



**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

SEPTEMBER 2020



**MECHANICAL TECHNOLOGY: AUTOMOTIVE
MARKING GUIDELINE**

MARKS: 200

This marking guideline consists of 15 pages.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

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

QUESTION 2: SAFETY (GENERIC)**2.1 Gas welding (PPE)**

- Eye protection ✓
- Overall / leather apron ✓
- Safety boots ✓
- Gloves ✓

(Any 2 x 1) (2)

2.2 Safety rules that must be followed whilst the surface grinder is in operation:

- Make sure that the sparks are of no danger to co-workers. ✓
- Do not force the material onto the grinding wheel. ✓
- Do not plunge grind. ✓
- Bring the material slowly into contact with the grinding wheel. ✓
- Never clean or adjust the machine whilst it is in motion. ✓
- Use cutting fluid. ✓
- Know where the emergency stop is located. ✓
- Stop the machine before any adjustment. ✓
- Keep tools clear from moving parts. ✓

(Any 2 x 1) (2)

2.3 Completing a task on any machine:

Switch the machine off. ✓

(1)

2.4 TWO safety measures to observe before switching the angle grinder on:

- Make sure that there are no cracks or chips on the disc. ✓
- Make sure that the emery disc that is fitted is rated above the revolutions at which it is turned by the motor. ✓
- Make sure that the space between the tool rest and the emery disc does not exceed 3 mm. ✓
- Ensure that guards are in place. ✓
- Do not stand in front of the machine when switching it on; wait until it reaches its full speed. ✓
- Do not force or bump the work piece against the emery disc. ✓
- Grind only on the front surface of the wheel, not the sides. ✓
- All grinding machines must have a sign indicating the revolutions at which the spindle rotates. ✓

(Any 2 x 1) (2)

2.5 Importance of a welding helmet:

- To protect your eyes and face from ultra-violet rays and radiation ✓

(1)

2.6 Types of workshop layouts:

- Process layout ✓
- Product layout ✓

(2)

[10]

QUESTION 3: MATERIALS (GENERIC)

3.1

MATERIALS	DIFFERENT TYPES OF TESTS		
	Sound	Filing	Bend
Cast iron	Very dull sound ✓	Easy ✓	Cannot bend ✓/ Snaps/breaks ✓/ Fracturea easily ✓
Mild steel	Medium metallic sound ✓	Easy ✓	Benda easily ✓

(6)

3.2 **Heat treatment process:**

- Is the heating and cooling of metals in their solid state so as to change their properties ✓

(1)

3.3 **Hardness factors:**

- Workpiece size ✓
- Quenching rate ✓
- Carbon content ✓

(Any 2 x 1) (2)

3.4 **Heat treatment processes:**3.4.1 **Tempering**

- Is a process applied to steel and it relieves the strains induced during the hardening process. ✓
- It decreases the degree of hardness ✓
- It increases toughness ✓
- It reduces brittleness ✓
- It gives steel fine grain structure ✓

(Any 2 x 1) (2)

3.4.2 **Annealing**

- Relieves internal stress ✓
- Softens the metal ✓
- Makes metal ductile ✓
- Refines the grain structure ✓
- Reduces brittleness ✓

(Any 2 x 1) (2)

3.5 **Hardness of steel depends upon**

- Carbon content ✓

(1)

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QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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



QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**5.1 Bubble gauge:**

5.1.1 • Bubble gauge ✓ (1)

5.1.2 A – King-pin inclination scale ✓
B – Caster scale ✓
C – Camber scale ✓
D – Gauge zero scale ✓
E – Mounting equipment on wheel ✓ (5)

5.1.3 • Caster angle ✓
• Camber angle ✓
• King-pin inclination ✓ (3)

5.2 Set-up procedure to read camber:

- Ensure that the wheels are in a straight ahead position. ✓
- Mount the bubble gauge on the centre of the wheel. ✓
- Zero the bubble gauge on the gauge zero scale. ✓
- Take the reading on the camber scale. ✓
- Do the same for the other wheels. ✓ (5)

