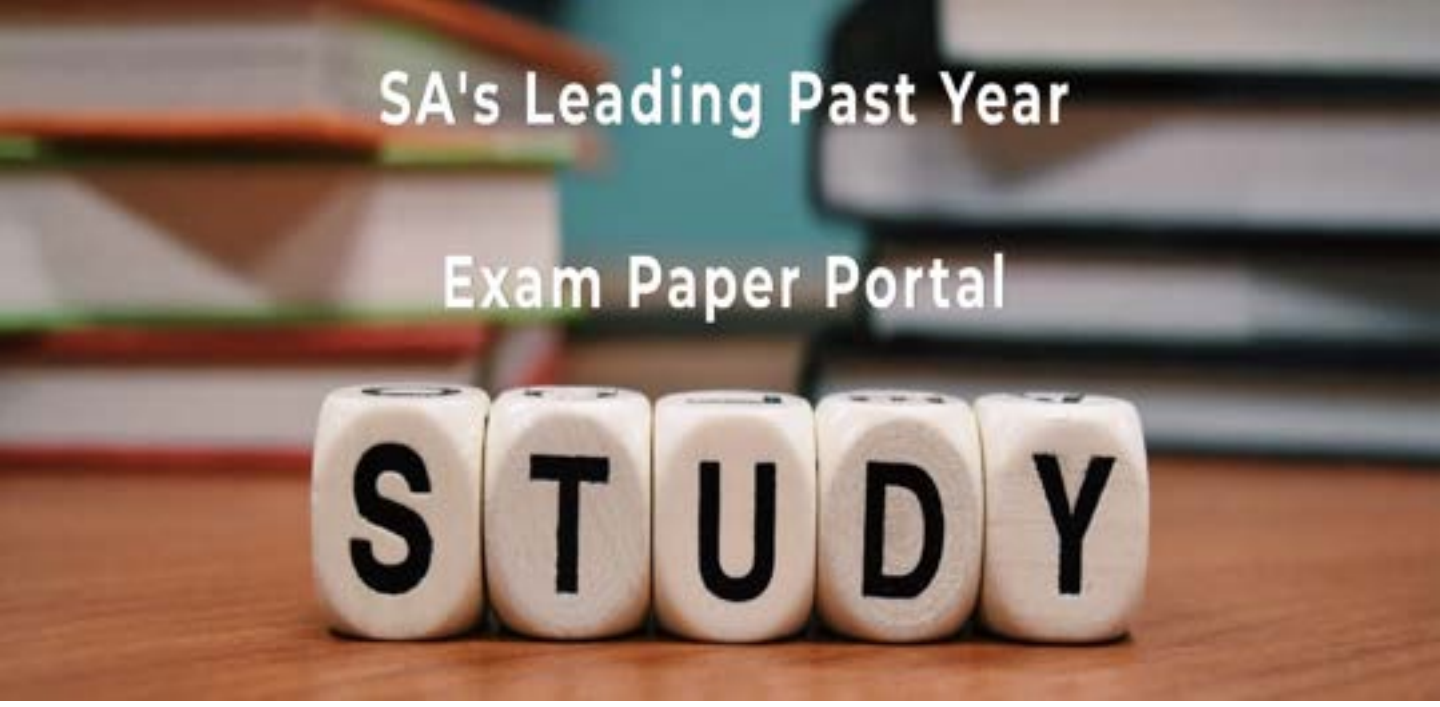


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# NATIONAL SENIOR CERTIFICATE

## GRADE 12

## MECHANICAL TECHNOLOGY: AUTOMOTIVE

## NOVEMBER 2022

## MARKING GUIDELINES

**MARKS: 200**

**These marking guidelines consist of 18 pages.**

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

1.1 B ✓ (1)

1.2 B ✓ (1)

1.3 C ✓ (1)

1.4 C ✓ (1)

1.5 A ✓ (1)

1.6 B ✓ (1)
**[6]**

## QUESTION 2: SAFETY (GENERIC)

2.1 **Vital functions:**

- Breathing ✓
- Heart rate / pulse ✓
- State of consciousness ✓

**(Any 2 x 1)** (2)

2.2 **Safety glasses during grinding:**

- To prevent any injuries to the operator's eyes. ✓
- To protect eyes from sparks and debris. ✓
- To prevent blindness due to injury. ✓

