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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

NOVEMBER 2022

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 18 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS(GENERIC)

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

QUESTION 2: SAFETY (GENERIC)**2.1 Vital functions:**

- Breathing ✓
- Heart rate / pulse ✓
- State of consciousness ✓

(Any 2 x 1) (2)**2.2 Safety glasses during grinding:**

- To prevent any injuries to the operator's eyes. ✓
- To protect eyes from sparks and debris. ✓
- To prevent blindness due to injury. ✓

(Any 1 x 1) (1)**2.3 Type of guards:**

- Fixed guard ✓
- Automatic sweep-away ✓
- Self-adjusting / automatic guard ✓
- Electronic presence sensing device ✓
- Two-hand control device. ✓

(Any 2 x 1) (2)**2.4 Precautions *before* gas welding operations can be undertaken:**

- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment (PPE). ✓
- Ensure that fire equipment is at hand. ✓
- Ensure that the equipment is in a safe working condition. ✓
- Ensure the gas equipment is set-up correctly. ✓
- Ensure the area is well ventilated. ✓
- Ensure that the working area is safe. ✓

(Any 3 x 1) (3)**2.5 TWO disadvantages of the product layout:**

- Lack of flexibility. ✓
- Optimum use of equipment is not possible. ✓

**(2)
[10]**

QUESTION 3: MATERIALS (GENERIC)**3.1 THREE properties:**

- Toughness ✓
- Hardness / Wear resistance ✓
- Softness ✓
- Case hardness ✓
- Ductility ✓
- Malleability ✓
- Elasticity ✓
- Brittleness ✓
- Strength ✓

(Any 3 x 1) (3)

3.2 Heat treatment processes:**3.2.1 Tempering:**

- It consists of heating the hardened steel ✓ to a temperature below its critical temperature (colour chart). ✓
- Soaking it at this temperature for a period of time, ✓
- Quenching/cooling it rapidly in water, brine or oil. ✓

(4)

3.2.2 Hardening:

- The steel is heated slightly higher than the upper critical temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in water, brine or oil. ✓

(3)

3.3 Examples of case-hardening:

- Bearing cases ✓
- Bearing ball ✓
- Bearing needles ✓
- Crankshafts ✓
- Gears ✓
- Camshafts ✓
- Cylinder sleeves ✓
- Hammer head ✓
- Jack Hammer drill bits ✓

(Any 2 x 1) (2)

3.4 Why steels are cooled down in still air away from draughts:

This prevents sudden cooling of localised spots, ✓ which might cause distortion/cracks. ✓

(2)

[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**5.1 Compression test:****5.1.1 The ignition system is disconnected:**

- To prevent a shocking hazard to the operator. ✓
- To prevent fire hazard. ✓
- Prevent any sparks / flow of current from the ignition system. ✓

(Any 2 x 1) (2)**5.1.2 All spark plugs are removed:**

- To ensure accurate readings. ✓
- To allow the engine to swing easier. ✓
- To fit the compression tester. ✓

(Any 2 x 1) (2)**5.1.3 Removing the air filter:**

- To allow maximum air flow into the cylinder. ✓
- To ensure accurate readings. ✓

(2)**5.2 Cylinder leakage tester:**

- Connect the compressed air hose from compressor to the tester. ✓
- Adjust the regulator valve knob and observe the gauge needle. ✓
- Stop turning the knob when the gauge is on 0%. ✓

(3)**5.3 Exhaust gas analyser:**

- Analyse exhaust gasses. ✓
- Indicate the amount of CO, CO₂, HC, NO_x, SO₂ and O₂. ✓
- Indicate the stoichiometric air/fuel ratio / Lambda reading. ✓

(Any 2 x 1) (2)**5.4 OBD scanners:**

- Bluetooth ✓
- Wi-Fi ✓
- Cable ✓

(3)**5.5 Static wheel balance and dynamic wheel balance:**

- Static balancing refers to the wheel's balance as it becomes stationary. ✓
- Dynamic balancing refers to the wheel's balance while in motion. ✓

