



Province of the  
**EASTERN CAPE**  
EDUCATION

Iphondo leMpuma Kapa: Isebe leMfundo  
Provinsie van die Oos Kaap: Departement van Onderwys  
Porafensie Ya Kapa Botjhabela: Lefapha la Thuto

# **NATIONAL SENIOR CERTIFICATE**

**GRADE 12**

**SEPTEMBER 2024**

**MECHANICAL TECHNOLOGY: AUTOMOTIVE**

**MARKS: 200**

**TIME: 3 hours**

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This question paper consists of 19 pages, including a 1-page formula sheet.

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**INSTRUCTIONS AND INFORMATION**

1. Write your NAME on the ANSWER BOOK.
2. Read ALL the questions carefully.
3. Answer ALL the questions.
4. Number the questions 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. You may use a non-programmable scientific calculator and drawing instruments.
8. The value of gravitational force should be taken as  $10 \text{ m/s}^2$ .
9. ALL dimensions are in millimetres, unless stated otherwise in the question.
10. A formula sheet is attached to the question paper.
11. Write neatly and legibly.
12. Use the criteria below to assist you in managing your time.

QUESTION	CONTENT	MARKS	TIME in minutes
	<b>GENERIC</b>		
1	Multiple-choice questions	6	6
2	Safety	10	10
3	Materials	14	14
	<b>SPECIFIC</b>		
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
	<b>TOTAL</b>	<b>200</b>	<b>180</b>

**QUESTION 1: MULTIPLE-CHOICE QUESTIONS (GENERIC) (COMPULSORY)**

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, for example 1.7 A.

- 1.1 Which safety law state that all employers must ensure that the workplace is safe, and that the employees are not at risk of becoming infected with HIV at work?
- A The code of good practice on HIV/Aids and employment.  
B Occupational Health and Safety Act (OHSA), 1993 (Act 85 of 1993)  
C Employment Equity Act (EEA), 1998 (Act 55 of 1998)  
D Basic Conditions of Employment Act (BCEA), 1997 (Act. 75 of 1997) (1)
- 1.2 Checking breathing, heart rate, consciousness, pulse and loss of blood of an injured person, is called ...
- A vital functions.  
B indicators to diagnosis.  
C visible signs and symptoms.  
D environmental observation. (1)
- 1.3 The safe working pressure must never be exceeded.
- At which of the following equipment is the safety precaution mentioned in the above statement applicable?
- A Drill press  
B Bench grinder  
C Hydraulic press  
D Guillotine machine (1)
- 1.4 It is important to stand and work only in dry surroundings. Always keep your hands and clothing dry.
- In which joining equipment is the above statement applicable?
- A Hand riveter  
B Gas welding  
C Arc welding  
D All the above-mentioned (1)

- 1.5 FIGURE 1.5 shows a spark test conducted on a material. Identify the material used during the spark test.

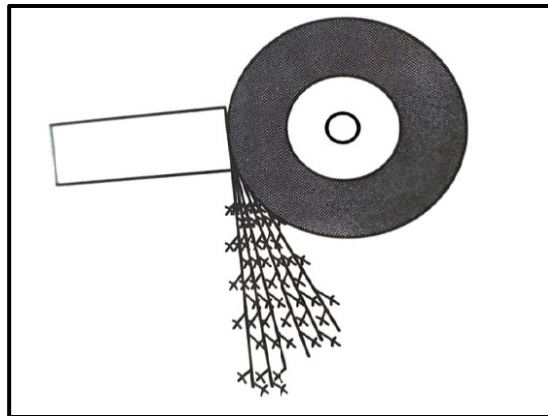


FIGURE 1.5

- A High-carbon steel
- B Low-carbon steel
- C Cast iron
- D None of the above-mentioned

(1)

- 1.6 FIGURE 1.6 below shows one of the heat treatment processes. Which heat-treatment process is represented by FIGURE 1.6?

