

# SA's Leading Past Year

Exam Paper Portal

S T U D Y

You have Downloaded, yet Another Great  
Resource to assist you with your Studies ☺

Thank You for Supporting SA Exam Papers

Your Leading Past Year Exam Paper Resource Portal

Visit us @ [www.saexamapers.co.za](http://www.saexamapers.co.za)





# **basic education**

Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS**

**MECHANICAL TECHNOLOGY: AUTOMOTIVE**

**2023**

**MARKING GUIDELINES**

**MARKS: 200**

These marking guidelines consist of 21 pages.

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)**

- |     |     |            |
|-----|-----|------------|
| 1.1 | C ✓ | (1)        |
| 1.2 | A ✓ | (1)        |
| 1.3 | A ✓ | (1)        |
| 1.4 | C ✓ | (1)        |
| 1.5 | B ✓ | (1)        |
| 1.6 | A ✓ | (1)<br>[6] |

**QUESTION 2: SAFETY (GENERIC)****2.1 Safety rule after the work procedures:**

Switch off the machine. ✓

(1)

**2.2 Space between the tool rest and the emery wheel:**

- To prevent the work piece from jamming between the wheel and tool rest. ✓
- Prevents the wheel from being damaged. ✓
- Prevents the work piece from being damaged. ✓
- Prevent injury. ✓

(Any 2 x 1) (2)

**2.3 Workshop layouts:**

2.3.1 Process layout. ✓

(1)

2.3.2 Product layout. ✓

(1)

**2.4 Hydraulic press:**

- Safety goggles ✓
- Safety gloves ✓
- Safety shoes ✓
- Overall ✓

(Any 1 x 1) (1)

**2.5 Safety guard on the portable angle grinder:**

- To protect one against sparks/metal particles. ✓
- To protect one from a breaking disc. ✓
- To protect your hand from coming into contact with the disc. ✓

(Any 1 x 1) (1)

**2.6 Shearing/Guillotine machine:**

- Follow the manufacturers recommendations. ✓
- Keep hands away from action points. ✓
- Do not exceed the maximum material thickness. ✓
- Ensure that all guards are in place and secure. ✓
- Report defects immediately. ✓

(Any 1 x 1) (1)

2.7

**Storing gas cylinders:**

- Upright position ✓
- Stored at 20°C / cool area ✓
- Empty cylinders stored separately from full cylinder. ✓
- Never store cylinders on top of each other. ✓
- Oxygen cylinders separate from fuel cylinders. ✓
- Secure gas cylinders. ✓
- Ensure that cylinders are properly closed. ✓
- Stored away from sparks / flammable material/ electrical switches. ✓
- Stored in a well-ventilated area. ✓
- Safety signs should be displayed. ✓
- Keep cylinders clearly labelled (Full/Empty). ✓

(Any 2 x 1)

(2)

[10]

**QUESTION 3: MATERIALS (GENERIC)****3.1 Purpose of tempering:**

- To relieve ✓ strain / brittleness. ✓
- To increase ✓ the toughness of the steel. ✓
- To refine ✓ grain structure. ✓

(Any 1 x 2) (2)

**3.2 Heat treatment processes:****3.2.1 Case hardening:**

- To obtain a wear-resistant surface ✓ and at the same time be tough enough internally at the core ✓ to withstand the applied loads.
- For a hard case ✓ over a tough core. ✓

(Any 1 x 2) (2)

**3.2.2 Annealing:**

- To relieve ✓ internal stresses. ✓
- To soften ✓ steel. ✓
- Facilitate ✓ the machining processes. ✓
- Increase ✓ the steel's ductility. ✓
- Reduce ✓ brittleness. ✓

(Any 1 x 2) (2)

**3.3 Spark test:**

- Hold steel against grinding wheel. ✓
- Observe the spark pattern to identify the type of steel. ✓

(2)

**3.4 Tests:****3.4.1 Filing test:**

File on the tip or near the edge ✓ of the material. The bite will determine the hardness. ✓

(2)

**3.4.2 Bend test:**

- Metal is subjected to deformation by bending. ✓
- Observe the rupture of the metal. ✓

(2)

**3.5 Sound test on steel:****3.5.1 Low carbon steel (LCS):**

Dull (low pitch)✓ sound.

(1)

**3.5.2 High carbon steel (HCS):**

Loud and clear (high pitch) ✓ sound.