(2)**5.6 Wheel imbalance:**

- The plane of imbalance / The imbalance is on the inner or outer side of the wheel. ✓
- The extent of the unbalancing forces / The mass of the balancing weights. ✓
- The sense of direction of these forces / Forces are clockwise or counter clockwise. ✓

(3)

5.7

Optical alignment:

- Look through the periscope gauge. ✓
- Align the vertical line through the triangle by moving the pointer arm. ✓
- Take the degree reading on the toe gauge. ✓
- Note if the reading is on the IN or the OUT of the scale. ✓

(4)

[23]

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

- Camshaft ✓
- Distributor ✓
- Oil pump ✓
- Water pump ✓
- Power steering pump ✓
- Air conditioner ✓
- Fan ✓
- Alternator ✓
- Supercharger ✓
- Mechanical fuel pump ✓
- Pistons ✓
- Valves / valve train ✓

(Any 3 x 1) (3)**6.2 Vibration dampers:**

6.2.1 Combined rubber and friction disc ✓ (1)

6.2.2 The friction face-type ✓ (1)

6.3 Features that improve engine balance:

- The crankshaft is carefully balanced / Counterweights on the crankshaft. ✓
- Connecting rods and pistons are kept as light as possible. ✓
- Flywheels are carefully balanced. ✓
- The mass of the reciprocating masses for each cylinder are kept as uniform as possible. ✓
- The power strokes should be spaced at equal intervals / Firing order configured for balancing. ✓
- Dual mass flywheels are fitted to the rear of the crankshaft. ✓
- Engine is fitted with crankshaft balance shafts. ✓

(Any 4 x 1) (4)**6.4 V-type engine advantages:**

- Can be mounted in smaller engine compartments. ✓
- The engine is shorter in length. ✓
- Improved power to weight ratio. ✓
- Lighter mass. ✓
- Improved fuel efficiency. ✓
- Crankshaft is less likely to twist. ✓

(Any 2 x 1) (2)

6.5 Four-cylinder firing orders:

- 1-3-4-2 ✓
- 1-2-4-3 ✓
- 1-3-2-4 ✓
- 1-4-3-2 ✓

(Any 2 x 1) (2)**6.6 Position of crankpin:**

6.6.1 • 8-cylinder ✓

(1)

6.6.2 • 3-cylinder ✓
• 6-cylinder ✓**(Any 1 x 1) (1)**6.6.3 • 4-cylinder ✓
• 2-cylinder ✓**(Any 1 x 1) (1)****6.7 Turbocharger:****6.7.1 Labelling the turbocharger:**

- A. Compressor outlet / Air outlet ✓
- B. Compressor / Compressor housing(casing) / Impeller housing(casing) ✓
- C. Turbine housing(casing)(section) ✓
- D. Exhaust gas outlet / Gas outlet ✓
- E. Exhaust gas inlet / Gas inlet ✓

(5)

6.7.2 Types of turbochargers:

- Non-variable type turbocharger ✓
- Variable geometry turbocharger (VGT) ✓
- Single turbocharger ✓
- Twin turbocharger ✓
- Twin-scroll turbocharger ✓
- Variable Twin-scroll turbocharger ✓
- Electric turbocharger ✓

(Any 2 x 1) (2)**6.7.3 Idling before turning the engine off:**

- Allows the turbo charger to slow down. ✓
- To cool down the turbo charger components. ✓
- To ensure lubrication to the turbo charger. ✓
- Prevent the oil to coke (carbon deposits). ✓

(Any 2 x 1) (2)

6.8 **Superchargers:**

- | | | |
|-------|----------------------------|-------------|
| 6.8.1 | Centrifugal supercharger ✓ | (1) |
| 6.8.2 | Roots supercharger ✓ | (1) |
| 6.8.3 | Twin-screw supercharger ✓ | (1) |
| | | [28] |