5.3 Dynamic balancing of wheels:

- The plane of imbalance ✓
- The extent of unbalanced forces ✓
- The sense of direction of these forces (clockwise or counter clockwise / anticlockwise) ✓
- Run-out of the tyre and wheel assembly ✓ (Any 3 x 1) (3)

5.4 Tools:**5.4.1 Turn table:**

To turn the front wheel 20° in and zero the bubble gauge ✓ and then turn the wheel 20° out to check the castor reading ✓ (2)

5.4.2 Wheel balancer:

To balance the wheels of a vehicle ✓ for static and dynamic balance. ✓ (2)

5.4.3 Optical alignment tool:

To check the toe-in ✓ and toe-out of a vehicle ✓ (2)

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QUESTION 6: ENGINES (SPECIFIC)**6.1 Causes of vibration:**

- The action of unbalance forces upon the shaft ✓
- The twisting effects of the power stroke ✓ (2)

6.2 Types of vibration damper:

- Friction face-type ✓
- Combined rubber and friction disc ✓ (2)

6.3 In-built engine balance features:

6.3.1 Crankshafts are carefully balanced with webs extended and drilled to form balance mass piece at points opposite the connecting rods. ✓✓ (2)

6.3.2 Connecting rods and pistons are kept as light as possible to reduce reciprocating forces. ✓✓ (2)

6.3.3 Flywheels are carefully balanced and are usually fitted to the crankshaft flange in one position only. ✓✓ (2)

6.4 Factors that determine engine configuration:

- Number of cylinders ✓
- Position of cylinders ✓
- Engine layout ✓
- Firing order ✓
- Engine location and mounting ✓ (Any 3 x 1) (3)

**6.5 Types of engine configuration:**

- In-line engine ✓
- V-type engine ✓
- Horizontally opposed engine ✓ (Any 2 x 1) (2)

6.6 Identification of an engine configuration:

The crankshaft of a V-engine ✓ (1)

6.7 Factors that determine the firing order:

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

6.8 Firing order of a 5-cylinder in-line engine:

12453 OR 13542 ✓ (1)

6.9 Turbocharger internal components:

- A – Turbine exhaust gas outlet ✓
- B – Turbine wheel OR impeller ✓
- C – Turbine exhaust gas inlet ✓
- D – Compressor air discharge ✓
- E – Compressor ✓
- F – Compressor air inlet ✓ (6)

6.10 **Disadvantages of a turbocharger:**

- It can have lag problems. ✓
- It tends to heat up the air, reducing density. ✓
- Some require shut-down process. ✓
- It requires pressure lubrication for high speed bearings. ✓
- Its lubricant must be air cooled. ✓
- Over-revving must be controlled by waste gate. ✓

(Any 3 x 1) (3)
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QUESTION 7: FORCES (SPECIFIC)7.1 **Compression ratio:**

The compression ratio of an internal combustion engine is the ratio of compression of the inlet charge during the compression stroke ✓ to the total volume of the cylinder. ✓ (2)

7.2 **Compression ratio:****Swept volume:**

$$\begin{aligned} \text{Swept volume} &= \frac{\pi D^2}{4} L \quad \checkmark \\ &= \frac{\pi(9.0^2)}{4} \times 11 \quad \checkmark \\ &= 700 \text{ cm}^3 \quad \checkmark \end{aligned}$$

$$\text{Compression ratio} = \frac{SV+CV}{CV}$$

$$= \frac{700+70}{70} \quad \checkmark$$

$$11 : 1 \quad \checkmark$$

(6)

7.3 **New compression ratio:**

$$\text{Swept volume} = \frac{\pi(9,61^2)}{4} \times 11$$

$$= 797,865 \text{ cm}^3 \quad \checkmark$$

$$\text{Compression ratio} = \frac{797,865 + 70}{70} \quad \checkmark$$

$$= 12,4 : 1 \quad \checkmark$$

(4)

(4)

7.4 **Methods used in raising 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 piston with higher crown. ✓
- Fit crankshaft with longer stroke. ✓
- Increase the bore of the cylinders. ✓

(Any 4 x 1) (4)

7.5 Indicated power:

Indicated power is a measure to determine the total power developed by the burning of fuel in the combustion chamber of an internal combustion engine. ✓✓

