



Province of the
EASTERN CAPE
EDUCATION

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

SEPTEMBER 2021

**MECHANICAL TECHNOLOGY: (AUTOMOTIVE)
MARKING GUIDELINE**

MARKS: 200

This marking guideline consists of 12 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

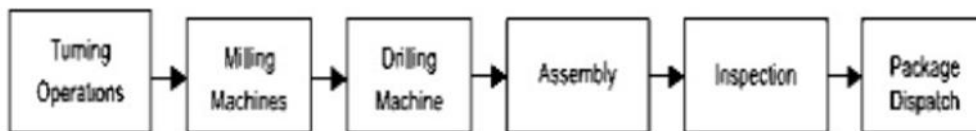
- 1.1 C ✓
 1.2 D ✓
 1.3 D ✓
 1.4 A ✓
 1.5 B ✓
 1.6 B ✓

(6 x 1) [6]

QUESTION 2: SAFETY (GENERIC)**2.1 Safety Precautions**

- Pressure gauges must be checked and tested regularly and adjusted or replaced if any malfunctioning occurs. ✓
- Supporting pins that keep the platform at a desired height on the frame must be inspected for damage. ✓
- Check the floor for oil and apparatus for leaks. ✓
- The platform on which the workpiece rests must be rigid and square with the press cylinder. ✓

(Any 2 x 1) (2)

2.2 Product layout

✓✓ (2)

2.3 Perspex shield

is installed to shield flying objects from harming the operator's eye. ✓

(1)

2.4 2.4.1 Machine Identification

Surface grinder ✓

(1)

2.4.2 Surface grinder parts label

- A Workpiece ✓
 B Machine spindle ✓
 C Magnetic table ✓
 D Grinding wheel ✓

(4)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Heat treatment refers to heating and cooling of metals under controlled conditions in their solid state so as to change their properties. ✓✓ (2)

3.2 Heat treatment properties

	PROCESS	PROPERTY
3.2.1	Hardening	Very hard, high tensile strength and brittle ✓
3.2.2	Tempering	Tough, hard ✓
3.2.3	Annealing	Soft, ductile, low tensile strength ✓
3.2.4	Normalising	Tough and machinable ✓

(4)

3.3 Purpose of case-hardening

- Harden surface ✓
 - Provides high surface wear resistance ✓
 - Tough core ✓
- (Any 2 x 1) (2)

3.4 Carbon effect

Steel with low carbon content ✓ will not respond very much to the hardening process. ✓ (2)

3.5 Workshop tests on materials

- Sound test ✓
 - Bend test ✓
 - Filing test ✓
 - Machining test ✓
- (Any 2 x 1) (2)

**3.6 Reasons for annealing**

- To relieve internal stresses that may have been set up during other processes. ✓
 - To soften them in order to facilitate the machining processes. ✓
 - To make material ductile. ✓
 - Refine their grain structures. ✓
 - Reduce brittleness ✓
- (Any 2 x 1) (2)

[14]

QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

(14 x 1) [14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

- 5.1 5.1.1 **Equipment**
 Compression tester ✓ (1)
- 5.1.2 **Parts of a compression tester**
 A – Flexible pipe ✓
 B – Adaptors' screw ✓
 C – Gauge ✓
 D – Relief valve (Release) ✓ (4)
- 5.1.3 **Purpose of a compression tester**
 To measure the pressure that the piston will create ✓ when moving from bottom dead centre to top dead centre ✓ (2)
- 5.2 **Function of a cylinder leakage tester**
 To check whether the engine leaks gases from the cylinder ✓ during compression stroke ✓ (2)
- 5.3 **Set-up procedure of cylinder leakage test**
- Turn the engine until both valves are closed on the cylinder under test ✓
 - Unscrew the spark plug and screw the adaptor into the spark plug hole ✓
 - Use the spanner to lock the crankshaft pulley ✓
 - Couple the compressed air pipe to the tester and then to the adaptor while the relief valve on the tester is closed ✓
 - Open the relief valve on the tester slowly ✓
 - Take the readings and compare with specification ✓ (6)
- 5.4 **Reason for analysing exhaust gases**
 To determine the amount of the different types of gases emitted from a car engine ✓ and compare with standards to ensure that it does not exceed the safety limit. ✓ (2)

