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**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

MECHANICAL TECHNOLOGY: AUTOMOTIVE

NOVEMBER 2022

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 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 ONE of the following is the last stage when applying first aid?
- A Examination
 - B Treatment
 - C Diagnosis
 - D Transport
- (1)
- 1.2 What is the maximum thickness of sheet metal that a manual guillotine can cut?
- A 0,2 mm
 - B 1,2 mm
 - C 2,2 mm
 - D 3,2 mm
- (1)
- 1.3 Which part of a hydraulic press is used to safely keep the platform at a desired height?
- A Return spring
 - B Plunger
 - C Supporting pin
 - D Base
- (1)
- 1.4 Which ONE of the following tests is used to determine resistance to penetration?
- A File test
 - B Machining test
 - C Hardness test
 - D Sound test
- (1)
- 1.5 Which machine is used to conduct a spark test on carbon steels?
- A Bench grinder
 - B Drilling machine
 - C Lathe machine
 - D Milling machine
- (1)
- 1.6 Which ONE of the following materials will have a high ringing sound when tapped with a hammer during a sound test?
- A Cast iron
 - B Cast steel
 - C Mild steel
 - D Aluminium
- (1)

[6]

QUESTION 2: SAFETY (GENERIC)

- 2.1 Name TWO vital functions of an injured person that must be checked when first aid is applied. (2)
- 2.2 Give a reason why safety goggles must be worn when working with an angle grinder. (1)
- 2.3 Name TWO types of safety guards that are used when the opening at the guillotine shears is greater than 10 mm. (2)
- 2.4 State THREE safety precautions that must be adhered to before gas welding is undertaken. (3)
- 2.5 State TWO disadvantages of the product layout of machines. (2)
- [10]**

QUESTION 3: MATERIALS (GENERIC)

- 3.1 State THREE properties that can be obtained from heat-treatment processes. (3)
- 3.2 Describe the following heat-treatment processes:
- 3.2.1 Tempering (4)
- 3.2.2 Hardening (3)
- 3.3 Give TWO examples of case-hardened products used in the industry. (2)
- 3.4 Why is steel cooled in still air, away from a draught, during the normalising 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 Which precaution must be taken before calibrating the emission (exhaust) gas analyser?
- A Ensure that the engine is at operating temperature.
- B The pick-up hose must be removed from the exhaust pipe.
- C Do not step on the pick-up hose or restrict it in any way.
- D The pick-up hose connections must be airtight. (1)

- 4.2 How many degrees are the wheels turned from the straight-ahead position when checking caster and king pin inclination (KPI) with a bubble gauge?
- A 20°
 - B 40°
 - C 15°
 - D 30°
- (1)
- 4.3 Why are flywheels fitted to the crankshaft flange in one position only?
- A To prevent it from loosening
 - B To maintain its balance
 - C To ensure that the clutch fits correctly
 - D To improve engine boost
- (1)
- 4.4 What is meant by the term *turbo lag*?
- A The delay between pressing the accelerator and the turbo kicking in
 - B The dirt found in the oil
 - C The turbo is placed after the catalytic converter
 - D The time it takes for the turbo to cool down
- (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 ONE of the following will result in a lower compression ratio?
- A Fit piston with suitable higher crowns
 - B Fit crankshaft with a longer stroke
 - C Fit a thicker gasket between the cylinder block and the cylinder head
 - D Increase bore size of cylinders
- (1)
- 4.7 Clearance volume is also known as ...
- A combustion volume.
 - B compression chamber volume.
 - C confined volume.
 - D cylinder volume.
- (1)