(1)

[14]

**QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)**

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

**QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)****5.1 Engine cylinder compression test:****5.1.1 Reasons for compression test:**

- To determine the amount of compression loss ✓ from a specific cylinder. ✓
- To determine if the compression rings ✓ are worn. ✓

(Any 1 x 2) (2)

**5.1.2 Type of compression test:**

- Dry test ✓
- Wet test ✓

(2)

**5.1.3 Reasons for low compression:**

- Worn / cracked cylinders ✓
- Worn / broken piston rings ✓
- Worn / broken piston ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Worn / cracked / bent valve assembly ✓
- Leaking cylinder head gasket ✓

(Any 2 x 1) (2)

**5.2 Cylinder leakage tester:****5.2.1 Labels for cylinder leakage tester:**

- A – Pressure control valve / - knob / - regulator ✓  
 B – Gauge / Meter ✓  
 C – Compressor hose / - air hose / -pipe ✓  
 D – Spark plug connector / - adapter / - hose / - pipe ✓

(4)

**5.2.2 Reason for pressurised air:**

To determine the ...

- percentage pressure leakage ✓ from the cylinder. ✓
- location ✓ of the cylinder leakage. ✓

(Any 1 x 2) (2)

**5.3 Precautions when performing the exhaust gas analysis:**

- The inlet hose must not be stepped on or restricted in any way. ✓
- The hose connections must be airtight. ✓
- There should be no leaks in the exhaust, manifolds or vacuum systems. ✓
- Condensate must be blown out of the hoses and pickup probe. ✓
- The condenser must be drained after each test. ✓
- When the paper filter becomes light grey, it should be replaced. ✓
- Test must be done in a well-ventilated area. ✓
- Ensure the tester is connected to the battery correctly. ✓

(Any 3 x 1) (3)

**5.4 Systems scanned by on-board diagnostic scanner:**

- Powertrain (PCM) ✓
- Transmission (TCM) ✓
- Brakes (ABS) ✓
- Body (BCM) ✓
- Engine (ECM) ✓
- Humidity, ventilation and air conditioning (HVAC) ✓
- Air bags (SRS) ✓

(Any 3 x 1) (3)

**5.5 Faults on the wheel established during dynamic wheel balancing:**

- The extent of the imbalance ✓
- The run-out of the tyre ✓
- The run-out of the wheel assembly ✓

(Any 2 x 1) (2)

**5.6 Perform dynamic wheel balancing:**

- Start the balancer and allow wheel to spin. ✓
- Obtain the imbalance readings and its locations on the rim. ✓
- Fit the correct weights. ✓

(3)  
[23]

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

6.1.1 Crankshaft ✓ (1)

6.1.2 **Function:**  
To convert the reciprocating motion of the pistons ✓ into rotary motion. ✓ (2)

6.1.3 Crank web / counterweight ✓ (1)

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

**6.2 Vibration damper:**

6.2.1 Crankshaft ✓ (1)

6.2.2 **Function:**  
To smooth/dampen out the engine vibrations. ✓ (1)

**6.3 Engine cylinder configurations:**

- Inline / straight ✓
  - V ✓
  - W ✓
  - Flat / horizontal ✓
  - Radial / X-Engine ✓
  - U-Engine ✓
  - K-engine ✓
  - Delta ✓
- (Any 3 x 1) (3)

**6.4 Power strokes intervals:**

- To reduce engine vibrations. ✓
  - To ensure smooth running of the engine. ✓
  - To reduce the wear rate on the engine components. ✓
- (Any 2 x 1) (2)

**6.5 Determine the firing order:**

- Read from the vehicle specifications. ✓
  - It may be written on the tappet cover. ✓
  - Check the order in which the valves rock. ✓
  - Check the order in which the sparks are distributed from the distributor. ✓
- (Any 3 x 1) (3)

**6.6 Turbocharger:****6.6.1 Boost:**

The increasing of manifold pressure ✓ above the normal atmospheric pressure. ✓

(2)

**6.6.2 Types:**

- Variable Geometry Turbocharger (VGT) ✓
- Non-variable Turbocharger ✓

(2)

**6.7 Supercharger:****6.7.1 Reasons for fitting:**

- To increase cylinder pressure / compression pressure. ✓
- To increase the volumetric efficiency. ✓
- To increase the engine output / performance. ✓
- Increase fuel efficiency. ✓

(Any 2 x 1) (2)

**6.7.2 Mechanical drive:**

- Belt ✓
- Gears ✓
- Chain ✓
- Shaft ✓

(Any 2 x 1) (2)

**6.8 Twin-charging:**

- A combination of a turbocharger ✓ and a supercharger. ✓
- Two turbochargers ✓ are combined on the same engine. ✓
- Two superchargers ✓ are combined on the same engine. ✓

(Any 1 x 2) (2)

