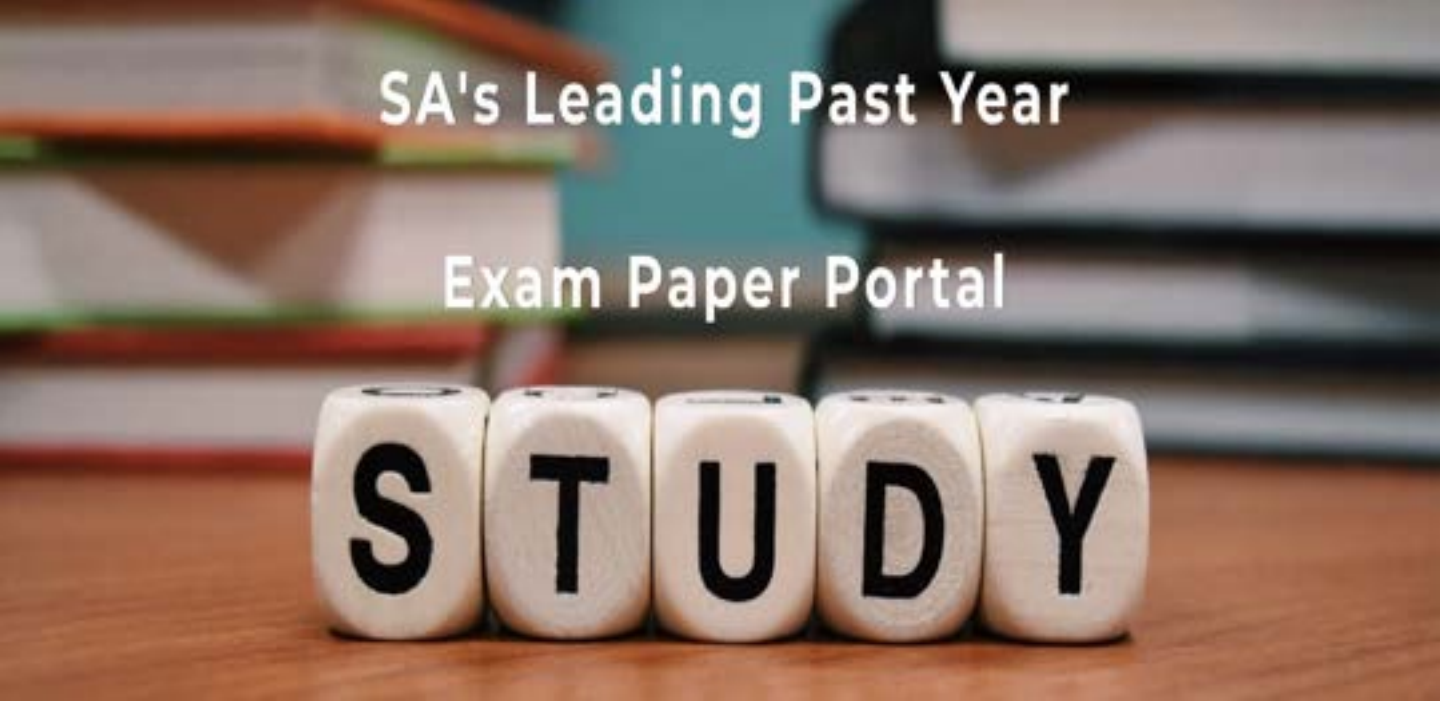

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GRADE 12

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)

[28]

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 cm^3

CR = 10 : 1

$\text{CR} = \frac{SV + CV}{CV}$ ✓

$= 10 = \frac{SV + 60}{60}$ ✓

SV = 540 cm^3 ✓

$540 = \frac{D^2}{4} \times L$ ✓

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

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 mm + 4,8 mm = 94,8 mm = 9,48 cm ✓

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

$= 600\ cm^3$ ✓

$CR = \frac{600+60}{60}$ ✓

$= 11 : 1$ ✓ (5)

7.5 7.5.1 **Indicated power**

P = PLANn ✓

P = 1°100 kPa = 1 100 000 Pa

L = 80 mm = 0,08 m

D = 95 mm = 0,095 m

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

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

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

$= 35 r/s$ ✓

N = 4 cylinders

Indicated power= 1 100 000 x 0,08 x 7,088218425 x 10^{-3} x 35 × 4 ✓

= 87 326,85 W

= 87,33 kW ✓ (6)

7.5.2 **Torque**

T = f×r

But f= mg = 35 x10

= 350 N ✓

T = 350 x 0,5 ✓

= 175 Nm ✓ (3)

7.5.3 **Brake power**

BP = 2 π NT ✓

= 2 x π x 70 x 175 ✓

= 76 969,02 W

= 77 kW ✓ (3)

7.5.4 **Mechanical efficiency**

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

$= \frac{77}{87.33} \times 100\%$ ✓

= 88,12% ✓ (2)

[32]

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