- It suffers from lag. ✓
- It tends to heat the air, reducing its density. ✓
- It needs to be controlled from over-revving by the waste gate. ✓
- Some require a special shut-down procedure before the engine can be switched off. ✓

(Any 3 x 1) (3)

6.7 Disadvantage of superchargers:

6.7.1 **Roots supercharger:**

- The least efficient supercharger. ✓
- They add more weight to the vehicle. ✓
- Usually large/bonnet(hood) must be modified. ✓
- They move air in bursts. ✓

(Any 1 x 1) (1)

6.7.2 **Twin-screw supercharger:**

- They are expensive. ✓
- They require more precision manufacturing. ✓

(Any 1 x 1) (1)

6.8 **Reasons for a supercharger with a turbocharger on its engine:**

- To overcome lag at low rpm. ✓
- To increase power at all rpm. ✓
- Outstanding fuel economy. ✓
- To increase torque at all rpm. ✓
- Reduces the parasitic effect/power sapping on the engine. ✓

(Any 2 x 1)

(2)

[28]

QUESTION 7: FORCES (SPECIFIC)

7.1

Indicated power:	Brake power
<ul style="list-style-type: none"> Calculated using the volume and the indicated mean effective pressure. ✓ 	<ul style="list-style-type: none"> Calculated using the torque developed. ✓
<ul style="list-style-type: none"> Indicated power is the theoretical power. ✓ 	<ul style="list-style-type: none"> Brake power is the actual power output of an engine. ✓
<ul style="list-style-type: none"> Indicated power is calculated without considering any mechanical or other losses of the engine. ✓ 	<ul style="list-style-type: none"> Calculated considering mechanical or other losses of the engine. ✓

(Any 1 x 2) (2)

7.2

Calculations:7.2.1 **Swept volume:**

$$\begin{aligned}
 \text{Swept volume} &= \frac{\pi \times D^2}{4} \times L \\
 &= \frac{\pi \times 7,5^2}{4} \times 8 \quad \checkmark \\
 &= 353,43 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

(3)

7.2.2 **Original clearance volume:**

$$\begin{aligned}
 CV &= \frac{SV}{(CR - 1)} \\
 &= \frac{353,43}{(10 - 1)} \quad \checkmark \\
 &= 39,27 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

(3)

7.2.3

Stroke length:

$$\begin{aligned}
 SV &= CV(CR - 1) \\
 &= 39,27(11 - 1) \checkmark \\
 &= 392,7 \text{ cm}^3 \checkmark
 \end{aligned}$$

$$\text{Swept volume} = \frac{\pi \times D^2}{4} \times L$$

$$L = \frac{SV}{\text{Area}} \checkmark$$

$$= \frac{392,70}{44,18} \checkmark$$

$$= 8,89 \text{ cm} \times 10$$

$$= 88,89 \text{ mm} \checkmark$$

$$\begin{aligned}
 \text{Area} &= \frac{\pi \times 7,5^2}{4} \\
 &= 44,18 \text{ cm}^2 \checkmark
 \end{aligned}$$

(6)

7.3

Methods to lower the compression:

- Fit thicker gasket between cylinder block and cylinder head. ✓
- Fit a shim between cylinder block and cylinder head. ✓
- Fit piston with suitable lower crowns. ✓
- Fit crankshaft with shorter stroke (with suitable connecting rods). ✓
- Decrease bore diameter. ✓

(Any 2 x 1) (2)

7.4

Prony brake test:

7.4.1

Torque:

$$\text{Torque} = \text{Force} \times \text{radius}$$

$$\begin{aligned}
 \text{Torque} &= (30 \times 10) \times \frac{400}{1000} \checkmark \quad (g = 10 \text{ m/s}^2) \\
 &= 120 \text{ Nm} \checkmark
 \end{aligned}$$

OR

$$\begin{aligned}
 \text{Torque} &= (30 \times 9,81) \times \frac{400}{1000} \checkmark \quad (g = 9,81 \text{ m/s}^2) \\
 &= 117,72 \text{ Nm} \checkmark
 \end{aligned}$$

(4)

7.4.2

Brake power:

$$BP = 2\pi NT$$

$$= 2 \times \pi \times \left(\frac{2000}{60} \right) \times 120 \checkmark \quad (g = 10 \text{ m/s}^2)$$

$$= 25,13 \text{ kW} \checkmark$$

OR

$$BP = 2\pi NT$$

$$= 2 \times \pi \times \left(\frac{2000}{60} \right) \times 117,72 \checkmark \quad (g = 9,81 \text{ m/s}^2)$$

$$= 24,66 \text{ kW} \checkmark$$

(3)

