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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: AUTOMOTIVE

MAY/JUNE 2024

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 19 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

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

QUESTION 2: SAFETY (GENERIC)**2.1 First aid:**

- When illness occurs. ✓
- When an injury is sustained. ✓
- When an accident occurs. ✓

(Any 2 x 1) (2)

2.2 Bench grinder:

- A. A fire extinguisher should be readily available. ✓
- B. Safety glasses must be worn. ✓
- C. Maximum grinding wheel speed. ✓
- D. Maximum distance between tool rest and grinding wheel. ✓

(4)

2.3 Drill press:

- Never try to stop/hold the work piece by hand when the drill bit get stuck during drilling. ✓
- Don't force a drill bit into the work piece. ✓
- Keep loose clothing and hair away from revolving parts. ✓
- Never leave the machine running if it is unattended. ✓
- Use a brush or wooden rod to remove chips from the drill. ✓
- Do not put hands near moving parts. ✓
- Never clean or adjust the machine while it is in motion. ✓
- Never try to stop the drill/chuck by hand. ✓

(Any 2 x 1) (2)

2.4 Surface grinder:

- Never clean or adjust the machine while it is in motion. ✓
- Know how to stop the machine in an emergency. ✓
- Do not use excessive force when grinding the work piece. ✓
- Immediately report any dangerous defects of the machine. ✓
- Stop using defective machinery until it has been repaired by a qualified person. ✓
- Ensure that the grinding wheel is not submerged in coolant. ✓
- Never leave the machine running if it is unattended. ✓
- Do not put hands near moving parts. ✓

(Any 2 x 1) (2)

[10]

QUESTION 3: MATERIALS (GENERIC)**3.1 Critical temperature:**

3.1.1 **Hardening:**
Above ✓ (1)

3.1.2 **Tempering:**
Below ✓ (1)

3.1.3 **Normalising:**
Above ✓ (1)

3.2 Machining test:

- The chips heating colour ✓
- The chips curl ✓ (2)

3.3 Material tests:

- Sound test ✓
 - Bending test ✓
 - Filing test ✓
 - Hardness test ✓
 - Density test ✓
 - Weight measurement ✓
 - Magnetic test ✓
 - Visual inspection/observation ✓
 - Scratch test ✓
- (Any 3 x 1) (3)

3.4 Quenching methods:

- Carburising ✓
 - Nitriding ✓
 - Cyaniding ✓
- (Any 2 x 1) (2)

3.5 Heat treatment temperature:

- Pyrometer ✓
 - Crayons ✓
 - Visually ✓
 - Magnet ✓
- (Any 1 x 1) (1)

3.6 Heat-treatment steps:

- Heat the metal. ✓
- Soak the metal. ✓
- Cool the metal. ✓ (3)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**5.1 Compression tester:****5.1.1 Functions:**

- A. To indicate the compression pressure. ✓
- B. To reset the pressure gauge./Release the pressure from the tester. ✓
- C. To fit the tester into the spark plug hole. ✓ (3)

5.1.2 Test battery voltage:

- To ensure that the engine is able to swing ✓ at the correct speed. ✓
- To ensure maximum compression pressure ✓ is developed. ✓
- It is to ensure that the correct reading ✓ is obtained. ✓
(Any 1 x 2) (2)

5.1.3 Perform the wet test:

- To check if the compression rings are worn. ✓
- To check for excessive wear between the piston/piston rings and cylinder wall. ✓ (2)

5.2 Cylinder leakage test:**5.2.1 Calibrate (zero):**

To obtain accurate readings. ✓ (1)

5.2.2 Piston at TDC:

The cylinder should have minimal leaks on the compression stroke. ✓ (1)

5.2.3 Crankshaft is locked:

Prevent the engine from turning during the test. ✓ (1)

5.3 Exhaust gasses:

- Carbon monoxide (CO) ✓
- Carbon dioxide (CO₂) ✓
- Oxygen (O₂) ✓
- Hydrocarbon (HC) ✓
- Sulphur dioxide (SO₂) ✓

(Any 4 x 1) (4)

5.4 OBD-II scanner:**5.4.1 Specifications:**

- VIN ✓
- Make of the vehicle ✓
- Model of the vehicle ✓
- Engine type ✓
- System to be scanned ✓

(Any 2 x 1) (2)**5.4.2 Functions of OBD-II scanner:**

- Scan diagnostic trouble codes ✓
- Clear the trouble codes ✓
- Programme ✓
- Retrieve information ✓

(Any 2 x 1) (2)**5.5 Correcting dynamic wheel balancing:**

Place the weights indicated on the balancer ✓ at the place indicated on the wheel. ✓

