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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: AUTOMOTIVE

2023

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 21 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

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

QUESTION 2: SAFETY (GENERIC)

- 2.1 **Safety rule after the work procedures:**
Switch off the machine. ✓ (1)
- 2.2 **Space between the tool rest and the emery wheel:**
- To prevent the work piece from jamming between the wheel and tool rest. ✓
 - Prevents the wheel from being damaged. ✓
 - Prevents the work piece from being damaged. ✓
 - Prevent injury. ✓
- (Any 2 x 1) (2)
- 2.3 **Workshop layouts:**
- 2.3.1 Process layout. ✓ (1)
- 2.3.2 Product layout. ✓ (1)
- 2.4 **Hydraulic press:**
- Safety goggles ✓
 - Safety gloves ✓
 - Safety shoes ✓
 - Overall ✓
- (Any 1 x 1) (1)
- 2.5 **Safety guard on the portable angle grinder:**
- To protect one against sparks/metal particles. ✓
 - To protect one from a breaking disc. ✓
 - To protect your hand from coming into contact with the disc. ✓
- (Any 1 x 1) (1)
- 2.6 **Shearing/Guillotine machine:**
- Follow the manufactures recommendations. ✓
 - Keep hands away from action points. ✓
 - Do not exceed the maximum material thickness. ✓
 - Ensure that all guards are in place and secure. ✓
 - Report defects immediately. ✓
- (Any 1 x 1) (1)

2.7 Storing gas cylinders:

- Upright position ✓
- Stored at 20°C / cool area ✓
- Empty cylinders stored separately from full cylinder. ✓
- Never store cylinders on top of each other. ✓
- Oxygen cylinders separate from fuel cylinders. ✓
- Secure gas cylinders. ✓
- Ensure that cylinders are properly closed. ✓
- Stored away from sparks / flammable material/ electrical switches. ✓
- Stored in a well-ventilated area. ✓
- Safety signs should be displayed. ✓
- Keep cylinders clearly labelled (Full/Empty). ✓

(Any 2 x 1)**(2)****[10]**

QUESTION 3: MATERIALS (GENERIC)**3.1 Purpose of tempering:**

- To relieve ✓ strain / brittleness. ✓
- To increase ✓ the toughness of the steel. ✓
- To refine ✓ grain structure. ✓

(Any 1 x 2) (2)**3.2 Heat treatment processes:****3.2.1 Case hardening:**

- To obtain a wear-resistant surface ✓ and at the same time be tough enough internally at the core ✓ to withstand the applied loads.
- For a hard case ✓ over a tough core. ✓

(Any 1 x 2) (2)**3.2.2 Annealing:**

- To relieve ✓ internal stresses. ✓
- To soften ✓ steel. ✓
- Facilitate ✓ the machining processes. ✓
- Increase ✓ the steel's ductility. ✓
- Reduce ✓ brittleness. ✓

(Any 1 x 2) (2)**3.3 Spark test:**

- Hold steel against grinding wheel. ✓
- Observe the spark pattern to identify the type of steel. ✓

(2)**3.4 Tests:****3.4.1 Filing test:**

File on the tip or near the edge ✓ of the material. The bite will determine the hardness. ✓

(2)**3.4.2 Bend test:**

- Metal is subjected to deformation by bending. ✓
- Observe the rupture of the metal. ✓

(2)**3.5 Sound test on steel:****3.5.1 Low carbon steel (LCS):**

Dull (low pitch) ✓ sound.

(1)**3.5.2 High carbon steel (HCS):**

Loud and clear (high pitch) ✓ sound.

(1)**[14]**

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**5.1 Engine cylinder compression test:****5.1.1 Reasons for compression test:**

- To determine the amount of compression loss ✓ from a specific cylinder. ✓
- To determine if the compression rings ✓ are worn. ✓

(Any 1 x 2) (2)**5.1.2 Type of compression test:**

- Dry test ✓
- Wet test ✓

(2)**5.1.3 Reasons for low compression:**

- Worn / cracked cylinders ✓
- Worn / broken piston rings ✓
- Worn / broken piston ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Worn / cracked / bent valve assembly ✓
- Leaking cylinder head gasket ✓

(Any 2 x 1) (2)**5.2 Cylinder leakage tester:****5.2.1 Labels for cylinder leakage tester:**

- A – Pressure control valve / - knob / - regulator ✓
- B – Gauge / Meter ✓
- C – Compressor hose / - air hose / -pipe ✓
- D – Spark plug connector / - adapter / - hose / - pipe ✓

(4)**5.2.2 Reason for pressurised air:**

To determine the ...

