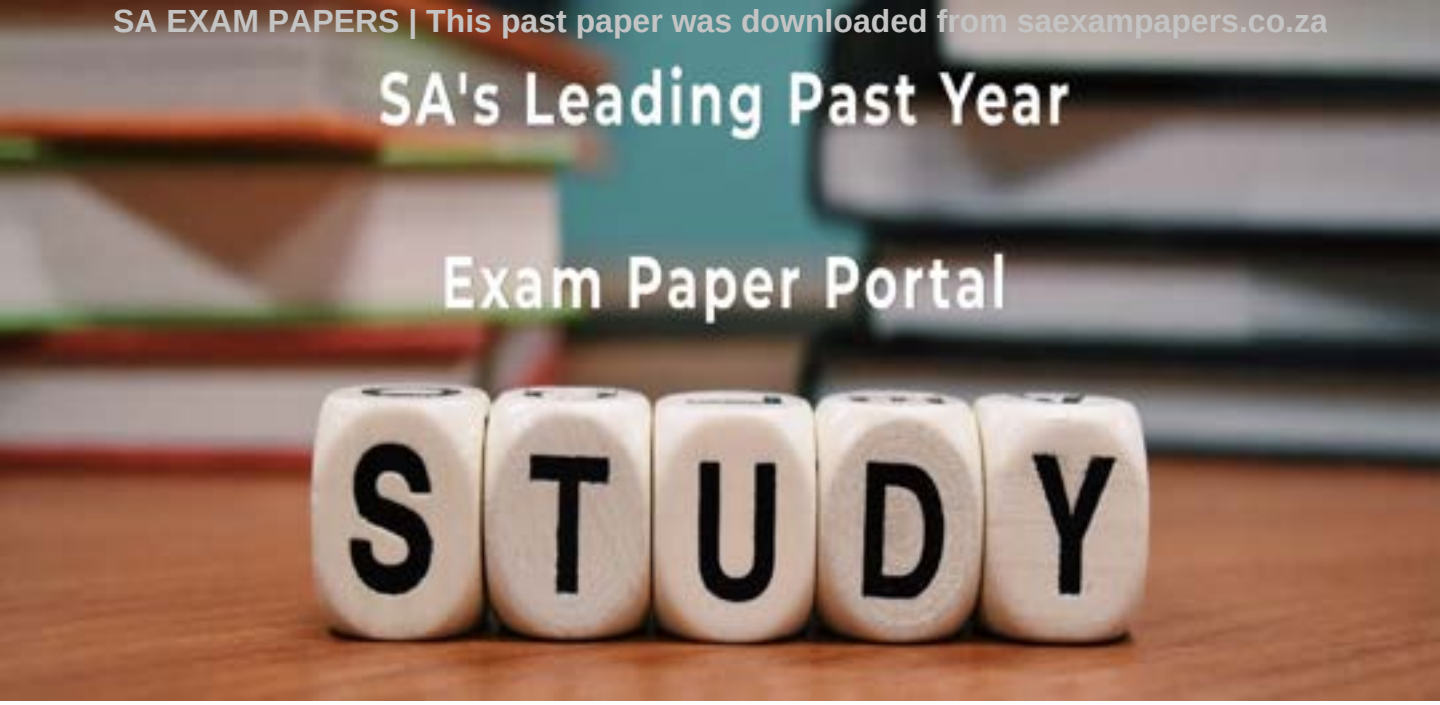


basic education

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)

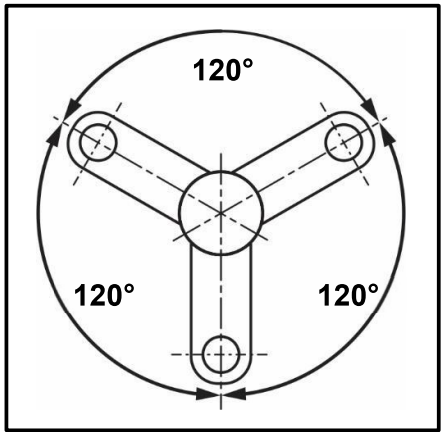
6.4 **Obtain the firing order:**
- Determine which valves are the inlet or which are the exhaust valves. ✓
- Turn the engine in the direction it rotates. ✓
- Observe the order in which the valves open to determine the firing order. ✓ (3)

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:**

$\text{Work} = \text{force} \times \text{distance}$
$= F \times s$
$= (690 \times 10)$ ✓ $\times 2$ ✓
$= 13800 \text{ J}$ ✓
$= 13{,}8 \text{ kJ}$

