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**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

NOVEMBER 2024

MARKS: 200

TIME: 3 hours

This question paper consists of 17 pages and a 2-page formula sheet.



INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the spaces provided on the ANSWER BOOK.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Number the answers correctly according to the numbering system used in this question paper.
5. Start EACH question on a NEW page.
6. Show ALL calculations and units. Round off final answers to TWO decimal places.
7. Candidates may use non-programmable scientific calculators and drawing instruments.
8. The value of gravitational acceleration should be taken as $9,81 \text{ m/s}^2$ or 10 m/s^2 .
9. All dimensions are in millimetres, unless stated otherwise in the question.
10. Write neatly and legibly.
11. A formula sheet is attached at the end of the question paper.
12. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME IN MINUTES
GENERIC			
1	Multiple-choice Questions	6	6
2	Safety	10	10
3	Materials	14	14
SPECIFIC			
4	Multiple-choice Questions	14	10
5	Tools and Equipment	23	20
6	Engines	28	25
7	Forces	32	25
8	Maintenance	23	20
9	Systems and Control (Automatic Gearbox)	18	20
10	Systems and Control (Axles, Steering Geometry and Electronics)	32	30
TOTAL		200	180



QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.6) in the ANSWER BOOK, e.g. 1.7 E. ...

- 1.1 Which statement below is CORRECT in terms of a recommendation for the application of first aid?
- Do NOT ...
- A remove anything that is stuck to the wound.
 - B check the pulse of the patient.
 - C give attention to the loss of blood or breathing difficulties.
 - D check the surroundings for dangerous objects. (1)
- 1.2 Where more than ... employees are employed at a workplace, the employer must provide an accessible first-aid box.
- A 2
 - B 3
 - C 4
 - D 5 (1)
- 1.3 What causes accidents when working with revolving machinery, such as a bench grinder?
- A Overconfidence
 - B Correct wheel size
 - C Gap between tool rest and grinding wheel not exceeding 3 mm
 - D Correctly rated grinding wheel for the bench grinder (1)
- 1.4 Which test does NOT damage a work piece?
- A Spark test
 - B Sound test
 - C Bending test
 - D Machining test (1)
- 1.5 Which of the following products is case-hardened?
- A Tin cans
 - B Machine guards
 - C Hand files
 - D Gears and cams (1)
- 1.6 Which process is the first step in the production of high-strength steel?
- A Normalising
 - B Annealing
 - C Hardening
 - D Tempering (1)



QUESTION 2: SAFETY (GENERIC)

- 2.1 State TWO safety precautions that must be adhered to after the horizontal band saw has been switched on. (2)
- 2.2 Name the THREE stages when basic first-aid treatment is given to help an injured person. (3)
- 2.3 Why must oil or grease NOT be in contact with the oxygen fittings when handling oxygen cylinders? (1)
- 2.4 State TWO disadvantages of the process workshop layout. (2)
- 2.5 State TWO advantages of the product workshop layout. (2)
- [10]**

QUESTION 3: MATERIALS (GENERIC)

- 3.1 State if the following materials are easy or hard to file during a filing test:
- 3.1.1 Cast iron (1)
- 3.1.2 Cast steel (1)
- 3.1.3 Mild steel (1)
- 3.2 Explain what *heat treatment* is. (3)
- 3.3 Explain what the effects will be if metal is heated too fast during the heat-treatment process. (4)
- 3.4 Name the TWO types of steel best suited for case hardening. (2)
- 3.5 Explain the reason for tempering steel during the heat-treatment process. (2)
- [14]**



QUESTION 4: MULTIPLE-CHOICE QUESTIONS (SPECIFIC)

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (4.1 to 4.14) in the ANSWER BOOK, e.g. 4.15 E.