- percentage pressure leakage ✓ from the cylinder. ✓
- location ✓ of the cylinder leakage. ✓

(Any 1 x 2) (2)**5.3 Precautions when performing the exhaust gas analysis:**

- The inlet hose must not be stepped on or restricted in any way. ✓
- The hose connections must be airtight. ✓
- There should be no leaks in the exhaust, manifolds or vacuum systems. ✓
- Condensate must be blown out of the hoses and pickup probe. ✓
- The condenser must be drained after each test. ✓
- When the paper filter becomes light grey, it should be replaced. ✓
- Test must be done in a well-ventilated area. ✓
- Ensure the tester is connected to the battery correctly. ✓

(Any 3 x 1) (3)

5.4 Systems scanned by on-board diagnostic scanner:

- Powertrain (PCM) ✓
- Transmission (TCM) ✓
- Brakes (ABS) ✓
- Body (BCM) ✓
- Engine (ECM) ✓
- Humidity, ventilation and air conditioning (HVAC) ✓
- Air bags (SRS) ✓

(Any 3 x 1) (3)**5.5 Faults on the wheel established during dynamic wheel balancing:**

- The extent of the imbalance ✓
- The run-out of the tyre ✓
- The run-out of the wheel assembly ✓

(Any 2 x 1) (2)**5.6 Perform dynamic wheel balancing:**

- Start the balancer and allow wheel to spin. ✓
- Obtain the imbalance readings and its locations on the rim. ✓
- Fit the correct weights. ✓

**(3)
[23]**

QUESTION 6: ENGINES (SPECIFIC)**6.1 Crankshaft:**

6.1.1 Crankshaft ✓ (1)

6.1.2 **Function:**
To convert the reciprocating motion of the pistons ✓ into rotary motion. ✓ (2)

6.1.3 Crank web / counterweight ✓ (1)

6.1.4 **Static balance:**
The crankshaft is in static balance when the mass in all directions ✓ from the centre of rotation is equal while it is at rest. ✓ (2)

6.2 Vibration damper:

6.2.1 Crankshaft ✓ (1)

6.2.2 **Function:**
To smooth/dampen out the engine vibrations. ✓ (1)

6.3 Engine cylinder configurations:

- Inline / straight ✓
- V ✓
- W ✓
- Flat / horizontal ✓
- Radial / X-Engine ✓
- U-Engine ✓
- K-engine ✓
- Delta ✓

(Any 3 x 1) (3)

6.4 Power strokes intervals:

- To reduce engine vibrations. ✓
- To ensure smooth running of the engine. ✓
- To reduce the wear rate on the engine components. ✓

(Any 2 x 1) (2)

6.5 Determine the firing order:

- Read from the vehicle specifications. ✓
- It may be written on the tappet cover. ✓
- Check the order in which the valves rock. ✓
- Check the order in which the sparks are distributed from the distributor. ✓

(Any 3 x 1) (3)

6.6 Turbocharger:**6.6.1 Boost:**

The increasing of manifold pressure ✓ above the normal atmospheric pressure. ✓

(2)

6.6.2 Types:

- Variable Geometry Turbocharger (VGT) ✓
- Non-variable Turbocharger ✓

(2)

6.7 Supercharger:**6.7.1 Reasons for fitting:**

- To increase cylinder pressure / compression pressure. ✓
- To increase the volumetric efficiency. ✓
- To increase the engine output / performance. ✓
- Increase fuel efficiency. ✓

(Any 2 x 1) (2)

6.7.2 Mechanical drive:

- Belt ✓
- Gears ✓
- Chain ✓
- Shaft ✓

(Any 2 x 1) (2)

6.8 Twin-charging:

- A combination of a turbocharger ✓ and a supercharger. ✓
- Two turbochargers ✓ are combined on the same engine. ✓
- Two superchargers ✓ are combined on the same engine. ✓

(Any 1 x 2) (2)

6.9 Advantages of twin-charging:

- Outstanding fuel economy. ✓
- Reduce/eliminates lag at low revolutions. ✓
- Increased power and torque across the entire power band. ✓
- Reduced power required (sapping effect) by the supercharger pulley from the engine. ✓

(Any 2 x 1) (2)

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QUESTION 7: FORCES (SPECIFIC)**7.1 Swept volume:**

- Total volume ✓ when the piston moves from bottom dead centre to top dead centre. ✓
- Total volume ✓ displaced during a stroke. ✓

