basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: AUTOMOTIVE

2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 16 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 A ✓ (1)

1.2 B ✓ (1)

1.3 C ✓ (1)

1.4 D ✓ (1)

1.5 A ✓ (1)

1.6 C ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Rated speed of a grinding wheel:**

- Because the wheel could burst/break if it turns faster than its revolution range. / Avoid an accident. ✓
- Effectiveness of the grinding process will be compromised. ✓ **(Any 1 x 1)** (1)

2.2 **Safety precautions of a band saw in operation:**

- Never leave the band saw unattended. ✓
- Use a push stick when cutting. ✓
- Hold the work piece firmly and flat on the table. ✓
- Don't adjust the machine while working. ✓
- Don't open any guard while the machine is on. ✓
- Make relief cuts before cutting tight curves. ✓
- Don't force the material into the blade. ✓
- Keep hands clear from the action point. ✓
- Keep hands braced against the table. ✓
- Keep your hands on either sides of the blade and not in line with the cutting line and the blade. ✓
- Keep loose clothing clear from action point. ✓ **(Any 2 x 1)** (2)

2.3 **Stages in which first aid is applied:**

- Examination ✓
- Diagnosis ✓
- Treatment ✓ (3)

2.4 **Causes of accidents:**

- Unsafe acts ✓
- Unsafe conditions ✓ (2)

2.5 **TWO advantages of the product layout:**

- Handling of material is kept to a minimum. ✓
- Time period of manufacturing cycle is less. ✓
- Production control is almost automatic. ✓
- Control over operations is easier. ✓
- Greater use of unskilled labour is possible. ✓
- Less total inspection is required. ✓
- Less total floor space is needed per unit of production. ✓ **(Any 2 x 1)** (2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **Tempering:**
Tempering is a process generally applied to steel to relieve the strains/brittleness/improve ductility ✓ induced during the hardening process. ✓ (2)

3.2 **Annealing:**
- To relieve internal stresses ✓ that may have been set up during working of metal.
- To soften steel ✓ in order to facilitate the machining process.
- To refine their grain structure. ✓
- Reduce brittleness. ✓
- Make the steel ductile. ✓ **(Any 3 x 1)** (3)

3.3 **Normalising temperature:**
- Above ✓ higher/upper critical temperature ✓
- Above ✓ AC_3 line. ✓ **(Any 1 x 2)** (2)

3.4 **Spark pattern for carbon steels:**

3.4.1 High-carbon steel ✓ (1)

3.4.2 Low-carbon steel / Mild steel ✓ (1)

3.4.3 Cast-iron ✓ (1)

3.5 **Carbon diagram:**
A. Temperature range / °C ✓
B. AC_3 line / Higher/upper critical temperature line ✓
C. AC_1 line / Lower critical temperature line ✓
D. Carbon content / % carbon ✓ (4)
[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1 **Wet compression test:**

- Pour/squirt some oil onto the piston through the spark plug hole. ✓
- Do the compression test. ✓
- Compare the readings to the dry compression test reading. ✓ (3)

5.2 **Functions:**

5.2.1 **Compression Test:**
Indicates ✓ the compression pressure ✓ created by piston in the cylinder. (2)

5.2.2 **Cylinder Leakage Test:**

- Indicates the % ✓ compressed air leakage from the cylinder. ✓
- Indicates the location ✓ of the leakage from the cylinder. ✓

(Any 1 x 2) (2)

5.3 **Gas analyser:**

- Inlet hose not to be stepped on. ✓
- Hose connection must be airtight, and valve closed. ✓
- No exhaust leaks. ✓
- Condensate must be blown out of the hose and pick-up probe. ✓
- Condenser must be drained after each test. ✓
- Filter on the condenser stand must be changed regularly. ✓
- Ensure test is done in a well-ventilated area. ✓
- On a 12v analyser, the battery clamps must be cleaned. ✓
- Make sure gas analyser is placed on a safe place. ✓ **(Any 4 x 1)** (4)

5.4 **Optical alignment gauges:**

- Centre the steering on your car. ✓
- Put each half of the tracking gauge against each of the front wheels. ✓
- Look through the periscope and you should see / identify the alignment mark. ✓
- Look through the periscope and align the vertical line with the triangle by moving the pointer arm. ✓
- Read off the toe-in or toe-out. ✓ (5)

5.5 **OBD-II scanner:**

- Plug the diagnostic tool into the OBD-II port. ✓
- Enter the vehicle's details into the scanner. ✓
- Turn on the vehicle's ignition. ✓
- Start the diagnostic scan. ✓
- Interpret the trouble codes and make a diagnosis. ✓ (5)