- 4.1 An OBD scanner is used on vehicles with ...
- A carburettors.
 - B no electronic control module (ECM).
 - C an electronic control unit (ECU).
 - D contact breaker ignition systems. (1)
- 4.2 Which wheel alignment tool is used to measure toe-out?
- A Turntable
 - B Dunlop gauge
 - C Bubble gauge
 - D Wheel balancer (1)
- 4.3 Which ONE of the following is part of the reciprocating mass in an engine?
- A Camshaft
 - B Valves
 - C Pistons
 - D Crankshaft (1)
- 4.4 Which ONE of the following is the cause of crankshaft vibrations?
- A Carefully balanced crank webs
 - B Oval crankshaft journals
 - C Balanced rotating mass
 - D Balanced reciprocating mass (1)
- 4.5 Torque is defined as ...
- A the rotational frequency of a shaft.
 - B a force causing linear movement.
 - C the rate at which work is done.
 - D the twisting force applied to a rotating shaft. (1)
- 4.6 Which method below is used to increase the compression ratio of an engine?
- A Fit a thinner gasket between the cylinder block and the cylinder head
 - B Fit the pistons with suitable lower crowns
 - C Fit a thicker gasket between the cylinder block and the cylinder head
 - D Fit a crankshaft with a shorter stroke (1)



4.7 Identify the diagram shown in FIGURE 4.7 below.

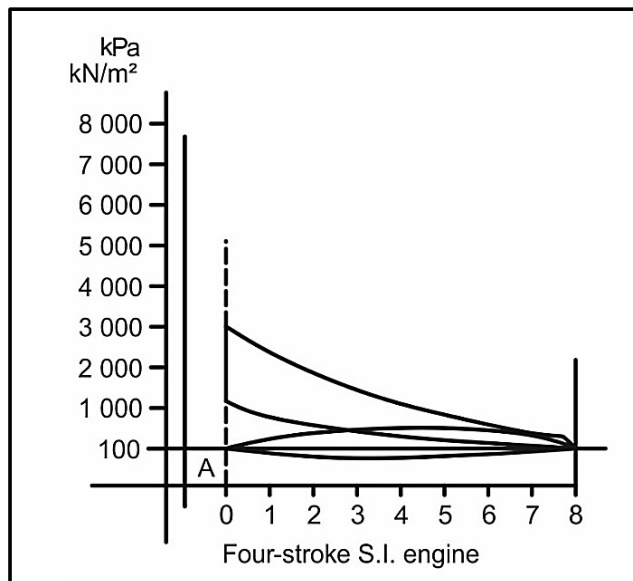


FIGURE 4.7

- A Planimeter
 - B Indicator diagram
 - C Carbon content equilibrium diagram
 - D Stress-strain diagram
- (1)

4.8 Which ONE of the following is a reason for a high hydrocarbon (HC) reading on an internal combustion engine?

- A Ideal air-fuel ratio
 - B Warm valves
 - C A clogged air filter
 - D Lean air-fuel ratio
- (1)

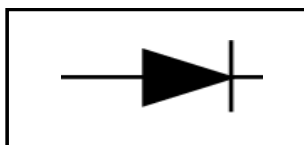
4.9 A wet compression test can be used to determine whether the cylinder has a leak at the ...

- A intake valve.
 - B exhaust valve.
 - C piston rings.
 - D head gasket.
- (1)

4.10 Which of the following determines the correct gear ratio according to load and speed in an automatic gearbox?

- A Brake bands
 - B Hydraulic pistons
 - C Valve body
 - D Oil pump
- (1)

- 4.11 Which gear is selected when the planet carrier is locked on an epicyclic gear system?
- A First or low gear
 - B Second or intermediate gear
 - C Third or top gear
 - D Reverse gear
- (1)
- 4.12 Which of the following will cause a large positive camber angle on the wheels of a vehicle?
- A Increase the negative effects of KPI
 - B A negative cornering effect of the vehicle
 - C The wheels will stop rotating
 - D The tyres will wear evenly
- (1)
- 4.13 Identify the symbol shown in FIGURE 4.13 below.