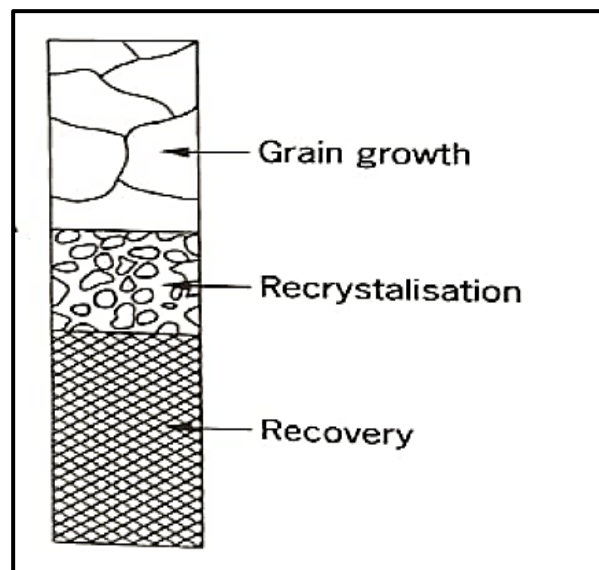


FIGURE 1.6

- A Hardening process
- B Tempering process
- C Normalising process
- D Annealing process

(1)  
[6]

**QUESTION 2: SAFETY (GENERIC)**

- 2.1 List TWO safety precautions when handling gas cylinders in a workshop. (2)
- 2.2 Describe the employer's responsibility regarding safety in the workplace. (2)
- 2.3 State TWO safety measures to observe before switching on an angle grinder. (2)
- 2.4 Give any TWO reasons why it is important to wear welding goggles during gas welding. (2)
- 2.5 State TWO disadvantages of a process layout of machines. (2)

**[10]**

**QUESTION 3: MATERIALS (GENERIC)**

3.1 Metals are usually marked or colourcoded on the ends. Why is it important to cut from the unmarked end of the metal? (1)

3.2 Tabulate the following heat-treatment processes and identify ONE property of each.

	PROCESS	PROPERTY
3.2.1	Hardening	
3.2.2	Tempering	
3.2.3	Annealing	
3.2.4	Normalising	

(4)

3.3 Explain THREE factors to considered when heat-treatment of steel is done. (3)

3.4 List THREE types of quenching media used to harden steel. (3)

3.5 State the type of test that can be used to obtain the following properties of metals:

3.5.1 Hardness (1)

3.5.2 Carbon content (1)

3.5.3 Ductility (1)

**[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, for example 4.15 E.

4.1 Name of the equipment shown in FIGURE 4.1 below.



**FIGURE 4.1**

- A Compression tester
- B Leakage tester
- C Tyre pressure tester
- D Water pressure tester

(1)

4.2 What is the function of the equipment that is shown in FIGURE 4.2 below?



**FIGURE 4.2**

- A To align the front wheels of a vehicle.
- B To balance the wheels of a vehicle.
- C To remove the tyre from the rim of a vehicle.
- D All the above-mentioned.

(1)

4.3 The power impulse of a V-8 engine is ... for each fourth of a crankshaft revolution.

- A  $120^\circ$
- B  $144^\circ$
- C  $90^\circ$
- D  $180^\circ$

(1)

4.4 ... refers to the increase in manifold pressure that is generated by the turbocharger in the intake manifold which exceeds normal atmospheric pressure.

- A Fuel efficiency
- B Reliability
- C Lag
- D Boost

(1)

4.5 What is the mechanical efficiency of an engine that generates 75 kW inside its cylinders and produces 66 kW of brake power?

- A 0,88%
- B 88%
- C 2,21%
- D 2,65%

(1)

4.6 An electric dynamometer is used to measure the ... of an engine.

- A brake power
- B indicated power
- C electric power
- D mean effective power

(1)

4.7 What is the special name given to the diagram in FIGURE 4.7 below?

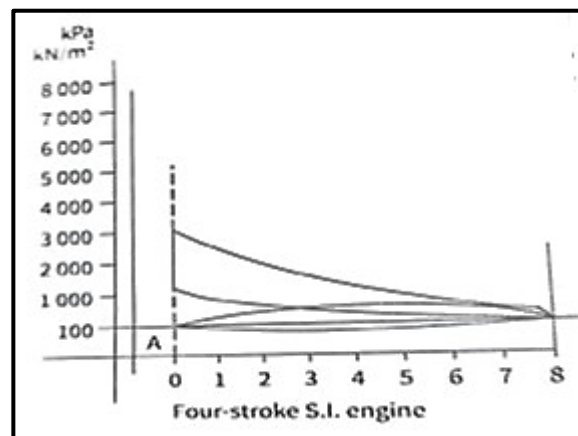


FIGURE 4.7

- A Indicator diagram
- B Dial indicator
- C Compression ratio diagram
- D Inversely proportional diagram

