Province of the EASTERN CAPE EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2023

MECHANICAL TECHNOLOGY: AUTOMOTIVE

MARKS: 200

TIME: 3 hours

This question paper consists of 17 pages, including a 1-page formula sheet.

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 calculators and drawing instruments.

8.   The value of gravitational acceleration should be taken as 10 m/s^2.

9.   All dimensions are in millimetres, unless stated otherwise in the question.

10.   A formulae sheet is attached to the question paper.

11.   Write neatly and legibly.

12.   Use the criteria below to assist you in managing your time management.

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**

SA EXAM PAPERS

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

Various options are provided as possible answers to the following questions. Choose the correct 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 of the following options below describes the Labour Relation Act (LRA No. 66 of 1995) in South Africa that protect the people living with HIV/Aids?

　　A　All employers must ensure that the workplace is safe, and that employees are not at risk of becoming infected with HIV at work.
　　B　Elaborates how everybody has the right to fair labour practice.
　　C　Employer cannot simply dismiss an employee who is infected with HIV.
　　D　Promotes non-discrimination in the workplace.　　(1)

1.2　Examination procedure is one of the processes undertaken to determine the type of first aid measures to be administered to an employee who is involved in an accident in a workplace.
　　Identify the option below that best describe this process.

　　A　Environmental observation
　　B　Visible signs and symptoms
　　C　Indicators to diagnosis
　　D　All of the above　　(1)

1.3　The following safety precautions must be followed when handling gas bottles:

　　A　All cylinders must be kept in horizontal position
　　B　Use completely insulated electrode holders
　　C　Never stack cylinders on top of each another
　　D　The colour code of an oxygen cylinder is green　　(1)

1.4　Which ONE of the heat treatment process is used to remove internal strain and brittleness caused by hardening?

　　A　Annealing
　　B　Case-hardening
　　C　Tempering
　　D　Normalising　　(1)

1.5　Which of the following test is used to determine the carbon content of steel?

　　A　Sound test
　　B　Bend test
　　C　Filing test
　　D　All of the above　　(1)

1.6   Why is it important to clamp a small workpiece securely before drilling operation can be carried out?

    A   To reduce friction
    B   To prevent the drill bit from breaking as well as preventing accident
    C   To keep the cutting tool and workpiece cool
    D   All of the above   (1)
                                                                            [6]

QUESTION 2: SAFETY (GENERIC)

2.1   Give THREE safety precautions you must take into consideration before arc welding operation can commence.   (3)

2.2   State TWO safety precautions that you must adhere to when you are operating a pedestal drilling machine to drill a hole on a solid square bar.   (2)

2.3   What is the maximum thickness of a steel plate that a manual guillotine can accommodate if cutting with it?   (1)

2.4   Give TWO advantages of each of the following workshop layouts:

    2.4.1   Product layout of machines   (2)

    2.4.2   Process layout of machines   (2)
           [10]

QUESTION 3: MATERIALS (GENERIC)

3.1   State the TWO main purpose of case hardening mild steel.   (2)

3.2   Why can high carbon steel not be used for case hardening?   (1)

3.3   State THREE factors that determine the hardness of steel during heat
        treatments of metal.   (3)

3.4   List THREE types of quenching mediums.   (3)

3.5   What is the purpose of the colour coding marked on engineering materials?   (1)

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

        3.6.1   Hardness   (1)

        3.6.2   Carbon content   (1)

        3.6.3   Ductility   (1)

3.7   List the machine that is used for a spark test.   (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   What prompts the maintenance department of an automobile company to carry out a compression test on an internal combustion engine of a vehicle?

    A   If the engine is vibrating.
    B   If the engine has lost power
    C   To compare the engine cylinder compression pressure with the manufactural specification.
    D   All of the above.   (1)

4.2   Which ONE of the following is a possible sign that there is a leakage in the cylinder of an internal combustion engine when doing cylinder leakage test?

    A   The radiator coolant become pink in colour
    B   Engine oil turns black
    C   Bubbles comes out of the radiator coolant
    D   Engine oil leaks from the crankshaft seal   (1)

4.3   What is the possible cause of high carbon monoxide (CO) reading of an exhaust gas from an internal combustion engine?

    A   Dirt or restricted air filter
    B   Vacuum leaks
    C   Too lean air-fuel ratio
    D   All of the above   (1)

4.4   When using gas analyser to check the content of an engine exhaust gas, which possible codes denote '*switch analyser off and then on again*'?

    A   000
    B   E R8 & E R9
    C   E R1
    D   E R2   (1)

4.5   Which component of an SI-engine can possibly cause overheating?

    A   Oil pump
    B   Thermostat
    C   Crankshaft oil seal
    D   Exhaust gas recirculation (EGR)   (1)

4.6 The low oil pressure warning light turns on when the oil pressure in the engine galleries is too low. The following factors are the possible causes of this problem.

