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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

NOVEMBER 2024

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 19 pages.

QUESTION 1: MULTIPLE-CHOICE (GENERIC)

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

QUESTION 2: SAFETY (GENERIC)**2.1 Horizontal band saw (Already been switched on):**

- Never leave the band saw unattended while in motion. ✓
- Switch off the band saw when leaving. ✓
- Use a brush or wooden rod to remove chips/swarf/filings. ✓
- When reaching around a revolving band saw, be careful that your clothes do not get caught in the blade. ✓
- Don't stop a revolving bandsaw blade with your hand. ✓
- Don't adjust the band saw while working. ✓
- Don't open any guard while in motion. ✓
- Keep hands away from action points. ✓
- Do not force the band saw blade into the material. ✓
- Apply cutting fluid if required. ✓
- Avoid overcrowding of persons around the machine. ✓
- Do not lean on the machine. ✓
- Check if the machine is running smoothly. ✓

(Any 2 x 1) (2)**2.2 First aid basic treatment:**

- Examination ✓
- Diagnosis ✓
- Treatment ✓

(3)**2.3 Oxygen fittings with oil and grease:**

It forms a flammable mixture. ✓

(1)**2.4 Disadvantages of the process layout:**

- Production is not always continuous. ✓
- Transportation costs between process departments may be high. ✓
- Additional time is spent in testing and sorting as the product moves to the different departments. ✓
- Damage to fragile goods may result from extra handling. ✓

(Any 2 x 1) (2)**2.5 Advantages of the product layout:**

- Handling of material is limited 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 Filing test:**

3.1.1 Files easily ✓ (1)

3.1.2 Hard to file ✓ (1)

3.1.3 Files easily ✓ (1)

3.2 Heat treatment:

It is the heating ✓ and cooling ✓ of metals under controlled conditions / as to change their properties. ✓ (3)

3.3 Heating of metal:

If metal is heated too fast, the outside of the metal becomes hotter ✓ than the inside, ✓ then it is very difficult ✓ to achieve a uniform structure. ✓ (4)

3.4 Case hardening:

- Low-carbon steel / Mild steel ✓
- Low-alloy steel ✓ (2)

3.5 Tempering:

- It is to relieve the strains ✓ induced during the hardening process. ✓
- Increase toughness. ✓✓
- Decrease brittleness. ✓✓
- Achieve a finer grain structure. ✓✓

(Any 1 x 2) (2)
[14]

QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**5.1 Compression test procedures:****5.1.1 Air filter removed:**

- To allow maximum amount of air to enter the cylinder. ✓
- To get the correct reading ✓

(Any 1 x 1) (1)**5.1.2 Clean around spark plug:**

Avoid dirt falling into the engine through the spark plug hole. ✓ (1)

5.1.3 Disconnect ignition system:

- To prevent a spark developing. ✓
- To prevent a fire hazard. ✓
- To prevent the possibility of shock. ✓

(Any 1 x 1) (1)**5.1.4 Record readings:**

- To check if there is a difference in the compression between each cylinder. ✓
- To compare the compression in all cylinders to the specification. ✓

(Any 1 x 1) (1)**5.2 Cylinder leakage tester:****5.2.1 Labels:**

- A. Pressure regulator ✓
- B. Adapter hose/pipe ✓
- C. Leakage gauge ✓

(3)

5.2.2 Unit of measurement:

kPa/Bar/PSI ✓

(1)

5.2.3 Unit of measurement:

Percentage (%) ✓

(1)

5.3 Exhaust gas analyser:

- The hot exhaust system should not be touched with the bare hand. ✓
- Perform the test in a well-ventilated area. ✓
- Keep hands and tools clear from moving engine parts. ✓
- Place the analyser in a secure position to prevent it from falling. ✓
- The inlet hose must not be restricted in any way. ✓
- The hose connections must be airtight. ✓
- Ensure no exhaust, manifolds or vacuum system leaks. ✓
- Condensate must be blown out of the hoses. ✓
- The condenser must be drained after each test. ✓
- When the paper filter becomes light grey, it should be changed. ✓
- The exhaust gas filter must be changed regularly. ✓
- Wear all necessary PPE. ✓
- Ensure that the gas analyser is safely connected to the battery. ✓