(Any 1 x 2) (2)**7.2 Method to increase compression ratio:**

- Remove shims between the cylinder block and cylinder head. ✓
- Fit thinner cylinder head gasket. ✓
- Machine metal from cylinder head. ✓
- Skim metal from cylinder block. ✓
- Fit a piston with a higher crown. ✓
- Fit a crankshaft with a longer stroke. ✓
- Increase the bore of the cylinders / bigger pistons. ✓

(Any 3 x 1) (3)**7.3 Calculation:****7.3.1 Swept volume:**

$$\begin{aligned}
 SV &= \frac{\pi \times D^2}{4} \times L \\
 &= \frac{\pi \times (9^2)}{4} \times 10 \quad \checkmark \\
 &= 636,17 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

(3)**7.3.2 Original clearance volume:**

$$\begin{aligned}
 CV &= \frac{SV}{CR - 1} \\
 &= \frac{636,17}{10,5 - 1} \quad \checkmark \\
 &= 66,97 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

(3)

7.3.3 New bore diameter:

$$\text{New compression ratio} = \frac{SV}{CV} + 1$$

$$SV = (CR - 1)(CV) \quad \checkmark$$

$$SV = (11 - 1)(66,97) \quad \checkmark$$

$$SV = 669,7 \text{ cm}^3 \quad \checkmark$$

$$SV = \frac{\pi \times D^2}{4} \times L$$

$$D = \sqrt{\frac{SV \times 4}{\pi \times L}} \quad \checkmark$$

$$= \sqrt{\frac{669,7 \times 4}{\pi \times 10}} \quad \checkmark$$

$$= 9,234 \text{ cm} \quad \checkmark$$

$$= 92,34 \text{ mm} \quad \checkmark$$

(7)

7.4 Prony brake calculations:**7.4.1 Indicated power in kW:**

$$P = 900 \times 10^3 \text{ Pa}$$

$$L = \frac{86}{1000}$$

$$= 0,086 \text{ m} \quad \checkmark$$

$$A = \frac{\pi \times D^2}{4}$$

$$= \frac{\pi \times 0,084^2}{4} \quad \checkmark$$

$$= 5,542 \times 10^{-3} \text{ m}^2 \quad \checkmark$$

$$N = \frac{2000}{60 \times 1} \quad \checkmark$$

$$= 33,33 \text{ power strokes/sec} \quad \checkmark$$

$$n = 2 \text{ cylinders}$$

$$IP = PLANn$$

$$= (900 \times 10^3)(0,086)(5,542 \times 10^{-3})(33,33)(2) \quad \checkmark$$

$$= 28593,86 \text{ W}$$

$$= 28,59 \text{ kW} \quad \checkmark$$

(7)

7.4.2 Brake power in kW:

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

$$= (25 \times 10)(0,4) \quad \checkmark$$

$$= 100 \text{ Nm} \quad \checkmark$$

$$\text{BP} = 2\pi NT$$

$$= 2 \times \pi \times 33,33 \times 100 \quad \checkmark$$

$$= 20941,85663 \text{ W}$$

$$= 20,94 \text{ kW} \quad \checkmark$$

(5)

7.4.3 Mechanical efficiency:

$$\eta = \frac{\text{BP}}{\text{IP}} \times 100$$

$$= \frac{20,94}{28,59} \times 100 \quad \checkmark$$

$$= 73,24 \% \quad \checkmark$$

(2)
[32]

QUESTION 8: MAINTENANCE (SPECIFIC)**8.1 Gas Analysis:**

FAULTS (DEFECTS)	POSSIBLE CAUSES	CORRECTIVE MEASURES
	8.1.1	8.1.2
High oxygen (O ₂) reading	Too lean air-fuel ratio. ✓	Reset fuel mixture. ✓
	Ignition problems. ✓	Check and reset ignition system. ✓
	Vacuum leaks. ✓	Repair vacuum leaks. ✓
	Catalytic converter not working. ✓ (Any 1 x 1)	Check and repair the catalytic converter. ✓ (Any 1 x 1)
	8.1.3	8.1.4
High hydrocarbon (HC) reading	Excessive unburned fuel. ✓	Reset fuel mixture. ✓
	Improper timing. ✓	Check and reset ignition system. ✓
	Vacuum leak. ✓	Repair vacuum leaks. ✓
	Faulty air management system. ✓	Check and repair the air management system. ✓
	(Any 1 x 1)	(Any 1 x 1)

(4)

