basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

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MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 18 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

1.1   A ✓   (1)

1.2   C ✓   (1)

1.3   A ✓   (1)

1.4   B ✓   (1)

1.5   D ✓   (1)

1.6   A ✓   (1)

TOTAL QUESTION 1:   [6]

QUESTION 2: SAFETY (GENERIC)

2.1 **Angle grinder: (Before using)**
- The safety guard must be in place before starting. ✓
- Protective shields must be placed around the object being grinded to protect the people around. ✓
- Use the correct grinding disc for the job. ✓
- Make sure that there are no cracks in the disc before you start. ✓
- Protective clothing and eye protection are essential. ✓
- Check electrical outlets and cord/plugs for any damages. ✓
- Ensure that lockable switch is disengaged. ✓
- Ensure that the disc and the nut are well secured. ✓
- Ensure that the removable handle is secured. ✓
- Remove all flammable material from the area. ✓
- Secure the work piece. ✓

(Any 2 x 1) (2)

2.2 **Welding goggles:**
- To protect your eyes against sparks ✓
- To protect your eyes against heat ✓
- To be able to see where to weld ✓
- To protect your eyes from UV rays / bright light ✓
- To protect your eyes from smoke ✓

(Any 2 x 1) (2)

2.3 **PPE for Hydraulic press:**
- Overall ✓
- Safety shoes ✓
- Safety goggle ✓
- Leather gloves ✓
- Leather apron ✓
- Face shield ✓

(Any 2 x 1) (2)

2.4 **Workshop layouts:**
- Process layout ✓
- Product layout ✓

(2)

2.5 **Employer's responsibility regarding first-aid:**
- Provision of first-aid equipment ✓
- First aid training ✓
- First-aid services by qualified personnel ✓
- Any first aid procedures ✓
- Display first aid safety signs ✓
- First aid personnel must be identified by means of arm bands or relevant personal signage ✓

(Any 2 x 1) (2)

TOTAL QUESTION 2: [10]

QUESTION 3: MATERIALS (GENERIC)

3.1 **Bending test:**
- Ductility ✓✓
- Malleability ✓✓
- Brittleness ✓✓
- Flexibility ✓✓

(Any 1 x 2) (2)

3.2 **Heat-treatment:**

3.2.1 **Annealing:**
- To relieve internal stresses ✓
- To soften the steel ✓
- To make the steel ductile ✓
- To refine the grain structure of the steel ✓
- To reduce the brittleness of the steel ✓

(Any 2 x 1) (2)

3.2.2 **Case hardening:**
- To produce a wear resistant surface ✓ and it must be tough enough internally ✓ at the core to withstand the applied loads.
- Hard case ✓ and tough core. ✓

(Any 1 x 2) (2)

3.3 **Tempering process:**
- To reduce ✓ the brittleness ✓ caused by the hardening process.
- Relieve ✓ strain ✓ caused during hardening process.
- Increase ✓ the toughness ✓ of the steel.

(Any 1 x 2) (2)

3.4 **Factors for heat-treatment processes:**
- Heating temperature / Carbon content ✓
- Soaking (Time period at temperature) / Size of the work piece ✓
- Cooling rate / Quenching rate ✓

(3)

3.5 **Hardening of steel:**
- Steel is heated to 30 – 50°C above the higher critical temperature. (AC_3) ✓
- It is then kept at that temperature to ensure (soaking) that the whole structure is Austenite. ✓
- The steel is then rapidly cooled by quenching it in clean water, brine or oil. ✓

(3)

TOTAL QUESTION 3: **[14]**

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

4.1   C ✓   (1)

4.2   B ✓   (1)

4.3   D ✓   (1)

4.4   D ✓   (1)

4.5   A ✓   (1)

4.6   C ✓   (1)

4.7   A ✓   (1)

4.8   D ✓   (1)

4.9   A / C ✓   (1)

4.10   A ✓   (1)

4.11   D ✓   (1)

4.12   D ✓   (1)

4.13   A ✓   (1)

4.14   A ✓   (1)

TOTAL QUESTION 4:   [14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1 **Equipment:**