(1)

4.8 What will the cause be if a gas analyser shows high carbon monoxide readings?

- A Vacuum leaks
- B Exhaust system leaks
- C Too rich mixture
- D Nearly ideal air-fuel ratio

(1)

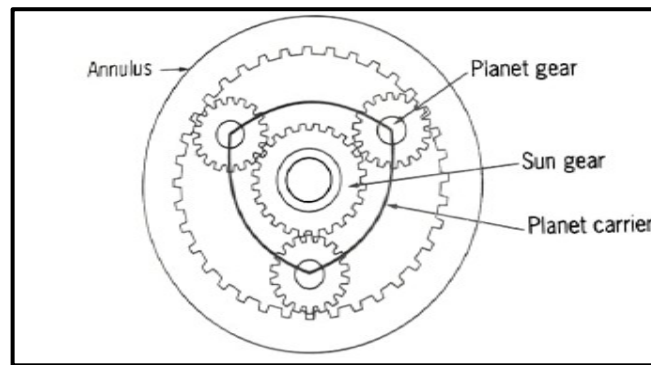


4.9 Which ONE of the following manufacturer's specifications is to be considered when conducting a cooling system pressure test?

- A Maximum fuel pressure before the fuel pump
- B Maximum pressure allowed in the radiator
- C Oil pressure on high revolutions
- D None of the above-mentioned

(1)

4.10 The gear train shown below in FIGURE 4.10 is called a ... gear train.



**FIGURE 4.10**

- A compound
- B epicyclic
- C simple
- D bevel

(1)

4.11 What is basic function of a torque converter?

- A To relieve the driver of clutch and gear-shifting operation.
- B To control the brake bands or the multi-disc clutches, which allow the change from one gear ratio to another.
- C To reduce the driving fatigue.
- D To multiply engine torque automatically according to road and engine speeds.

(1)

4.12 FIGURE 4.12 below shows a tyre wear which is caused by ...



**FIGURE 4.12**

- A camber wear.
- B caster wear.
- C under-inflated tyre.
- D over-inflated tyre.

(1)

4.13 The sensor that measures the intake air volume and engine load is the ...

- A manifold absolute pressure (MAP) sensor.
- B throttle position sensor (TPS).
- C idle speed control valve (ISC).
- D engine coolant temperature sensor.

(1)

4.14 What is the function of the idle control valve in an engine?

- A It regulates the idle speed by adjusting the volume of air that is allowed to by-pass the closed throttle valve.
- B It adapts the speed and maintain a safe distance from the vehicle in front.
- C It provides a warning if there is a risk of collision.
- D It controls the valve opening angle and engine revolutions per minute (rpm).

(1)

**[14]**

**QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)**

- 5.1 FIGURE 5.1 below shows testing equipment. Answer the questions that follow.