Choose ONE that is not a possible cause.

A Worn oil pump
B Blocked oil pump pick-up screen in the sump
C Too much oil in the sump
D Blocked or restricted oil filter (1)

4.7 Calculate the torque applied to lock a bolt on a cylinder head using a torque wrench with a length of 600 mm when a force of 120 N is applied.

A 480 Nm
B 720 Nm
C 72 Nm
D 72000 Nm (1)

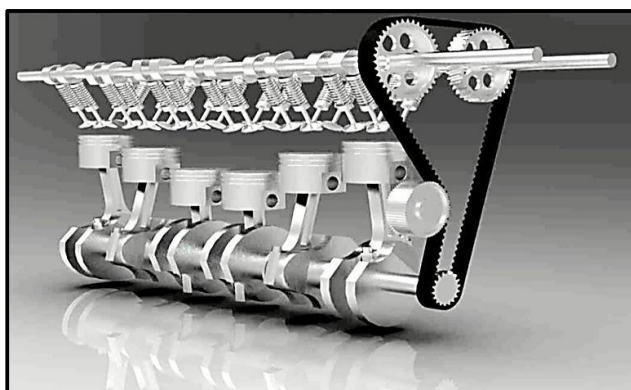4.8 Identify the type of engine cylinder configuration shown in FIGURE 4.8 below.

FIGURE 4.8

A In-line engine
B V-engine
C Horizontally opposed engine
D W-engine (1)

4.9 An engine has a clearance volume of 59 cm^3 and a compression ratio of 10 : 1.

Calculate the swept volume.

A 767 cm^3
B 295 cm^3
C 495 cm^3
D 531 cm^3 (1)

4.10 Which ONE of the following options is a function of an optical alignment tool?

     A   It is used to read kingpin inclination.
     B   It is used to determine the correct castor.
     C   It is used to check the toe-in and toe-out of a vehicle.
     D   It used to carry out dynamic wheel balancing.   (1)

4.11 Which term describes the condition when the driver of a turbo charged vehicle feels a delay between pressing the accelerator pedal and feeling the kick-in?

     A   Torque speed
     B   Lag
     C   Boost
     D   Stall speed   (1)

4.12 What type of alignment is displayed in FIGURE 4.12 below?
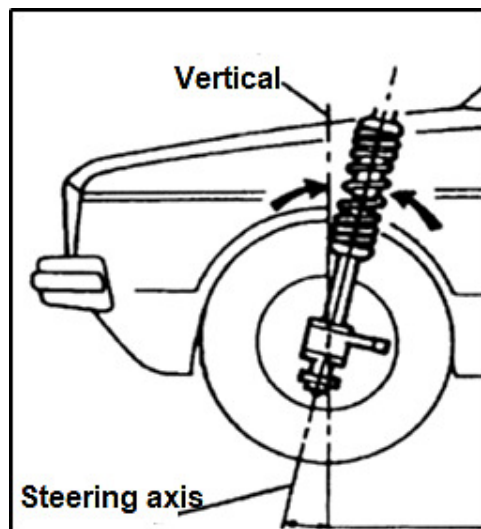
FIGURE 4.12

     A   Positive castor
     B   Negative castor
     C   Positive chamber
     D   Negative chamber   (1)

4.13 How does the wheel alignment shown in FIGURE 4.13 below affect the wear of tyre?
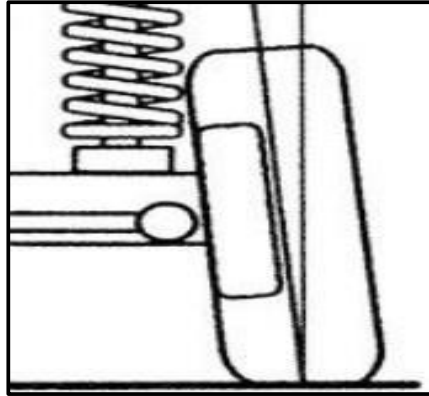
FIGURE 4.13

A   Wear excessively from the outside
B   Wears uniformly
C   Wear excessively from the inside
D   All of the above. (1)

4.14 Which ONE of the following is the purpose of an oil pump in a three-speed automatic gearbox?

A   To drive the plates of both clutches to rotate with the turbine.
B   To regulate the speed of the sun gear.
C   To activate the smooth transfer of power.
D   To control the break band and the multi-disc clutches. (1)
[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

5.1   Give TWO safety precautions you must adhere to when using an emission gas analyser.   (2)

5.2   What is the purpose of a diagnostic scanner?   (2)

5.3   Briefly explain the set-up procedure of a diagnostic scanner on an engine.   (3)

5.4   What is the main purpose of the following wheel alignment equipment?

      5.4.1   Bubble gauge   (2)

      5.4.2   Turntable   (2)

5.5   In point forms, briefly describe the procedure to read kingpin inclination (KPI) in degrees on the right-hand side.   (9)