**(Any 1 x 1)** (1)

2.3 **Type of guards:**

- Fixed guard ✓
- Automatic sweep-away ✓
- Self-adjusting / automatic guard ✓
- Electronic presence sensing device ✓
- Two-hand control device. ✓

**(Any 2 x 1)** (2)

2.4 **Precautions *before* gas welding operations can be undertaken:**

- An operator has been instructed on how to use the equipment safely. ✓
- A workplace is effectively partitioned off. ✓
- An operator uses protective equipment (PPE). ✓
- Ensure that fire equipment is at hand. ✓
- Ensure that the equipment is in a safe working condition. ✓
- Ensure the gas equipment is set-up correctly. ✓
- Ensure the area is well ventilated. ✓
- Ensure that the working area is safe. ✓

**(Any 3 x 1)** (3)

2.5 **TWO disadvantages of the product layout:**

- Lack of flexibility. ✓
- Optimum use of equipment is not possible. ✓

(2)
**[10]**

## QUESTION 3: MATERIALS (GENERIC)

3.1 **THREE properties:**

- Toughness ✓
- Hardness / Wear resistance ✓
- Softness ✓
- Case hardness ✓
- Ductility ✓
- Malleability ✓
- Elasticity ✓
- Brittleness ✓
- Strength ✓

**(Any 3 x 1)** (3)

3.2 **Heat treatment processes:**

3.2.1 **Tempering:**

- It consists of heating the hardened steel ✓ to a temperature below its critical temperature (colour chart). ✓
- Soaking it at this temperature for a period of time, ✓
- Quenching/cooling it rapidly in water, brine or oil. ✓ (4)

3.2.2 **Hardening:**

- The steel is heated slightly higher than the upper critical temperature. ✓
- The steel is soaked at that temperature for the required time. ✓
- The steel is then rapidly cooled by quenching in water, brine or oil. ✓ (3)

3.3 **Examples of case-hardening:**

- Bearing cases ✓
- Bearing ball ✓
- Bearing needles ✓
- Crankshafts ✓
- Gears ✓
- Camshafts ✓
- Cylinder sleeves ✓
- Hammer head ✓
- Jack Hammer drill bits ✓

**(Any 2 x 1)** (2)

3.4 **Why steels are cooled down in still air away from draughts:**
This prevents sudden cooling of localised spots, ✓ which might cause distortion/cracks. ✓ (2)

**[14]**

## QUESTION 4: MULTIPLE-CHOICE (SPECIFIC)

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

**[14]**

## QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1 **Compression test:**

5.1.1 **The ignition system is disconnected:**
- To prevent a shocking hazard to the operator. ✓
- To prevent fire hazard. ✓
- Prevent any sparks / flow of current from the ignition system. ✓

**(Any 2 x 1)** (2)

5.1.2 **All spark plugs are removed:**
- To ensure accurate readings. ✓
- To allow the engine to swing easier. ✓
- To fit the compression tester. ✓

**(Any 2 x 1)** (2)

5.1.3 **Removing the air filter:**
- To allow maximum air flow into the cylinder. ✓
- To ensure accurate readings. ✓ (2)

5.2 **Cylinder leakage tester:**
- Connect the compressed air hose from compressor to the tester. ✓
- Adjust the regulator valve knob and observe the gauge needle. ✓
- Stop turning the knob when the gauge is on 0%. ✓ (3)

5.3 **Exhaust gas analyser:**
- Analyse exhaust gasses. ✓
- Indicate the amount of CO, $CO_2$, HC, $NO_X$, $SO_2$ and $O_2$. ✓
- Indicate the stoichiometric air/fuel ratio / Lambda reading. ✓

