



Province of the  
**EASTERN CAPE**  
EDUCATION



# **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**SEPTEMBER 2023**

## **MECHANICAL TECHNOLOGY: AUTOMOTIVE MARKING GUIDELINE**

**MARKS: 200**

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This marking guideline consists of 12 pages.

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

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

**QUESTION 2: SAFETY (GENERIC)****2.1 Arc welding safety precautions:**

- Wear the correct PPE ✓
- Ensure the electrode holder is well insulated ✓
- The environment must be free of water and combustible materials ✓
- Ensure the environment is well ventilated ✓ (Any 3 x 1) (3)

**2.2 Pedestal drilling machine safety precautions:**

- Wear correct PPE ✓
- Make sure all guards are in place ✓
- Clamp the workpiece securely ✓
- Use the correct drill bit ✓
- Do not make any adjustment while the machine is in motion ✓
- Use the correct speed ✓
- Do not remove chips by hand ✓ (Any 2 x 1) (2)

2.3 Manual guillotine maximum cutting thickness is 1,20 mm ✓ (1)

**2.4 2.4.1 Advantages of product layout:**

- Handling of material is limited to a minimum. ✓
- Time period of manufacturing cycle is less. ✓
- Production control is almost automatic. ✓
- 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)

**2.4.2 Advantages of the process layout:**

- High machine utilisation because more than one product is manufactured. ✓
- Better supervision as a result of subdivision of processes. ✓
- Less interruption in flow of work when machines become defective. ✓
- Lower equipment cost, since one machine can produce more than one product. ✓
- Better control of total manufacturing cost. ✓
- Greater flexibility in the production process. ✓ (Any 2 x 1) (2)

**[10]**

**QUESTION 3: MATERIALS (GENERIC)****3.1 Purpose of case hardening:**

- To produce a hard case over ✓ and a tough core. ✓ (2)

**3.2 Using high carbon steel for case hardening:**

- The hardness will penetrate the core ✓ (1)

**3.3 Factors of hardness:**

- Work piece size ✓
- Quenching rate ✓
- Carbon content ✓ (3)

**3.4 Types of quenching mediums:**

- Water and salt (brine) ✓
- Tap water ✓
- Liquid salts ✓
- Molten lead ✓
- Soluble oil and water ✓
- Oil ✓ (Any 3 x 1) (3)

**3.5 Colour coding of engineering materials:**

- To identify the type of materials as well as the carbon content of steel ✓ (1)

**3.6 Types of tests:**

- 3.6.1
- Filing test ✓
  - Machining test ✓ (Any 1 x 1) (1)

- 3.6.2
- Sound test ✓
  - Spark test ✓ (Any 1 x 1) (1)

- 3.6.3
- Bending test ✓ (1)

**3.7 Machine for spark test:**

- Pedestal grinding machine ✓ (1)

**[14]**

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

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

**QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)****5.1 Safety precautions of an emission gas analyser:**

- The inlet hose must not be restricted in any way. ✓
- The hose connection must be airtight. ✓
- The valve on the condenser must be in the horizontal position (closed). ✓
- The vehicle must not have any exhaust leakage. ✓
- Condensate must be blown out of hose regularly with compressed air. ✓
- The hoses must be disconnected from the analyser, otherwise the pump will be damaged. ✓
- The condenser must be drained after each test. ✓
- When the paper filter becomes light grey, it should be changed. ✓
- The fuel filter on the condenser stand must be changed regularly. ✓

(Any 2 x 1) (2)

**5.2 Purpose of a diagnostic scanner:**

Scans all systems on the vehicle ✓ and make adjustment on different sensors. ✓ (2)

**5.3 Set-up procedure of a diagnostic scanner:**

- Plug the scan tool into the OBD-II connector under the dashboard. ✓
- Turn the key on, but do not start the engine. ✓
- Follow the instructions shown on the screen and enter the necessary information. ✓

(3)

**5.4 Wheel alignment equipment:**

5.4.1 Bubble gauge is used to test the castor, chamber and king pin inclination angle of a motor vehicle. ✓✓ (2)

5.4.2 Turntable makes it possible to turn the front wheel to the required angle when taking caster reading. ✓✓ (2)

**5.5 Procedure to read kingpin inclination on the right-side:**

- Apply brake lock ✓
- Make sure the wheels are straight ahead and the turntable is on zero ✓
- Level bubble D ✓
- Turn the wheel 20° to the right ✓
- Level bubble D ✓
- Zero the KPI scale on the left ✓
- Turn the wheel 40° to the left ✓
- Zero bubble D ✓
- Read the KPI in degree on the right-hand scale ✓