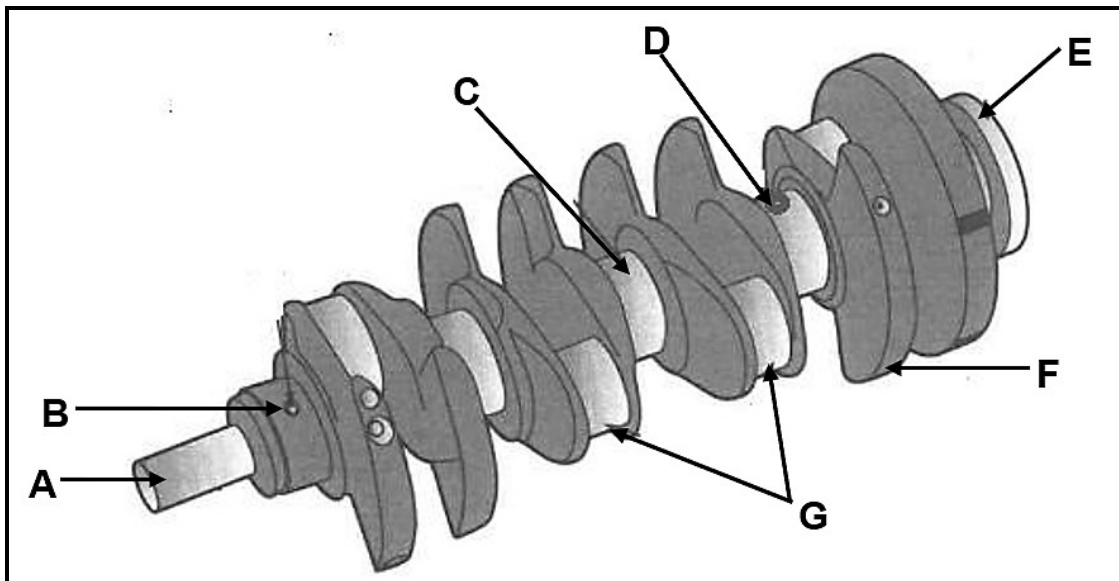
**FIGURE 5.1**

- 5.1.1 Identify the tester shown in FIGURE 5.1. (1)
- 5.1.2 Label components **A–D**. (4)
- 5.1.3 What is the purpose of the equipment shown in FIGURE 5.1? (2)
- 5.2 With reference to a gas analyser, answer the following questions.
- 5.2.1 What is the purpose of the gas analyser? (2)
- 5.2.2 List FOUR gases that a gas analyser can measure. (4)
- 5.3 Explain the set-up procedure to perform a compression test on a four-stroke petrol engine. (4)
- 5.4 Explain the purpose of each of the following tools listed below:
- 5.4.1 Bubble gauge (2)
- 5.4.2 Wheel balancer (2)
- 5.4.3 Turn-table (2)

**[23]**

**QUESTION 6: ENGINES (SPECIFIC)**

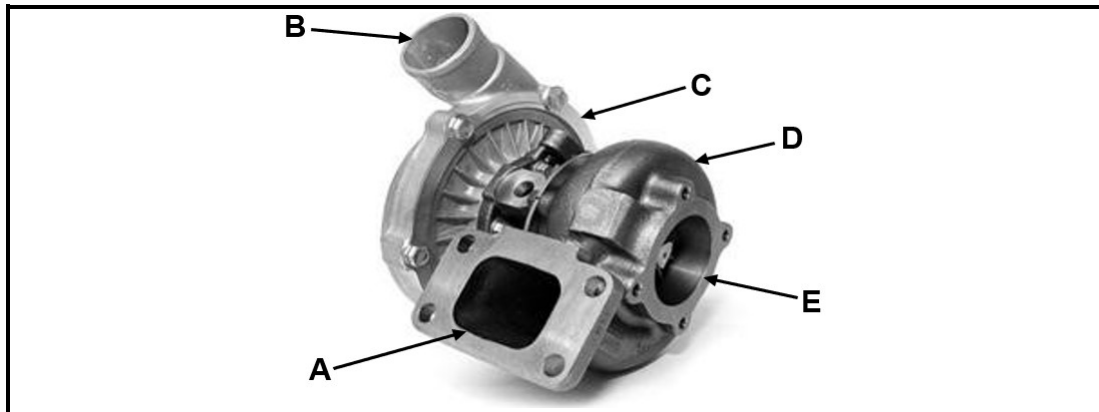
- 6.1 FIGURE 6.1 below shows the crankshaft of a four-cylinder in-line engine. Answer the questions that follow.



**FIGURE 6.1**

- 6.1.1 Give the main function of the crankshaft shown in FIGURE 6.1. (2)
- 6.1.2 Label parts **A–G**. (7)
- 6.1.3 State TWO factors that determines the firing order of an internal combustion engine. (2)
- 6.2 Explain each of the following terms with reference to the built-in features to improve engine balance:
- 6.2.1 Connecting rods and pistons (2)
- 6.2.2 Flywheels (2)
- 6.2.3 Vibration dampers (2)

- 6.3 FIGURE 6.3 below shows a component that is fitted to an internal combustion engine to increase the power output. Answer the questions that follow.