**6.9 Advantages of twin-charging:**

- Outstanding fuel economy. ✓
- Reduce/eliminates lag at low revolutions. ✓
- Increased power and torque across the entire power band. ✓
- Reduced power required (sapping effect) by the supercharger pulley from the engine. ✓

(Any 2 x 1) (2)  
[28]

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

- Total volume ✓ when the piston moves from bottom dead centre to top dead centre. ✓
- Total volume ✓ displaced during a stroke. ✓

(Any 1 x 2) (2)

**7.2 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 3 x 1) (3)

**7.3 Calculation:****7.3.1 Swept volume:**

$$\begin{aligned}
 SV &= \frac{\pi \times D^2}{4} \times L \\
 &= \frac{\pi \times (9^2)}{4} \times 10 \quad \checkmark \\
 &= 636,17 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

(3)

**7.3.2 Original clearance volume:**

$$\begin{aligned}
 CV &= \frac{SV}{CR - 1} \\
 &= \frac{636,17}{10,5 - 1} \quad \checkmark \\
 &= 66,97 \text{ cm}^3 \quad \checkmark
 \end{aligned}$$

(3)

## 7.3.3 New bore diameter:

$$\text{New compression ratio} = \frac{SV}{CV} + 1$$

$$SV = (CR - 1)(CV) \quad \checkmark$$

$$SV = (11 - 1)(66,97) \quad \checkmark$$

$$SV = 669,7 \text{ cm}^3 \quad \checkmark$$

$$SV = \frac{\pi \times D^2}{4} \times L$$

$$D = \sqrt{\frac{SV \times 4}{\pi \times L}} \quad \checkmark$$

$$= \sqrt{\frac{669,7 \times 4}{\pi \times 10}} \quad \checkmark$$

$$= 9,234 \text{ cm} \quad \checkmark$$

$$= 92,34 \text{ mm} \quad \checkmark$$
(7)

## 7.4 Prony brake calculations:

## 7.4.1 Indicated power in kW:

$$P = 900 \times 10^3 \text{ Pa}$$

$$L = \frac{86}{1000}$$

$$= 0,086 \text{ m} \quad \checkmark$$

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

$$= \frac{\pi \times 0,084^2}{4} \quad \checkmark$$

$$= 5,542 \times 10^{-3} \text{ m}^2 \quad \checkmark$$

$$N = \frac{2000}{60 \times 1} \quad \checkmark$$

$$= 33,33 \text{ power strokes / sec} \quad \checkmark$$

$n = 2$  cylinders

$$IP = P \times A \times n$$

$$= (900 \times 10^3)(0,086)(5,542 \times 10^{-3})(33,33)(2) \quad \checkmark$$

$$= 28593,86 \text{ W}$$

$$= 28,59 \text{ kW} \quad \checkmark$$
(7)

**7.4.2 Brake power in kW:**

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

$$\begin{aligned} &= (25 \times 10)(0,4) \quad \checkmark \\ &= 100 \text{ Nm} \quad \checkmark \end{aligned}$$

$$\begin{aligned} \text{BP} &= 2\pi \text{NT} \\ &= 2 \times \pi \times 33,33 \times 100 \quad \checkmark \\ &= 20941,85663 \text{ W} \\ &= 20,94 \text{ kW} \quad \checkmark \end{aligned}$$

(5)

**7.4.3 Mechanical efficiency:**

$$\begin{aligned} \eta &= \frac{\text{BP}}{\text{IP}} \times 100 \\ &= \frac{20,94}{28,59} \times 100 \quad \checkmark \\ &= 73,24 \% \quad \checkmark \end{aligned}$$

(2)  
[32]

## **QUESTION 8: MAINTENANCE (SPECIFIC)**

## 8.1 Gas Analysis:

FAULTS (DEFECTS)	POSSIBLE CAUSES	CORRECTIVE MEASURES
	<b>8.1.1</b>	<b>8.1.2</b>
High oxygen (O <sub>2</sub> ) reading	Too lean air-fuel ratio. ✓ Ignition problems. ✓ Vacuum leaks. ✓ Catalytic converter not working. ✓	Reset fuel mixture. ✓ Check and reset ignition system. ✓ Repair vacuum leaks. ✓ Check and repair the catalytic converter. ✓
	<b>(Any 1 x 1)</b>	<b>(Any 1 x 1)</b>
	<b>8.1.3</b>	<b>8.1.4</b>
High hydrocarbon (HC) reading	Excessive unburned fuel. ✓ Improper timing. ✓ Vacuum leak. ✓ Faulty air management system. ✓	Reset fuel mixture. ✓ Check and reset ignition system. ✓ Repair vacuum leaks. ✓ Check and repair the air management system. ✓
	<b>(Any 1 x 1)</b>	<b>(Any 1 x 1)</b>