5.6   Briefly explain the purpose of a wheel balancer.   (2)

5.7   What is the advantage of using card-type compression tester?   (1)
                                                                                         [23]

QUESTION 6: ENGINES (SPECIFIC)

6.1   Name TWO main functions of a crankshaft in an engine that enables it to set
       the engine in motion?   (2)

6.2   A crankshaft is subjected to vibrations as the engine is running or idling. Give
       TWO reasons responsible for these vibrations.   (2)

6.3   Give FOUR built-in features applicable in improving engine balance.   (4)

6.4   Name TWO factors that determine the firing order of an engine.   (2)

6.5   In points form, briefly explain the procedure to follow in determining the firing
       order of an engine if no specifications given.   (5)

6.6   The diagram in FIGURE 6.6 below shows an additional engine component that
       supports engine combustion. Answer the questions that follow.
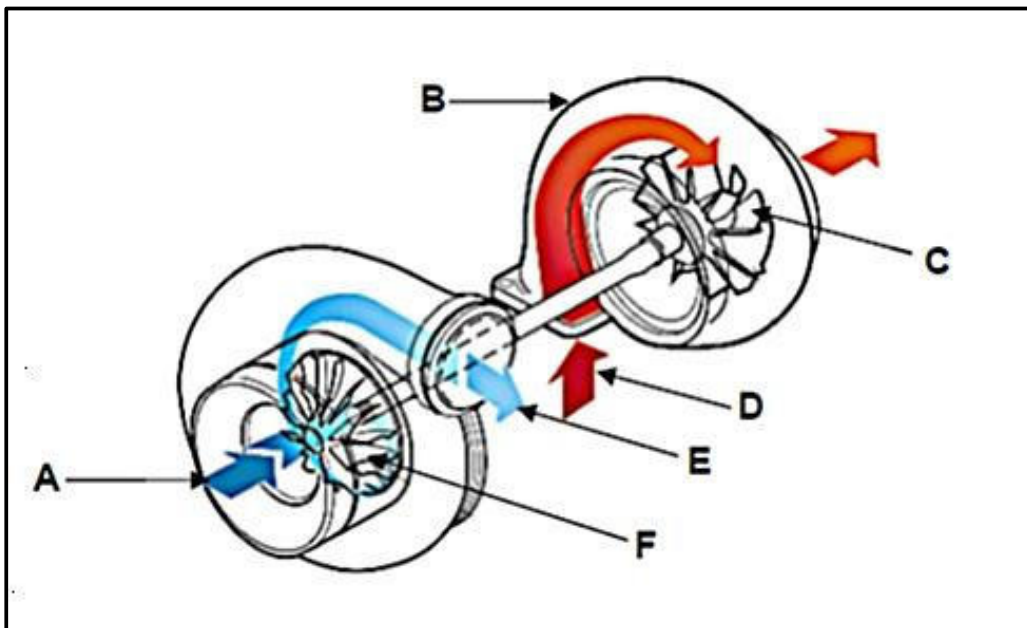
FIGURE 6.6

6.6.1   Identify the engine component in FIGURE 6.6 above.   (1)

6.6.2   Label the parts **A–F**.   (6)

6.6.3   What is the function of part **C**?   (1)

6.6.4   What is the function of part **F**?   (1)

6.6.5   What is the purpose of installing the component shown in FIGURE 6.6
         above in an engine.   (2)

6.6.6   What do you understand by the term *boost* in relation, of the FIGURE
         6.6 above, to an engine?   (2)
                                                                              [28]

Please turn over

QUESTION 7: FORCES (SPECIFIC)

7.1   Briefly explain the following terms in the cylinder of an internal combustion engine.

      7.1.1   Swept volume   (2)

      7.1.2   Clearance volume   (2)

      7.1.3   Compression ratio   (2)

      7.1.4   Mechanical efficiency   (2)

7.2   Briefly explain any FOUR methods used in raising the compression ratio of an engine.   (4)

7.3   Calculate the compression ratio of an engine with a bore of 86 mm and a stroke of 82 mm if the combustion chamber volume is 56 cm^3.   (6)

7.4   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: 80 mm
    Cylinder bore: 96
    Revolutions per minute: 4 800 rpm
    Torque: 260 Nm @ 3 600 rpm
    Number of cylinders: 4

    Calculate the following:

      7.4.1   Indicated power in kW   (8)

      7.4.2   The brake power in kW   (4)

      7.4.3   Mechanical efficiency   (2)
           [32]

QUESTION 8: MAINTENANCE (SPECIFIC)

8.1   State THREE different types of gases coming out of an exhaust system that are analysed.   (3)

8.2   Briefly explain TWO corrective measures that need to be carried out when there are high oxygen readings from an exhaust system.   (2)

8.3   After a cylinder leakage test has been conducted on an internal combustion engine, the results indicated high percentage leakage in the cylinders. Three possible faults were detected.

