basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

NOVEMBER 2021

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 21 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1 .B ✓ (1)

1.2 A ✓ (1)

1.3 D ✓ (1)

1.4 A / C ✓ (1)

1.5 A ✓ (1)

1.6 C ✓ (1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 **First-aid applications to an open wound:**

- Use surgical gloves. ✓
- Do not remove anything that is stuck to the wound. ✓
- Never use sticky plaster on the wound. ✓
- Cover the wound with a clean, lint-free cloth. ✓
- Avoid using any oily substances or lotions on wounds. ✓
- If necessary, cool wounds with cold water. ✓
- Apply pressure to prevent blood loss if necessary. ✓
- Avoid contact with blood from patient. ✓
- If the wound is on your arm, raise the arm above your head to stop the bleeding. ✓

(Any 2 x 1) (2)

2.2 **Surface grinder: (Already switched on**)

- Never leave the grinder unattended. ✓
- Switch off the machine when leaving. ✓
- Don't try to stop revolving emery wheel with your hand. ✓
- Don't adjust the machine while working. ✓
- Don't open any guard while the machine is on. ✓
- Do not force the grinding wheel on to the work piece. ✓
- Approach the work piece slowly and evenly. ✓
- Don't clean the machine while working. ✓
- Do not put hands near the work piece when grinder is in motion. ✓
- Don't clean or adjust the machine while working.✓
- Check for oil on the floor <u>while working</u> (spilling of cutting fluid on floor while working) ✓
- Check that the grinding wheel is running evenly. ✓

(Any 2 x 1) (2)

2.3 **Gauges calibrated:**

- To ensure accurate readings. ✓
- To prevent overloading. ✓

(Any 1 x 1) (1)

2.4 **Finger protectors' hazards on power driven guillotines:**

- The finger protector prevents the hazards of getting the fingers cut by the blades. ✓
- To be crushed by the hold-downs. ✓ (2)

2.5 **Welding or flame cutting operation safety:**

- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment. ✓
- Ensure that all equipment is in safe working condition. ✓
- Ensure that here are no flammable materials around the welding area. ✓
- Weld area must be well ventilated. ✓
- Fire extinguisher must be in close proximity. ✓

(Any 2 x 1) (2)

2.6 **Workshop layout:**

Product layout. ✓ (1)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **File test:**

3.1.1 Difficult ✓ (1)

3.1.2 Easy ✓ (1)

3.1.3 Difficult ✓ (1)

3.2 **Heat treatment:**

A. – Grain growth. ✓
B. – Recrystallisation. ✓
C. – Recovery. ✓ (3)

3.3 **Bending test:**

- Bend the test piece through a specific angle or around a mandrel or bar, ✓ having a defined radius, ✓ until a rupture in the metal occurs.✓
- Place the material in a vice and bend it ✓ then observe ✓ the ductility of the material. ✓

(Any 1 x 3) (3)

3.4 **Purpose of case hardening:**

Creates a hard surface ✓ with a tough core. ✓ (2)

3.5 **Quenching media for hardening:**

- Water ✓
- Brine (saltwater) ✓
- Oil ✓
- Soluble oil and water ✓
- Nitrogen air-infused air ✓

(Any 3 x 1) (3)
[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

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QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1 **Compression test: (Please note that if one step is missing and others still follow the sequence, marks can still be allocated accordingly) 5.1.1 – 5.1.4**

- Completely open the throttle valve. ✓ (1)
- Crank the engine until maximum pressure is reached (normally 4 to 10 revolutions)/needle stops moving. ✓ (1)
- Read the pressure that the piston created, off the gauge. ✓ (1)
- Move on to the next cylinders/Compare the readings of all the cylinders to the manufacturer's specification's readings/Compare readings with each other. ✓ (1)

5.2 **Cylinder leakage tester:**

5.2.1 **Labelling:**
A - Leakage meter / gauge ✓
B - Control valve ✓
C - Flexible hose / pipe / tube ✓
D - Spark plug connector / adaptor ✓ (4)

5.2.2 **Unit of measure:**
Percentage or % ✓ (1)

5.3 **Exhaust gas analyser:**

- Water trap ✓
- Paper filter ✓
- Condenser ✓

(Any 2 x 1) (2)