(9 x 1) (9)

**5.6 Purpose of a wheel balancer:**

- To balance the wheel of a vehicle, ✓ for static and dynamic balance. ✓

(2)

**5.7 Advantage of using card type compressor tester:**

The result is printed on the card which serves as evidence for report making. ✓

(1)

**[23]**

**QUESTION 6: ENGINES (SPECIFIC)****6.1 Functions of crankshaft:**

- It converts oscillatory motion of piston power stroke drive into rotary motion. ✓
- It drives the cam shaft that controls the engine valve timing ✓
- It transmits primary power from kick starter to the piston for an effective power stroke that set the engine in motion. ✓ (Any 2 x 1) (2)

**6.2 Causes of crankshaft vibration:**

- Action of unbalanced forces upon the crankshaft ✓
- Torsional effect of the power stroke on the crankshaft ✓ (2)

**6.3 Features to improve engine balance:**

- Webs are extended and drilled to form balanced mass pieces at points opposite the connecting rod. ✓
- Connecting rods and pistons are kept as light as possible. ✓
- The flywheel must be carefully fitted and balanced with the crankshaft flange. ✓
- Vibration dampers are fitted to the front of the crankshaft to smooth out engine vibrations. ✓ (4)

**6.4 Factors that determine firing order:**

- Position of the cranks on the crankshaft. ✓
- Arrangement of the cams on the camshaft. ✓ (2)

**6.5 Procedure to determining firing order if no specifications given:**

- Remove the tappet cover to determine the intake and exhaust valve ✓
- Rotate the engine in the direction in which it runs ✓
- 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 ✓ (5)

**6.6 6.6.1 Turbocharger ✓ (1)**

- 6.6.2
- A** – Air inlet ✓
  - B** – Turbine housing ✓
  - C** – Turbine wheel (exhaust) ✓
  - D** – Exhaust inlet ✓
  - E** – Compressor air discharge ✓
  - F** – Compressor turbine wheel ✓ (6)

6.6.3 Converts exhaust energy to rotary motion. ✓ (1)

6.6.4 Pumps air into the inlet manifold. ✓ (1)

6.6.5 To increase engine power, ✓ and improve fuel consumption. ✓ (2)

6.6.6 It is an increase in manifold pressure that is generated by the turbocharger in the intake manifold, ✓ which is greater than the atmospheric pressure. ✓ (2)

**[28]**

**QUESTION 7: FORCES (SPECIFIC)****7.1 7.1.1 Swept volume:**

It is the volume between the BDC ✓ and TDC in a cylinder. ✓ (2)

**7.1.2 Clearance volume:**

It is the volume of the space above the crown of the piston ✓ when it is at TDC in the combustion chamber. ✓ (2)

**7.1.3 Compression ratio:**

It is the relationship between the total volume of a cylinder when the piston is at BDC, ✓ to the volume of the charge in the cylinder when the piston is at TDC. ✓ (2)

**7.1.4 Mechanical efficiency:**

The relationship between engine power ✓ and brake power at the drive shaft. ✓ (2)

**7.2 Methods of raising compression ratio:**

- Fit a thinner gasket between cylinder block and cylinder head ✓
  - Machined metals from the cylinder head ✓
  - Skim metals from the cylinder block ✓
  - Fit piston with a suitable higher crown ✓
  - Fit crankshaft with suitable longer stroke connecting rods ✓
  - Increase the bore of cylinder ✓
- (Any 4 x 1) (4)

**7.3 Swept volume:**

$$SV = \frac{\pi d^2}{4} \times L \quad \checkmark$$

$$SV = \frac{\pi \times 8,6^2}{4} \times 8,2 \quad \checkmark$$

$$= 476,32 \text{ cm}^3 \quad \checkmark \quad (3)$$

**Compression ratio:**

$$CR = \frac{SV + CV}{CV} \quad \checkmark$$

$$CR = \frac{476,32 + 56}{56} \quad \checkmark$$

$$= 9,5 : 1 \quad \checkmark \quad (3)$$

7.4 7.4.1 **Indicated power**

$$P = 1\,200\,000 \text{ Pa} \quad \checkmark$$

$$L = \frac{80}{1\,000} = 0,080 \text{ m} \quad \checkmark$$

$$A = \frac{\pi d^2}{4}$$

$$= \frac{\pi 0,096^2}{4} \quad \checkmark$$

$$= 7,24 \times 10^{-3} \text{ m}^2 \quad \checkmark$$

$$N = \frac{4\,800}{60 \times 2}$$

$$= 40 \text{ r/s} \quad \checkmark$$

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

$$\text{Indicated power} = PLANn \quad \checkmark$$

$$= 1\,200\,000 \times 0,08 \times 7,24 \times 10^{-3} \times 40 \times 4 \quad \checkmark$$

$$= 111\,206,4 \text{ W}$$

$$= 111,21 \text{ KW} \quad \checkmark$$

(8)