5.6 **Wheel balance methods:**

- Dynamic balance ✓
- Static balance ✓ (2)

[23]

QUESTION 6: ENGINES (SPECIFIC)

6.1 **Components driven by the crankshaft:**

- Flywheel ✓
- Camshaft ✓
- Supercharger ✓
- Connecting rod/Pistons ✓
- Oil pump ✓
- Water pump ✓
- Power steering pump ✓
- Air conditioning pump ✓
- Radiator fan ✓
- Distributor ✓
- Alternator ✓
- Transmission/gearbox ✓ **(Any 4 x 1)** (4)

6.2 **Combustion engines:**

6.2.1 **Rotating mass:**
The crank pin, big-end ✓ and the lower two-thirds of the connecting rod. ✓ (2)

6.2.2 **Reciprocating mass:**
The pistons, gudgeon pins ✓ and the upper third of the connecting rod. ✓ (2)

6.3 **Advantages of a six-cylinder V-engine over a six-cylinder straight engine:**

- Can be mounted in smaller engine compartments. ✓
- Improved power to weight ratio. ✓
- More compact engine. ✓ **(Any 2 x 1)** (2)

6.4 **Turbocharger:**

6.4.1 **Turbocharger parts:**
A – Compressor/Compressor housing/casing ✓
B – Exhaust gas out/discharge ✓
C – Turbine wheel/blades ✓
D – Exhaust gas in ✓
E – Compressed air out/discharge ✓ (5)

6.4.2 **Operation of the vanes in a variable geometry turbocharger at low speed:**

- At low-speed range the variable nozzle vanes are almost closed. ✓
- The vanes create a narrow path to the exhaust turbine blades. ✓
- The angle of the vanes, directs the gases to hit the blades at the correct angle ✓
- This causes the turbocharger to spin faster. ✓ (4)

6.5 **Types of superchargers:**

- Roots ✓
- Twin-screw ✓
- Centrifugal ✓
- Eccentric / sliding-vane ✓ (4)

6.6 **Disadvantages of superchargers compared to turbochargers:**

- 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 3 x 1)** (3)

6.7 **Difference between twin-turbocharging and twin-charging:**

Twin-turbocharging uses two turbochargers ✓ while twin-charging uses a combination of a turbocharger and a supercharger. ✓ (2)

[28]

QUESTION 7: FORCES (SPECIFIC)

7.1 **Definitions:**

7.1.1 **Work:**
Work is done when a force ✓ overcomes resistance and causes movement. ✓ (2)

7.1.2 **Clearance volume:**
This is the volume above the crown of the piston, ✓ when the piston is at TDC / combustion chamber. ✓ (2)

7.2 **The mean effective pressure represented:**

7.2.1 Indicator diagram / Pressure-volume diagram ✓ (1)

7.2.2 kPa/Pa or kN/m^2 /Nm^2 ✓ (1)

7.3 **Calculations:**

7.3.1 **Swept Volume:**

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

$$= \frac{\pi \times 7^2}{4} \checkmark \times \frac{65}{10} \checkmark$$

$$= 250{,}15\,cm^3 \checkmark$$

(3)

7.3.2 **Original clearance volume:**

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

$$= \frac{250{,}15}{9 - 1} \checkmark \checkmark$$

$$= 31{,}27 cm^3 \checkmark$$

(3)

7.3.3 **Stroke length:**

$$SV = CV(CR-1) \checkmark$$
$$= 31,27(10-1) \checkmark$$
$$= 281,42\,cm^3 \checkmark$$

$$SV = \frac{\pi D^2}{4} x\, L$$
$$L = \frac{SV x\ 4}{\pi\ x\ D^2} \checkmark$$
$$= \frac{281,42 x\ 4}{\pi\ x\ 7,2^2} \checkmark$$
$$= 6,912\,cm \checkmark$$
$$= 69,12\,mm \checkmark$$ (7)

7.4 **Calculations:**

7.4.1 **Indicated power:**

$$L = \frac{10}{100}$$
$$= 0,1\ m \checkmark$$

$$Area = \frac{\pi\ D^2}{4}$$
$$= \frac{\pi x\ 0,08^2}{4} \checkmark$$
$$= 5,03 x\ 10^{-3}\ m^2 \checkmark$$

$$N = \frac{2\,500}{60 x\ 2} \checkmark$$
$$= 20,83\ firing\ strokes/sec \checkmark$$

$$IP = PLANn$$
$$IP = \left(1250 \times 10^3\right) \times 0,1 \times \left(5,03 \times 10^{-3}\right) \times 20,83 \times 4 \checkmark$$
$$= 52387,45\,W$$
$$IP = 52,39\,kW \checkmark$$ (7)