OR

$\text{Work} = \text{force} \times \text{distance}$
$= F \times s$
$= (690 \times 9{,}81)$ ✓ $\times 2$ ✓
$= 13537{,}8 \text{ J}$ ✓
$= 13{,}54 \text{ kJ}$ (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:**

$$CV = \frac{SV}{CR - 1}$$
$$= \frac{427{,}44}{9 - 1} \checkmark \checkmark$$
$$= 53{,}43 \text{ cm}^3 \checkmark$$ (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:**

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

$$= \frac{3{,}67}{50} \checkmark \times 100$$

$$= 7{,}33\% \checkmark$$

(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**
• Too rich mixture. ✓	• Reset/adjust the air fuel mixture. ✓
• Dirty or restricted air filter. ✓	• Replace/Clean air filter. ✓
• Ignition misfire. ✓	• Repair ignition misfire. ✓
• Thermostat stuck open. ✓	• Replace thermostat. ✓
• Faulty coolant sensor. ✓	• Replace coolant sensor. ✓
• Blocked PCV valve. ✓	• Unblock/clean/replace PCV valve. ✓
• Faulty catalytic convertor. ✓	• Replace catalytic convertor. ✓
• Carburettor flooding. ✓	• Correct carburettor fault. ✓
• Choke valve stuck closed. ✓	• Repair choke valve. ✓
• Fuel pressure too high. ✓	• 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 (CO_2) reading:

8.1.3 **POSSIBLE CAUSES**	8.1.4 **CORRECTIVE MEASURES**
• Incorrect air-fuel mixture. ✓	• Reset/ adjust the air fuel mixture. ✓
• Dirty or restricted air filter. ✓	• Replace/Clean air filter. ✓
• Ignition misfire. ✓	• Repair ignition misfire. ✓
• Thermostat stuck open. ✓	• Replace thermostat. ✓
• Faulty coolant sensor. ✓	• Replace coolant sensor. ✓
• Blocked PCV valve. ✓	• Unblock clean/replace PCV valve. ✓
• Faulty catalytic convertor. ✓	• Replace catalytic convertor. ✓
• Carburettor flooding. ✓	• Correct carburettor fault. ✓
• Choke valve stuck closed. ✓	• Repair choke valve. ✓
• Fuel pressure too high. ✓	• Check and repair the return fuel line of restrictions or kinks. ✓ • Replace fuel pressure regulator✓ • Select correct pump according to vehicle specification. ✓
• Exhaust gas leaks. ✓	• Repair exhaust leaks. ✓
• Vacuum leaks on the intake. ✓	• 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:**

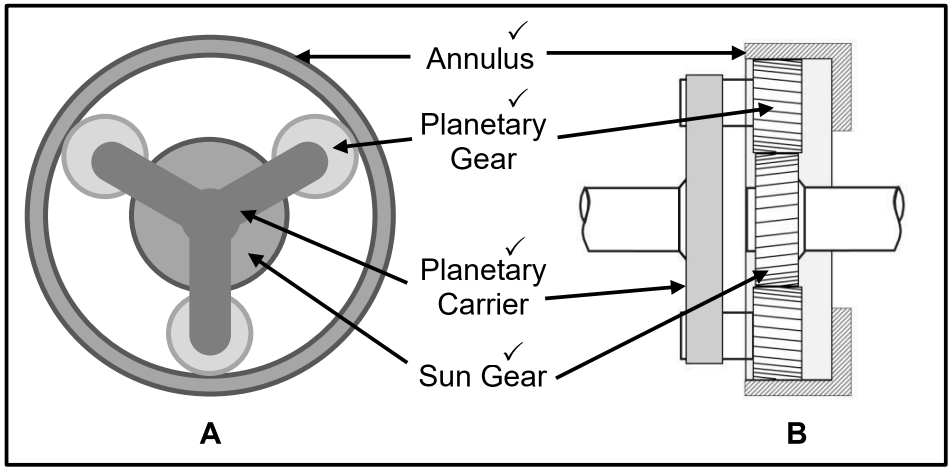
- More expensive to manufacture. ✓
- Repairs are expensive. ✓
- Special tools and training needed to repair gearbox. ✓
- Special towing techniques must be used when towed over a long distance. ✓
- Generally heavier than a manual gearbox. ✓
- Vehicle cannot be push-started. ✓

(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