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

The volume displaced by the piston ✓ during a stroke (BDC to TDC). ✓ (2)

7.2 Work:

7.2.1 Work = Force (m × g) × distance

$$\begin{aligned}
 &= \overset{\checkmark}{(980 \times 10)} \times \overset{\checkmark}{35} \\
 &= 343000 \text{ J} \\
 &= 343 \text{ kJ} \quad \checkmark \quad (3)
 \end{aligned}$$

7.3 Cylinder:

7.3.1 A. Bore / Cylinder diameter ✓

B. Stroke length ✓ (2)

7.3.2 Swept volume:

A. 120 mm = 12 cm

B. 135 mm = 13,5 cm ✓ (for converting to cm)

$$\text{Swept volume} = \frac{\pi \times D^2}{4} \times \text{Stroke length}$$

$$\begin{aligned}
 &= \frac{\pi \times \overset{\checkmark}{12^2}}{4} \times \overset{\checkmark}{13,5} \\
 &= 1526,81 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

OR

$$\text{Swept volume} = \frac{\pi \times D^2}{4} \times \text{Stroke length}$$

$$\begin{aligned}
 &= \frac{\pi \times \overset{\checkmark}{120^2}}{4} \times \overset{\checkmark}{135} \\
 &= 1\,526\,814,03 \text{ mm}^3 \\
 &= 1\,526,81 \text{ cm}^3 \quad \checkmark \text{ (for converting to cm}^3\text{)} \quad (4)
 \end{aligned}$$

7.3.3 Compression ratio (CR):

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

$$CR = \frac{1526,81}{102,5} + 1$$

$$CR = 15,9 : 1$$

$$CR = \frac{SV + CV}{CV}$$

$$OR \quad = \frac{1526,81 + 102,5}{102,5}$$

$$= 15,9 : 1$$

(3)

7.4 Calculate Indicated power:

$$P = 1150 \text{ kPa}$$

$$L = \frac{77}{1000}$$

$$= 0,077 \text{ m}$$

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

$$= \frac{\pi \times 0,1^2}{4}$$

$$= 7,85 \times 10^{-3} \text{ m}^2$$

$$N = \frac{1800}{60 \times 2}$$

$$= 15 \text{ power strokes/sec.}$$

$$n = 4 \text{ cylinders}$$

$$\text{Indicated Power} = PLAN$$

$$= (1150 \times 10^3) \times 0,077 \times (7,85 \times 10^{-3}) \times 15 \times 4$$

$$= 41,73 \text{ kW}$$

(7)

7.5 Dynamometers to measure brake power:

- Prony brake ✓
- Electric dynamometer ✓
- Eddy current dynamometer ✓
- Hydraulic dynamometer ✓
- DC dynamometer ✓
- Rope brake ✓

(Any 2 x 1)

(2)

7.6 Calculations:**7.6.1 Torque:**

$$\begin{aligned}\text{Force} &= m \times g \\ &= 120 \times 10 \\ &= 1200\text{N} \quad \checkmark\end{aligned}$$

$$\begin{aligned}\text{radius} &= \frac{500}{1000} \\ &= 0,5\text{m} \quad \checkmark\end{aligned}$$

$$\begin{aligned}\text{Torque} &= \text{force} \times \text{radius} \\ \text{Torque} &= 1200 \times 0,5 \quad \checkmark \\ \text{Torque} &= 600\text{Nm} \quad \checkmark\end{aligned}$$

(4)

7.6.2 Brake power:

$$\begin{aligned}\text{Brake power} &= 2 \times \pi \times N \times T \\ \text{Brake power} &= 2 \times \pi \times \frac{2500}{60} \quad \checkmark \times 600 \quad \checkmark \\ \text{Brake power} &= 157,08\text{kW} \quad \checkmark\end{aligned}$$

(3)