7.4.2 **Torque:**

$$BP = 2\pi NT$$

$$N = \frac{2500}{60}$$
$$= 41,67 \text{ r/s} \checkmark$$

$$T = \frac{BP}{2\pi N} \checkmark$$
$$= \frac{(46,08 \text{ x } 10^3)}{2 \text{ x } \pi \text{ x } 41,67} \checkmark$$
$$= 176 \text{ Nm} \checkmark \quad (4)$$

7.4.3 **Mechanical efficiency:**

$$\text{Mechanical efficiency} = \frac{BP}{IP} \text{ x } 100$$
$$= \frac{46,08}{52,39} \text{ x } 100 \checkmark$$
$$= 87,96 \text{ \%} \checkmark \quad (2)$$

[32]

QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 **Lean fuel mixture:**

- High oxygen (O_2) ✓
- Low Carbon dioxide (CO_2) ✓
- High Nitrogen oxide (NO_x) ✓ (3)

8.2 **High hydrocarbon (HC) exhaust gas reading:**

- Incomplete combustion ✓
- Improper valve timing ✓
- Improper ignition timing ✓
- Faulty air management system ✓
- Blocked or restricted air-filter ✓
- Faulty temperature sensor ✓
- Faulty oxygen sensor ✓
- Excessive fuel pressure ✓
- Non-functioning PCV valve ✓
- Faulty catalytic convertor ✓ **(Any 3 x 1)** (3)

8.3 **Compression test:**

Causes	Corrective Measures
• Blown cylinder head gasket ✓ • Cracked cylinder head ✓	• Replace with new gasket ✓ • Replace/repair cylinder head ✓

(4)

8.4 **Bubbles in the radiator water:**

- Blown cylinder head gasket ✓
- Cracked cylinder head ✓ (2)

8.5 **Oil pressure test:**

- Oil pressure at idling speed. ✓
- Oil pressure at high revolutions. ✓
- Oil pressure when engine is cold. ✓
- Oil pressure when engine is hot. ✓ **(Any 3 x 1)** (3)

8.6 **Precautions while setting up the fuel tester:**

- Ensure that you wear the correct PPE e.g. safety goggles. ✓
- Ensure that the tester can read the fuel pressure of the engine. ✓
- Ensure that the place where you will couple the tester is clean before you remove the sender unit. ✓
- Ensure the rubber pipe on the tester is not perished. ✓
- Put the tester at a place on the engine that is safe from the running engine. ✓
- Ensure that there are no flammable materials in proximity. ✓
- Ensure that there is a fire-extinguisher. ✓ **(Any 4 x 1)** (4)

8.7 **Radiator pressure drop:**

- Repair leaks between components / gasket leaks. ✓
- Repair leaking hoses. ✓
- Tighten loose hose clamps. ✓
- Repair or replace leaking water pump. ✓
- Repair or replace corroded pipes. ✓
- Replace blown head gasket. ✓
- Repair or replace leaking radiator. ✓
- Repair or replace leaking cabin heater radiator. ✓
- Renew the heater tap. ✓
- Renew the welch or core plugs. ✓ **(Any 4 x 1)** (4)

[23]

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)

9.1 **Lock-up torque converter:**

9.1.1 **Function of the lock-up clutch:**
- The lock-up clutch improves efficiency ✓
- Prevents slip ✓ (2)

9.1.2 **Functions of a stator:**
- Redirects oil back to the impeller. ✓
- Increases the engine torque. ✓ (2)

9.1.3 **Lock-up clutch is engaged:**
- The oil pressure in the torque converter increases with engine speed. ✓
- The pressurised oil is channelled to the lock-up clutch piston. ✓
- The lock-up clutch piston pushes the friction plate against the clutch friction surface attached to the housing. ✓
- Since the friction plate is splined to the impeller, it connects the impeller and turbine. ✓
- The turbine and impeller begin to turn as one. ✓ (5)

9.2 **Automatic gearbox:**

9.2.1 Double epicyclic gear train. ✓ (1)

9.2.2
- Three forward ✓
- One reverse ✓ (2)