**FIGURE 6.3**

- 6.3.1 Identify the component shown in FIGURE 6.3 above. (1)
- 6.3.2 Label parts **A–E**. (5)
- 6.4 Explain the following terms with reference to the component in FIGURE 6.3 above.
- 6.4.1 Lag (2)
- 6.4.2 Boost (2)
- 6.5 Give ONE advantage of twin-charging, that is used in a motor vehicle. (1)

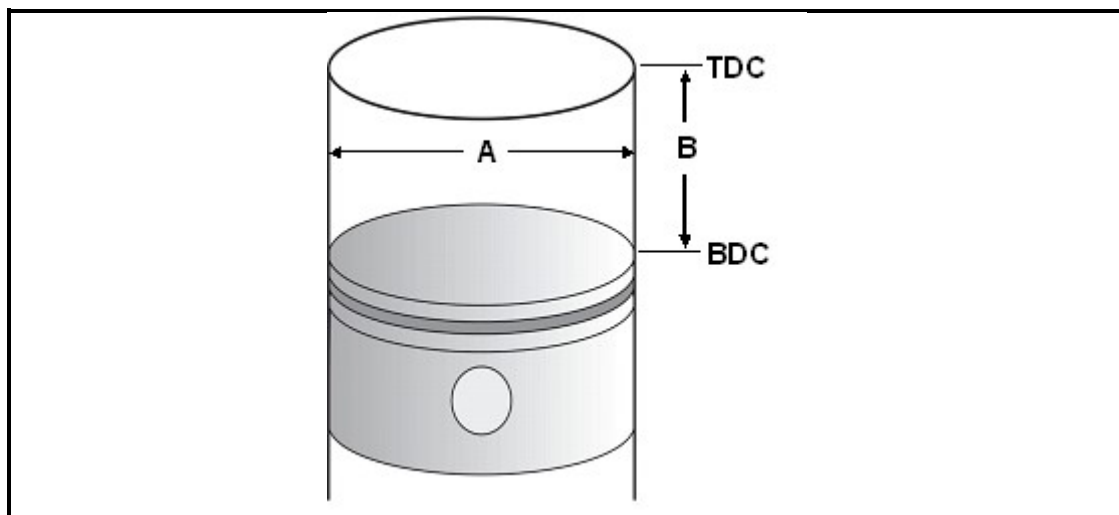
**[28]**

**QUESTION 7: FORCES (SPECIFIC)**

7.1 Define the *compression ratio* of an engine. (2)

7.2 The hydraulic engine crane is used to hoist an engine with a mass of 560 kg up to a height of 20 m. Calculate the work done in kJ. (4)

7.3 FIGURE 7.3 below shows an engine cylinder. Answer the questions that follow.



**FIGURE 7.3**

7.3.1 Name the distances labelled **A** and **B**. (2)

7.3.2 Calculate the swept volume in  $\text{cm}^3$ , if **A** = 110 mm and **B** = 120 mm. (4)

7.3.3 Calculate the compression ratio of this engine if the clearance volume is  $100 \text{ cm}^3$ . (2)

7.4 List FOUR methods of raising the compression ratio of an engine. (4)

7.5 Explain term *mean effective pressure*. (2)

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

Mean effective pressure on the piston:	1 200 kPa
Stroke length:	86 mm
Cylinder bore diameter:	90 mm
Crankshaft speed:	4 200 rpm
Torque:	180 Nm @ 4 200 rpm
Number of cylinders:	4

Calculate the following:

7.6.1 Indicated power in kW (7)

7.6.2 The brake power in kW (3)

7.6.3 Mechanical efficiency (2)

**[32]**

**QUESTION 8: MAINTENANCE (SPECIFIC)**

- 8.1 State at least FOUR safety requirements needed to consider when setting up the radiator pressure tester on a vehicle's cooling system. (4)

- 8.2 During a cylinder leakage test, it was found that there are some signs of failure in the cylinder.

State the causes of failure in each of the following cases:

- 8.2.1 Hissing sound from the dipstick (1)

- 8.2.2 Hissing sound from the inlet manifold (1)

- 8.2.3 Bubbles from radiator (1)

- 8.3 The table below shows information regarding the results of the gas analyser of an internal combustion engine.

Re-draw the table in your ANSWER BOOK and complete it by writing ONE cause and ONE corrective measure for EACH of the given faults.

