These marking guidelines consist of 18 pages.
QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

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

TOTAL QUESTION 1: [6]
QUESTION 2: SAFETY (GENERIC)

2.1 Angle grinder: (Before using)
- The safety guard must be in place before starting. ✓
- Protective shields must be placed around the object being grinded to protect the people around. ✓
- Use the correct grinding disc for the job. ✓
- Make sure that there are no cracks in the disc before you start. ✓
- Protective clothing and eye protection are essential. ✓
- Check electrical outlets and cord/plugs for any damages. ✓
- Ensure that lockable switch is disengaged. ✓
- Ensure that the disc and the nut are well secured. ✓
- Remove all flammable material from the area. ✓
- Secure the work piece. ✓

(Any 2 x 1) (2)

2.2 Welding goggles:
- To protect your eyes against sparks ✓
- To protect your eyes against heat ✓
- To be able to see where to weld ✓
- To protect your eyes from UV rays / bright light ✓
- To protect your eyes from smoke ✓

(Any 2 x 1) (2)

2.3 PPE for Hydraulic press:
- Overall ✓
- Safety shoes ✓
- Safety goggle ✓
- Leather gloves ✓
- Leather apron ✓
- Face shield ✓

(Any 2 x 1) (2)

2.4 Workshop layouts:
- Process layout ✓
- Product layout ✓

(2)

2.5 Employer’s responsibility regarding first-aid:
- Provision of first-aid equipment ✓
- First aid training ✓
- First-aid services by qualified personnel ✓
- Any first aid procedures ✓
- Display first aid safety signs ✓
- First aid personnel must be identified by means of arm bands or relevant personal signage ✓

(Any 2 x 1) (2)

TOTAL QUESTION 2: [10]
QUESTION 3: MATERIALS (GENERIC)

3.1 Bending test:
- Ductility ✓✓
- Malleability ✓✓
- Britteness ✓✓
- Flexibility ✓✓

(Any 1 x 2) (2)

3.2 Heat-treatment:

3.2.1 Annealing:
- To relieve internal stresses ✓
- To soften the steel ✓
- To make the steel ductile ✓
- To refine the grain structure of the steel ✓
- To reduce the brittleness of the steel ✓

(Any 2 x 1) (2)

3.2.2 Case hardening:
- To produce a wear resistant surface ✓ and it must be tough enough internally ✓ at the core to withstand the applied loads.
- Hard case ✓ and tough core. ✓

(Any 1 x 2) (2)

3.3 Tempering process:
- To reduce ✓ the brittleness ✓ caused by the hardening process.
- Relieve ✓ strain ✓ caused during hardening process.
- Increase ✓ the toughness ✓ of the steel.

(Any 1 x 2) (2)

3.4 Factors for heat-treatment processes:
- Heating temperature / Carbon content ✓
- Soaking (Time period at temperature) / Size of the work piece ✓
- Cooling rate / Quenching rate ✓

(3)

3.5 Hardening of steel:
- Steel is heated to 30 – 50°C above the higher critical temperature. (AC₃)
- It is then kept at that temperature to ensure (soaking) that the whole structure is Austenite.
- The steel is then rapidly cooled by quenching it in clean water, brine or oil.

(3)

TOTAL QUESTION 3: [14]
QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

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

TOTAL QUESTION 4: [14]
QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1 Equipment:

5.1.1 Compression tester ✓

5.1.2 A – Flexible piping / hose / tubing ✓
     B – Adaptor screw / Fitting / Attachment / Connector ✓
     C – Gauge ✓
     D – Pressure release valve ✓

5.1.3 Compression Tester:
It measures the pressure created, ✓ when the piston is at top dead centre on power stroke. ✓

5.2 Cylinder leakage:
To check whether the engine leaks gases ✓ from the cylinder during the compression stroke. ✓

5.3 Gas Analyser:
• To ensure ✓ an accurate reading. ✓
• To prevent ✓ a lean reading. ✓

(Any 1 x 2 )

5.4 Function of a computerized diagnostic scanner:
• Scans all systems ✓ on the vehicle.
• Informs what adjustments can be made after diagnosis ✓

(Any 1 x 1 )

5.5 Bubble gauge camber procedure:
• Mount the bubble gauge on to the straightened wheel ✓
• Zero the bubble gauge at the gauge zero scale ✓
• Take the reading on the camber scale ✓
• Do the same for the other wheel ✓

(Any 3 x 1 )

5.6 Dynamic balance on wheels:
• The plane of imbalance ✓
• The extent of the unbalancing forces ✓
• The sense of direction of these forces (clockwise or counter-clockwise) ✓
• Determine the location of weight placement ✓
• Magnitude of the weights ✓
• The run-out of the tyre and wheel assembly ✓

(Any 3 x 1 )

5.7 Purpose of turn tables:
To make it possible to turn ✓ the front wheels in or out ✓ to check ✓ the wheel angles. ✓

TOTAL QUESTION 5: [23]
QUESTION 6: ENGINES (SPECIFIC)

6.1 **Static balancing of the crankshaft:**
The crankshaft is in static when the mass in all directions from the centre of rotation is equal while it is at rest.  