(2)**5.6 Wheel alignment equipment:****5.6.1 Identify the equipment:**

- Periscope optical alignment gauge ✓
- Optical alignment gauge ✓

(Any 1 x 1) (1)**5.6.2 Function:**

- To check toe. ✓
- To check toe-out. ✓
- To check toe-in. ✓

(Any 1 x 1) (1)**5.6.3 Unit of measurement:**

- Degrees ✓
- Millimetres ✓

(Any 1 x 1) (1)**[23]**

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

6.1.1 Vibration damper ✓ (1)

- 6.1.2
- Mass pieces are added to the crankshaft counterweights/webs. ✓
 - Holes are drilled in the crankshaft counterweights/webs. ✓ (2)

6.1.3 Connecting rod ✓ (1)

6.1.4 **Causes of the crankshaft twist:**

- The torque or turning movement of the crankshaft. ✓
- The torque produced alternates between high and low value. ✓
- The shaft alternately winds up and releases as it rotates. ✓
- Natural frequency of crankshaft vibrations. ✓
- Resonance on crankshaft. ✓
- Imbalanced crankshaft. ✓
- Faulty vibration damper. ✓
- Imbalanced flywheel. ✓

(Any 3 x 1) (3)

6.2 Rotating mass:

- Crank pin ✓
- Big-end bearing ✓
- The lower two-thirds of the connecting rod ✓ (3)

6.3 Engine cylinder layouts:

- 6.3.1
- A. V-engine ✓
 - B. Inline ✓
 - C. W-engine/double V engine ✓ (3)

6.3.2 **Advantages of V- engine over inline-engine:**

- Shorter in length ✓
- Can be mounted in smaller engine compartments ✓
- Lighter in weight ✓
- Better power to weight ratio ✓

(Any 2 x 1) (2)

6.4 Degrees of crankshaft rotation:

6.4.1 180° ✓ (1)

6.4.2 120° ✓ (1)

6.4.3 90° ✓ (1)

6.5 Turbocharger on an internal combustion engine:

- 6.5.1 A. Air/Air intake ✓
 B. Exhaust gas/Exhaust gas inlet ✓
 C. Turbine housing ✓
 D. Turbine wheel ✓ (4)

- 6.5.2 Vanes ✓ (1)

6.6 Types of superchargers:

- Roots ✓
- Twin-screw ✓
- Centrifugal ✓
- Sliding-vane/Eccentric ✓

(Any 3 x 1) (3)

6.7 Disadvantages of superchargers:

- Superchargers are less effective at increasing engine power at high revolutions. ✓
- Superchargers use engine power to drive it (parasitic). ✓
- Higher fuel consumption if generated power is not fully used. ✓
- More space required to mount the Roots supercharger. ✓
- Roots and twin-screw superchargers deliver air in bursts. ✓
- It is more expensive than a turbocharger. ✓

(Any 2 x 1) (2)

[28]

QUESTION 7: FORCES (SPECIFIC)**7.1 Definition:****7.1.1 Torque:**

It is the twisting effort/force ✓ transmitted by a rotating shaft or wheel. ✓

(2)

7.1.2 Brake power:

- The useable power ✓ developed at the flywheel or the wheels. ✓
- The actual output power ✓ of an engine measured at the flywheel or the wheels. ✓

(Any 1 x 2)

(2)

7.2 Increase swept volume:

- Fit crankshaft with longer stroke (with suitable connecting rods). ✓
- Increase bore of cylinders. ✓

(Any 1 x 1)

(1)

7.3 Calculations:**7.3.1 Swept volume:**

$$\begin{aligned}\text{Swept volume} &= \frac{\pi \times d^2}{4} \times L \\ &= \frac{\pi \times 7,4^2}{4} \times 7,7 \checkmark \\ &= 331,16 \text{ cm}^3 \checkmark\end{aligned}$$

(3)

7.3.2 Compression ratio:

$$42 \text{ ml} = 42 \text{ cm}^3 \checkmark$$

$$\begin{aligned}\text{Compression ratio} &= \frac{SV}{CV} + 1 \\ &= \frac{331,16}{42} + 1 \checkmark \\ &= 8,88:1 \checkmark\end{aligned}$$

OR

$$\begin{aligned}\text{Compression ratio} &= \frac{SV + CV}{CV} \\ &= \frac{331,16 + 42}{42} \checkmark \\ &= 8,88:1 \checkmark\end{aligned}$$

(4)

7.3.3 **Stroke length:**

$$CV = \frac{SV}{CR - 1}$$

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

$$SV = 42 (10 - 1) \checkmark$$

$$= 378 \text{ cm}^3 \checkmark$$

$$SV = \frac{\pi \times d^2}{4} \times \text{length}$$

$$\text{length} = \frac{SV \times 4}{\pi \times d^2} \checkmark$$

$$= \frac{378 \times 4}{\pi \times 7,4^2} \checkmark$$

$$= 8,789 \text{ cm}$$

$$= 87,89 \text{ mm} \checkmark$$

(6)