	FAULTS	POSSIBLE CAUSES	CORRECTIVE MEASURES
8.3.1	Low carbon monoxide (CO) reading		
8.3.2	Low carbon dioxide (CO <sub>2</sub> ) reading		
8.3.3	High hydrocarbon (HC) reading		

(6)

- 8.4 Give the FOUR manufacturer's specifications that must be considered when conducting oil pressure testing. (4)

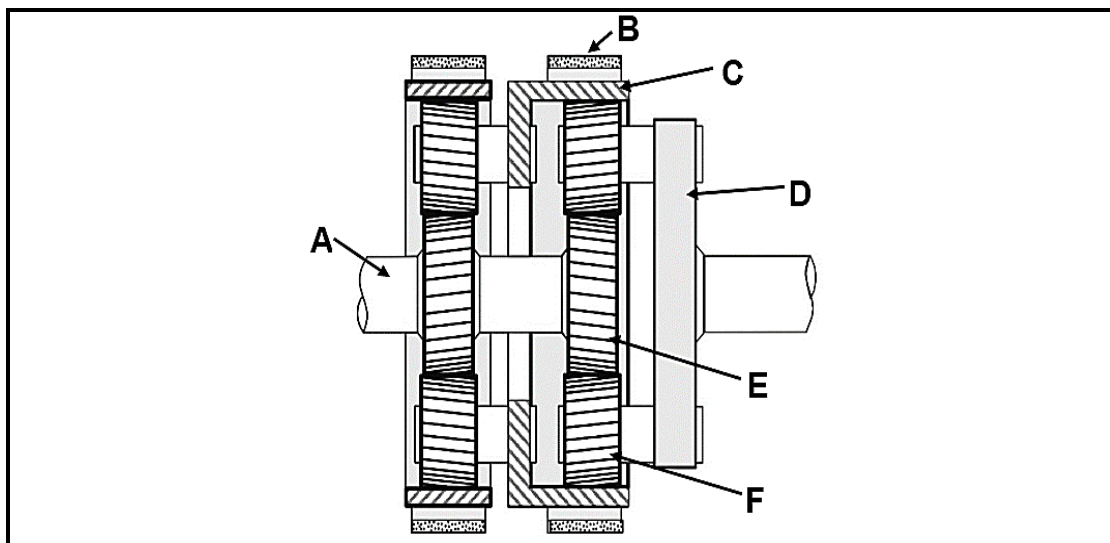
- 8.5 State FOUR possible causes of low fuel pressure readings. (4)

- 8.6 Give TWO manufacturer's specifications that must be considered when conducting fuel pressure testing. (2)

**[23]**

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

- 9.1 State the purpose of installing an automatic transmission on a modern vehicle. (2)
- 9.2 Name ONE advantage of an automatic transmission. (1)
- 9.3 Give TWO methods of cooling the oil in an automatic transmission. (2)
- 9.4 What is the function of the hydraulic piston in an automatic transmission? (2)
- 9.5 The FIGURE 9.5 below shows a double epicyclic gear train. Answer the questions that follow.