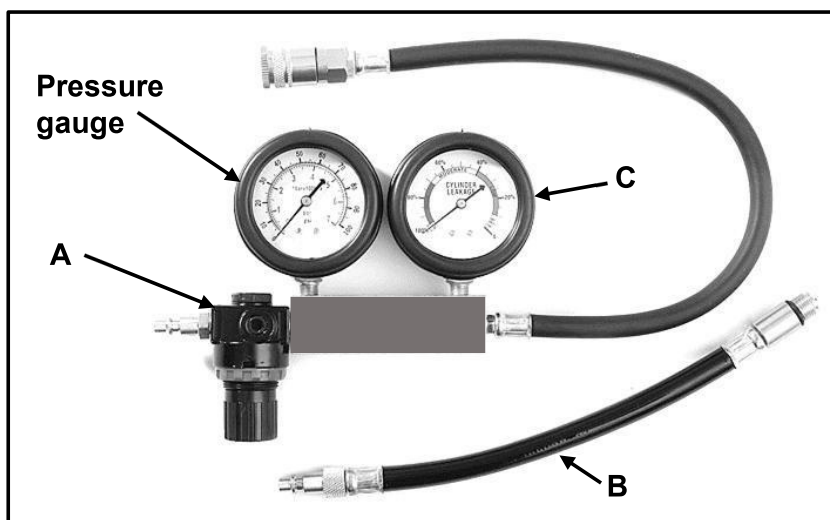
**FIGURE 4.13**

- A Regulator
 - B Capacitor
 - C Diode
 - D Distributor
- (1)
- 4.14 What is the function of a diesel particulate filter (DPF)?
- A To clean the intake air
 - B To clean the particles from the fuel
 - C To atomise the fuel
 - D To convert soot into ash
- (1)

[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

- 5.1 Why are the following procedures performed during a compression test?
- 5.1.1 The air filter is removed (1)
- 5.1.2 Dirt is removed from around the spark plugs before removing the spark plugs (1)
- 5.1.3 Disconnect the ignition system (1)
- 5.1.4 Record the readings (1)
- 5.2 FIGURE 5.2 below shows a cylinder leakage tester. Answer the questions that follow.

**FIGURE 5.2**

- 5.2.1 Label **A–C**. (3)
- 5.2.2 What is the unit of measurement on the pressure gauge? (1)
- 5.2.3 What is the unit of measurement of gauge **C**? (1)
- 5.3 State **FOUR** safety precautions that must be observed when performing the exhaust gas analysis. (4)
- 5.4 Describe **TWO** functions of the on-board diagnostic scanner. (2)

- 5.5 FIGURE 5.5 below shows a machine used in an automotive workshop. Answer the questions that follow.

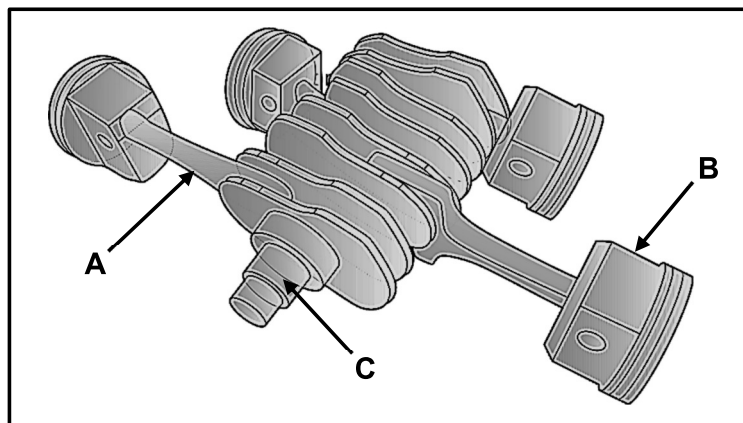


FIGURE 5.5

- 5.5.1 Identify the machine. (1)
- 5.5.2 State TWO functions of this machine. (2)
- 5.5.3 What safety device is NOT attached to this machine? (1)
- 5.5.4 Why should this machine be calibrated? (1)
- 5.6 Explain, in THREE steps, how to measure the camber angle after the bubble gauge is fitted to the wheel. (3)
- [23]**

QUESTION 6: ENGINES (SPECIFIC)

- 6.1 What is the primary function of the crankshaft? (2)
- 6.2 Name the part that is usually attached to the nose of the crankshaft to decrease vibrations. (1)
- 6.3 Why is the reciprocating mass kept as light as possible? (1)
- 6.4 Explain how to obtain the firing order from the valve train of an engine, after the tappet cover has been removed. (3)
- 6.5 FIGURE 6.5 below shows the configuration of a four-stroke four-cylinder engine. Answer the questions that follow.