7.4 **Calculations:**7.4.1 **Indicated power:**

$$IP = PLAN_n$$

$$P = 950 \times 10^3$$

$$L = \frac{70}{1000} = 0,07 \text{ m} \checkmark$$

$$\text{Area} = \frac{\pi \times 0,065^2}{4} \checkmark = 3,318307 \times 10^{-3} \text{ m}^2 \checkmark$$

$$N = \frac{2500}{60 \times 2} \checkmark = 20,833 \checkmark \text{ power strokes/ sec}$$

$$n = 4$$

$$IP = (950 \times 10^3) \times (0,07) \times (3,318307 \times 10^{-3}) \times (20,833) \times (4) \checkmark$$

$$= 18388,95 \text{ W}$$

$$= 18,39 \text{ kW} \checkmark$$

(7)

7.4.2 Torque:

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

$$= 142,5 \times 0,4 \checkmark$$

$$= 57 \text{ Nm} \checkmark$$

(2)

7.4.3 Brake power :

$$\text{Brake power} = 2\pi NT$$

$$= 2 \times \pi \times \left(\frac{2500}{60} \right) \checkmark \times 57 \checkmark$$

$$= 14922,565 \text{ W}$$

$$= 14,92 \text{ kW} \checkmark$$

(3)

7.4.4 Mechanical efficiency:

$$\text{Mechanical efficiency} = \frac{\text{BP}}{\text{IP}} \times 100$$

$$= \frac{14,92}{18,39} \checkmark \times 100$$

$$= 81,13 \% \checkmark$$

(2)

[32]

QUESTION 8: MAINTENANCE (SPECIFIC)**8.1 Exhaust gas analysis:****8.1.1 Gas analysis results:**

- High oxygen (O₂) ✓
- High nitrogen oxide (NO_x) ✓

(2)

8.1.2 High nitrogen oxide (NO_x):

- Improper spark advance ✓
- Malfunctioning exhaust gas regulator (EGR) ✓
- Malfunctioning catalytic converter ✓
- Lean fuel mixture ✓
- Lower octane fuel ✓
- Vacuum leaks ✓

(Any 3 x 1)

(3)

8.2 Compression test:**8.2.1 Possible causes:**

- Piston rings are worn. ✓
- Piston is damaged. ✓
- Valves leaking. ✓
- Cracked cylinder head. ✓
- Blown head gasket. ✓
- Cylinder walls are worn. ✓

(Any 1 x 1)

(1)

8.2.2 Corrective measures:

- Fit new rings. ✓
- Fit new pistons. ✓
- Replace/Re-seat valves. ✓
- Stitch weld/Replace the cylinder head. ✓
- Replace the cylinder head gaskets. ✓
- Re-bore cylinders. ✓

(Any 1 x 1)

(1)

8.2.3 Fault:

Low to no compression pressure readings. ✓

(1)

8.2.4 Corrective measures:

- Replace the bent valves. ✓
- Correct the cambelt tension. ✓
- Fit a new cambelt. ✓
- Reset valve timing. ✓

(Any 1 x 1)

(1)

8.3 Place of hissing sounds:

- 8.3.1
- Dipstick ✓
 - Oil filler cap hole ✓
 - Breather pipe ✓

(Any 1 x 1) (1)

8.3.2 Intake manifold ✓

(1)

8.3.3 Exhaust pipe ✓

(1)

8.4 Oil pressure test:

- Oil pressure when 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 Low fuel pressure:****NOTE:** The cause and the corrective measure must match each other.

CAUSES	CORRECTIVE MEASURES
Faulty fuel pump. ✓	• Replace fuel pump. ✓
Blocked or restricted fuel filter. ✓	• Replace fuel filter. ✓
Cracked or restricted fuel line. ✓	• Renew or repair fuel line. ✓ • Blow out fuel lines. ✓ (Any 1 x 1)
Clogged pump inlet strainer. ✓	• Clean the strainer. ✓
Low voltage to the fuel pump. ✓	• Repair faulty wiring and connections. ✓ • Recharge or replace battery. ✓ (Any 1 x 1)
Faulty or failed fuel pressure regulator. ✓	• Replace fuel pressure regulator. ✓
Defective fuel pump relay. ✓	• Replace relay. ✓
Empty fuel tank. ✓	• Refuel. ✓

(Any 2 causes x Any 2 matching corrective measures) (4)**8.6 Test the cooling system:**

- Fit radiator pressure tester to the radiator. ✓
- Pressurize the cooling system according to manufacturer's specification. ✓
- Watch the pressure for a while, ✓ if it drops there is a leak.
- Conduct a visual check for leaks. ✓

(4)
[23]