5.4 **Set up of the on-board diagnostics (OBD) scanner:**

- Plug the on-board diagnostics (OBD) scanner into the connector. ✓
- Turn on the ignition but do not start the car. ✓
- Enter the vehicle information as required by the scanner. ✓
- Select correct system to scan (diagnostics) ✓

(Any 3 x 1) (3)

5.5 **Wheel balancer:**

5.5.1 Wheel balancer ✓ (1)

5.5.2 **Function of the wheel balancer:**
To balance wheels / statically / dynamically. ✓ (1)

5.5.3 **Safety feature:**
Wheel safety cover / guard / hood ✓ (1)

5.6 **Wheel alignment angles:**

- Caster ✓
- Camber ✓
- King pin inclination (KPI) / steering axis ✓ (3)

5.7 **Wheel alignment precautions:**

- Ensure the wheels are in a straight-ahead position ✓
- Ensure the steering box is on its high spot. ✓
- Centralise the steering wheel. ✓
- Lock the steering wheel in place. ✓
- Lock the brake pedal. ✓
- Check tire and rim condition. ✓
- Check tyre pressure and size. ✓
- Calibrate / zero the equipment before it is fitted to the wheels. ✓

(Any 3 x 1) (3)

[23]

QUESTION 6: ENGINES (SPECIFIC)

6.1 **Crankshaft firing order:**

- To overcome the twisting effect of the power stroke on the crankshaft. ✓
- To reduce vibrations on the crankshaft. ✓
- Increase the lifespan of the crankshaft. ✓
- To improve engine cooling evenly throughout the engine. ✓

(Any 3 x 1) (3)

6.2 **Crankshaft dynamic imbalance:**

- Fit balance mass pieces to the crank webs. ✓
- Remove metal from the crank webs. ✓
- Arrange the crank webs on opposite sides of the crank pins. ✓
- Add a vibration damper. ✓

(Any 2 x 1) (2)

6.3 **Engine vibration:**

- The varying quantity of torque / low compression produced on power strokes. ✓
- The crankshaft alternately winding up and releasing as it rotates. ✓
- The crankshaft also has its own natural frequency of vibration. ✓
- The coinciding of different dynamic imbalances could produce excessive vibration called resonance. ✓
- The torsional/twisting effect of the power strokes upon the crankshaft. ✓
- The crankshaft is not statically balanced. ✓
- The crankshaft is not dynamically balanced. ✓
- The flywheel is not statically balanced. ✓
- The flywheel is not dynamically balanced. ✓
- The reciprocating mass is not balanced. ✓
- Faulty vibration damper. ✓
- Engine misfire. ✓
- Incorrect air/fuel ratio.
- Improper tightened / loose engine components. ✓
- Worn parts.✓

(Any 4 x 1) (4)

6.4 **Power Impulses:**

6.4.1 180° ✓ (1)

6.4.2 144° ✓ (1)

6.4.3 120° ✓ (1)

6.4.4 90° ✓ (1)

6.5 **Roots supercharger:**

6.5.1 **Labels:**
A – Casing / housing ✓
B – Air inlet / fill side ✓
C – Rotor ✓ (3)

6.5.2 **Operation of the Roots supercharger:**
- The engine drives the rotors by means of gears, belt or a chain. ✓
- Two symmetrical rotors spin. ✓
- Trapped air, between the rotors and casing, is pushed from the inlet side to the discharge side. ✓
- Large quantities of air move into the intake manifold. ✓
- This creates increased pressure in the cylinder. ✓ (5)

6.6 **Variable geometry turbocharger:**

6.6.1 **Function of intercooler:**
- Intercooler is used to cool air ✓ that has been compressed by a turbocharger ✓
- It reduces the volume ✓ and increases the density of the air. ✓
- Improving ✓ volumetric efficiency. ✓

(Any 1 x 2) (2)

6.6.2 **Function of vanes:**
Vanes alter the air flow path of the exhaust gases ✓ to optimize the turbine speed. ✓ (2)

6.7 **Advantages of a supercharger over a turbocharger:**
- Does not suffer lag. ✓
- It is more efficient at lower r/min. ✓
- Simpler installation. ✓
- Cheaper to service and maintain. ✓
- Does not always need an intercooler. ✓
- No special lubrication required. ✓

(Any 3 x 1) (3)
[28]