**FIGURE 6.5**

- 6.5.1 Identify the type of engine configuration. (1)
- 6.5.2 Label **A–C**. (3)
- 6.6 Draw a neat, labelled sketch to illustrate the position of the crank pins in a six-cylinder in-line engine. (3)
- 6.7 Answer the following questions with regard to turbochargers:
- 6.7.1 Describe **THREE** advantages of using a turbocharger on an engine. (3)
- 6.7.2 Give **TWO** reasons why synthetic oil is used to lubricate turbochargers. (2)
- 6.7.3 Which type of turbocharger does not have vanes? (1)

6.8 Explain the following terms with regard to turbochargers:

6.8.1 Boost (2)

6.8.2 Turbo lag (2)

6.9 FIGURE 6.9 below shows a supercharger. Answer the questions that follow.

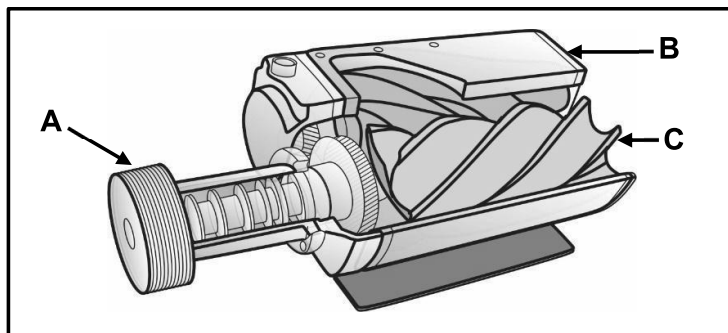


FIGURE 6.9

6.9.1 Identify the type of supercharger. (1)

6.9.2 Label A–C. (3)

[28]

QUESTION 7: FORCES (SPECIFIC)

7.1 Define the following terms:

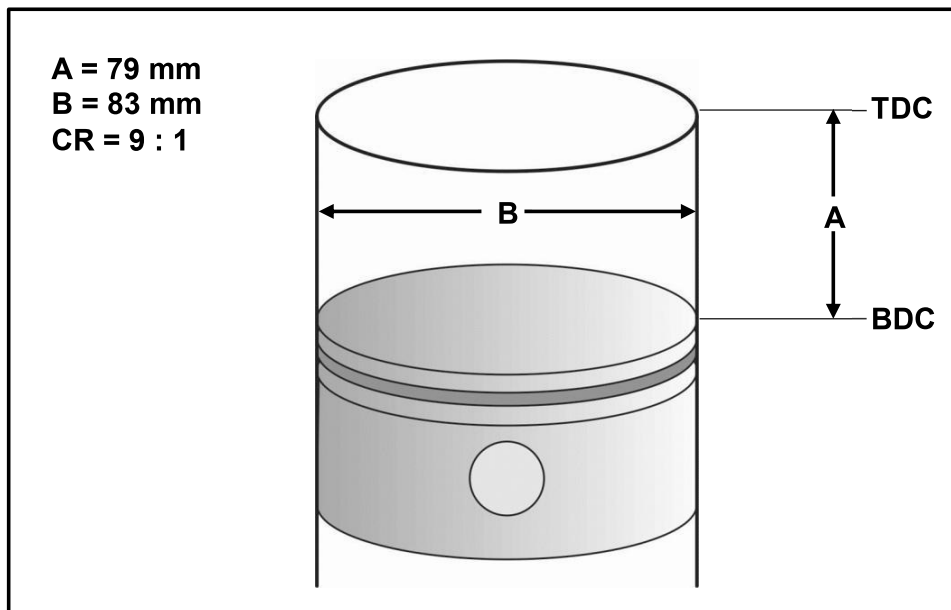
7.1.1 Clearance volume (2)