**(Any 2 x 1)** (2)

5.4 **OBD scanners:**
- Bluetooth ✓
- Wi-Fi ✓
- Cable ✓ (3)

5.5 **Static wheel balance and dynamic wheel balance:**
- Static balancing refers to the wheel's balance as it becomes stationary. ✓
- Dynamic balancing refers to the wheel's balance while in motion. ✓ (2)

5.6 **Wheel imbalance:**
- The plane of imbalance / The imbalance is on the inner or outer side of the wheel. ✓
- The extent of the unbalancing forces / The mass of the balancing weights. ✓
- The sense of direction of these forces / Forces are clockwise or counter clockwise. ✓ (3)

5.7 **Optical alignment:**

- Look through the periscope gauge. ✓
- Align the vertical line through the triangle by moving the pointer arm. ✓
- Take the degree reading on the toe gauge. ✓
- Note if the reading is on the IN or the OUT of the scale. ✓ (4)

**[23]**

## QUESTION 6: ENGINES (SPECIFIC)

6.1 **Crankshaft indirectly drives:**

- Camshaft ✓
- Distributor ✓
- Oil pump ✓
- Water pump ✓
- Power steering pump ✓
- Air conditioner ✓
- Fan ✓
- Alternator ✓
- Supercharger ✓
- Mechanical fuel pump ✓
- Pistons ✓
- Valves / valve train ✓

**(Any 3 x 1)** (3)

6.2 **Vibration dampers:**

6.2.1 Combined rubber and friction disc ✓ (1)

6.2.2 The friction face-type ✓ (1)

6.3 **Features that improve engine balance:**

- The crankshaft is carefully balanced / Counterweights on the crankshaft. ✓
- Connecting rods and pistons are kept as light as possible. ✓
- Flywheels are carefully balanced. ✓
- The mass of the reciprocating masses for each cylinder are kept as uniform as possible. ✓
- The power strokes should be spaced at equal intervals / Firing order configured for balancing. ✓
- Dual mass flywheels are fitted to the rear of the crankshaft. ✓
- Engine is fitted with crankshaft balance shafts. ✓

**(Any 4 x 1)** (4)

6.4 **V-type engine advantages:**

- Can be mounted in smaller engine compartments. ✓
- The engine is shorter in length. ✓
- Improved power to weight ratio. ✓
- Lighter mass. ✓
- Improved fuel efficiency. ✓
- Crankshaft is less likely to twist. ✓

**(Any 2 x 1)** (2)

6.5 **Four-cylinder firing orders:**

- 1-3-4-2 ✓
- 1-2-4-3 ✓
- 1-3-2-4 ✓
- 1-4-3-2 ✓

**(Any 2 x 1)** (2)

6.6 **Position of crankpin:**

6.6.1
- 8-cylinder ✓ (1)

6.6.2
- 3-cylinder ✓
- 6-cylinder ✓

**(Any 1 x 1)** (1)

6.6.3
- 4-cylinder ✓
- 2-cylinder ✓

**(Any 1 x 1)** (1)

6.7 **Turbocharger:**

6.7.1 **Labelling the turbocharger:**

A. Compressor outlet / Air outlet ✓
B. Compressor / Compressor housing(casing) / Impeller housing(casing) ✓
C. Turbine housing(casing)(section) ✓
D. Exhaust gas outlet / Gas outlet ✓
E. Exhaust gas inlet / Gas inlet ✓ (5)

6.7.2 **Types of turbochargers:**

- Non-variable type turbocharger ✓
- Variable geometry turbocharger (VGT) ✓
- Single turbocharger ✓
- Twin turbocharger ✓
- Twin-scroll turbocharger ✓
- Variable Twin-scroll turbocharger ✓
- Electric turbocharger ✓

**(Any 2 x 1)** (2)

6.7.3 **Idling before turning the engine off:**

- Allows the turbo charger to slow down. ✓
- To cool down the turbo charger components. ✓
- To ensure lubrication to the turbo charger. ✓
- Prevent the oil to coke (carbon deposits). ✓