(4)

## 8.2 Compression test:

- 8.2.1      
  - Prevent distribution of high voltage. ✓
  - To prevent electrical shock. ✓
  - To gain access to the spark plugs. ✓

(Any 1 x 1) (1)

- 8.2.2      • To prevent fuel entering the exhaust system. ✓  
                • To prevent fuel from entering the tester. ✓

(Any 1 x 1) (1)

- 8.2.3     • To obtain the correct amount of air entering the cylinder. ✓  
              • To obtain a correct reading. ✓

(Any 1 x 1) (1)

- 8.2.4      • To compare reading to the specifications. ✓  
                • To check if the pressure is correct or not. ✓

(Any 1 x 1) (1)

8.3 **Cylinder leakage test:**

	<b>FAULTS (DEFECTS)</b>	<b>POSSIBLE CAUSES</b>	<b>CORRECTIVE MEASURES</b>	
8.3.1	Hissing sound at the air intake	Leaking inlet valves. ✓	Replace or reseat valves. ✓	(2)
		Gasket blown between adjacent cylinders. ✓  (Any 1 x 1)	Replace head gasket. ✓  (Any 1 x 1)	
8.3.2	Hissing sound at the dipstick	Worn piston rings. ✓	<ul style="list-style-type: none"> <li>• Overhaul engine. ✓</li> <li>• Fit new rings. ✓</li> </ul>	(2)
		Worn piston. ✓  (Any 1 x 1)	<ul style="list-style-type: none"> <li>• Fit new pistons. ✓</li> <li>• Overhaul engine. ✓</li> </ul>	

8.4 **Causes of a high oil pressure reading:**

- Blocked oil passages ✓
- Too little crankshaft bearing clearances ✓
- Dirty or contaminated oil ✓
- Oil viscosity is too high ✓
- Pressure relief valve stuck in closed position. ✓

(Any 3 x 1) (3)

8.5 **Fuel pressure test:**8.5.1 **Manufacturer's specifications for fuel pressure test:**

- Fuel pressure after the fuel pump. ✓
- Fuel pressure when the engine is idling. ✓
- Fuel pressure on high revolutions. ✓

(Any 2 x 1) (2)

8.5.2 **Placement of fuel pressure tester:**

Fit the fuel pressure tester to the fuel line. ✓

(1)

8.5.3 **Perished rubber pipe of fuel pressure tester:**

- Fuel / pressure will leak from the pipe. ✓
- The tester will give inaccurate results. ✓
- Fire hazard. ✓

(Any 1 x 1) (1)

8.6 **Causes of cooling system pressure drop:**

Coolant leaks from ...

- between gaskets/seals of the cooling system. ✓
- water hoses. ✓
- blown cylinder head gasket. ✓
- the water pump. ✓
- radiator. ✓
- heater radiator. ✓
- corroded welch or core plugs. ✓
- components not fitted correctly. ✓

(Any 4 x 1) (4)  
[23]

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

### 9.1 Solutions for an automatic gearbox:

- 9.1.1     • Remove the propeller / drive shaft. ✓  
          • Use a flatbed tow-truck. ✓  
          • Use a mobi-jack / lift the drive wheels off the ground. ✓

(Any 1 x 1) (1)

- 9.1.2     • Use a lock-up clutch. ✓  
              • The torque converter needs to be replaced. ✓  
              • The torque converter to be repaired. ✓  
              • Top-up fluids/oil. ✓

- 9.1.3     • Identify the cause of the problem and repair. ✓  
          • Use an oil cooler. ✓  
          • Top-up/replace fluids/oil. ✓

(Any 1 x 1) (1)

- 9.1.4 Ensure the lever is shifted to:

  - Park (P) ✓
  - Neutral (N) ✓

(Any 1 x 1) (1)

- 9.1.5 Use automatic transmission fluid (ATF). ✓ (1)

## 9.2 Components of the torque converter:

- 9.2.1      • Pump ✓  
                • Impeller ✓

- 9.2.2 Turbine ✓ (1)

- 9.2.3 Stator ✓ (1)

- 9.3 Manual valve ✓ (1)

#### 9.4 Advantages of epicyclic gear trains:

- Provides a variation in torque. ✓
  - Changes the direction of rotation. ✓
  - It's compact in design. ✓
  - Gears are in constant mesh. ✓