7.6.3 Mechanical efficiency:

$$\begin{aligned}\text{Mechanical efficiency} &= \frac{\text{BP}}{\text{IP}} \times 100 \\ \text{ME} &= \frac{157,08}{196} \quad \checkmark \times 100 \\ \text{ME} &= 80,14\% \quad \checkmark\end{aligned}$$

(2)

[32]

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

- High carbon monoxide (CO) ✓
- High oxygen (O₂) ✓
- High nitrogen oxides (NO_x) ✓
- High hydrocarbon (HC) ✓

(Any 3 x 1) (3)**8.2 Cylinder leakage test:**

- Listen for hissing sound at the air intake. ✓
- Listen for hissing sound at the exhaust pipe. ✓
- Listen for hissing sound in the dipstick hole / oil filler cap. ✓
- Look for bubbles in the radiator water. ✓
- Listen for hissing sound at the adjacent cylinder spark plug hole. ✓

(Any 3 x 1) (3)**8.3 Compression test:**8.3.1 10% ✓ **(1)**

8.3.2 Variation = highestreading- lowestreading
 = 11 – 8,2 ✓
 = 2,8 bar ✓

OR

Variation = $\frac{11 - 8,2}{11}$ ✓
 = 25,5% ✓ **(2)**

8.3.3 Low Compression:

- Worn compression rings ✓
- Worn pistons ✓
- Worn cylinders ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Blown head gasket ✓
- Cracked cylinder head ✓
- Cracked cylinder ✓
- Cracked cylinder sleeves ✓

(Any 2 x 1) (2)

8.3.4 Corrective measure:

- Repair or replace cracked cylinder head. ✓
- Reset or replace or adjust the valves. ✓
- Replace cylinder head gaskets. ✓
- Replace pistons. ✓
- Repair (bore) or replace cylinder sleeves. ✓
- Replace piston rings. ✓

(Any 2 x 1)**(2)****8.4 Causes of a low oil pressure:**

- Worn oil pump. ✓
- Blocked oil pump/screen in sump. ✓
- Worn main bearings. ✓
- Worn big-end bearings. ✓
- Worn camshaft bearings. ✓
- Pressure after blocked or restricted oil filter. ✓
- Oil leaks / Insufficient oil. ✓
- Defective oil pressure relief valve. ✓
- Low viscosity. ✓
- Dirty or contaminated oil. ✓

(Any 2 x 1)**(2)****8.5 Corrective measures with oil if the oil pressure reading is high:**

- Use the correct oil grade. ✓
- Change the oil with clean oil. ✓

(2)**8.6 Pre-checks fuel pressure tester:**

- Ensure that the tester can read the pressure of the engine. ✓
- Use the right adaptor for the engine. ✓
- Ensure that the rubber pipe is not perished on the tester. ✓
- Ensure that the pressure relieve valve is working properly. ✓

(Any 3 x 1)**(3)****8.7 Cooling system pressure test:**

- Renew the gaskets or seals. ✓
- Renew the faulty water hose. ✓
- Secure water hose clamps. ✓
- Skim the cylinder head and replace cylinder head gasket. ✓
- Renew the water pump. ✓
- Renew or repair the radiator. ✓
- Renew the welch or core plugs. ✓
- Renew or repair the interior radiator. ✓
- Renew the heater tap. ✓

(Any 3 x 1)**(3)****[23]**

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)**9.1 Double-epicyclic gear system:****9.1.1 Labels:**

- A. Input shaft/Sun gear shaft ✓
- B. Brake band ✓
- C. Annulus/Ring gear ✓
- D. Planet carrier ✓
- E. Sun gear ✓
- F. Planetary gear ✓

(6)**9.1.2 Operation of this gear system:**

- Sun gears are driven by the input shaft (A). ✓
- Annulus (C) is held stationary by its brake bands (B). ✓
- Planetary gears (F) walk around sun gear (E). ✓
- The planet carrier (D) and output main shaft will rotate slowly. ✓

(4)**9.2 Torque converter function:**

9.2.1 One-way clutch on the stator ✓

(1)