8.2 Compression test:

- 8.2.1
- Prevent distribution of high voltage. ✓
 - To prevent electrical shock. ✓
 - To gain access to the spark plugs. ✓
- (Any 1 x 1) (1)
- 8.2.2
- To prevent fuel entering the exhaust system. ✓
 - To prevent fuel from entering the tester. ✓
- (Any 1 x 1) (1)
- 8.2.3
- To obtain the correct amount of air entering the cylinder. ✓
 - To obtain a correct reading. ✓
- (Any 1 x 1) (1)
- 8.2.4
- To compare reading to the specifications. ✓
 - To check if the pressure is correct or not. ✓
- (Any 1 x 1) (1)

8.3 Cylinder leakage test:

	FAULTS (DEFECTS)	POSSIBLE CAUSES	CORRECTIVE MEASURES	
8.3.1	Hissing sound at the air intake	Leaking inlet valves. ✓	Replace or reseal valves. ✓	(2)
		Gasket blown between adjacent cylinders. ✓ (Any 1 x 1)	Replace head gasket. ✓ (Any 1 x 1)	

8.3.2	Hissing sound at the dipstick	Worn piston rings. ✓	<ul style="list-style-type: none"> Overhaul engine. ✓ Fit new rings. ✓ 	(2)
		Worn piston. ✓ (Any 1 x 1)	<ul style="list-style-type: none"> Fit new pistons. ✓ Overhaul engine. ✓ (Any 1 x 1)	

8.4 Causes of a high oil pressure reading:

- Blocked oil passages ✓
- Too little crankshaft bearing clearances ✓
- Dirty or contaminated oil ✓
- Oil viscosity is too high ✓
- Pressure relief valve stuck in closed position. ✓

(Any 3 x 1) (3)

8.5 Fuel pressure test:**8.5.1 Manufacturer's specifications for fuel pressure test:**

- Fuel pressure after the fuel pump. ✓
- Fuel pressure when the engine is idling. ✓
- Fuel pressure on high revolutions. ✓

(Any 2 x 1) (2)

8.5.2 Placement of fuel pressure tester:

Fit the fuel pressure tester to the fuel line. ✓

(1)

8.5.3 Perished rubber pipe of fuel pressure tester:

- Fuel / pressure will leak from the pipe. ✓
- The tester will give inaccurate results. ✓
- Fire hazard. ✓

(Any 1 x 1) (1)

8.6 **Causes of cooling system pressure drop:**

Coolant leaks from ...

- between gaskets/seals of the cooling system. ✓
- water hoses. ✓
- blown cylinder head gasket. ✓
- the water pump. ✓
- radiator. ✓
- heater radiator. ✓
- corroded welch or core plugs. ✓
- components not fitted correctly. ✓

(Any 4 x 1)

(4)

[23]

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)**9.1 Solutions for an automatic gearbox:**

- 9.1.1
- Remove the propeller / drive shaft. ✓
 - Use a flatbed tow-truck. ✓
 - Use a mobi-jack / lift the drive wheels off the ground. ✓
- (Any 1 x 1) (1)**

- 9.1.2
- Use a lock-up clutch. ✓
 - The torque converter needs to be replaced. ✓
 - The torque converter to be repaired. ✓
 - Top-up fluids/oil. ✓
- (Any 1 x 1) (1)**

- 9.1.3
- Identify the cause of the problem and repair. ✓
 - Use an oil cooler. ✓
 - Top-up/replace fluids/oil. ✓
- (Any 1 x 1) (1)**

- 9.1.4
- Ensure the lever is shifted to:
- Park (P) ✓
 - Neutral (N) ✓
- (Any 1 x 1) (1)**

- 9.1.5
- Use automatic transmission fluid (ATF). ✓
- (1)**

9.2 Components of the torque converter:

- 9.2.1
- Pump ✓
 - Impeller ✓
- (Any 1 x 1) (1)**

- 9.2.2
- Turbine ✓
- (1)**

- 9.2.3
- Stator ✓
- (1)**

- 9.3
- Manual valve ✓
- (1)**

9.4 Advantages of epicyclic gear trains:

- Provides a variation in torque. ✓
 - Changes the direction of rotation. ✓
 - It's compact in design. ✓
 - Gears are in constant mesh. ✓
- (Any 2 x 1) (2)**