- 5.5 5.5.1 **Bubble gauge**
It is used to test the caster, camber and king pin inclination angle of a motor vehicle ✓✓ (2)
- 5.5.2 **Turntable**
A turntable makes it possible to turn the front wheel 20° ✓ in and zero the bubble gauge ✓ and then turn the wheel 20° out and check the caster reading ✓ (3)
- 5.5.3 **Periscopic optical alignment gauge**
To check the toe-in and toe-out of a vehicle ✓ (1)
- [23]

QUESTION 6: ENGINES (SPECIFIC)

- 6.1 6.1.1 **Engine component**
Crankshaft ✓ (1)
- 6.1.2 **Crankshaft parts labeling**
A – Crank nose ✓
B – Crankpin journals/Big end journal ✓
C – Flywheel mounting ✓
D – Main journals ✓
E – Counterweights ✓
F – Main journal oil way ✓ (6)
- 6.1.3 **Function of the crankshaft**
To convert the reciprocating motion of the piston ✓ into a rotary motion ✓ (2)
- 6.1.4 **Number of cylinders**
4-cylinder ✓ (1)
- 6.2 6.2.1 **Function of a vibration damper**
A vibration damper adds mass to the crankshaft on the opposite side of a normal flywheel in order to counteract the torsion of the crankshaft ✓✓ (2)
- 6.2.2 **Parts labeling**
A – Crankshaft ✓
B – Crankshaft flange ✓
C – Secondary flywheel ✓
D – Friction disc ✓
E – Friction spring ✓
F – Spring plate ✓ (6)
- 6.3 **Engine cylinder configuration**
- In-line engines ✓
 - V-type engines ✓
 - Flat engines (Horizontally opposed engines) ✓ (Any 2 x 1) (2)

6.4 Factors that determine firing order

- Position of the crank on the crankshaft ✓
- The arrangement of cams on the camshaft ✓ (2)

6.5.1 Lag

It is a delay felt by the driver between pressing the accelerator pedal and feeling the turbo kick in ✓✓ (2)

6.5.2 Boost

It is the increase in manifold pressure generated by the turbocharger in the intake manifold which exceeds the atmospheric pressure. ✓✓ (2)

6.5.3 Waste gate

A component of a turbocharger that wastes some of the exhaust gases by causing it to bypass the turbocharger turbine. ✓✓ (2)

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QUESTION 7: FORCES (SPECIFIC)

7.1 7.1.1 Clearance volume

The volume of the space above the crown of the piston in the combustion chamber when the piston is at the top dead centre ✓✓ (2)

7.1.2 Compression ratio

The relationship between the total volume of a cylinder when the piston is at bottom dead centre to the volume of the charge in the cylinder when the piston is at top dead centre. ✓✓ (2)

7.2 Cylinder bore

Stroke = 85 mm = 8,5 cm

CV = 60 cm³

CR = 10 : 1

CR = $\frac{SV + CV}{CV}$ ✓

$$= 10 = \frac{SV + 60}{60} \quad \checkmark$$

SV = 540 cm³ ✓

$$540 = \frac{D^2}{4} \times L \quad \checkmark$$

$$540 = \frac{\pi \times D^2}{4} \times 8,5 \quad \checkmark$$

D = 8,994 cm

= 90 mm ✓

(6)

7.3 Methods of increasing compression ratio

- Remove shims from between crankcase and cylinder block ✓
- Fit thinner gasket between cylinder block and cylinder head ✓
- Machine metal from cylinder head ✓
- Skim metal from cylinder block ✓
- Fit piston with suitable higher crowns ✓
- Fit crankshaft with longer stroke ✓
- Increase cylinder bore ✓

(Any 3 x 1) (3)

7.4 New compression ratio

Bore increase by 4,8 mm

$$90 \text{ mm} + 4,8 \text{ mm} = 94,8 \text{ mm} = 9,48 \text{ cm} \checkmark$$

$$SV = \frac{\pi \times 9,48^2}{4} \times 8,5 \checkmark$$

$$= 600 \text{ cm}^3 \checkmark$$

$$CR = \frac{600+60}{60} \checkmark$$

$$= 11 : 1 \checkmark$$

(5)

7.5 7.5.1 Indicated power

$$P = PLAN \checkmark$$

$$P = 1^\circ 100 \text{ kPa} = 1\,100\,000 \text{ Pa}$$

$$L = 80 \text{ mm} = 0,08 \text{ m}$$

$$D = 95 \text{ mm} = 0,095 \text{ m}$$

$$A = \frac{\pi \times 0,095^2}{4} \checkmark$$

$$= 7,088218425 \times 10^{-3} \text{ m}^2 \checkmark$$

$$N = \frac{4\,200}{60 \times 2}$$

$$= 35 \text{ r/s} \checkmark$$

N = 4 cylinders

$$\text{Indicated power} = 1\,100\,000 \times 0,08 \times 7,088218425 \times 10^{-3} \times 35 \times 4 \checkmark$$

$$= 87\,326,85 \text{ W}$$

$$= 87,33 \text{ kW} \checkmark$$

(6)