    5.1.1 Compression tester ✓ (1)

    5.1.2 A – Flexible piping / hose / tubing ✓
            B – Adaptor screw / Fitting / Attachment / Connector ✓
            C – Gauge ✓
            D – Pressure release valve ✓ (4)

    5.1.3 **Compression Tester:**
            It measures the pressure created, ✓ when the piston is at top dead centre on power stroke. ✓ (2)

5.2 **Cylinder leakage:**
To check whether the engine leaks gases ✓ from the cylinder during the compression stroke. ✓ (2)

5.3 **Gas Analyser:**
- To ensure ✓ an accurate reading. ✓
- To prevent ✓ a lean reading. ✓

                                      (Any 1 x 2) (2)

5.4 **Function of a computerized diagnostic scanner:**
- Scans all systems ✓ on the vehicle.
- Informs what adjustments can be made after diagnosis ✓

                                        (Any 1 x 1) (1)

5.5 **Bubble gauge camber procedure:**
- Mount the bubble gauge on to the straightened wheel ✓
- Zero the bubble gauge at the gauge zero scale ✓
- Take the reading on the camber scale ✓
- Do the same for the other wheel ✓ (4)

5.6 **Dynamic balance on wheels:**
- The plane of imbalance ✓
- The extent of the unbalancing forces ✓
- The sense of direction of these forces (clockwise or counter-clockwise) ✓
- Determine the location of weight placement ✓
- Magnitude of the weights ✓
- The run-out of the tyre and wheel assembly ✓

                                        (Any 3 x 1) (3)

5.7 **Purpose of turn tables:**
To make it possible to turn ✓ the front wheels in or out ✓ to check ✓ the wheel angles. ✓ (4)

                                  TOTAL QUESTION 5: **[23]**

QUESTION 6: ENGINES (SPECIFIC)

6.1 **Static balancing of the crankshaft:**
The crankshaft is in static when the mass in all directions ✓ from the centre of rotation is equal while it is at rest. ✓ (2)

6.2 **Cylinder layouts:**

6.2.1 V - engine layout ✓ (1)

6.2.2 In line (straight) engine layout ✓ (1)

6.3 **Firing order in an engine:**
- By removing the tappet cover and determining which are intake valves and which are exhaust valves ✓
- Rotating the engine in the direction in which it turns. ✓
- Watch the order in which one set of valves, inlet or exhaust operates ✓
- This will give the order in which the inlet stroke or exhaust stroke occurs ✓
- The power strokes occur in the same order ✓

OR

- Cylinder 1 must be at TDC on power stroke ✓
- Remove the distributor cap ✓
- Ensure to turn the engine in the correct direction of rotation ✓
- Determine the direction of rotation of the rotor ✓
- Trace the firing order by the HT leads ✓

(Any 1 x 5) (5)

6.4 **Firing order of engines:**

6.4.1 **Four cylinder in-line engine:**
- 1,3,4,2; or ✓
- 1,2,4,3 ✓

(Any 1 x 1) (1)

6.4.2 **V6-cylinder engine:**
- 1,4,2,5,3,6 ✓
- 1,2,3,4,5,6 ✓
- 1,6,5,4,3,2 ✓
- 1,4,5,6,3,2 ✓

(Any 1 x 1) (1)

6.5 **Turbo charger:**

6.5.1 **Turbocharger:**
A – Compressor air inlet ✓
B – Turbine housing ✓
C – Turbine exhaust gas outlet ✓
D – Turbine wheel ✓
E – Turbine exhaust gas inlet ✓
F – Compressed air outlet ✓
G – Compressor wheel ✓ (7)

6.5.2 **Turbocharger advantages:**
- More power / speed / boost is obtained from an engine with the same capacity ✓
- There is no power loss as the turbocharger is driven by exhaust gasses ✓
- Improved fuel consumption ✓
- The effect of height above sea level is eliminated ✓
- Generally, cheaper than superchargers ✓
Any (2 x 1) (2)

6.6 **Terminology:**

6.6.1 **Boost:**
Refers to the increase in manifold pressure ✓ that is generated by the turbocharger in the intake that exceeds the normal atmospheric pressure. ✓ (2)