State the faults in each of the following cases:

8.3.1   Hissing sound from the exhaust manifold   (1)

8.3.2   Hissing sound from the dipstick   (1)

8.4   Name the FOUR manufacturer's specifications that are needed when doing a fuel pressure test.   (4)

8.5   State THREE possible causes of low fuel pressure readings.   (3)

8.6   When an oil pressure test was done on two different cars that have similar engine capacity of 1.2 L TSi (turbo spark injection), the following faults were discovered:

• Oil pressure was too low in the first car engine
• Oil pressure was far higher than the specification in the second car engine

8.6.1   Give TWO possible causes of the problem in the first car engine.   (2)

8.6.2   Give TWO possible solutions required to resolve the problem in the second car engine.   (2)

8.7   Why must cooling system pressure testing be done?   (1)

8.8   In point form, briefly explain the procedure to follow when doing a radiator cap pressure test.   (4)

[23]

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

9.1   What is the purpose of installing an automatic transmission on modern vehicles? (2)

9.2   Give TWO advantages of automatic transmission. (2)

9.3   In point forms explain the operation of the double epicyclic gear train in low gear. (5)

FIGURE 9.4 below shows a double epicyclic drive train in low gear.
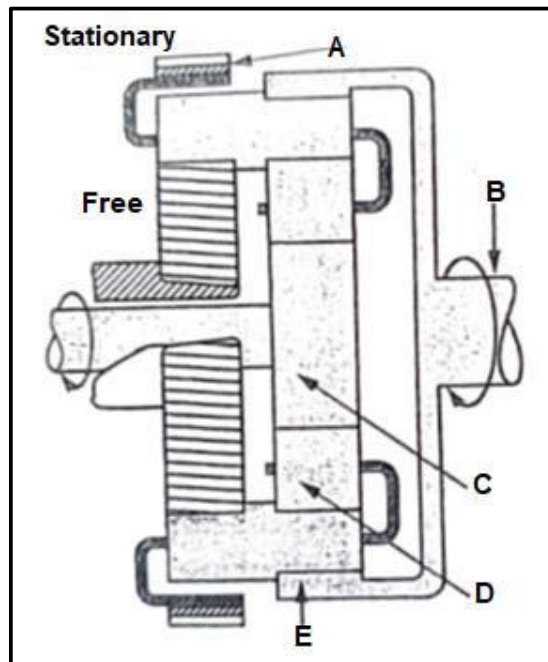

FIGURE 9.4

9.4   Label parts **A**–**E**. (5)

9.5   Give TWO methods of cooling the oil in an automatic transmission. (2)

9.6   What is the function of hydraulic piston in automatic transmission? (2)

[18]

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

10.1   What is the function of a steering mechanism?   (2)

10.2   State TWO properties that a good steering mechanism must have.   (2)

10.3   Use a neat sketch to explain the difference between *toe-in* and *toe-out*.   (4)

10.4   Give THREE advantages of positive camber alignment.   (3)

10.5   Briefly explain the purpose of the following alignment incorporation:

      10.5.1   King pin inclination   (2)

      10.5.2   Ackermann principle   (2)

10.6   Pre-check on a wheel must be carried out before balancing can be done. Give any THREE possible conditions that are expected to be checked.   (3)

10.7   What is the purpose of a catalytic converter?   (2)

10.8   Give TWO requirements for a catalytic converter to function effectively.   (2)

10.9   Briefly explain the function of the following components of a vehicle engine alternator:

      10.9.1   Diode   (2)

      10.9.2   Heat sink   (2)

      10.9.3   Voltage regulator   (2)

10.10   What is the function of a fuel pump in a 4-stroke SI-engine?   (2)

10.11   Give TWO advantages of an electronic fuel pump over a mechanical driven fuel pump.   (2)
[32]

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY (AUTOMOTIVE)

Force = m x a   where m = mass
                                a = acceleration

Work = force x distance (F x d)

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

Torque = force x radius

Indicated power = P x L x A x N x 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 = 2π N x T
where   N = revolutions per second
                  T = torque

Brake power (Prony brake) = F x 2 x π x R x N
where   F = force
                                   R = length of brake arm
                                   N = revolutions per second

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

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

where swept volume = $\frac{\pi \text{ x } D^2}{4}$ x L   clearance volume = $\frac{\pi \text{ x } D^2}{4}$ x l

where L = length of stroke   where D = diameter of bore
          D = diameter of bore   l = clearance

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