**FIGURE 9.5**

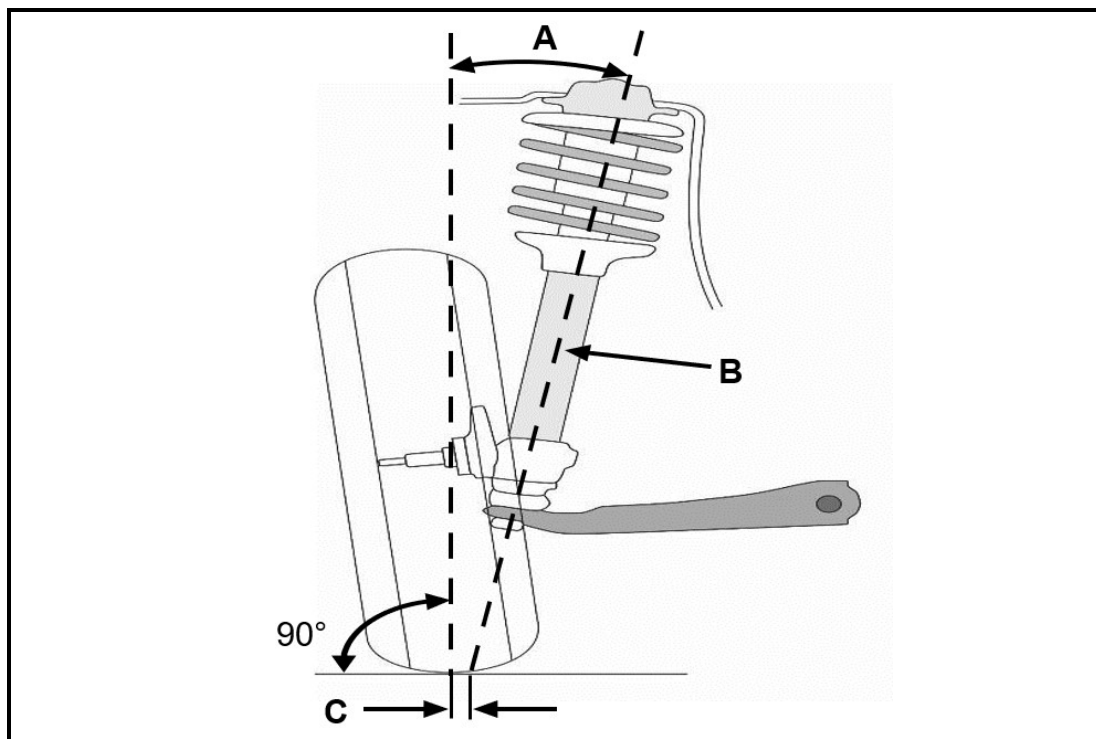
- 9.5.1 Label parts **A–F**. (6)
- 9.5.2 In point form, explain the operation of the double epicyclic gear train when a first gear is selected. (5)

**[18]**



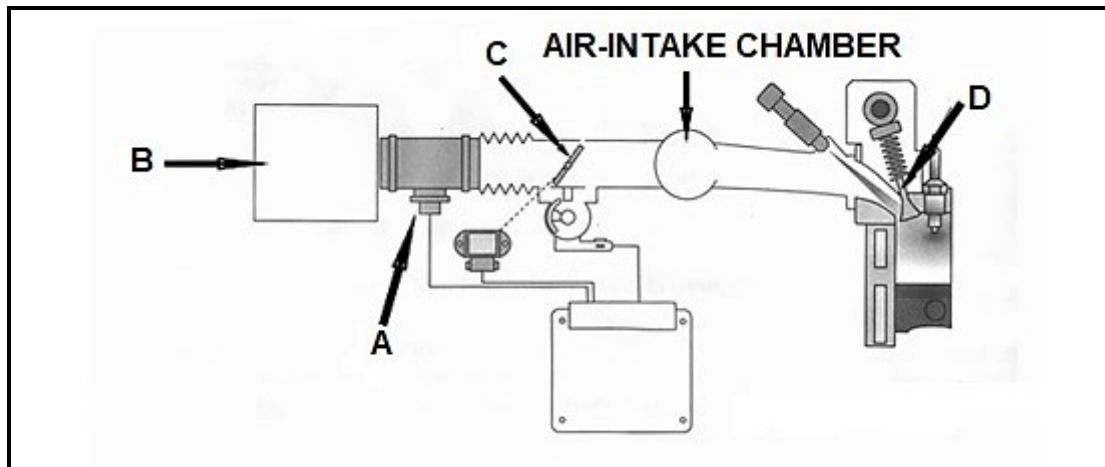
**QUESTION 10: SYSTEMS AND CONTROL (AXLES, STEERING GEOMETRY AND ELECTRONICS) (SPECIFIC)**

- 10.1 FIGURE 10.1 below shows the king pin inclination, as seen from the front. Answer the questions that follow.