QUESTION 7: FORCES (SPECIFIC)

7.1 **Definitions:**

7.1.1 **Brake power:**
Brake power is the useable power / actual power / output power ✓ developed at the flywheel or at the drive wheels. ✓ (2)

7.1.2 **Torque:**
- Torque is the twisting effort / force ✓ on a shaft or wheel. ✓
- Torque is the twisting effort / force ✓ measured over the applied radius. ✓

(Any 1 x 2) (2)

7.2 **Indicated power diagram:**
- Compression stroke - pressure rise / increase. ✓
- Power stroke - pressure drop / decrease. ✓ (2)

7.3 **Calculations:**

7.3.1 $\mathbf{V_1}$ - Clearance volume ✓ (1)

7.3.2 $\mathbf{V_2}$ - Swept volume ✓ (1)

7.3.3 **Cylinder volume:**

$$330\,\text{ml} = 330\,\text{cm}^3 \checkmark$$

$$\text{Total cylinder volume} = V_1 + V_2$$
$$= 39 + 330 \checkmark$$
$$= 369\,\text{cm}^3 \checkmark$$ (3)

7.3.4 **Bore diameter in mm:**

$$\text{Swept Volume} = \frac{\pi D^2}{4} \times L$$
$$D^2 = \frac{SV \times 4}{\pi \times L} \checkmark$$
$$= \frac{330 \times 4}{\pi \times 6{,}5} \checkmark$$
$$D = \sqrt{64{,}641} \checkmark$$
$$= 8{,}04\,\text{cm} \checkmark$$
$$= 80{,}4\,\text{mm} \checkmark$$

(5)

7.3.5 **Compression ratio:**

$$CR = \frac{\text{Total cylinder volume}}{\text{Clearance volume}}$$
$$= \frac{369}{39} \checkmark$$
$$= 9.46$$
$$= 9{,}5:1 \checkmark$$ (2)

7.4 **Methods to lower the compression ratio:**

- Fit thicker gasket between cylinder block and cylinder head. ✓
- Fit pistons with suitable lower crowns. ✓
- Fit crankshaft with shorter stroke. ✓
- Fit suitable shorter connecting rods. ✓
- Re-sleeve to a smaller bore size. ✓
- Fit a shim between the cylinder head and engine block. ✓

(Any 2 x 1) (2)

7.5 **Calculations:**

7.5.1 **Torque:**

$$BP = \frac{2\pi NT}{60}$$

$$T = \frac{BP}{2\pi N} \checkmark$$

$$= \frac{48\,000 \times 60}{2 \times \pi \times 6\,500} \checkmark$$

$$= 70{,}52\ N.m \checkmark$$

(4)

7.5.2 **Indicated power in kW:**

$$L \times A = Volume$$

$$= 580{,}7\ cm^3$$

$$= 580{,}7 \times 10^{-6}\ m^3 \checkmark$$

$$N = \frac{6\,500}{60 \times 1} \checkmark$$

$$= 108{,}33\ power\ stroke/sec \checkmark$$

$$IP = PLANn$$

$$= 450 \times 10^3 \times 580{,}7 \times 10^{-6} \times 108{,}33 \times 2 \checkmark$$

$$= 56\,618{,}25\ W \checkmark$$

$$= 56{,}62\ kW \checkmark$$

(6)

7.5.3 **Mechanical efficiency:**

$$\text{Mechanical Efficiency } (\eta) = \frac{BP}{IP} \times 100$$

$$= \frac{48}{56{,}62} \times 100 \checkmark$$

$$= 84{,}78\% \checkmark$$

(2)
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QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 **Low CO_2 exhaust gas reading:**

8.1.1 **Possible causes:**

- Too rich air/fuel mixture. ✓
- Ignition misfire / Blown cylinder head or block. ✓
- Dirty or restricted air filter. ✓
- Improper operation of the fuel delivery system / Excessive fuel delivery pressure. ✓
- Faulty thermostat or coolant sensor. ✓
- Faulty PCV valve system. ✓
- Catalytic converter not working. ✓
- Exhaust system leaks ✓

(Any 2 x 1) (2)

8.1.2 **Corrective measures:**
Note: The answer for 8.1.2 must correspond with the causes mentioned in 8.1.1.