7.4.2 **Brake power** =  $2\pi NT$ 

$$N = \frac{3\,600}{60} \quad \checkmark$$

$$= 60 \text{ r/s} \quad \checkmark$$

$$BP = 2 \times \pi \times 60 \times 260 \quad \checkmark$$

$$= 9\,8017,69 \text{ W}$$

$$= 98,02 \text{ KW} \quad \checkmark$$

(4)

7.4.3 **Mechanical efficiency** =  $\frac{BP}{IP} \times 100\%$ 

$$= \frac{98,02}{111,21} \times 100\% \quad \checkmark$$

$$= 88,14\% \quad \checkmark$$

(2)

**[32]**



**QUESTION 8: MAINTENANCE (SPECIFIC)****8.1 Exhaust gases:**

- Hydrocarbon ✓
- Carbon monoxide ✓
- Carbon dioxide ✓
- Nitrogen oxide ✓
- Sulphur dioxide ✓

(Any 3 x 1) (3)

**8.2 Possible causes of high oxygen readings:**

- Too lean air fuel ratio ✓
- Ignition problems ✓
- Vacuum leaks ✓
- Catalytic convertor not working ✓

(Any 2 x 1) (2)

8.3 8.3.1 Hissing sound from exhaust manifold indicate worn out exhaust valve. ✓ (1)

8.3.2 Hissing sound from the dip stick or oil cap indicates worn out rings. ✓ (1)

**8.4 Fuel pressure test specifications:**

- Fuel pressure at engine idle ✓
- Fuel pressure when engine is cold ✓
- Fuel pressure when engine is hot ✓
- Fuel pressure at high revolution ✓

(4)

**8.5 Possible causes of low fuel pressure readings:**

- Faulty fuel pump ✓
- Blocked or restricted fuel filter ✓
- Cracked or restricted fuel line ✓
- Clogged pump inlet strainer ✓
- Low voltage to the fuel pump ✓
- Faulty or failed fuel pressure regulator ✓
- Defective fuel pump relay ✓
- Empty fuel tank ✓

(Any 3 x 1) (3)

**8.6 8.6.1 Possible causes of low oil pressure reading:**

- Blocked oil pump sleeve in sump ✓
- Blocked or restricted oil filter ✓
- Dirty or contaminated oil ✓
- Oil leaks ✓
- Defective oil pressure release valve ✓
- Incorrect grade of oil (too thin) ✓
- Too little oil in the sump ✓

(Any 2 x 1) (2)

**8.6.2 Possible solutions to a very high oil pressure readings:**

- Change oil ✓
- Use the correct grade of oil ✓
- Replace oil filter ✓
- Overhaul the engine ✓
- Renew the relief valve ✓

(Any 2 x 1) (2)

**8.7 Cooling system pressure test:**

To detect leakage in the cooling system ✓ (1)

**8.8 Radiator cap pressure testing procedure:**

- Install the cap on a cooling system pressure tester ✓
- Pump the tester while watching the pressure gauge ✓
- The cap should release air at the stipulated pressure stamped on the cap ✓
- If the air is released at a pressure much greater or less than the stamped pressure on the cap, it means that the pressure cap is faulty ✓

(4)

**[23]****QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)****9.1 Purpose of automatic transmission on modern vehicles:**

- It relieves the driver of clutch and gearshift operation ✓ and for effective automated mechanical drive on the road (auto piloting) ✓

(2)

**9.2 Advantages of automatic transmission:**

- Reduces driving fatigue ✓
- It ensures great reduction of wheel spin under bad road conditions ✓
- Vehicle can stop suddenly without engine stalling ✓
- The system dampens out engine torsional vibration ✓
- Auto piloting can be achieved e.g., self-parking

(Any 2 x 1)

(2)

**9.3 Operation of double epicyclic gear train in low gear:**

- The turbine shaft and the primary sun gear are coupled by the front clutch. ✓
- The planet-gear carrier is held stationary by the rear brake band. ✓
- The rear clutch is dis-engaged and the front brake band is free, leaving the secondary sun gear free. ✓
- Drive is from the primary sun gear to the primary and secondary planet gears, which rotate around their own axis, to the annulus that is part of the output shaft. ✓
- The secondary sun gear is also driven but performs no driving function ✓