9.3 **Cooling the hydraulic transmission fluid in an automatic transmission:**
- The hydraulic transmission fluid is circulated through an oil cooler at the radiator. /Oil is cooled by circulating through the bottom tank of the radiator. ✓
- The airflow over the transmission sump allow for cooling of the oil. ✓ (2)

9.4 **Differences between the construction of a manual transmission and automatic transmission:**

Manual	Automatic
• Less complex design. ✓ • Different gear sets used to obtain different gear ratios. ✓ • Cluster and simple gear trains used. ✓ • Dry clutch used when changing gears. ✓	• More complex design. ✓ • Same gear sets used to obtain different gear ratios. ✓ • Epicyclic-gear trains used. ✓ • Wet clutch used to engage gears. ✓

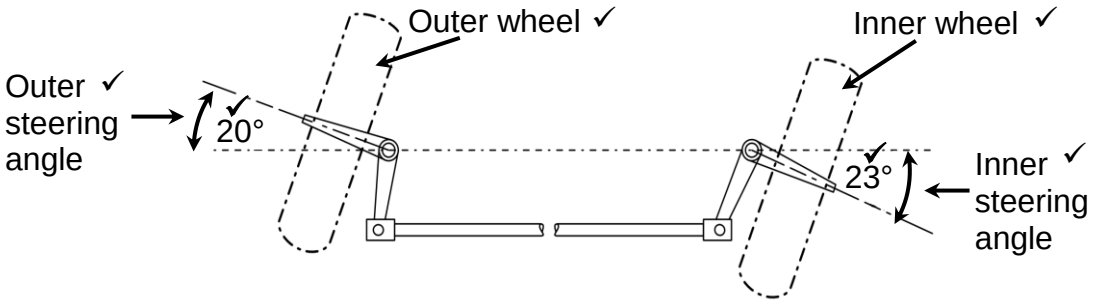
(Any 2 x 2) **(4)**
[18]

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONIC) (SPECIFIC)

10.1 **Pre-checks on vehicle suspension before wheel alignment:**

- Correct preload on the wheel (hub) bearings ✓
- Kingpins and bushes ✓
- Suspension ball joints for wear, locking and lifting ✓
- Suspension bushes for excessive free movement ✓
- Steering box play and whether secure on chassis ✓
- Tie-rod ends ✓
- Sagged springs, which includes riding height ✓
- Ineffective shock absorbers ✓
- Spring U-bolts ✓
- Chassis for possible cracks and loose cross-members ✓ **(Any 3 x 1)** (3)

10.2 **Toe out on turns:**



NOTE: Steering angles should be different. If degrees indicated are the same, candidate loses the TWO marks. Angles sizes shown are just an example. (6)

10.3 **Faults toe-out on turns:**

- Wear on the suspension parts ✓
- Wheel bearing wear ✓
- Steering system wear ✓ **(Any 2 x 1)** (2)

10.4 **Static balancing:**

- Mount the wheel so that it is free to spin on a spindle. ✓
- Spin the wheel slowly. ✓
- If the wheel is out of balance, it will always come to rest at the same point, ✓ the 'heavy spot', at the bottom.
- To correct static imbalance, a small weight is fitted to the wheel rim by trial and error, opposite the 'heavy spot'. ✓
- Repeat until the wheel stops at random positions. ✓ (5)

10.5 **Electronic Control Unit (ECU) functions:**

10.5.1 **Air-induction system:**
The air-induction system measures ✓ and controls ✓ the air required for the combustion. (2)

10.5.2 **Ignition system:**
The purpose of the ignition system is to ignite ✓ the air/fuel mixture in the combustion chamber at the correct time. ✓ (2)

10.6 **Catalytic convertor gases:**
- Hydrocarbons (HC) ✓
- Carbon monoxide (CO) ✓
- Nitrogen oxide (NOx) ✓ **(Any 2 x 1)** (2)

10.7 **Labels common rail direct injection (CRDI) system:**
A. Common rail ✓
B. High pressure pump / pump / diesel pump ✓
C. Diesel/fuel filter ✓
D. Injectors ✓ (4)

10.8 **Function of the pressure regulator:**
- It keeps the pressure ✓ in the common rail at a specified pressure. ✓
- It relieves excessive pressure ✓ in the common rail. ✓ **(Any 1 x 2)** (2)

10.9 **The alternator:**

10.9.1 **Component:**
A. Rotor ✓
B. Capacitor ✓ (2)

10.9.2 **Winding connection:**
Star / Y ✓ connected stator windings (1)

10.9.3 **Diodes:**
Six (6) ✓ (1)
[32]

TOTAL: 200