basic education

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)
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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)

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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)

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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 (CO_2) ✓
- Oxygen (O_2) ✓
- Hydrocarbon (HC) ✓
- Sulphur dioxide (SO_2) ✓

(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)
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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)
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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:**

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

(3)

7.3.2 **Compression ratio:**

$42 \text{ ml} = 42 \text{ cm}^3$ ✓

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

OR

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

(4)

7.3.3 **Stroke length:**

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

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

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

$$= 378\ cm^3\ \checkmark$$

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

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

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

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

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

(6)

7.4 **Calculations:**

7.4.1 **Indicated power:**

$$IP = PLANn$$

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

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

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

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

$$n = 4$$

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

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

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

(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:**

$$\text{Mechanical efficiency} = \frac{BP}{IP} \times 100$$
$$= \frac{14,92}{18,39} \checkmark \times 100$$
$$= 81,13 \% \checkmark$$

(2)
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QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 **Exhaust gas analysis:**

8.1.1 **Gas analysis results:**
- High oxygen (O_2) ✓
- High nitrogen oxide (NOx) ✓ (2)

8.1.2 **High nitrogen oxide (NOx)**:
- 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)

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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)

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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)
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TOTAL: 200