**(Any 2 x 1)** (2)

6.8 **Superchargers:**

6.8.1 Centrifugal supercharger ✓ (1)

6.8.2 Roots supercharger ✓ (1)

6.8.3 Twin-screw supercharger ✓ (1)

**[28]**

## QUESTION 7: FORCES (SPECIFIC)

7.1 **Swept volume:**
The volume displaced by the piston ✓ during a stroke (BDC to TDC). ✓ (2)

7.2 **Work:**

7.2.1 $\text{Work} = \text{Force}\,(m \times g) \times \text{distance}$

$= (980 \times 10) \times 35$ ✓ ✓

$= 343000\,\text{J}$

$= 343\,\text{kJ}$ ✓ (3)

7.3 **Cylinder:**

7.3.1 A. Bore / Cylinder diameter ✓
B. Stroke length ✓ (2)

7.3.2 **Swept volume:**
A. 120 mm = 12 cm
B. 135 mm = 13,5 cm ✓(for converting to cm)

$$\text{Swept volume} = \frac{\pi \times D^2}{4} \times \text{Stroke length}$$

$$= \frac{\pi \times 12^2}{4} \times 13,5 \quad \text{✓ ✓}$$

$$= 1526,81\,\text{cm}^3 \quad \text{✓}$$

**OR**

$$\text{Swept volume} = \frac{\pi \times D^2}{4} \times \text{Stroke length}$$

$$= \frac{\pi \times 120^2}{4} \times 135 \quad \text{✓ ✓}$$

$$= 1\,526\,814,03\ \text{mm}^3$$

$$= 1\,526,81\ \text{cm}^3 \quad \text{✓(for converting to cm}^3\text{)}$$ (4)

7.3.3 **Compression ratio (CR):**

$$CR = \frac{SV}{CV} + 1$$

$$CR = \frac{1526,81}{102,5} + 1 \quad ✓ \quad ✓$$

$$CR = 15,9 : 1 \quad ✓$$

**OR**

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

$$= \frac{1526,81 + 102,5}{102,5} \quad ✓ \quad ✓$$

$$= 15,9 : 1 \quad ✓$$

(3)

7.4 **Calculate Indicated power:**

$$P = 1150\,kPa$$

$$L = \frac{77}{1000}$$
$$= 0,077\,m \quad ✓$$

$$A = \frac{\pi D^2}{4} \quad ✓$$
$$= \frac{\pi \times 0,1^2}{4}$$
$$= 7,85 \times 10^{-3}\,m^2 \quad ✓$$

$$N = \frac{1800}{60 \times 2} \quad ✓$$
$$= 15\,\text{power strokes/sec.} \quad ✓$$

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

$$\text{Indicated Power} = PLANn$$
$$= (1150 \times 10^3) \times 0,077 \times (7,85 \times 10^{-3}) \times 15 \times 4 \quad ✓$$
$$= 41,73\,kW \quad ✓$$

(7)

7.5 **Dynamometers to measure brake power:**

- Prony brake ✓
- Electric dynamometer ✓
- Eddy current dynamometer ✓
- Hydraulic dynamometer ✓
- DC dynamometer ✓
- Rope brake ✓

**(Any 2 x 1)** (2)

7.6 **Calculations:**

7.6.1 **Torque:**

$$\text{Force} = m \times g$$
$$= 120 \times 10$$
$$= 1200\text{N} \checkmark$$

$$\text{radius} = \frac{500}{1000}$$
$$= 0{,}5\text{m} \checkmark$$

$$\text{Torque} = \text{force} \times \text{radius}$$
$$\text{Torque} = 1200 \times 0{,}5 \checkmark$$
$$\text{Torque} = 600\text{Nm} \checkmark$$ (4)

7.6.2 **Brake power:**

$$\text{Brake power} = 2 \times \pi \times N \times T$$
$$\text{Brake power} = 2 \times \pi \times \frac{2500}{60} \checkmark \times 600 \checkmark$$
$$\text{Brake power} = 157{,}08\text{kW} \checkmark$$ (3)