6.6.2 **Turbo lag:**
- It is a delay ✓ between pushing on the accelerator and feeling turbo kick in. ✓ or
- The time ✓ it takes the turbo charger to reach operating speed. ✓
(Any 1 x 2) (2)

6.7 **Purpose of waste gate:**
It diverts exhaust gases ✓ away from the turbine wheel to regulate the turbine speed ✓ and consequently boost pressure. (2)

6.8 **Oil cooler:**
To cool (prevent overheating) the oil ✓ that lubricates the turbocharger bearings and shaft. ✓ (2)

TOTAL QUESTION 6: **[28]**

QUESTION 7: FORCES (SPECIFIC)

7.1 **Torque:**
- Torque is the twisting effort ✓ transmitted by a rotating shaft or wheel. ✓
- Turning force applied ✓ over a centre of a round object. ✓

(Any 1 x 2) (2)

7.2 **Clearance volume:**
This is the volume of the space ✓ above the crown of the piston at TDC. ✓ (2)

7.3 **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 2 x 1) (2)

7.4 **Calculation of compression ratio:**

7.4.1
$$\text{Swept Volume} = \frac{\pi D^2}{4} \times L \quad ✓$$
$$= \frac{\pi (7,5)^2}{4} \, 8,0 \quad ✓$$
$$= 353,43 \text{ cm}^3 \quad ✓$$

(3)

7.4.2
$$\text{Compression Ratio} = \frac{SV + CV}{CV}$$
$$CV = \frac{SV}{CR - 1} \quad ✓$$
$$= \frac{353,43}{8,5 - 1} \quad ✓$$
$$= \frac{353,43}{7,5}$$
$$= 47,12 \text{ cm}^3 \quad ✓$$

(3)

7.4.3 **New compression ratio:**

$$Sweptvolume = \frac{\pi D^2}{4} \times L \qquad \checkmark$$

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

$$= 382,27 \ cm^3 \qquad \checkmark$$

$$New \ compression \ Ratio = \frac{SV}{CV} + 1 \qquad \checkmark$$

$$= \frac{382,27}{47,12} + 1 \qquad \checkmark$$

$$= 8,11 + 1:1$$

$$= 9.11:1 \qquad \checkmark$$

OR

$$New \ compression \ Ratio = \frac{SV + CV}{CV} \qquad \checkmark$$

$$= \frac{382.27 + 47.12}{47.12} \qquad \checkmark$$

$$= 9.11:1 \qquad \checkmark$$

(6)

7.5 **Calculations: Power:**

7.5.1 $\text{Indicated Power} = P \times L \times A \times N \times n$

$$P = 1400 \text{ kPa}$$

$$L = \frac{110}{1000}$$
$$= 0,11 \text{ m} \quad \checkmark$$

$$A = \frac{\pi D^2}{4} \quad \checkmark$$
$$= \frac{\pi 0,10^2}{4}$$
$$= 7,85 \times 10^{-3} \text{ m}^2 \quad \checkmark$$

$$N = \frac{3600}{60 \times 2} \quad \checkmark$$
$$= 30 \text{ r/s} \quad \checkmark$$

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

$$\text{Indicated Power} = P \times L \times A \times N \times n \quad \checkmark$$
$$= \left(1400 \times 10^3\right) \times 0,11 \times \left(7,85 \times 10^{-3}\right) \times 30 \times 4 \quad \checkmark$$
$$= 145068 \text{ W}$$
$$= 145,07 \text{ kW} \quad \checkmark$$

(8)

7.5.2 $T = F \times r \quad \checkmark$
$$= (75 \times 10) \times 0,45$$
$$= 337,5 \text{ N.m} \quad \checkmark$$

$$\text{Brake power} = 2\pi \times N \times T \quad \checkmark$$
$$= 2\pi \times 60 \times 337,5$$
$$= 127234,5 \text{ W}$$
$$= 127,23 \text{ kW} \quad \checkmark$$

(4)

7.5.3 $\text{Mechanical efficiency} = \dfrac{BP}{IP}\,100\%$

$= \dfrac{127,23}{145,07} \times 100\%$ ✓

$= 87,70\%$ ✓

(2)

TOTAL QUESTION 7: [32]

QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 **Gas analyser:**
- Exhaust gasses ✓
- CO gasses ✓
- CO_2 gasses ✓
- SO_2 gasses ✓
- NOx gasses ✓
- HC gasses ✓
- O_2 gasses ✓

(Any 1 x 1)   (1)

8.2 **Specification for gas analysis:**
- % Hydrocarbon / HC ✓
- % Carbon monoxide / CO ✓
- % Carbon dioxide / CO_2 ✓
- % Nitrogen oxide / NOx ✓
- % Sulphur dioxide / SO_2 ✓

(Any 3 x 1)   (3)

8.3 **Cylinder leakage test: (Results)**
- Hissing noise at air intake ✓
- Hissing noise at exhaust pipe ✓
- Hissing noise in dipstick hole ✓
- Hissing noise under tappet cover ✓
- Bubbles in radiator water ✓
- Hissing noise at adjacent cylinders ✓

(Any 2 x 1)   (2)

8.4 **Cylinder Leakage test: (Causes)**
- Worn cylinders ✓
- Worn piston ✓
- Worn piston rings ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Leaking cylinder head gasket ✓
- Cracked cylinder head / block ✓

(Any 2 x 1)   (2)

8.5 **Compression test procedures:**
- Get the engine to normal operating temperature. ✓
- Disconnect the fuel supply and ignition system. ✓
- Remove spark plugs. ✓
- Fit the compression tester ✓
- Depress the throttle and crank the engine a few revolutions. ✓
- Record and compare the pressure reading for each cylinder with manufacturers specifications. ✓

(6)

8.6 **Reasons for low oil pressure:**
- Worn oil pump ✓
- Blocked oil pump screen/filter/strainer in the sump ✓
- Worn main, big-end and camshaft bearings ✓
- Blocked or restricted oil filter ✓
- Dirty or contaminated oil ✓
- Oil leaks ✓
- Too little oil in engine ✓
- Incorrect grade (viscosity) of oil ✓
- Pressure relief valve spring too weak or damaged ✓
- Plunger / Ball stuck in open position ✓
- Dirt stuck between ball and seat ✓

(Any 2 x 1) (2)

8.7 **Cooling system pressure test:**
- Start engine and allow to heat up. Fit radiator pressure tester to radiator. ✓
- Pressurize the cooling system according to manufacture's specification. ✓
- Watch the pressure for a while, if it drops there is a leak. ✓
- Make a visual check for leaks. ✓
- Install radiator cap to tester and pump tester, the cap should release air at its rated pressure. ✓
- Check the rubber seal for cracks and damage. ✓
- Check the vacuum valve for free movement and operation. ✓ (7)

TOTAL QUESTION 8: **[23]**

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

9.1 **Differences between an automatic and manual gearbox:**
- There is no clutch pedal in a motor vehicle with an automatic gearbox. / There is a clutch pedal in a motor vehicle with a manual gearbox. ✓
- There is no need to change gears, the shifting of the gears happens automatically. ✓
- Automatic transmission uses thin oil while manual gearbox uses thicker oil. ✓
- Automatic transmission uses torque converter while manual gearbox uses clutch assembly. ✓

(Any 2 x 1) (2)

9.2 **Advantages of automatic gearbox:**
- It reduces driver fatigue ✓
- It ensures great reduction of wheel spin under bad road conditions ✓
- The vehicle can be stopped suddenly without the engine stalling ✓
- The system dampens all engine torsional vibrations ✓
- Easier to drive (e.g. Disabled person with one leg) ✓

(Any 2 x 1) (2)

9.3 **Torque converter:**

9.3.1 **Torque converter function:**
- Transfers engine torque to the transmission. ✓
- It multiplies the engine torque to the transmission. ✓
- Provides a direct-drive, or mechanical link from the engine to the transmission. ✓
- The torque converter dampens all engine torsional vibrations. ✓
- The torque converter acts as a flywheel. ✓

(Any 2 x 1) (2)

9.3.2 **Parts:**
A – One-way clutch / Turbine ✓
B – Turbine / Impeller ✓
C – Pump ✓
D – Turbine shaft ✓
E – Gearbox housing ✓ (5)

