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

1.1 B ✔
1.2 B ✔
1.3 C ✔
1.4 C ✔
1.5 A ✔
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)
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)
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, CO₂, HC, NOₓ, SO₂ and O₂. ✓
- 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. ✓

[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 ✓

6.8.2 Roots supercharger ✓

6.8.3 Twin-screw supercharger ✓
QUESTION 7: FORCES (SPECIFIC)

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

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

\[ = \frac{\pi \times 12^2}{4} \times 13,5 \]

\[ = 1526,81 \text{ cm}^3 \]

7.2 **Work:**

7.2.1 Work = Force \( (m \times g) \times \) distance

\[ = (980 \times 10) \times 35 \]

\[ = 343000 \text{ J} \]

\[ = 343 \text{ kJ} \]

7.3 **Cylinder:**

7.3.1 A. Bore / Cylinder diameter

B. Stroke length

7.3.2 **Swept volume:**

A. 120 mm = 12 cm  (for converting to cm)

B. 135 mm = 13,5 cm

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

\[ = \frac{\pi \times 120^2}{4} \times 135 \]

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

\[ = 1 526,81 \sqrt[3]{\text{cm}^3} \]  (for converting to cm³)
7.3.3 Compression ratio (CR):

\[
CR = \frac{SV}{CV} + 1
\]

\[
CR = \frac{1526.81}{102.5} + 1
\]

OR

\[
CR = \frac{1526.81 + 102.5}{102.5}
\]

\[
CR = 15.9 : 1
\]

(3)

7.4 Calculate Indicated power:

\[
P = 1150 \text{kPa}
\]

\[
L = \frac{77}{1000} = 0.077 \text{m}
\]

\[
A = \frac{\pi D^2}{4} = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-3} \text{m}^2
\]

\[
N = \frac{1800}{60 \times 2} = 15 \text{power strokes/sec.}
\]

\[
n = 4 \text{ cylinders}
\]

Indicated Power = PLANn

\[
= (1150 \times 10^3) \times 0.077 \times (7.85 \times 10^{-3}) \times 15 \times 4
\]

\[
= 41.73 \text{kW}
\]

(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)
7.6 **Calculations:**

7.6.1 **Torque:**

Force = \( m \times g \)

\[ = 120 \times 10 \]

\[ = 1200 \text{N} \checkmark \]

radius = \( \frac{500}{1000} \)

\[ = 0,5 \text{m} \checkmark \]

Torque = force \times radius

Torque = 1200 \times 0,5  \checkmark

Torque = 600 \text{Nm}  \checkmark

\[ (4) \]

7.6.2 **Brake power:**

Brake power = \( 2 \times \pi \times N \times T \)

Brake power = \( 2 \times \pi \times \frac{2500}{60} \checkmark \times 600 \checkmark \)

Brake power = 157,08 kW  \checkmark

\[ (3) \]

7.6.3 **Mechanical efficiency:**

Mechanical efficiency = \( \frac{BP}{IP} \times 100 \)

\[ ME = \frac{157,08}{196} \checkmark \times 100 \]

\[ ME = 80,14\% \checkmark \]

\[ (2) \]
QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 Gas analyser:
- High carbon monoxide (CO) ✓
- High oxygen (O₂) ✓
- 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% ✓

8.3.2 Variation = highest reading - lowest reading

\[ \frac{11 - 8.2}{11} \] ✓

\[ = 2.8 \text{ bar} \] ✓

OR

\[ \frac{11 - 8.2}{11} \] ✓

\[ = 25.5\% \] ✓

(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 ✓

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. ✓

9.2 Torque converter function:

9.2.1 One-way clutch on the stator ✓

9.2.2 Turbine ✓

9.2.3 Stator ✓

9.2.4 Impeller ✓

9.3 Oil used in the torque converter:
ATF or Automatic transmission fluid ✓

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)

[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