7.4.3

Indicated power:

$$IP = PLANn$$

$$\text{Where } P = 950 \times 10^3 \text{ Pa}$$

$$L = \frac{85}{1000}$$

$$= 0,085 \text{ m} \checkmark$$

$$A = \left(\frac{\pi \times 0,09^2}{4} \right) \checkmark$$

$$= 6,36 \times 10^{-3} \text{ m}^2 \checkmark$$

$$N = \frac{2000}{60 \times 2} \checkmark$$

$$= 16,67 \text{ power strokes per second} \checkmark$$

$$n = 4$$

$$IP = (950 \times 10^3) \times 0,085 \times (6,36 \times 10^{-3}) \times (16,67) \times 4 \checkmark$$

$$= 34,24 \text{ kW} \checkmark$$

(7)

7.4.4 **Mechanical efficiency:**

$$\begin{aligned} \text{ME} &= \frac{\text{BP}}{\text{IP}} \times 100 \\ &= \frac{25,13}{34,24} \checkmark \times 100 & (g = 10 \text{ m/s}^2) \\ &= 73,39 \% \checkmark \end{aligned}$$

OR

$$\begin{aligned} \text{ME} &= \frac{\text{BP}}{\text{IP}} \times 100 \\ &= \frac{24,66}{34,24} \checkmark \times 100 & (g = 9,81 \text{ m/s}^2) \\ &= 72,02 \% \checkmark \end{aligned}$$

(2)
[32]

QUESTION 8: MAINTENANCE (SPECIFIC)**8.1 Exhaust gas analysis:****8.1.1 Readings caused by a leak:**

- Incorrect ✓ readings ✓
- No ✓ readings at all ✓

(Any 1 x 2) (2)**8.1.2 Ideal exhaust gas readings:**

- Low carbon monoxide ✓
- High carbon dioxide ✓
- Low Hydrocarbon ✓

(Any 2 x 1) (2)**8.2 Compression tester:**

- Ensure that the tester can handle the pressure you want to test. ✓
- Ensure the rubber pipes are not perished. ✓
- Ensure the relief valve is working on the tester. / Zero the tester. ✓
- Ensure you use the correct adapter for the plug hole. ✓

(Any 2 x 1) (2)**8.3 Cylinder leakage test:**

Fault	Possible cause
• Hissing noise at air intake. ✓	• Leaking inlet valve. ✓
• Hissing noise at exhaust. ✓	• Leaking exhaust valve. ✓
• Hissing noise at oil filler cap/dipstick. ✓	• Piston rings are worn. ✓
• Bubbles in the radiator. ✓	• Blown cylinder head gasket/Cracked cylinder head. ✓
• Hissing sound from adjacent spark plug hole ✓	• Blown cylinder head gasket between cylinders / crack between cylinders. ✓

(Any 3 x 2) (6)**8.4 Oil pressure test:**

- Oil pressure when engine is idling. ✓
- Oil pressure when engine is cold. ✓
- Oil pressure when engine is hot. ✓
- Oil pressure on high revolutions. ✓

(Any 3 x 1) (3)

8.5 Fuel pressure:

- Faulty fuel pump ✓
- Blocked fuel filter ✓
- Cracked fuel line ✓
- Clogged pump strainer ✓
- Low voltage to the fuel pump ✓
- Faulty fuel pressure regulator ✓
- Empty fuel tank ✓
- Faulty fuel pump relay ✓
- Leaking fuel injectors ✓
- Blocked fuel line ✓

(Any 4 x 1) (4)**8.6 Radiator cap pressure test:**

Step 1: Obtain the release pressure on the cap or from manufacturer's specifications. ✓

Step 2: Fit the radiator cap with the correct adaptor on the cooling system pressure tester. ✓

Step 3: Now pump the tester while watching the release pressure on the gauge. ✓

Step 4: Check that the cap holds the specified pressure. ✓

**(4)
[23]**

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)**9.1 Reasons for automatic gearbox preferred over manual gearbox:**

- There is no clutch pedal. (relieve the driver of clutch operation). ✓
- There is no need to change gears. (relieve the driver of gearshift operation). ✓
- Allows the driver to concentrate on driving. ✓
- Smoother and easier driving of the vehicle. ✓
- It reduces driving fatigue. ✓
- It ensures great reduction of wheel spin. ✓
- The vehicle can be stopped suddenly without the engine stalling. ✓
- The system dampens all engine torsional vibrations. ✓

(Any 4 x 1) (4)**9.2 Towing vehicle with automatic gearbox:**

- The drive wheels ✓ must be lifted off the ground. ✓
- The vehicle ✓ should be lifted on a flatbed tow truck. ✓
- The drive shaft/propeller ✓ shaft should be removed.