9.4 **Single epicyclic gear train:**
- Overdrive forward ✓
- Overdrive reverse ✓
- Gear reduction forward ✓
- Gear reduction reverse ✓
- Direct drive ✓
- Neutral ✓

(Any 5 x 1) (5)

9.5   **Purpose of gear ratio in the gearbox:**
- It is used in order to utilise the usable torque ✓ developed in a relatively limited speed range of the engine over a greater road speed range. ✓
- Allows different speeds ✓   depending on the different loads. ✓

                                           (Any 1 x 2)   (2)

                         TOTAL QUESTION 9:   **[18]**

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

10.1   **Preliminary wheel alignment checks:**
- Kerb mass (tank full of petrol, spare wheel and tools) against the manufacturer's specifications. ✓
- Uneven wear on the tyre. ✓
- Tyre pressure. ✓
- Run-out on the wheels; check wheel nuts with torque wrench. ✓
- 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, this includes riding height. ✓
- Ineffective shock absorbers. ✓
- Spring U-bolts. ✓
- Chassis for possible cracks and loose cross-members. ✓
- Wheels must be balanced ✓
- Wheel alignment specifications ✓
- Drive shafts / CV-joints ✓

                                                 (Any 5 x 1)   (5)

10.2   **Caster**

     10.2.1   Negative ✓ Caster ✓   (2)

     10.2.2   **Parts:**
                A – Contact point of king pin centre line ✓
                B – King pin ✓
                C – Perpendicular line / vertical line / normal line ✓
                D – Negative caster angle ✓
                E – Centre line of king pin ✓
                F – Front of vehicle / Direction of wheel motion ✓
                G – Point of wheel contact / Wheel ✓   (7)

     10.2.3   Negative caster angle is the forward tilt ✓ of the kingpin at the top, ✓ viewed from the side. ✓   (3)

10.3   **Toe-out:**
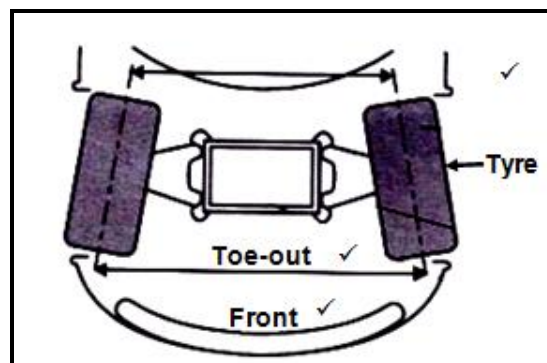
                                                     (3)

10.4 **Purpose of the king pin inclination:**
- To bring the front wheels back to the straight-ahead position ✓ after rounding a corner without any driver effort. ✓
- Reduce ✓ the scrub radius. ✓

(Any 1 x 2) (2)

10.5 **Catalytic converter:**
- Oxidation ✓
- Reduction ✓

(Any 1 x 1) (1)

10.6 **Purpose of the speed control system:**
The purpose of the speed control system is to control the throttle opening ✓ and to keep the vehicle speed constant. ✓ (2)

10.7 **Advantage of speed control:**
- Driver fatigue is reduced. ✓
- The set speed is controlled constantly. ✓
- Improved fuel consumption. ✓
- A consistently controlled speed helps to prevent speeding fines. ✓

(Any 2 x 1) (2)

10.8 **Fuel pressure regulator:**
- Fuel pressure regulator regulates the fuel pressure in relation to the manifold pressure. ✓ (1)

10.9 **Output frequency of an alternator:**
- Increase the turns of wire on the stationary coil. ✓
- Increase the magnetic fields. ✓
- Increase the rotational frequency at which the magnet rotates. ✓

(Any 2 x 1) (2)

10.10 **Stator and stator windings:**
- To provide a core which concentrates the magnetic lines of force onto the stator windings ✓
- To provide a coil into which a voltage is induced which is used to charge the battery. ✓

(Any 1 x 1) (1)

10.11 **Function of rotor assembly:**
- Is to provide a rotating electro-magnet. ✓ (1)

TOTAL QUESTION 10: **[32]**

TOTAL: **200**