(5)

**9.4 Double epicyclic gear drive train in low gear parts label:**

- A** – Rear brake band ✓
- B** – Output shaft ✓
- C** – Primary sun gear ✓
- D** – Planet gear ✓
- E** – Annulus ✓

(5)

**9.5 Methods of cooling oil in automatic transmission:**

- By using special oil cooler alongside the engine cooling radiator. ✓
- Oil circulates through a tank built into the bottom radiator tank. ✓

(2)

**9.6 Function of hydraulic piston in automatic transmission:**

- It controls the brake bands and multi-disc clutches ✓ allowing gear control from one ratio to another ✓

(2)

**[18]**

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

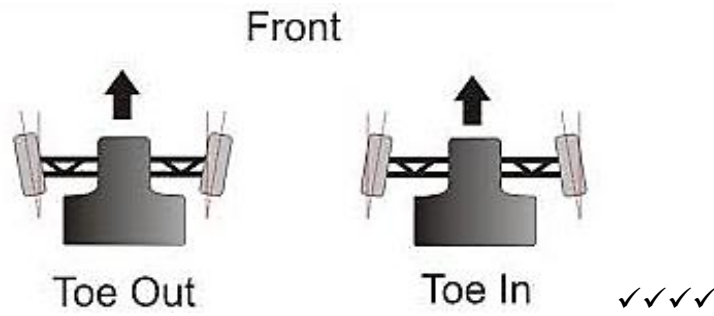
### 10.1 Functions of a steering mechanism:

- It enables the driver to be in control of the path always taken by the vehicle, ✓ and limit tyre wear. ✓ (2)

### 10.2 Properties of a good steering mechanism:

- Light and easy to control ✓
- Free from vibrations and road shocks ✓
- It must be as direct as possible without needing too much driver's attention or effort ✓
- Self-centring ✓
- Must be able to operate effectively when affected by the action of the suspension or brake system ✓ (Any 4 x 1) (4)

### 10.3 Diagram describing difference between toe-in and toe-out:



### 10.4 Advantages of positive camber:

- Easier steering ✓
- Better grip on cambered road ✓
- Worn out tyres are easy to identify ✓ (3)

### 10.5 10.5.1 Purpose of kingpin inclination:

It is designed to bring the front wheel back to the straight-ahead position ✓ after navigating a curve. ✓ (2)

### 10.5.2 Purpose of Ackermann principle:

It is designed to enable a car to navigate a curve effectively, ✓ without skidding. ✓ (2)

### 10.6 Pre-checks on wheels:

- Check the tyre for bruises, cracks and damaged side-walls. ✓
- Check the rim for damaged beads. ✓
- Check for foreign matter on the rim and tyres. ✓ (3)

### 10.7 Purpose of the catalytic converter:

It converts the pollutants in the exhaust gases of the engine, ✓ into a non-toxic substance, making it environmentally friendly. ✓ (2)

- 10.8 **Requirements for a catalytic converter to function properly:**
- Unleaded petrol must be used. ✓
  - Working temperature must not be less than 250 °C. ✓
  - The ignition system must be accurately control. ✓
  - The Lambda probe exhaust gas sensor must function correctly. ✓
  - Persistent misfire damages the ceramic monolith. ✓
  - Burnt engine oil also damages the monolith. ✓
- (Any 2 x 1) (2)
- 10.9 10.9.1 **Diode**
- Allows the flow of current only in one direction and blocks it from flowing in opposite direction. ✓✓ (2)
- 10.9.2 **Heat sink**
- Absorbs the heat produced in the diode and dissipates it into the atmosphere. ✓✓ (2)
- 10.9.3 **Voltage regulator**
- Regulates the output current of the alternator by controlling the strength its magnetic field. ✓✓ (2)
- 10.10 **Function of a pump:**
- Feeds the fuel from the fuel tank to the injector or carburettor at a predetermine pressure, ✓ at a rate higher than the maximum fuel consumption of the engine. ✓ (2)
- 10.11 **Advantages of electric fuel pump over a mechanical driven fuel pump**
- Immediate supply of fuel as soon as the ignition key is turned on ✓
  - Low operating noise ✓
  - Less discharge pulsation of fuel ✓
  - Compact and light in design ✓
  - Characterised to prevent fuel leak ✓
- (Any 2 x 1) (2)

**[32]****TOTAL: 200**