7.1.2 Compression ratio (2)

7.2 Calculate the work done if a hoist needs to raise a vehicle weighing 690 kg to a height of 2 m. (3)

7.3 State TWO methods to lower the clearance volume on an internal combustion engine. (2)

7.4 FIGURE 7.4 below shows a cylinder. Answer the questions that follow.

**FIGURE 7.4**7.4.1 Label distances **A** and **B**. (2)7.4.2 Calculate the swept volume in the cylinder in cm^3 when $A = 79 \text{ mm}$ and $B = 83 \text{ mm}$. (3)

7.4.3 Calculate the clearance volume of the cylinder. (3)

7.5 The following data was recorded during a test carried out on a four-stroke four-cylinder petrol engine:

Mean effective pressure: 1 400 kPa
 Stroke: 110 mm
 Bore diameter: 100 mm
 Engine revolutions: 3 600 r/min

Calculate the indicated power in kW. (7)



- 7.6 The indicated power of a two-stroke engine is 50 kW at 2 000 r/min. It has a cylinder bore diameter of 35 mm with a stroke length of 40 mm. The force required to stop the flywheel is 50 N with a brake arm length of 350 mm.

Calculate the following:

- 7.6.1 Torque (3)
- 7.6.2 Brake power in kW (3)
- 7.6.3 Mechanical efficiency (2)
- [32]**



QUESTION 8: MAINTENANCE (SPECIFIC)

8.1 TABLE 8.1 below shows information regarding the results of the exhaust gas analysis of an internal combustion engine.

Complete TABLE 8.1 by giving ONE cause and ONE appropriate corrective measure for EACH fault. Write only the answer next to the question numbers (8.1.1 to 8.1.4) in the ANSWER BOOK.

FAULTS (READING)	POSSIBLE CAUSES	CORRECTIVE MEASURES
High carbon monoxide (CO) reading	8.1.1	8.1.2
Low carbon dioxide (CO ₂) reading	8.1.3	8.1.4

TABLE 8.1

(4)

8.2 The readings below were taken during a compression test on a four-cylinder internal combustion engine. Answer the questions that follow.

Cylinder 1:	9 bars
Cylinder 2:	7,1 bars
Cylinder 3:	8,7 bars
Cylinder 4:	8,9 bars

8.2.1 What is the maximum variation allowed, in percentage (%), between the compression readings? (1)

8.2.2 State ONE possible cause and its corrective measure for the low reading in cylinder 2. (2)

8.3 Identify FOUR locations where leakages can be detected during a cylinder leakage test. (4)

8.4 State FOUR causes of a low oil-pressure reading on an internal combustion engine. (4)

8.5 State TWO possible causes and the corrective measures for a high fuel-pressure reading during a fuel pressure test. (4)

8.6 State TWO manufacturers' specifications required before performing a cooling system pressure test. (2)

8.7 State TWO functions of the radiator cap. (2)

[23]

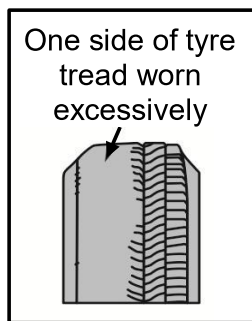
QUESTION 9: SYSTEMS AND CONTROL (AUTOMATIC GEARBOX) (SPECIFIC)

- 9.1 State TWO disadvantages of a vehicle fitted with an automatic gearbox when compared to a manual gearbox. (2)
- 9.2 Explain the operation of a torque converter. (5)
- 9.3 Draw a single epicyclic gear system and label the FOUR basic components. (5)
- 9.4 State ONE advantage of using EACH of the following gear ratios in the gearbox of a motor vehicle:
- 9.4.1 Forward reduction (1st gear) (1)
- 9.4.2 Reverse gear (1)
- 9.4.3 Forward overdrive (5th gear) (1)
- 9.5 State ONE use of EACH of the following components with regard to an automatic gearbox:
- 9.5.1 Hydraulic pistons (1)
- 9.5.2 Brake bands (1)
- 9.5.3 Transmission control unit (1)
- [18]**