(Any 4 x 1) (4)**5.4 On-board diagnostic scanner:**

- Scan diagnostic trouble codes ✓
- Clear the trouble codes ✓
- Programme (e.g. make adjustment to electronic control unit) ✓
- Retrieve information ✓

(Any 2 x 1) (2)**5.5 Wheel balancing machine:****5.5.1 Identify:**

Wheel balancing machine ✓

(1)**5.5.2 Functions:**

- Balance a wheel dynamically. ✓
- Balance a wheel statically. ✓

(2)**5.5.3 Safety device:**

Safety cover/hood/guard ✓

(1)**5.5.4 Calibration reason:**

So that the machine can display accurate/optimum results. ✓

(1)**5.6 Measure camber with the bubble gauge:**

1. Ensure bubble gauge is on the centre of the wheel hub. ✓
2. Level bubble gauge. ✓
3. Read the CAMBER angle. ✓

(3)**[23]**

QUESTION 6: ENGINES (SPECIFIC)**6.1 Function of the crankshaft:**

To convert reciprocating motion ✓ into rotary motion. ✓

(2)

6.2 Part attached to crankshaft nose:

Vibration damper ✓

(1)

6.3 Reciprocating mass kept light:

- To reduce engine vibrations. ✓
- Less twisting force acting on the crankshaft. ✓
- The engine is able to reach its speed sooner. ✓
- Reduced rate of wear on the bore. ✓

(Any 1 x 1)

(1)

6.4 Obtain the firing order:

- Determine which valves are the inlet or which are the exhaust valves. ✓
- Turn the engine in the direction it rotates. ✓
- Observe the order in which the valves open to determine the firing order. ✓

(3)

6.5 Engine configuration:**6.5.1 Type of engine configuration:**

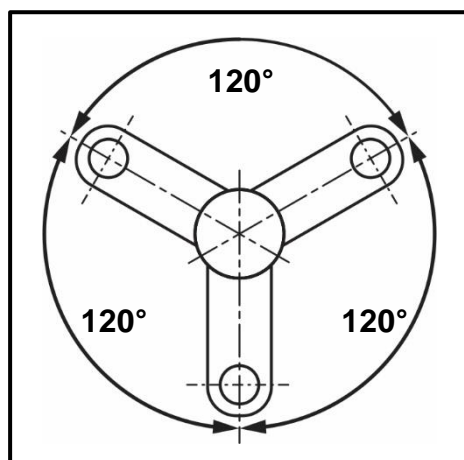
Flat engine/boxer type engine/horizontally opposed engine ✓

(1)

6.5.2 Labels:

- A. Connecting rod ✓
- B. Piston ✓
- C. Crankshaft/Crankshaft nose ✓

(3)

6.6 Crankpins of six-cylinder in-line engine:

- THREE crankpins ✓
- Position of crankpins ✓
- Angles labeled ✓

(3)

6.7 Turbochargers:**6.7.1 Advantages:**

- Increases engine torque. ✓
- Increases engine power. ✓
- Increases volumetric efficiency. ✓
- Improves fuel consumption. ✓
- No engine power sapped./Driven by exhaust gases. ✓
- Power loss due to low atmospheric pressure/high altitude eliminated. ✓
- Smaller capacity engine required for similar power output. ✓
- It is generally cheaper than a supercharger. ✓

(Any 3 x 1) (3)**6.7.2 Synthetic oil for turbochargers:**

- Can withstand high pressures. ✓
- Can withstand high temperatures. ✓
- Higher flash point. ✓
- Tends to have a low viscosity. ✓
- Capable of better cooling. ✓
- Faster flow rate. ✓