- Gear system of an automatic gearbox.**

9.5.2      **Obtain reverse gear:**

- The brake band locks the annulus 1. ✓
- The input shaft (engine) drives the sun gears. ✓
- Planet gear 1 walks around the sun gear 1 in a reverse direction. ✓
- Planet gear 1 turns the planet carrier in a reverse direction. ✓
- Planet carrier turns the output shaft. ✓

(5)

9.6      Oil pump ✓

(1)  
[18]

**QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONIC) (SPECIFIC)****10.1 Well-designed steering system:**

- Light and easy to control ✓
  - Free from vibration and road shocks ✓
  - As direct as possible without much drivers effort. ✓
  - Self centering ✓
  - Not unduly affected by the suspension or braking system operation ✓
- (Any 2 x 1) (2)

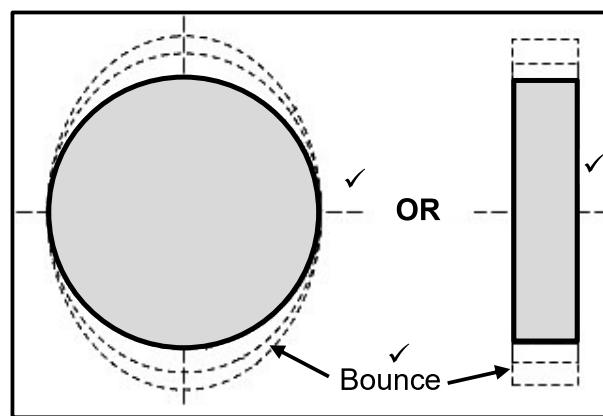
**10.2 Wheel alignment angle:****10.2.1 Label A-C:**

- A. Axle centre ✓
  - B. Rear axle ✓
  - C. Steering arms ✓
- (3)

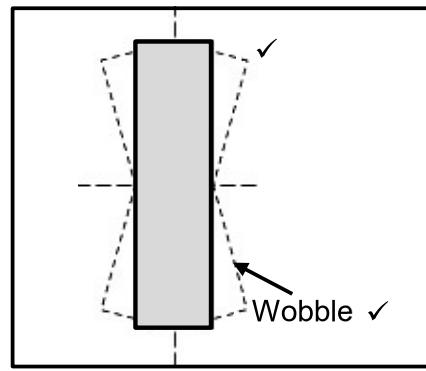
**10.2.2 Angle D:**

- Ackermann's angle ✓
- (1)

- 10.2.3 It gives variable toe-out ✓ to the front wheels on turns. ✓
- (2)

**10.3 Unbalanced wheels drawings:****10.3.1 Wheel bounce (hop):**

(2)

10.3.2 **Wheel wobble (shimmy):**

(2)

10.3.3 **Difference between wheel wobble and wheel bounce:**

- Wheel wobble is the side to side movement (vibration) of a wheel. ✓
- Wheel bounce is the up and down movement (vibration) of a wheel. ✓

(2)

10.4 **Materials coating the monolith:**

- Aluminium oxide ✓
- Platinum ✓
- Rhodium ✓
- Palladium ✓

(Any 2 x 1) (2)

10.5 **Functions of sensors:**10.5.1 **Lambda sensor:**

- The sensor measures the oxygen content in the flow of the exhaust gas. ✓
- Sends the information to the electronic control unit (ECU). ✓

(2)

10.5.2 **Throttle position sensor (TPS) sensor:**

- Detects the position of the throttle. ✓
- Sends the information to the electronic control unit (ECU). ✓

(2)

10.5.3 **Mass Air Flow (MAF) sensor:**

- To measure the air flow to the engine. ✓
- To measure the air flow temperature. ✓
- Sends the information to the electronic control unit (ECU). ✓

(Any 2 x 1) (2)

**10.6 Operation of common rail direct injection (CRDI):**

- The high pressure pump transfers the fuel under high pressure to the common rail. ✓
- The common rail holds and distributes the pressurised fuel to the injectors. ✓
- The injectors spray the fuel directly into the cylinder. ✓

(3)

**10.7 Current is generated:**

- If a magnetic field is moved across a conductor ✓, a voltage is induced across the ends of the conductor ✓, which will cause a current to flow ✓
- Convert mechanical energy ✓ into electrical energy ✓ by electromagnetic induction. ✓

(Any 1 x 3) (3)

**10.8 Alternator stator tests:**

- Continuity ✓
- Leakage ✓

(2)

**10.9 Positions electrical fuel pump is placed:**

- Inside the fuel tank ✓
- External – anywhere on the fuel line. ✓

(2)  
[32]**TOTAL: 200**