7.5.2 Torque

$$T = f \times r$$

$$\text{But } f = mg = 35 \times 10$$

$$= 350 \text{ N} \checkmark$$

$$T = 350 \times 0,5 \checkmark$$

$$= 175 \text{ Nm} \checkmark$$

(3)

7.5.3 Brake power

$$BP = 2 \pi NT \checkmark$$

$$= 2 \times \pi \times 70 \times 175 \checkmark$$

$$= 76\,969,02 \text{ W}$$

$$= 77 \text{ kW} \checkmark$$

(3)

7.5.4 Mechanical efficiency

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

$$= \frac{77}{87,33} \times 100\% \checkmark$$

$$= 88,12\% \checkmark$$

(2)

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QUESTION 8: MAINTENANCE (SPECIFIC)**8.1 8.1.1 High hydrocarbon reading (possible causes)**

- Incomplete combustion ✓
- Improper timing ✓
- Vacuum leak ✓
- Faulty air management system ✓

(Any 1 x 1) (1)

8.1.2 Corrective measures

- Reset fuel mixture ✓
- Check and reset ignition system ✓
- Check and repair vacuum leaks ✓

(Any 1 x 1) (1)

8.1.3 High carbon monoxide (possible causes)

- Too rich mixture ✓
- Ignition misfire ✓
- Dirty air filter ✓
- Bad fuel delivery system ✓
- Faulty thermostat ✓
- Bad PVC valve system ✓
- Catalytic converter not working ✓

(Any 1 x 1) (1)

8.1.4 Corrective measures

- Reset fuel mixture ✓
- Check misfire and repair ✓
- Replace air filter ✓
- Check and correct fuel delivery system ✓
- Check and repair coolant sensor ✓
- Check and replace the catalytic converter ✓

(Any 1 x 1) (1)

8.2 Compression test safety requirements

- Ensure the tester can handle the pressure you want to test ✓
- Clean the plug hole environment with compressed air before removing the spark plug ✓
- Ensure the relief valve is working ✓
- Ensure the use of the correct adaptor for the plug hole ✓
- Ensure the throttle valve is opened ✓

(Any 3 x 1) (3)

8.3 Manufactural specification (cylinder leakage test)

- Listen at intake for hissing sound (inlet valve leaking) ✓
- Listen at exhaust for hissing sound (exhaust valve leaking) ✓
- Listen for hissing sound in dip stick (piston rings worn) ✓
- Listen for hissing sound after opening the tapper cover fillet cap (piston ring worn) ✓
- If you see bubbles in the radiator water, the cylinder head gasket is blown ✓

(Any 3 x 1) (3)

8.4 Low oil pressure reading (possible causes)

- Worn oil pump ✓
- Blocked pick-up screen in the oil sump ✓
- Worn main big-end and camshaft bearings ✓
- Blocked oil filter ✓
- Dirty or contaminated oil ✓
- Oil leaks ✓
- Too little oil in the engine ✓
- Incorrect oil viscosity ✓
- Defective oil pressure relief valve ✓

(Any 3 x 1) (3)

8.5 Components for possible leakage

- Water hoses ✓
- Blown cylinder head gasket ✓
- Water pump ✓
- Radiator ✓
- Corroded core plugs ✓
- Interior heater radiator ✓
- Faulty radiator cap ✓

(Any 4 x 1) (4)

8.6 Manufactural specifications (cooling system pressure test)

- Ratio combination of antifreeze and water in the system ✓
- Pressure allowed in the radiator ✓
- Pressure of the radiator cap ✓
- Reading of the water coolant tester ✓

(Any 2 x 1) (2)

8.7 8.7.1 Fuel pressure too high (possible causes)

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

(Any 2 x 1) (2)

8.7.2 Fuel pressure too high (possible causes)

- Restriction in return fuel line ✓
- Faulty fuel pressure regulator ✓

(2)

[23]

QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)**9.1 Purpose of automatic gearbox**

To relieve the driver of clutch and gearshift operation thereby allowing the driver to concentrate on driving the vehicle, promoting smoother and easier driving ✓✓