7.6.3 **Mechanical efficiency:**

$$\text{Mechanical efficiency} = \frac{BP}{IP} \times 100$$
$$ME = \frac{157{,}08}{196} \checkmark \times 100$$
$$ME = 80{,}14\% \checkmark$$ (2)

**[32]**

## QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 **Gas analyser:**

- High carbon monoxide (CO) ✓
- High oxygen ($O_2$) ✓
- High nitrogen oxides (NOx) ✓
- High hydrocarbon (HC) ✓

**(Any 3 x 1)** (3)

8.2 **Cylinder leakage test:**

- Listen for hissing sound at the air intake. ✓
- Listen for hissing sound at the exhaust pipe. ✓
- Listen for hissing sound in the dipstick hole / oil filler cap. ✓
- Look for bubbles in the radiator water. ✓
- Listen for hissing sound at the adjacent cylinder spark plug hole. ✓

**(Any 3 x 1)** (3)

8.3 **Compression test:**

8.3.1 10% ✓ (1)

8.3.2 $\text{Variation} = \text{highestreading} - \text{lowestreading}$

$= 11 - 8{,}2$ ✓

$= 2{,}8 \text{ bar}$ ✓

**OR**

$\text{Variation} = \frac{11 - 8{,}2}{11}$ ✓

$= 25{,}5\%$ ✓ (2)

8.3.3 **Low Compression:**

- Worn compression rings ✓
- Worn pistons ✓
- Worn cylinders ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Blown head gasket ✓
- Cracked cylinder head ✓
- Cracked cylinder ✓
- Cracked cylinder sleeves ✓

**(Any 2 x 1)** (2)

8.3.4 **Corrective measure:**

- Repair or replace cracked cylinder head. ✓
- Reset or replace or adjust the valves. ✓
- Replace cylinder head gaskets. ✓
- Replace pistons. ✓
- Repair (bore) or replace cylinder sleeves. ✓
- Replace piston rings. ✓

**(Any 2 x 1)** (2)

8.4 **Causes of a low oil pressure:**

- Worn oil pump. ✓
- Blocked oil pump/screen in sump. ✓
- Worn main bearings. ✓
- Worn big-end bearings. ✓
- Worn camshaft bearings. ✓
- Pressure after blocked or restricted oil filter. ✓
- Oil leaks / Insufficient oil. ✓
- Defective oil pressure relief valve. ✓
- Low viscosity. ✓
- Dirty or contaminated oil. ✓

**(Any 2 x 1)** (2)

8.5 **Corrective measures with oil if the oil pressure reading is high:**

- Use the correct oil grade. ✓
- Change the oil with clean oil. ✓ (2)

8.6 **Pre-checks fuel pressure tester:**

- Ensure that the tester can read the pressure of the engine. ✓
- Use the right adaptor for the engine. ✓
- Ensure that the rubber pipe is not perished on the tester. ✓
- Ensure that the pressure relieve valve is working properly. ✓

**(Any 3 x 1)** (3)

8.7 **Cooling system pressure test:**

- Renew the gaskets or seals. ✓
- Renew the faulty water hose. ✓
- Secure water hose clamps. ✓
- Skim the cylinder head and replace cylinder head gasket. ✓
- Renew the water pump. ✓
- Renew or repair the radiator. ✓
- Renew the welch or core plugs. ✓
- Renew or repair the interior radiator. ✓
- Renew the heater tap. ✓

**(Any 3 x 1)** (3)
**[23]**

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

9.1 **Double-epicyclic gear system:**

9. 1.1 **Labels:**

A. Input shaft/Sun gear shaft ✓
B. Brake band ✓
C. Annulus/Ring gear ✓
D. Planet carrier ✓
E. Sun gear ✓
F. Planetary gear ✓ (6)

9.1.2 **Operation of this gear system:**

- Sun gears are driven by the input shaft (A). ✓
- Annulus (C) is held stationary by its brake bands (B). ✓
- Planetary gears (F) walk around sun gear (E). ✓
- The planet carrier (D) and output main shaft will rotate slowly. ✓ (4)