(Any 2 x 1) (2)**6.7.3 Turbocharger without vanes:**

Non-variable turbocharger ✓

(1)**6.8 Turbocharger terms:****6.8.1 Boost:**

Increase of intake manifold pressure ✓ above atmospheric pressure. ✓

(2)**6.8.2 Turbo lag:**

The delay between pressing the accelerator pedal ✓ and feeling the turbo kick in. ✓

(2)**6.9 Supercharger:****6.9.1 Identify supercharger:**

Twin-Screw supercharger ✓

(1)**6.9.2 Label supercharger:**

- A. Pulley ✓
- B. Casing/housing ✓
- C. Twin screw ✓

(3)**[28]**

QUESTION 7: FORCES (SPECIFIC)**7.1 Definition of terms:****7.1.1 Clearance volume:**

The volume of the space above the piston crown ✓ in the cylinder when the piston is at TDC. ✓

(2)

7.1.2 Compression ratio:

The relationship between the total volume ✓ and the clearance volume ✓ of a cylinder.

(2)

7.2 Calculate the work done:

Work = force × distance

$$= F \times s$$

$$= (690 \times 10) \checkmark \times 2 \checkmark$$

$$= 13800 \text{ J } \checkmark$$

$$= 13,8 \text{ kJ}$$

OR

Work = force × distance

$$= F \times s$$

$$= (690 \times 9,81) \checkmark \times 2 \checkmark$$

$$= 13537,8 \text{ J } \checkmark$$

$$= 13,54 \text{ kJ}$$

(3)

7.3 Methods to lower the clearance volume:

- Fit thinner gasket between cylinder block and cylinder head. ✓
- Fit piston with suitable higher crowns. ✓
- Machine (Skim) cylinder head. ✓
- Machine (Skim) engine block. ✓

(Any 2 x 1)

(2)

7.4 Cylinder:**7.4.1 Labels:**

A. Stroke length ✓

B. Bore/cylinder diameter ✓

(2)

7.4.2 Calculate the swept volume:

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

$$= \frac{\pi \times 8,3^2}{4} \checkmark \times 7,9 \checkmark$$

$$= 427,44 \text{ cm}^3 \checkmark$$

(3)

7.4.3 Calculate the clearance volume:

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

$$= \frac{427,44}{9 - 1} \checkmark$$

$$= 53,43 \text{ cm}^3 \checkmark$$

(3)

7.5 Calculate the indicated power:

$$P = 1400 \times 10^3$$

$$L = \frac{110}{1000}$$

$$= 0,11 \text{ m} \checkmark$$

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

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

$$= 0,00785398 \text{ m}^2 \checkmark$$

$$N = \frac{3600}{60 \times 2} \checkmark$$

$$= 30 \text{ firing strokes per second} \checkmark$$

$$IP = PLANn$$

$$= (1400 \times 10^3) \times (0,11) \times (0,00785398) \times (30) \times (4) \checkmark$$

$$= 145,14 \text{ kW} \checkmark$$

(7)

7.6 Calculations:**7.6.1 Torque:**

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

$$= 50 \checkmark \times \frac{350}{1000} \checkmark$$

$$= 17,5 \text{ Nm} \checkmark$$

(3)

7.6.2 Brake power:

$$BP = 2\pi NT$$

$$= 2 \times \pi \times \frac{2000}{60} \checkmark \times 17,5 \checkmark$$

$$= 3,67 \text{ kW} \checkmark$$

(3)

7.6.3 Mechanical efficiency:

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

$$= \frac{3,67}{145,14} \checkmark \times 100$$

$$= 2,53\% \checkmark$$

(2)

[32]

QUESTION 8: MAINTENANCE (SPECIFIC)**8.1 Exhaust gas analysis:****High carbon monoxide (CO) reading:**