**FIGURE 10.1**

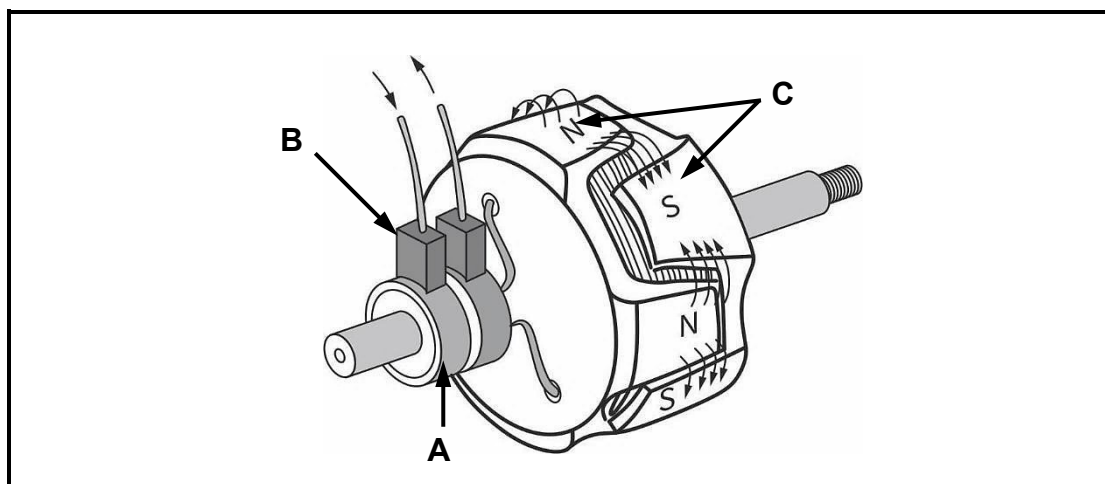
- 10.1.1 Label parts **A–C**. (3)
- 10.1.2 Define *king pin inclination*. (2)
- 10.2 State THREE properties of a good steering mechanism. (3)
- 10.3 Name THREE pre-checks that should be carried out before wheel balancing can be done. (3)
- 10.4 What is the purpose of a catalytic converter? (2)
- 10.5 Name TWO requirements for a catalytic converter to function effectively. (2)
- 10.6 Give TWO types of diesel particulate filters used within the automotive trade. (2)

- 10.7 FIGURE 10.7 below shows one of the engine systems controlled by the **ECU**. Answer the following questions.



**FIGURE 10.7**

- 10.7.1 Identify the system shown in FIGURE 10.7. (1)
- 10.7.2 Label the parts **A–D**. (4)
- 10.7.3 What is the purpose of the system shown in FIGURE 10.7? (2)
- 10.8 State **THREE** main purposes of adaptive speed control systems. (3)
- 10.9 FIGURE 10.9 below shows the rotor of an alternator. Answer the questions that follow.



**FIGURE 10.9**

- 10.9.1 Label parts **A–C**. (3)
- 10.9.2 State **TWO** methods of increasing the output frequency of an alternator. (2)

**[32]**

**TOTAL: 200**

**FORMULA SHEET FOR MECHANICAL TECHNOLOGY (AUTOMOTIVE)**

Force =  $m \times a$      where  $m$  = mass  
     $a$  = acceleration

Work = force  $\times$  distance ( $F \times d$ )

Power =  $\frac{\text{force} \times \text{distance}}{\text{time}}$

Torque = force  $\times$  radius

Indicated power =  $P \times L \times A \times N \times n$

where      $P$  = mean effective pressure  
                   $L$  = length of stroke  
                   $A$  = area of piston crown  
                   $N$  = number of power strokes per second  
                   $n$  = number of cylinders

Brake power =  $2\pi N \times T$

where      $N$  = revolutions per second  
                   $T$  = torque

Brake power (Prony brake) =  $F \times 2 \times \pi \times R \times N$

where      $F$  = force  
                   $R$  = length of brake arm  
                   $N$  = revolutions per second

Mechanical efficiency =  $\frac{\text{brake power}}{\text{indicated power}} \times 100$

Compression ration =  $\frac{\text{swept volume} + \text{clearance volume}}{\text{clearance volume}}$

where swept volume =  $\frac{\pi \times D^2}{4} \times L$

clearance volume =  $\frac{SV}{CR-1}$

where  $L$  = length of stroke  
                   $D$  = diameter of bore

where  $D$  = diameter of bore  
                   $l$  = clearance

Gear ration =  $\frac{\text{product of the number of teeth of the driven gears}}{\text{product of the number of teeth of the driver gears}}$