- Reset fuel mixture. ✓
- Correct cause of misfire / Replace cylinder head or block. ✓
- Replace air filter. ✓
- Correct fuel delivery system pressure. ✓
- Repair or replace thermostat or coolant sensor. ✓
- Repair PCV system. ✓
- Repair or replace catalytic converter. ✓
- Repair exhaust system. ✓

(Any 2 x 1) (2)

8.2 **Indicate lean air/fuel mixture:**

- High oxygen (O_2). ✓
- High carbon dioxide (CO_2). ✓
- High nitrogen oxide (NO_x). ✓

(Any 2 x 1) (2)

8.3 **Cylinder leakage test:**

8.3.1 **Hissing sound at the exhaust pipe:**

Cause	Corrective measure
• Leaking exhaust valve ✓	• Replace the exhaust valve ✓ • Re-seat (lap) the exhaust valve ✓ • Adjust exhaust valve clearance ✓ **(Any 1 x 1)**

(2)

8.3.2 **Bubbles in the radiator water:**

Cause	Corrective measure
• Blown cylinder head gasket ✓	• Skim the cylinder head ✓ • Skim the engine block ✓ • Replace cylinder head gasket ✓
• Cracked cylinder head ✓ • Cracked cylinder block ✓ **(Any 1 x 1)**	• Replace cylinder head ✓ • Replace cylinder block ✓ **(Any 1 x 1)**

(2)

8.4 **Engine temperature:**
To allow the expansion of the components ✓ to obtain accurate readings. ✓ (2)

8.5 **Fuel pressure test:**

8.5.1 Replace fuel filter ✓ (1)

8.5.2
- Cracked fuel line ✓
- Restricted / blocked fuel line ✓

(Any 1 x 1) (1)

8.5.3
- Clean the strainer ✓
- Replace the strainer ✓

(Any 1 x 1) (1)

8.5.4
- Incorrect / Low voltage to the fuel pump ✓
- Pump speed is slow ✓
- Pump is not operational ✓

(Any 1 x 1) (1)

8.6 **Oil pressure test:**

- Oil pressure when engine is idling. ✓
- Oil pressure when engine is cold. ✓
- Oil pressure when engine is hot. ✓
- Oil pressure when engine is at high revolutions. ✓

(Any 3 x 1) (3)

8.7 **Radiator cap pressure test:**

- Obtain the radiator cap's opening pressure specifications (stamped on the cap). ✓
- Install the cap onto the adapter of the cooling system pressure tester. ✓
- Pump up the tester while watching the pressure gauge. ✓
- Note the reading when the pressure is released. ✓ (4)

[23]

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

9.1 **Torque converters:**

9.1.1 **Torque converter labels:**

A. Turbine ✓
B. Casing / housing ✓
C. Pump / Impeller ✓
D. Turbine shaft / output shaft ✓
E. Stator ✓ (5)

9.1.2 **Functions of torque converters:**

- Multiplies engine torque automatically according to road and engine speeds. ✓
- Transfers drive from the engine to the transmission. ✓
- Acts as a flywheel to keep the engine turning during the idle strokes. ✓
- Slips during initial acceleration and while stopping to prevent stalling. ✓
- Dampens torsional vibrations of the engine. ✓
- Wheel spin is greatly reduced. ✓
- Drive the transmission oil pump. ✓
- Contributes toward smooth gear changing. ✓

(Any 3 x 1) (3)

9.1.3 **Maximum torque multiplication:**

- When there is the largest speed difference ✓ between the impeller and turbine. ✓
- Maximum torque multiplication occurs at rest, ✓as the vehicle just starts to move. ✓

(Any 1 x 2) (2)

9.2 **Epicyclic gear train: (forward overdrive)**

- The sun gear is locked ✓ with the planet carrier as driving ✓ member and the annulus as driven component. ✓
- The annulus is locked ✓ with the planet carrier as driving ✓ member and the sun gear is the driven component. ✓

(Any 1 x 3) (3)

9.3 **Gearshift lever positions:**

9.3.1 P – park ✓ (1)

9.3.2 R – reverse ✓ (1)

9.3.3 D – drive ✓ (1)

9.4 P ✓
N ✓ (2)
[18]

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

10.1 **Reasons for wheel alignment:**

To achieve:

- desirable steering / Drive with least resistance. ✓
- easier steering control. ✓
- better tracking. ✓
- minimal vibrations. ✓
- even road-holding. ✓
- increase tyre life. ✓
- Checking of the camber angle. ✓
- Checking of the kingpin inclination. ✓
- Checking of the castor angle.✓
- Checking of the toe-out / toe-in. ✓
- Less fuel consumption. ✓

(Any 3 x 1) (3)

10.2 **Camber:**

10.2.1 **Camber wear causes:**

- Suspension misalignment. ✓
- A bent strut. ✓
- Dislocated strut tower. ✓
- A weak or broken spring. ✓
- A bent stub axle. ✓
- Collapsed or damaged control arm bushings. ✓
- Worn upper strut bearing. ✓
- Bent control arms. ✓
- Improper wheel alignment setting. ✓
- Damaged / worn ball joints. ✓

(Any 4 x 1) (4)

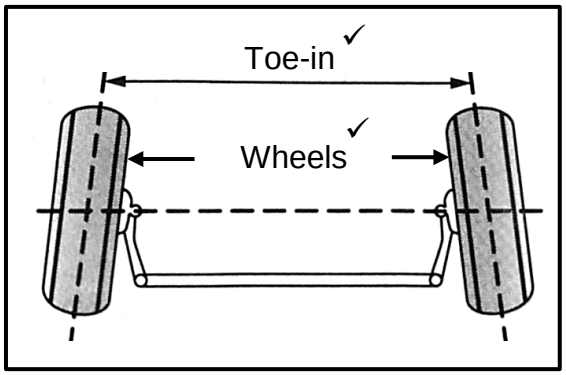
10.2.2 **Positive camber angle:**

Positive camber angle refers to the outward tilt ✓ of the top of the wheel. ✓ (2)

10.2.3 **Camber adjustment:**

Camber is adjusted by means of a cam / wedge bolts ✓ or wedge plates (shims) ✓ on the suspension. (2)

10.3 **Toe-in:**



✓ (Drawing)

(3)

10.4 **Effects of wheel imbalances:**

- Wheel shimmy (wobble). ✓
- Wheel bounce (hop). ✓
- Uneven tyre wear. ✓
- Premature wheel bearing failure. ✓
- Rapid tyre wear. ✓
- Increased friction between road surface and the tyre. ✓

(Any 2 x 1) (2)

10.5 **Types of injectors:**

- Solenoid injector ✓
- Piezo injector ✓ (2)

10.6 **Purpose of the diesel particulate filter:**

It is a filter that converts particulate matter or soot ✓ into ash. ✓ (2)

10.7 **The headway sensor:**

- The headway sensor detects an obstruction ahead of a vehicle. ✓
- The headway sensor will send a signal to the ECU. ✓ (2)

10.8 **The alternator:**

10.8.1 **Component:**

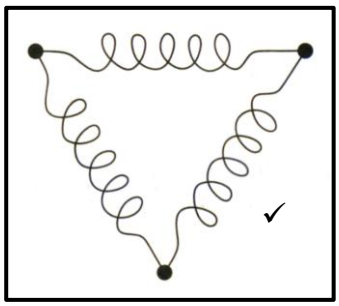
Stator ✓ (1)

10.8.2 **Stator function:**

- It provides a coil ✓ into which a voltage is induced, ✓
- Converts the rotating magnetic field ✓ to electric current. ✓

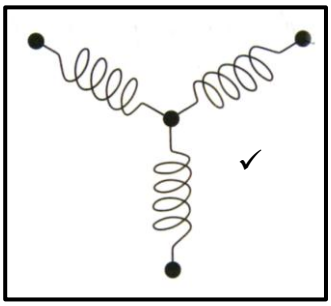
(Any 1 x 2) (2)

10.8.3 **Stator windings:**



Delta connected stator windings ✓ (2)

10.8.4 **Stator windings:**



Star or Y connected stator windings ✓ (2)

10.9 **Advantages of an electric fuel pump:**

- Immediate/quicker supply of fuel when the ignition switch is turned on. ✓
- Low sound during operation. ✓
- Less discharge pulsation of fuel. ✓
- Compact and light design. ✓
- Able to prevent internal fuel leaks and vapour lock. ✓
- Can be fitted within any location on the fuel line. ✓

(Any 3 x 1) (3)

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TOTAL: 200