8.1.1 POSSIBLE CAUSES	8.1.2 CORRECTIVE MEASURES
<ul style="list-style-type: none"> • Too rich mixture. ✓ • Dirty or restricted air filter. ✓ • Ignition misfire. ✓ • Thermostat stuck open. ✓ • Faulty coolant sensor. ✓ • Blocked PCV valve. ✓ • Faulty catalytic convertor. ✓ • Carburettor flooding. ✓ • Choke valve stuck closed. ✓ • Fuel pressure too high. ✓ 	<ul style="list-style-type: none"> • Reset/adjust the air fuel mixture. ✓ • Replace/Clean air filter. ✓ • Repair ignition misfire. ✓ • Replace thermostat. ✓ • Replace coolant sensor. ✓ • Unblock/clean/replace PCV valve. ✓ • Replace catalytic convertor. ✓ • Correct carburettor fault. ✓ • Repair choke valve. ✓ • Check and repair the return fuel line of restrictions or kinks. ✓ • Replace fuel pressure regulator ✓ • Select correct pump according to vehicle specification. ✓
(Any 1 x 1)	(Any 1 x 1)

Low carbon dioxide (CO₂) reading:

8.1.3 POSSIBLE CAUSES	8.1.4 CORRECTIVE MEASURES
<ul style="list-style-type: none"> • Incorrect air-fuel mixture. ✓ • Dirty or restricted air filter. ✓ • Ignition misfire. ✓ • Thermostat stuck open. ✓ • Faulty coolant sensor. ✓ • Blocked PCV valve. ✓ • Faulty catalytic convertor. ✓ • Carburettor flooding. ✓ • Choke valve stuck closed. ✓ • Fuel pressure too high. ✓ 	<ul style="list-style-type: none"> • Reset/ adjust the air fuel mixture. ✓ • Replace/Clean air filter. ✓ • Repair ignition misfire. ✓ • Replace thermostat. ✓ • Replace coolant sensor. ✓ • Unblock clean/replace PCV valve. ✓ • Replace catalytic convertor. ✓ • Correct carburettor fault. ✓ • Repair choke valve. ✓ • Check and repair the return fuel line of restrictions or kinks. ✓ • Replace fuel pressure regulator ✓ • Select correct pump according to vehicle specification. ✓
<ul style="list-style-type: none"> • Exhaust gas leaks. ✓ • Vacuum leaks on the intake. ✓ 	<ul style="list-style-type: none"> • Repair exhaust leaks. ✓ • Repair vacuum leaks on the intake. ✓
(Any 1 x 1)	(Any 1 x 1)

(4)

8.2 Compression test:

8.2.1 **Maximum variation allowed:**
10% ✓

(1)

8.2.2 **Low compression reading:**

POSSIBLE CAUSES	CORRECTIVE MEASURES
• Worn rings. ✓	• Fit new rings. ✓
• Worn piston. ✓	• Fit new pistons. ✓
• Worn bore. ✓	• Re-bore the cylinders or resleeve. ✓
• Leaking inlet valve. ✓	• Replace or lap valve. ✓
• Leaking exhaust valve. ✓	• Replace or lap valve. ✓
• Blown head gasket. ✓	• Replace head gasket. ✓
• Cracked cylinder head. ✓	• Replace or repair cylinder head. ✓
• Cracked engine block. ✓	• Replace engine block. ✓
(Any 1 x 1)	(Any 1 x 1)

(2)

8.3 Cylinder leakage test locations:

- Exhaust pipe/system ✓
- Intake system ✓
- Oil filler hole ✓
- Dipstick ✓
- Expansion tank/radiator ✓
- Adjacent spark plug hole ✓

(Any 4 x 1) (4)

8.4 Causes of a low oil pressure reading:

- Blocked strainer ✓
- Worn oil pump ✓
- Oil viscosity too low ✓
- Dirty oil ✓
- Low oil level ✓
- Blocked oil filter ✓
- Blocked oil channels ✓
- Excessive oil clearances ✓
- Defective pressure relief valve ✓

