basic education

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)
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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)
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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)

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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)

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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:**

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

(3)

7.3.2 **Original clearance volume:**

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

(3)

7.3.3 **New bore diameter:**

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

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

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

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

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

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

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

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

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

(7)

7.4 **Prony brake calculations:**

7.4.1 **Indicated power in kW:**

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

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

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

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

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

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

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

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

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

$$IP = PLANn$$

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

$$= 28593,86\,W$$

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

(7)

7.4.2 **Brake power in kW:**

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

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

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

$$BP = 2\pi NT$$

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

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

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

(5)

7.4.3 **Mechanical efficiency:**

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

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

$$= 73,24 \text{ \%} \quad \checkmark$$

(2)
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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 reseat valves. ✓	
		Gasket blown between adjacent cylinders. ✓ **(Any 1 x 1)**	Replace head gasket. ✓ **(Any 1 x 1)**	(2)
8.3.2	Hissing sound at the dipstick	Worn piston rings. ✓	• Overhaul engine. ✓ • Fit new rings. ✓	
		Worn piston. ✓ **(Any 1 x 1)**	• Fit new pistons. ✓ • Overhaul engine. ✓ **(Any 1 x 1)**	(2)

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)
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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)

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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:**

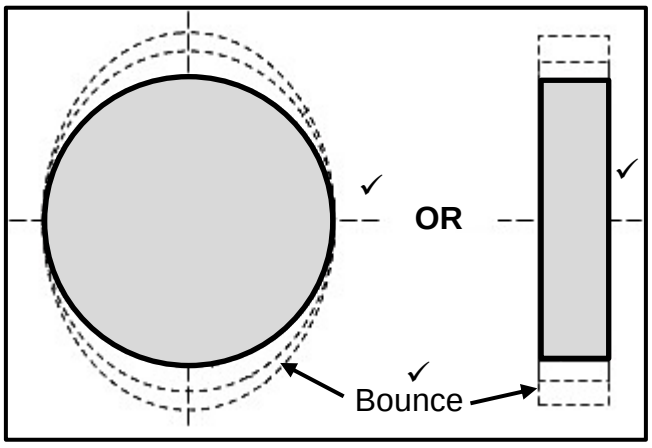
10.2.1 **Label A-C:**
A. Axle centre ✓
B. Rear axle ✓
C. Steering arms ✓ (3)

10.2.2 **Angle D:**
Ackermann's angle ✓ (1)

10.2.3 It gives variable toe-out ✓ to the front wheels on turns. ✓ (2)

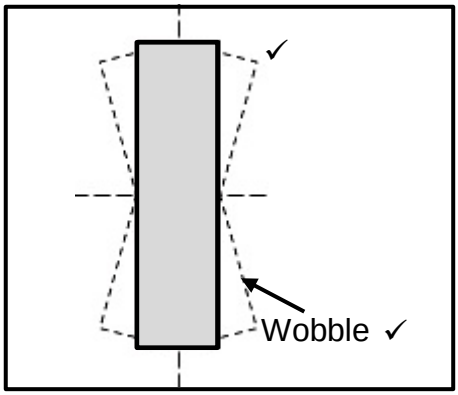
10.3 **Unbalanced wheels drawings:**

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)

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TOTAL: 200