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

- It reduces driver fatigue. ✓
- It ensures great reduction of wheel spin under bad road conditions. ✓
- The vehicle can be stopped suddenly without the engine stalling. ✓
- The system dampens all engine torsional vibrations. ✓
- Easier to drive (e.g. disabled person with one leg/no clutch pedal pressing). ✓

(Any 3 x 1) (3)**9.2 Torque converter:****9.2.1 Labelling:**

- A. Turbine ✓
- B. Impeller/Pump ✓
- C. Stator ✓
- D. Output shaft/Turbine shaft ✓

(4)**9.2.2 Stall speed:**

- When the impeller rotates at maximum speed ✓ and the turbine is almost stationary. ✓
- When the pump has reached the highest velocity ✓ and the turbine is at stall (standing still). ✓
- When the vehicle is stationary ✓ and just before it starts moving. ✓

(Any 1 x 2) (2)**9.2.3 Converter stops multiplying torque:**

- When the turbine turns at almost the same speed ✓ as the pump. ✓
- When the speed of the oil leaving the pump ✓ is almost the same as the pump speed. ✓

(Any 1 x 2) (2)**9.3 Advantages of transmission control unit:**

- Better fuel economy ✓
- Reduced engine emissions ✓
- Greater shift system reliability ✓
- Improved shift feel ✓
- Improved shift speed ✓
- Improved vehicle handling ✓

(Any 2 x 1) (2)

9.4 **Cooling oil in the automatic transmission:**

- Use a separate oil cooler. ✓
- Circulating fluid through the bottom radiator tank. ✓
- Air flowing over the transmission housing and oil sump. ✓

(Any 2 x 1)

(2)

9.5 **Forward overdrive:**

1. Input shaft drives the sun gear. ✓
2. Annulus 2/Ring gear 2 is held stationery. ✓
3. Planet carrier rotates faster than the input shaft. ✓

(3)

[18]

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONICS) (SPECIFIC)**10.1 Features wheel alignment**

- Desirable steering ✓
- Good wheel tracking ✓
- Better road-holding ✓
- Improved fuel economy ✓
- Even tyre wear ✓
- Reduced wear on the suspension ✓

(Any 2 x 1) (2)**10.2 Positive camber:****10.2.1 Labels:**

- A. Centre line of wheel ✓
- B. Positive camber angle/Camber angle ✓
- C. Strut ✓
- D. Lower control arm ✓

(4)**10.2.2 Camber adjustment:**

- Cam on the suspension ✓
- Wedge plates on the suspension ✓
- Offset screw ✓
- Upper strut mounting ✓

(Any 1 x 1) (1)**10.2.3 Excessive positive camber:**

- Hard steering ✓
- Rapid tyre wear ✓
- Increased chance of vehicle rolling when cornering ✓

(Any 2 x 1) (2)**10.3 Wheel pre-checks:**

- Tyre pressure ✓
- Tyre wear ✓
- Tyre for bruises, cracks ✓
- Damaged side walls of tyre ✓
- Wheel rim for damaged beads ✓
- Foreign matter on the rim and tyre ✓
- Tyre expiry date ✓

(Any 3 x 1) (3)

10.4 Fuel-delivery system:**10.4.1 Pressure regulator:**

The fuel pressure is kept constant ✓ in relation to the manifold pressure. ✓

(2)

10.4.2 Fuel pump:

The fuel pump transfers the fuel ✓ from fuel tank to the engine through fuel lines. ✓

(2)

10.5 Ignition timing:

- Engine speed ✓
- Engine load ✓
- Engine temperature ✓
- Throttle position ✓
- Engine knocking ✓
- Altitude ✓

(Any 2 x 1)

(2)

10.6 Common rail direct injection (CRDI) system:

- A. Common rail ✓
- B. Fuel injector ✓
- C. Fuel line ✓
- D. Fuel filter ✓

(4)

10.7 Requirements for the catalytic converter to function:

- A temperature of at least 250°C. ✓
- Unleaded petrol must be used. ✓
- Accurate ignition timing. ✓
- No misfiring. ✓
- No burnt engine oil in the exhaust gases. ✓
- Functioning oxygen/lambda sensor. ✓

(Any 2 x 1)

(2)

10.8 Alternator:**10.8.1 Labels:**

- A. Rotor ✓
- B. Stator ✓
- C. Battery ✓

(3)

10.8.2 Diodes:

Six ✓

(1)

10.8.3 Function of the diodes:

- Allows the current to flow in one direction ✓ only. ✓
- It blocks the current ✓ from flowing in the opposite direction. ✓

(Any 1 x 2)

(2)

10.9 **Deactivate speed control:**

- Switch it off. ✓
- Apply brakes. ✓
- Press the clutch pedal/change gears. ✓
- ECU mapping. ✓

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

TOTAL: 200