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

10.1 FIGURE 10.1 below shows a tyre wear pattern. Answer the questions that follow.

**FIGURE 10.1**

- 10.1.1 Which wheel alignment angle will cause the tyre wear pattern shown? (1)
- 10.1.2 State TWO faults on the vehicle suspension that could cause this tyre wear. (2)
- 10.1.3 Describe TWO ways to correct the cause of this tyre wear. (2)
- 10.2 Define the following wheel alignment angles:
- 10.2.1 Positive caster (2)
- 10.2.2 King pin inclination (2)
- 10.3 Name THREE sensors found on an air-intake system of an internal combustion engine. (3)
- 10.4 What is the function of the knock sensor fitted to the engine? (2)
- 10.5 Name TWO components of a distributorless ignition system (DIS). (2)
- 10.6 Name TWO chemical reactions that occur in the catalytic convertor. (2)
- 10.7 State TWO functions of the speed control system. (2)

10.8 FIGURE 10.8 below shows an exploded view of an alternator. Answer the questions that follow.

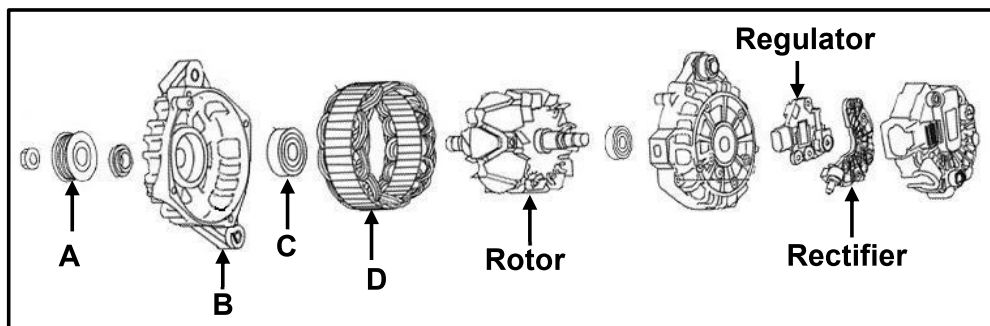


FIGURE 10.8

- 10.8.1 Label A–D. (4)
- 10.8.2 What is the function of the rotor? (2)
- 10.8.3 What does the regulator control in the alternator? (1)
- 10.8.4 What is the function of the rectifier? (2)

10.9 State THREE factors that influence the amount of fuel sprayed by the injector. (3)
[32]

TOTAL: 200



FORMULA SHEET FOR MECHANICAL TECHNOLOGY: AUTOMOTIVE

1. $F = m \times a$

Where: $m = \text{Mass}$ $a = \text{Acceleration}$

2. $\text{Work done} = \text{Force} \times \text{Displacement}$ OR $W = F \times s$

3. $\text{Power} = \frac{\text{Force} \times \text{Displacement}}{\text{Time}}$ OR $P = \frac{F \times s}{t}$

4. $\text{Torque} = \text{Force} \times \text{Radius}$ OR $T = F \times r$

5. $IP = P \times L \times A \times N \times n$

Where: $IP = \text{Indicated power}$ $P = \text{Mean effective pressure}$ $L = \text{Stroke length}$ $A = \text{Area of piston crown}$ $N = \text{Number of power strokes per second}$ $n = \text{Number of cylinders}$

6. $BP = 2 \pi N T$

Where: $BP = \text{Brake power}$ $N = \text{Revolutions per second}$ $T = \text{Torque}$

7. $\text{Brake power with Pröny brake} = 2 \times \pi \times N \times F \times R$

Where: $BP = \text{Brake power}$ $N = \text{Revolutions per second}$ $F = \text{Force}$ $R = \text{Brake arm length}$ 

$$8. \quad \text{Mechanical efficiency} = \frac{BP}{IP} \times 100\%$$

$$9. \quad \text{Compression ratio} = \frac{SV + CV}{CV}$$

Where:

SV = Swept volume

CV = Clearance volume

$$10. \quad SV = \frac{\pi D^2}{4} \times L$$

Where:

D = Bore diameter

L = Stroke length

$$11. \quad CV = \frac{SV}{CR - 1}$$

$$12. \quad \text{Gear ratio} = \frac{\text{Product of teeth on driven gears}}{\text{Product of teeth on driver gears}}$$