(Any 1 x 2) (2)**9.3 Torque converter:****9.3.1 Functions:**

- It transfers the torque and power from the engine to the gearbox. ✓
- It drives the front pump of the gearbox. ✓
- It isolates the engine from the gearbox when the vehicle is stationary. ✓
- It multiplies the torque of the engine. ✓
- Reduction of engine vibrations transmitted to the gearbox. ✓
- Turn the engine during the idle strokes. (flywheel effect) ✓

(Any 3 x 1) (3)**9.3.2 Component that prevents slip:**

Pressure plate/Clutch assembly ✓

(1)

9.4 Brake band in automatic gearbox:**9.4.1 Label:**

A – Band adjuster ✓

B – Anchor ✓

C – Lever ✓

D – Brake band ✓

(4)

9.4.2 Function of brake band:

The brake band holds the drum/annulus in a stationary position. ✓

(1)

9.4.3 Component controlling the brake band:

Hydraulic piston ✓

(1)

9.5 Double epicyclic gear train:9.5.1 First (1st) gear / Gear reduction ✓

(1)

9.5.2 Second (2nd) gear / Overdrive ✓

(1)

[18]

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONIC) (SPECIFIC)**10.1 Steering mechanism:**

The steering mechanism must enable the driver ✓ to be in control of the path taken by the vehicle at all times. ✓

(2)

10.2 Signs of wheel imbalance:

- Excessive tyre wear ✓
- A poor ride/tracking ✓
- Vibrations on the steering wheel ✓
- Wheel bounce/hop ✓
- Wheel shimmy/wobble ✓
- Vibrations on the brake pedal ✓
- Excessive wear on the suspension ✓

(Any 2 x 1)

(2)

10.3 Static wheel balance:

- Mount the wheel so that it is free to turn on a spindle through its center. ✓
- The spindle must be approximately horizontal and the wheel turning slowly. ✓
- If the wheel is out of balance, it will always come to rest with one point, the 'heavy spot', at the bottom. ✓
- To correct static imbalance, a small mass (weight) is applied to the wheel rim, diametrically opposite the 'heavy spot'. The size and position of the weight to be fitted are found by trial and error. ✓

(4)

10.4 Negative caster angle:

- A - Kingpin ✓
- B - Perpendicular line ✓
- C - Negative caster angle ✓
- D - Centre line of kingpin ✓

(4)

10.5 Electric fuel pump:

- Immediate supply of fuel when the ignition switch is turned on. ✓
- Low operation noise. ✓
- Less discharge pulsation of fuel. ✓
- Compact and light design. ✓
- It helps to prevent fuel leak. ✓
- It reduces vapour lock. ✓
- Delivers fuel at a higher rate / pressure. ✓

(Any 2 x 1)

(2)

10.6 Fuel delivery system:**10.6.1 Pressure regulator:**

- It keeps the pressure in the rail at a specified value. ✓
- It regulates the pressure in the rail. ✓

(Any 1 x 1) (1)**10.6.2 Fuel filter:**

- Prevents dirt from entering the fuel line. ✓
- Prevents damaging or clogging of the injectors. ✓
- Prevents damage to the pressure regulator. ✓

(Any 1 x 1) (1)**10.7 Air induction system:****10.7.1 Label:**

- A - MAF sensor ✓
- B - Air filter/Air filter housing ✓
- C - Throttle valve / Throttle body ✓
- D - Intake valve ✓

(4)

10.7.2 Purpose:

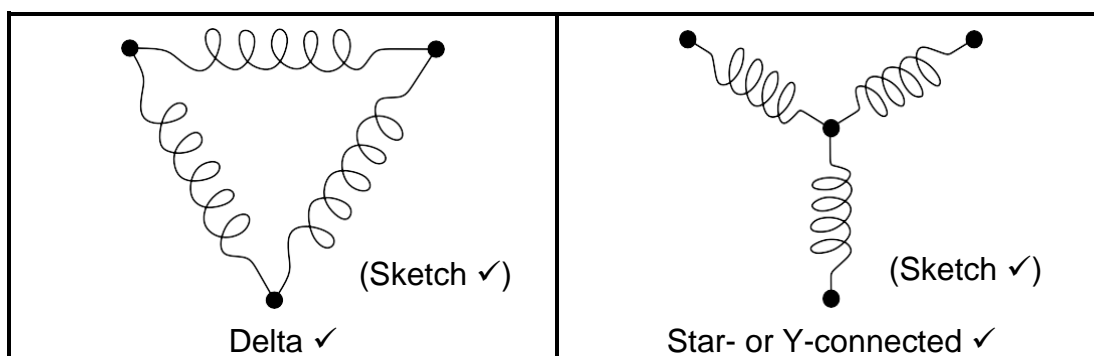
The air-induction system measures ✓ and controls the air required for the combustion. ✓

(2)

10.8 Purpose of lambda sensor:

The sensor measures the oxygen content in the flow of the exhaust gas ✓ and then sends a signal to the engine control unit. ✓

(2)

10.9 Stator windings:

(4)

10.10 Increase the output frequency:

- Increase the turns of wire/windings on the stationary coil/stator. ✓
- Increase the strength of the magnetic fields. ✓
- Increase the rotational frequency at which the magnets rotate. ✓

(Any 2 x 1) (2)

10.11 Adaptive speed control:

- To maintain a speed as set by the driver. ✓
- To adapt this speed and maintain a safe distance from the vehicle in front. ✓
- To provide a warning if there is a risk of a collision. ✓
- To provide a warning if the set speed is exceeded. ✓
- Reduces driver fatigue. ✓
- Improves fuel consumption. ✓

(Any 2 x 1) (2)
[32]

TOTAL: 200