(2)

7.6 Power calculations:

7.6.1 Indicated power = $P \times L \times A \times N \times n$

$$P = 1200000 \text{ Pa}$$

$$L = \frac{86}{1000} \\ = 0,086 \text{ m } \checkmark$$

$$A = \frac{\pi D^2}{4} \\ = \frac{\pi \times 0,09^2}{4} \checkmark$$

$$= 6,36 \times 10^{-3} \text{ m}^2 \checkmark$$

$$N = \frac{4200}{60 \times 2} \checkmark$$

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

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

$$\text{Indicated power} = 1200000 \times 0,086 \times 6,36 \times 10^{-3} \times 35 \times 4 \checkmark$$

$$= 91889,28 \text{ W}$$

$$= 92 \text{ kW } \checkmark$$

(7)

7.6.2 Brake power = $2 \pi NT$

$$N = \frac{4200}{60}$$

$$70 \text{ r/s } \checkmark$$

$$= 2 \times \pi \times 70 \times 180 \checkmark$$

$$= 211115,03 \text{ W}$$

$$= 79168,13 \text{ W}$$

$$= 79,2 \text{ kW } \checkmark$$

(3)

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

$$= \frac{79,2}{92} \times 100\% \quad \checkmark$$

$$= 82,5\% \quad \checkmark \quad (2)$$

7.7 **Term definition:**

It is the percentage energy that an engine puts out due to mechanical losses as compared to the ideal engine power. $\checkmark\checkmark$

(2)
[32]



QUESTION 8: MAINTENANCE (SPECIFIC)**8.1 Reasons for high CO (carbon monoxide) reading:**

- 8.1.1
- Too rich mixture ✓
 - Ignition misfire ✓
 - Dirty or restricted air filter ✓
 - Improper operation of the fuel delivery system ✓
 - Faulty thermostat or coolant sensor ✓
 - Non-functioning PVC valve system ✓
 - Catalytic converter not working ✓
- (Any 3x1) (3)

8.1.2 Corrective measures:

- Reset fuel mixtures. ✓
 - Check for misfire and repair. ✓
 - Replace air filter. ✓
 - Check and correct fuel delivery system. ✓
- (Any 3 x 1) (3)

8.1.3 Gases analysed:

- CO₂ ✓
 - SO₂ ✓
 - NO ✓
 - HC ✓
 - O₂ ✓
- (Any 3 x 1) (3)

8.2 Cylinder leakage testing:

- Wet test ✓



(1)

8.3 Cylinder leakage and causes:

- 8.3.1 Leakage inlet valve ✓ (1)
- 8.3.2 Blown cylinder head gasket or cracked cylinder block ✓ (1)
- 8.3.3 Piston rings are worn ✓ (1)

8.4 Oil pressure testing:

- Oil pressure when the engine is idling. ✓
 - Oil pressure when the engine is cold. ✓
 - Oil pressure when the engine is hot. ✓
 - Oil pressure on high revolution. ✓
- (4)

8.5 Causes of low fuel pressure reading:

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

(Any 3 x 1) (3)

8.6 Cooling system pressure testing:

- Water hoses ✓
- Water pump ✓
- Radiator ✓
- Corroded core plugs ✓
- Interior heater radiator ✓
- Faulty radiator cap ✓

(Any 3 x 1) (3)
[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 ✓ (2)

9.2 Advantages of an automatic gearbox

- It reduces driving fatigue. ✓
 - It ensures reduction of wheel spin under bad road condition. ✓
 - The vehicle can be stopped suddenly without the engine stalling ✓
 - The system puts a damper on/muffles all engine vibrations. ✓
- (Any 3 x 1) (3)

9.3 Torque converter:

9.3.1 Torque converter ✓ (1)

9.3.2 Parts

- A – One-way clutch ✓
 - B – Turbine ✓
 - C – Pump ✓
 - D – Turbine shaft ✓
 - E – Gearbox housing ✓
- (5)

9.3.3 Torque converter functions:

- Transfers engine torque to the transmission. ✓
 - Multiplies the engine torque. ✓
 - Provides a direct drive from engine to transmission. ✓
 - It muffles/puts a damper on all engine vibrations. ✓
 - It acts as flywheel. ✓
- (Any 3 x 1) (3)