6.2 **Cylinder layouts:**

6.2.1 **V - engine layout**  

6.2.2 **In line (straight) engine layout**

6.3 **Firing order in an engine:**

- By removing the tappet cover and determining which are intake valves and which are exhaust valves.
- Rotating the engine in the direction in which it turns.
- 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.

**OR**

- Cylinder 1 must be at TDC on power stroke.
- Remove the distributor cap.
- Ensure to turn the engine in the correct direction of rotation.
- Determine the direction of rotation of the rotor.
- Trace the firing order by the HT leads.

(Any 1 x 5 )

6.4 **Firing order of engines:**

6.4.1 **Four cylinder in-line engine:**

- 1,3,4,2; or
- 1,2,4,3

(Any 1 x 1)

6.4.2 **V6-cylinder engine:**

- 1,4,2,5,3,6
- 1,2,3,4,5,6
- 1,6,5,4,3,2
- 1,4,5,6,3,2

(Any 1 x 1)
6.5 **Turbo charger:**

6.5.1 **Turbocharger:**
- A – Compressor air inlet ✓
- B – Turbine housing ✓
- C – Turbine exhaust gas outlet ✓
- D – Turbine wheel ✓
- E – Turbine exhaust gas inlet ✓
- F – Compressed air outlet ✓
- G – Compressor wheel ✓

6.5.2 **Turbocharger advantages:**
- More power / speed / boost is obtained from an engine with the same capacity ✓
- There is no power loss as the turbocharger is driven by exhaust gasses ✓
- Improved fuel consumption ✓
- The effect of height above sea level is eliminated ✓
- Generally, cheaper than superchargers ✓

Any (2 x 1)

6.6 **Terminology:**

6.6.1 **Boost:**
Refers to the increase in manifold pressure ✓ that is generated by the turbocharger in the intake that exceeds the normal atmospheric pressure. ✓

6.6.2 **Turbo lag:**
- It is a delay ✓ between pushing on the accelerator and feeling turbo kick in. ✓ or
- The time ✓ it takes the turbo charger to reach operating speed. ✓

(Any 1 x 2)

6.7 **Purpose of waste gate:**
It diverts exhaust gases ✓ away from the turbine wheel to regulate the turbine speed ✓ and consequently boost pressure.

6.8 **Oil cooler:**
To cool (prevent overheating) the oil ✓ that lubricates the turbocharger bearings and shaft. ✓

TOTAL QUESTION 6: [28]
QUESTION 7: FORCES (SPECIFIC)

7.1 Torque:
- Torque is the twisting effort ✓ transmitted by a rotating shaft or wheel. ✓
- Turning force applied ✓ over a centre of a round object. ✓

7.2 Clearance volume:
This is the volume of the space ✓ above the crown of the piston at TDC. ✓

7.3 Method to increase 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 a piston with a higher crown. ✓
- Fit a crankshaft with a longer stroke. ✓
- Increase the bore of the cylinders / bigger pistons. ✓

7.4 Calculation of compression ratio:

7.4.1 Swept Volume: \[ \frac{\pi D^2}{4} \times L \] ✓
\[ \frac{\pi (7,5)^2}{4} 8,0 \] ✓
\[ = 353,43 \text{ cm}^3 \] ✓

7.4.2 Compression Ratio: \[ \frac{SV + CV}{CV} \]
\[ CV = \frac{SV}{CR-1} \] ✓
\[ = \frac{353,43}{8,5-1} \] ✓
\[ = \frac{353,43}{7,5} \]
\[ = 47,12 \text{ cm}^3 \] ✓
7.4.3 **New compression ratio:**

Swept volume \( = \frac{\pi D^2}{4} \times L \)
\[ = \frac{\pi 7.8^2}{4} \times 8 \]
\[ = 382.27 \text{ cm}^3 \]

New compression ratio \( = \frac{SV}{CV} + 1 \)
\[ = \frac{382.27}{47.12} + 1 \]
\[ = 8.11 + 1:1 \]
\[ = 9.11:1 \]

**OR**

New compression ratio \( = \frac{SV + CV}{CV} \)
\[ = \frac{382.27 + 47.12}{47.12} \]
\[ = 9.11:1 \]

\[ (6) \]
7.5 Calculations: Power:

7.5.1 Indicated Power \( P = \frac{L \times A \times N \times n}{1000} \)

\( P = 1400 \text{ kPa} \)

\[
L = \frac{110}{1000} = 0.11 \text{ m} \quad \checkmark
\]

\[
A = \frac{\pi D^2}{4} = \frac{\pi 0.10^2}{4} = 7.85 \times 10^{-3} \text{ m}^2 \quad \checkmark
\]

\[
N = \frac{3600}{60 \times 2} = 30 \text{ r/s} \quad \checkmark
\]

\( n = 4 \text{ cylinders} \)

\[
\text{Indicated Power} = P \times L \times A \times N \times n
\]

\[
= \left(1400 \times 10^3\right) \times 0.11 \times \left(7.85 \times 10^{-3}\right) \times 30 \times 4 \quad \checkmark
\]

\[
= 145068 \text{ W} \quad \checkmark
\]

\[
= 145.07 \text{ kW} \quad \text{(8)}
\]

7.5.2 Brake power \( T = F \times r \)

\[
= \left(75 \times 10\right) \times 0.45
\]

\[
= 337.5 \text{ N.m} \quad \checkmark
\]

\[
\text{Brake power} = 2 \times N \times T
\]

\[
= 2 \times 60 \times 337.5
\]

\[
= 127234.5 \text{ W} \quad \checkmark
\]

\[
= 127.23 \text{ kW} \quad \text{(4)}
\]
7.5.3

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

= \frac{127.23}{145.07} \times 100\% \quad \checkmark

= 87.70\% \quad \checkmark

(2)

TOTAL QUESTION 7: [32]
QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 Gas analyser:
- Exhaust gasses ✓
- CO gasses ✓
- CO₂ gasses ✓
- SO₂ gasses ✓
- NOₓ gasses ✓
- HC gasses ✓
- O₂ gasses ✓

(Any 1 x 1) (1)

8.2 Specification for gas analysis:
- % Hydrocarbon / HC ✓
- % Carbon monoxide / CO ✓
- % Carbon dioxide / CO₂ ✓
- % Nitrogen oxide / NOₓ ✓
- % Sulphur dioxide / SO₂ ✓

(Any 3 x 1) (3)

8.3 Cylinder leakage test: (Results)
- Hissing noise at air intake ✓
- Hissing noise at exhaust pipe ✓
- Hissing noise in dipstick hole ✓
- Hissing noise under tappet cover ✓
- Bubbles in radiator water ✓
- Hissing noise at adjacent cylinders ✓

(Any 2 x 1) (2)

8.4 Cylinder Leakage test: (Causes)
- Worn cylinders ✓
- Worn piston ✓
- Worn piston rings ✓
- Leaking inlet valve ✓
- Leaking exhaust valve ✓
- Leaking cylinder head gasket ✓
- Cracked cylinder head / block ✓

(Any 2 x 1) (2)

8.5 Compression test procedures:
- Get the engine to normal operating temperature. ✓
- Disconnect the fuel supply and ignition system. ✓
- Remove spark plugs. ✓
- Fit the compression tester ✓
- Depress the throttle and crank the engine a few revolutions. ✓
- Record and compare the pressure reading for each cylinder with manufacturers specifications. ✓

(6)
8.6 **Reasons for low oil pressure:**
- Worn oil pump ✓
- Blocked oil pump screen/filter/strainer in the sump ✓
- Worn main, big-end and camshaft bearings ✓
- Blocked or restricted oil filter ✓
- Dirty or contaminated oil ✓
- Oil leaks ✓
- Too little oil in engine ✓
- Incorrect grade (viscosity) of oil ✓
- Pressure relief valve spring too weak or damaged ✓
- Plunger / Ball stuck in open position ✓
- Dirt stuck between ball and seat ✓

(Any 2 x 1) (2)

8.7 **Cooling system pressure test:**
- Start engine and allow to heat up. Fit radiator pressure tester to radiator. ✓
- Pressurize the cooling system according to manufacture’s specification. ✓
- Watch the pressure for a while, if it drops there is a leak. ✓
- Make a visual check for leaks. ✓
- Install radiator cap to tester and pump tester, the cap should release air at its rated pressure. ✓
- Check the rubber seal for cracks and damage. ✓
- Check the vacuum valve for free movement and operation. ✓

(7)

**TOTAL QUESTION 8:** [23]
QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)

9.1 Differences between an automatic and manual gearbox:
- There is no clutch pedal in a motor vehicle with an automatic gearbox. / There is a clutch pedal in a motor vehicle with a manual gearbox. ✓
- There is no need to change gears, the shifting of the gears happens automatically. ✓
- Automatic transmission uses thin oil while manual gearbox uses thicker oil. ✓
- Automatic transmission uses torque converter while manual gearbox uses clutch assembly. ✓