(Any 4 x 1) (4)

8.5 High fuel pressure reading:

POSSIBLE CAUSES	CORRECTIVE MEASURES
• Restriction in the return fuel line post the fuel tester. ✓	• Check and repair the return fuel line of restrictions or kinks. ✓
• Faulty fuel pressure regulator. ✓	• Replace fuel pressure regulator. ✓
• Wrong fuel pump used. ✓	• Select correct pump according to vehicle specification. ✓
(Any 2 x 1)	(Any 2 x 1)

(4)

8.6 **Cooling system pressure test manufacturers' specifications:**

- Coolant (Antifreeze-water) ratio. ✓
- Pressure in the cooling system. ✓
- Pressure on the radiator cap. ✓

(Any 2 x 1) (2)

8.7 **Functions of the radiator cap:**

- Regulate the cooling system pressure. ✓
- Seals the cooling system from leaks. ✓
- Allows coolant to be drawn back into the radiator when engine cools down. ✓

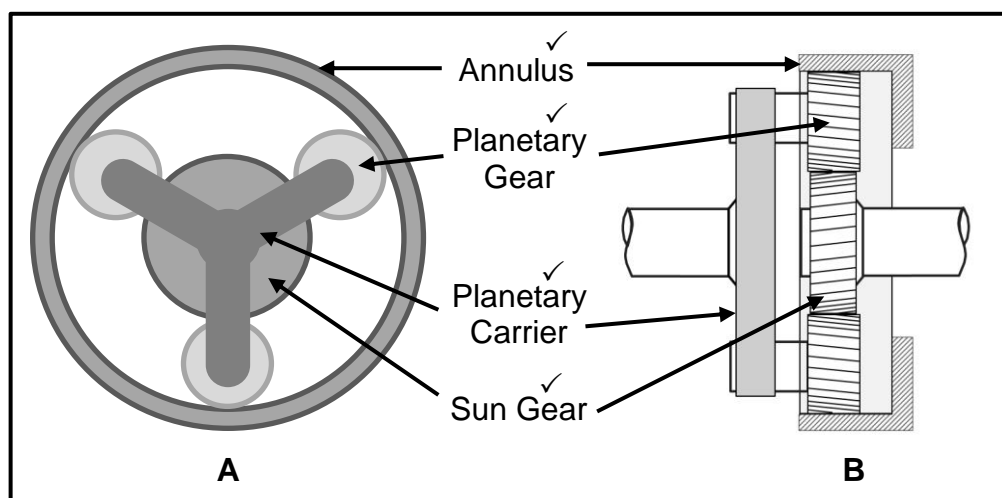
(Any 2 x 1) (2)
[23]

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

- More expensive to manufacture. ✓
- Repairs are expensive. ✓
- Special tools and training needed to repair gearbox. ✓
- Special towing techniques must be used when towed over a long distance. ✓
- Generally heavier than a manual gearbox. ✓
- Vehicle cannot be push-started. ✓

(Any 2 x 1) (2)**9.2 Torque converter operation:**

- The spinning pump/impeller throws the oil into the vanes of the turbine. ✓
- This turbine rotates the gearbox input shaft. ✓
- The oil circulates through the turbine vanes and strikes the stator. ✓
- The stator redirects the path of the oil in the direction of pump rotation. ✓
- Torque is multiplied when it leaves the pump again to enter the turbine. ✓

(5)**9.3 Single epicyclic gear system:**

- Complete sketch ✓

Candidate may draw either sketches **A** or **B**.**(5)****9.4 Advantages of gear ratios:****9.4.1 Forward reduction (1st gear):**

- Improved pull away of vehicle. ✓
- Increased torque output. ✓
- Easier hill climbing. ✓

(1)**9.4.2 Reverse gear:**

Vehicle is able to travel backwards. ✓

(1)