(2)

9.2 Differences between an automatic gearbox and manual gearbox

- There is no clutch pedal in vehicles with automatic gearbox but there is a clutch pedal in vehicles with manual gearbox ✓
- Gear shift happens automatically in automatic gearbox but it's the driver's responsibility to change gears in manual gearbox ✓
- Automatic transmission uses thin oil while manual gearbox uses thicker oil ✓
- Automatic transmission uses torque converter while manual gearbox uses clutch assemble ✓

(Any 2 x 1) (2)

9.3 Disadvantages of automatic gearbox

- It's more expensive to manufacture ✓
- The propeller shaft of an automatic transmission must be removed if the car is to be towed over a long distance ✓
- If the starter fails, there are no other alternatives to get the engine running ✓

(Any 2 x 1) (2)

9.4 Function of a torque converter

To multiply engine torque automatically according to road and engine speeds ✓✓

(2)

9.5 9.5.1 Stall speed

At stall speed, the maximum torque multiplication is delivered ✓ as the pump reaches the highest velocity but the turbine is still at rest. ✓ That is when the vehicle is just about to start moving. ✓

(3)

9.5.2 Increasing speed

The vehicle starts moving as the turbine begins to turn. As the speed increases, the torque multiplication tapers off gradually. ✓✓

(2)

9.6 Advantages of torque converter

- Torque increases automatically ✓
- Torque is transferred smoothly ✓
- Minimum servicing is required ✓

(Any 2 x 1) (2)

9.7 Advantages of transmission control unit (TCU)

- Better fuel economy ✓
- Reduces engine emissions ✓
- Greater shift system reliability ✓
- Improved shift feel ✓
- Improved shift speed ✓
- Improved vehicle handling ✓

(Any 3 x 1) (3)

[18]

QUESTION 10: SYSTEMS AND CONTROL (AXLES AND STEERING GEOMETRY AND ELECTRONICS) (SPECIFIC)**10.1 Causes of camber wear**

- Suspension misalignment ✓
- Bent strut ✓
- Dislocated strut tower ✓
- Weak or broken spring ✓
- Bent spindle ✓
- Damaged control arm ✓

(Any 2 x 1) (2)

10.2 Different between positive and negative camber

Positive camber is the outward tilt of the front wheel away from the vehicle ✓ when viewed from the front of the vehicle. ✓ While negative camber is the inward tilt of the front wheel into the vehicle ✓ when viewed from the front of the vehicle. ✓

(4)

10.3 10.3.1 Alignment angle

Negative ✓ caster ✓

(2)

10.3.2 Parts labeling

- A – Contact point of king pin Centre line ✓
- B – King pin ✓
- C – Perpendicular line ✓
- D – Negative caster angle ✓
- E – Centre line of king pin ✓
- F – Front of vehicle ✓
- G – Point of wheel contact ✓

(7)

10.3.3 Advantages of negative caster

- Easier turning of wheels ✓
- Better corner qualities ✓

(2)

10.4 Factors to be considered before attempting wheel alignment adjustment

- Kerb mass ✓
- Uneven wear on tyres ✓
- Tyre pressure ✓
- Run-out on the wheels ✓
- Correct pre-load on the wheel bearing ✓
- Kingpins and bushes ✓
- Suspension ball joints for wears ✓
- Suspension bushes for excessive free movement ✓
- Steering box play ✓
- Tie-rod ends ✓
- Sagged springs ✓
- Shock absorber ✓
- Spring U-bolts ✓
- Chassis for possible cracks and loose cross members ✓

(Any 2 x 1) (2)

10.5 Static balance

It is the equal distribution of all weight around the axis of rotation in the rotation plane (2)

10.6 Pre-checks on wheels before balancing

- Check the tyres for bruises, cracks and damaged side walls ✓
- Check the rim for any damage ✓
- Check for any foreign object on the rim and tyre ✓ (Any 2 x 1) (2)

10.7 10.7.1 Alignment

Ackermann principle ✓ (1)

10.7.2 Parts Labelling

- A – Rear axle ✓
- B – Longitudinal axis ✓
- C – Steering arm ✓
- D – Front wheel ✓
- E – Extended centre lines from steering arms ✓
- F – Intersection ✓ (6)

10.7.3 Purpose

To enable the correct turning angle of the front wheels ✓ when negotiating a curve in order to prevent skidding ✓ (2)

[32]**TOTAL: 200**