9.2.2 Turbine ✓

(1)

9.2.3 Stator ✓

(1)

9.2.4 Impeller ✓

(1)**9.3 Oil used in the torque converter:**

ATF or Automatic transmission fluid ✓

(1)**9.4 Advantages of epicyclic gear trains:**

- The co-axial arrangement of input shaft and output shaft. ✓
- Load distribution is to several planetary gears. ✓
- High efficiency. ✓
- Several gear ratios can be obtained. ✓
- Longer service life compared to traditional gearboxes for similar load. ✓
- Epicyclic gearbox has a higher torque transmission capability. ✓
- Also has lower inertia. ✓
- Used to obtain higher gear ratios. ✓
- Compact in size / Lighter in design ✓
- Used to obtain variation in direction (reverse). ✓
- Provides for a variation in torque output. ✓
- Smoother operation (quieter/less vibration) compared to manual gearbox. ✓

(Any 3 x 1)**(3)****[18]**

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONIC) (SPECIFIC)**10.1 Tyre wear:****10.1.1 Over inflation:**

Excessive wear in the middle of the tyre. ✓

(1)

10.1.2 Negative camber:

Excessive wear on the inside edge or inside shoulder of the tyre. ✓

(1)

10.2 Purpose of wheel alignment angles:**10.2.1 Toe-in:**

- Toe-in is used to overcome the tendency of wheels with positive camber ✓ to point outwards. ✓
- To overcome the tendency of wheels to move outwards ✓ on a rear wheel drive vehicle. ✓

(Any 1 x 2)

(2)

10.2.2 Negative caster:

Negative caster ensures easier turning. ✓ ✓

(2)

10.3 King pin inclination:**10.3.1 Labels:**

- A. King pin inclination (angle) / KPI / Steering axis inclination (angle) / SAI ✓
- B. Steering axis centre line / King pin centre line ✓
- C. Off set ✓

(3)

10.3.2 Definition:

King pin inclination is the inward tilt ✓ of the top of the king pin. ✓

(2)

10.3.3 No ✓

(1)

10.4 Unbalanced wheels:

- Shimmy / wobble ✓
- Bounce ✓
- Vibration on steering ✓
- Poor steering control ✓
- Tyres wear away faster ✓
- Wearing out of steering arms / tie rod ends / suspension rubbers ✓

(Any 2 x 1)

(2)

- 10.5 **Air-intake sensors:**
- Throttle position sensor (TPS) ✓
 - Idle speed control (ISC) ✓
 - Manifold absolute pressure (MAP) ✓
 - Mass air flow meter (MAF) ✓
- (Any 3 x 1) (3)
- 10.6 **Function of the speed control system:**
- To control the throttle opening electronically. ✓
 - To keep the vehicle at a constant speed. ✓
- (2)
- 10.7 **Alternator:**
- 10.7.1 **Label:**
- A. Slip ring ✓
 - B. Brushes ✓
 - C. Pole pieces ✓
- (3)
- 10.7.2 **Function of the rectifier:**
- Converts alternating current (AC) ✓ to direct current (DC) ✓ used by the battery and electrical components.
- (2)
- 10.7.3 **Methods to increase the output frequency of the alternator:**
- Increase the turns of wire / windings on the stator. ✓
 - Increase the amount of magnetic poles. ✓
 - Increase the rotational frequency of the rotor. ✓
- (Any 2 x 1) (2)
- 10.8 **Catalytic converter:**
- Oxidation ✓
 - Reduction ✓
- (2)
- 10.9 **Label piezo injector:**
- A. Fuel intake/ inlet ✓
 - B. Nozzle / Spray hole / Casing ✓
- (2)
- 10.10 **Functions of the check valve:**
- It maintains the pressure in the fuel. ✓
 - Prevents vapour lock. ✓
 - Ensures easier starting. ✓
- (Any 2 x 1) (2)

[32]

TOTAL: 200