(Any 2 x 1) (2)

9.2 Advantages of automatic gearbox:
- It reduces driver fatigue ✓
- It ensures great reduction of wheel spin under bad road conditions ✓
- The vehicle can be stopped suddenly without the engine stalling ✓
- The system dampens all engine torsional vibrations ✓
- Easier to drive (e.g. Disabled person with one leg) ✓

(Any 2 x 1) (2)

9.3 Torque converter:

9.3.1 Torque converter function:
- Transfers engine torque to the transmission. ✓
- It multiplies the engine torque to the transmission. ✓
- Provides a direct-drive, or mechanical link from the engine to the transmission. ✓
- The torque converter dampens all engine torsional vibrations. ✓
- The torque converter acts as a flywheel. ✓

(Any 2 x 1) (2)

9.3.2 Parts:
A – One-way clutch / Turbine ✓
B – Turbine / Impeller ✓
C – Pump ✓
D – Turbine shaft ✓
E – Gearbox housing ✓

(Any 5 x 1) (5)

9.4 Single epicyclic gear train:
- Overdrive forward ✓
- Overdrive reverse ✓
- Gear reduction forward ✓
- Gear reduction reverse ✓
- Direct drive ✓
- Neutral ✓

(Any 5 x 1) (5)
9.5 **Purpose of gear ratio in the gearbox:**

- It is used in order to utilise the usable torque developed in a relatively limited speed range of the engine over a greater road speed range.
- Allows different speeds depending on the different loads.

(Any 1 x 2) \( (2) \)

**TOTAL QUESTION 9:** [18]
QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONICS) (SPECIFIC)

10.1 Preliminary wheel alignment checks:
- Kerb mass (tank full of petrol, spare wheel and tools) against the manufacturer’s specifications.
- Uneven wear on the tyre.
- Tyre pressure.
- Run-out on the wheels; check wheel nuts with torque wrench.
- Correct preload on the wheel (hub) bearings.
- Kingpins and bushes.
- Suspension ball joints for wear, locking and lifting.
- Suspension bushes for excessive free movement.
- Steering box play and whether secure on chassis.
- Tie-rod ends.
- Sagged springs, this includes riding height.
- Ineffective shock absorbers.
- Spring U-bolts.
- Chassis for possible cracks and loose cross-members.
- Wheels must be balanced.
- Wheel alignment specifications.
- Drive shafts / CV-joints.

(Any 5 x 1) (5)

10.2 Caster

10.2.1 Negative ✓ Caster ✓ (2)

10.2.2 Parts:
- A – Contact point of king pin centre line ✓
- B – King pin ✓
- C – Perpendicular line / vertical line / normal line ✓
- D – Negative caster angle ✓
- E – Centre line of king pin ✓
- F – Front of vehicle / Direction of wheel motion ✓
- G – Point of wheel contact / Wheel ✓ (7)

10.2.3 Negative caster angle is the forward tilt ✓ of the kingpin at the top, ✓ viewed from the side. ✓ (3)

10.3 Toe-out:

(3)
10.4 **Purpose of the king pin inclination:**
- To bring the front wheels back to the straight-ahead position ✓ after rounding a corner without any driver effort. ✓
- Reduce ✓ the scrub radius. ✓

(Any 1 x 2)  (2)

10.5 **Catalytic converter:**
- Oxidation ✓
- Reduction ✓

(Any 1 x 1)  (1)

10.6 **Purpose of the speed control system:**
The purpose of the speed control system is to control the throttle opening ✓ and to keep the vehicle speed constant. ✓

(2)

10.7 **Advantage of speed control:**
- Driver fatigue is reduced. ✓
- The set speed is controlled constantly. ✓
- Improved fuel consumption. ✓
- A consistently controlled speed helps to prevent speeding fines. ✓

(Any 2 x 1)  (2)

10.8 **Fuel pressure regulator:**
- Fuel pressure regulator regulates the fuel pressure in relation to the manifold pressure. ✓

(1)

10.9 **Output frequency of an alternator:**
- Increase the turns of wire on the stationary coil. ✓
- Increase the magnetic fields. ✓
- Increase the rotational frequency at which the magnet rotates. ✓

(Any 2 x 1)  (2)

10.10 **Stator and stator windings:**
- To provide a core which concentrates the magnetic lines of force onto the stator windings ✓
- To provide a coil into which a voltage is induced which is used to charge the battery. ✓

(Any 1 x 1)  (1)

10.11 **Function of rotor assembly:**
- Is to provide a rotating electro-magnet. ✓

(1)

**TOTAL QUESTION 10:**  [32]

**TOTAL:**  200