9.4.3 Forward overdrive (5th gear):

- Increase speed ✓
- Decrease engine revolutions ✓
- Better fuel economy ✓

(Any 1 x 1) (1)**9.5 Components relating to an automatic gearbox:****9.5.1 Hydraulic pistons:**

- Control the brake bands which allows for the change of gear ratio. ✓
- Engage the clutches which allows for the change of gear ratio. ✓

(Any 1 x 1) (1)**9.5.2 Brake bands:**

The brake band holds the annulus stationary. ✓

(1)**9.5.3 Transmission control unit:**

It controls the electronic gear shifting in an automatic gearbox. ✓

(1)**[18]**

QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONIC) (SPECIFIC)**10.1 Tyre wear pattern:****10.1.1 Cause the tyre wear pattern:**

Camber ✓

(1)

10.1.2 Faults on the vehicle suspension:

- Suspension misalignment ✓
- Worn wheel bearings ✓
- Bent strut ✓
- Bent/Damaged lower control arms ✓
- Damaged lower control arms bushes ✓
- Damaged strut mountings ✓
- Worn ball joints ✓

(Any 2 x 1) (2)

10.1.3 Correct tyre wear cause:

- Re-align suspension ✓
- Replace wheel bearings ✓
- Replace strut ✓
- Replace lower control arm ✓
- Replace lower control arm bushes ✓
- Replace strut mountings ✓
- Replace ball joints ✓

(Any 2 x 1) (2)

10.2 Definitions of alignment angles:**10.2.1 Positive caster:**Positive caster is the backward tilt of the king pin at the top, ✓
when viewed from the side. ✓

(2)

10.2.2 King pin inclination:King pin inclination is the inward tilt of the top ✓ of the king pin
viewed from the front. ✓

(2)

10.3 Air-intake system sensors:

- Throttle position sensor (TPS) ✓
- Manifold absolute pressure sensor (MAP) ✓
- Mass air flow sensor (MAF) ✓
- Air intake temperature sensor. ✓

(Any 3 x 1) (3)

10.4 Function of knock sensor:

- Senses engine knock. ✓
- Sends signal to the ECU. ✓

(2)

- 10.5 **Components of Distributorless Ignition System (DIS):**
- ECU ✓
 - Integrated coil ✓
 - Spark plug ✓
 - Ignition switch ✓
 - Crankshaft position sensor ✓
- (Any 2 x 1) (2)**
- 10.6 **Catalytic convertor:**
- Oxidation ✓
 - Reduction ✓
- (2)**
- 10.7 **Functions of the speed control system:**
- Controls the throttle opening electronically. ✓
 - Keeps the vehicle at a constant speed. ✓
- (2)**
- 10.8 **Alternator:**
- 10.8.1 **Labels:**
- A. Pulley ✓
 - B. Front bracket/Front cover/housing ✓
 - C. Bearing ✓
 - D. Stator ✓
- (4)**
- 10.8.2 **Rotor:**
- Contains the slip rings ✓ which provides a movable electrical connection. ✓
 - Induces current ✓ flow into the stator. ✓
 - To create a rotating ✓ magnetic field/electromagnet. ✓
- (Any 1 x 2) (2)**
- 10.8.3 **Regulator:**
- Controls voltage ✓
 - Controls current flow ✓
- (Any 1 x 1) (1)**
- 10.8.4 **Function of the rectifier:**
- Converts the AC ✓ to DC. ✓
- (2)**

10.9

Injector:

- The fuel pressure at the injector ✓
- Injection duration ✓
- Size of the injector nozzle hole/orifice ✓
- Throttle position ✓
- Amount of atmospheric pressure ✓
- Ambient temperature ✓
- Air-fuel ratio ✓
- Engine load ✓
- Engine speed (RPM) ✓
- Fuel type ✓
- Engine temperature ✓
- Fuel temperature ✓

(Any 3 x 1)**(3)****[32]****TOTAL:****200**