9.2 **Torque converter function:**

9.2.1 One-way clutch on the stator ✓ (1)

9.2.2 Turbine ✓ (1)

9.2.3 Stator ✓ (1)

9.2.4 Impeller ✓ (1)

9.3 **Oil used in the torque converter:**
ATF or Automatic transmission fluid ✓ (1)

9.4 **Advantages of epicyclic gear trains:**

- The co-axial arrangement of input shaft and output shaft. ✓
- Load distribution is to several planetary gears. ✓
- High efficiency. ✓
- Several gear ratios can be obtained. ✓
- Longer service life compared to traditional gearboxes for similar load. ✓
- Epicyclic gearbox has a higher torque transmission capability. ✓
- Also has lower inertia. ✓
- Used to obtain higher gear ratios. ✓
- Compact in size / Lighter in design ✓
- Used to obtain variation in direction (reverse). ✓
- Provides for a variation in torque output. ✓
- Smoother operation (quieter/less vibration) compared to manual gearbox. ✓

**(Any 3 x 1)** (3)
**[18]**

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

10.1 **Tyre wear:**

10.1.1 **Over inflation:**
Excessive wear in the middle of the tyre. ✓ (1)

10.1.2 **Negative camber:**
Excessive wear on the inside edge or inside shoulder of the tyre. ✓ (1)

10.2 **Purpose of wheel alignment angles:**

10.2.1 **Toe-in:**
- Toe-in is used to overcome the tendency of wheels with positive camber ✓ to point outwards. ✓
- To overcome the tendency of wheels to move outwards ✓ on a rear wheel drive vehicle. ✓

**(Any 1 x 2)** (2)

10.2.2 **Negative caster:**
Negative caster ensures easier turning. ✓ ✓ (2)

10.3 **King pin inclination:**

10.3.1 **Labels:**
A. King pin inclination (angle) / KPI / Steering axis inclination (angle) / SAI ✓
B. Steering axis centre line / King pin centre line ✓
C. Off set ✓ (3)

10.3.2 **Definition:**
King pin inclination is the inward tilt ✓ of the top of the king pin. ✓ (2)

10.3.3 No ✓ (1)

10.4 **Unbalanced wheels:**
- Shimmy / wobble ✓
- Bounce ✓
- Vibration on steering ✓
- Poor steering control ✓
- Tyres wear away faster ✓
- Wearing out of steering arms / tie rod ends / suspension rubbers ✓

**(Any 2 x 1)** (2)

10.5 **Air-intake sensors:**
- Throttle position sensor (TPS) ✓
- Idle speed control (ISC) ✓
- Manifold absolute pressure (MAP) ✓
- Mass air flow meter (MAF) ✓

**(Any 3 x 1)** (3)

10.6 **Function of the speed control system:**
- To control the throttle opening electronically. ✓
- To keep the vehicle at a constant speed. ✓ (2)

10.7 **Alternator:**

10.7.1 **Label:**
A. Slip ring ✓
B. Brushes ✓
C. Pole pieces ✓ (3)

10.7.2 **Function of the rectifier:**
Converts alternating current (AC) ✓ to direct current (DC) ✓ used by the battery and electrical components. (2)

10.7.3 **Methods to increase the output frequency of the alternator:**
- Increase the turns of wire / windings on the stator. ✓
- Increase the amount of magnetic poles. ✓
- Increase the rotational frequency of the rotor. ✓

**(Any 2 x 1)** (2)

10.8 **Catalytic converter:**
- Oxidation ✓
- Reduction ✓ (2)

10.9 **Label piezo injector:**
A. Fuel intake/ inlet ✓
B. Nozzle / Spray hole / Casing ✓ (2)

10.10 **Functions of the check valve:**
- It maintains the pressure in the fuel. ✓
- Prevents vapour lock. ✓
- Ensures easier starting. ✓

**(Any 2 x 1)** (2)
**[32]**

**TOTAL: 200**