9.3.4 Function of parts:

It sets the fluid in motion at high pressure to the turbine, ✓ thereby causing the turbine to rotate with great torque. ✓ (2)

9.4 Torque multiplication:

As the car speed increases, ✓ the torque multiplication tapers off gradually. ✓ (2)

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

10.1 Properties of a good steering mechanism:

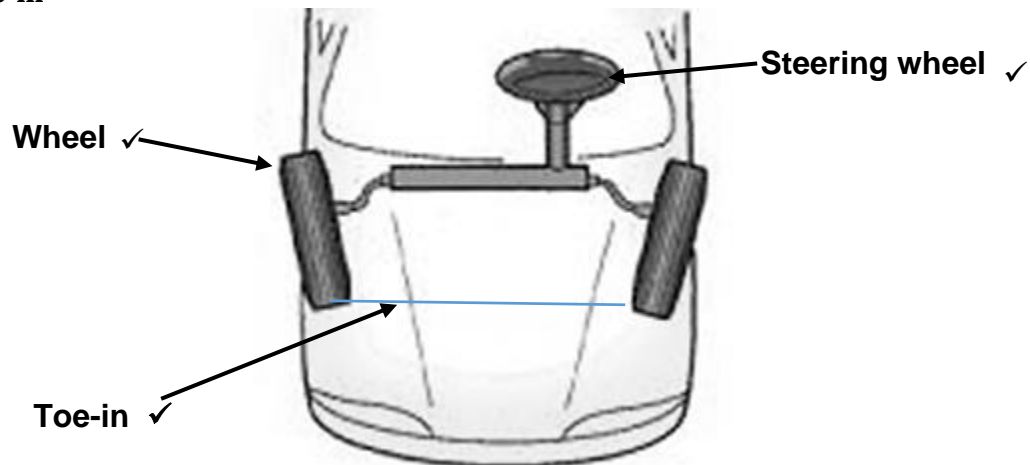
- Light and easy to control ✓
- Free from vibration and road shocks ✓
- Self-centring ✓
- Able to operate effectively under the influence of the suspension and braking system ✓
- It must be as direct as possible to reduce too much driver's attention. ✓

(Any 4 x 1)

(4)

10.2

Toe-in



FRONT

(4)

10.3 Alignments:

10.3.1 Caster angle:

It gives self-centring action to the steering ✓ thereby keeping the wheels in straight ahead position. ✓

(2)

10.3.2 Ackermann principle:

To avoid the need for tyres to slip sideways ✓ when following the path around a curve. ✓

(2)

10.3.3 King pin inclination:

To bring the front wheel back to the straight ahead position ✓ after rounding a corner without any driver effort. ✓

(2)

10.4 Camber:

10.4.1 Positive camber. ✓

(1)

10.4.2 A – Tyre ✓

B – Vertical line ✓

C – Centre line ✓

D – Positive camber angle ✓

E – Lower control arm ✓

F – Road surface ✓

(6)

10.4.3 Positive camber angle is the outward tilt ✓ of a front wheel away from The vehicle when viewed from the front. ✓

(2)

10.5 Factors to be taken into account before attempting alignment adjustment:

- Kerb mass must be checked against the manufacturer's specifications ✓
- Uneven wear on tyres ✓
- Tyre pressure ✓
- Run-out on wheels ✓
- Kingpins and bushes ✓
- Suspension ball joints for wears ✓
- Suspension bushes for excessive free movements ✓
- Tie-rod ends ✓
- Sagged springs ✓
- Ineffective shock absorbers ✓
- Spring U-bolts ✓
- Chassis for possible cracks ✓
- Wheel must be balanced ✓
- Wheel alignment specifications ✓
- Drive shaft CV-joints ✓

(Any 5 x 1)

(5)

10.6 Purpose of wheel balancing:

To avoid shimmying and bouncing of wheel assembly which can cause wearing of the steering mechanism and suspension parts. ✓✓

(2)

10.7 Wheel balancing:

- Static balance ✓
- Dynamic balance ✓

(2)

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