9.5 Gear system of an automatic gearbox:

- 9.5.1
- Double epicyclic gear system ✓
- (1)**

9.5.2 **Obtain reverse gear:**

- The brake band locks the annulus 1. ✓
- The input shaft (engine) drives the sun gears. ✓
- Planet gear 1 walks around the sun gear 1 in a reverse direction. ✓
- Planet gear 1 turns the planet carrier in a reverse direction. ✓
- Planet carrier turns the output shaft. ✓

(5)

9.6 Oil pump ✓

(1)

[18]

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONIC) (SPECIFIC)**10.1 Well-designed steering system:**

- Light and easy to control ✓
- Free from vibration and road shocks ✓
- As direct as possible without much drivers effort. ✓
- Self centering ✓
- Not unduly affected by the suspension or braking system operation ✓

(Any 2 x 1) (2)**10.2 Wheel alignment angle:****10.2.1 Label A-C:**

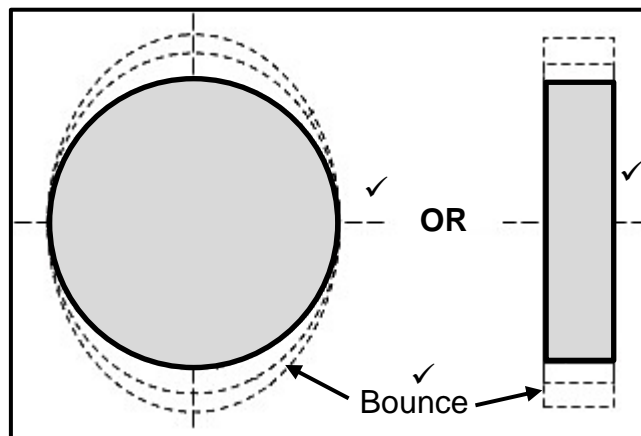
- A. Axle centre ✓
- B. Rear axle ✓
- C. Steering arms ✓

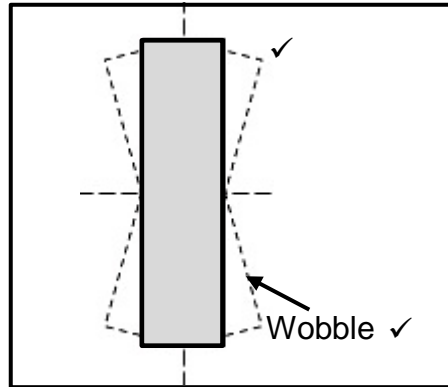
(3)**10.2.2 Angle D:**

Ackermann's angle ✓

(1)

10.2.3 It gives variable toe-out ✓ to the front wheels on turns. ✓

(2)**10.3 Unbalanced wheels drawings:****10.3.1 Wheel bounce (hop):****(2)**

10.3.2 Wheel wobble (shimmy):

(2)

10.3.3 Difference between wheel wobble and wheel bounce:

- Wheel wobble is the side to side movement (vibration) of a wheel. ✓
- Wheel bounce is the up and down movement (vibration) of a wheel. ✓

(2)

10.4 Materials coating the monolith:

- Aluminium oxide ✓
- Platinum ✓
- Rhodium ✓
- Palladium ✓

(Any 2 x 1) (2)

10.5 Functions of sensors:**10.5.1 Lambda sensor:**

- The sensor measures the oxygen content in the flow of the exhaust gas. ✓
- Sends the information to the electronic control unit (ECU). ✓

(2)

10.5.2 Throttle position sensor (TPS) sensor:

- Detects the position of the throttle. ✓
- Sends the information to the electronic control unit (ECU). ✓

(2)

10.5.3 Mass Air Flow (MAF) sensor:

- To measure the air flow to the engine. ✓
- To measure the air flow temperature. ✓
- Sends the information to the electronic control unit (ECU). ✓

(Any 2 x 1) (2)

10.6 Operation of common rail direct injection (CRDI):

- The high pressure pump transfers the fuel under high pressure to the common rail. ✓
- The common rail holds and distributes the pressurised fuel to the injectors. ✓
- The injectors spray the fuel directly into the cylinder. ✓ (3)

10.7 Current is generated:

- If a magnetic field is moved across a conductor ✓, a voltage is induced across the ends of the conductor ✓, which will cause a current to flow ✓
- Convert mechanical energy ✓ into electrical energy ✓ by electro-magnetic induction. ✓

(Any 1 x 3) (3)**10.8 Alternator stator tests:**

- Continuity ✓
- Leakage ✓ (2)

10.9 Positions electrical fuel pump is placed:

- Inside the fuel tank ✓
 - External – anywhere on the fuel line. ✓ (2)
- [32]**

TOTAL: 200