4.8 What type of engine diagnostic test is shown in FIGURE 4.8 below?

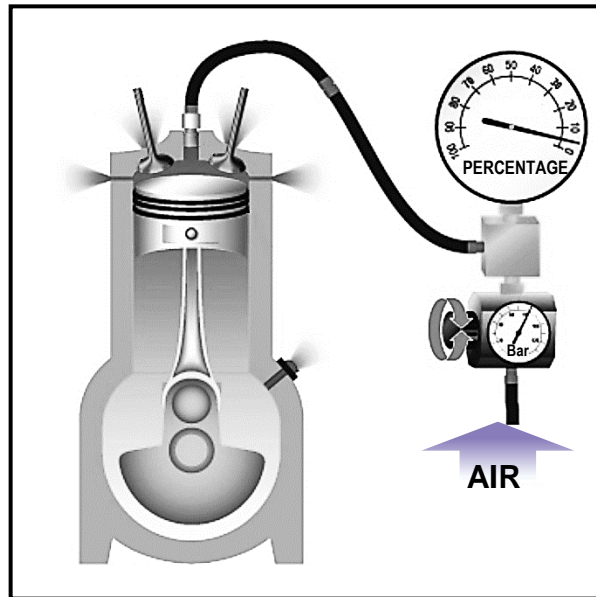


FIGURE 4.8

- A Radiator pressure test
- B Fuel pressure test
- C Cylinder leakage test
- D Compression pressure test (1)

4.9 Which ONE of the following setup procedures refer to an oil pressure test?

Ensure that ...

- A a fire extinguisher is close by.
- B both intake and exhaust valves are closed.
- C the rubber hose is not damaged.
- D the throttle valve is completely open. (1)

4.10 Which ONE of the following is a reduction gear ratio?

- A 1 : 3
- B 2 : 1
- C 1 : 1
- D 2 : 3 (1)

4.11 An advantage of using a transmission control unit (TCU) is ...

- A better fuel ignition.
- B increased harmful engine emissions.
- C that no gearbox is required.
- D improved vehicle handling. (1)

- 4.12 What is the purpose of the Ackermann angle on a vehicle?
It allows for variable ... on turns.
- A toe-in
 - B toe-out
 - C camber
 - D caster
- (1)
- 4.13 What is the function of the coil on a distributorless ignition system?
- A It converts battery voltage to high voltage.
 - B It supplies low voltage to the ignition system.
 - C It heats the fuel to room temperature.
 - D It will melt the ceramic monolith of the catalytic converter.
- (1)
- 4.14 Which ONE of the following is an advantage of an electric fuel pump?
- A Low delivery pressure
 - B Noisy operation
 - C Inconsistent discharge pulsation of fuel
 - D Compact and light design
- (1)
[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

- 5.1 Give TWO reasons why EACH of the following precautions should be observed before a compression test:
- 5.1.1 The ignition system is disconnected. (2)
 - 5.1.2 All spark plugs are removed. (2)
 - 5.1.3 The air filter is removed. (2)
- 5.2 Explain in THREE steps how to calibrate a cylinder leakage tester. (3)
- 5.3 State TWO functions of an exhaust gas analyser. (2)
- 5.4 State THREE ways in which on-board diagnostic (OBD) scanners can be connected to a laptop or computer. (3)
- 5.5 Explain the difference between *static* and *dynamic wheel balancing*. (2)
- 5.6 Which THREE factors are used to locate a wheel's dynamic imbalance? (3)
- 5.7 How do you obtain a reading for toe-in/toe-out, using the periscope optical alignment gauge, after it has been set up against the wheels? (4)
[23]

QUESTION 6: ENGINES (SPECIFIC)

6.1 Name THREE engine parts that are indirectly driven by the crankshaft. (3)

6.2 Identify the TWO vibration dampers shown in FIGURES 6.2.1 and 6.2.2 below.

6.2.1

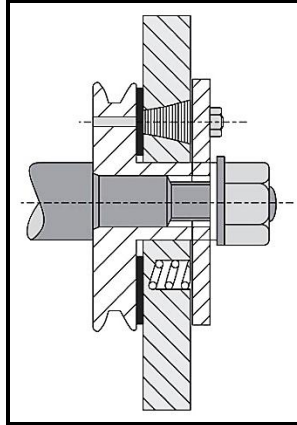


FIGURE 6.2.1

(1)

6.2.2

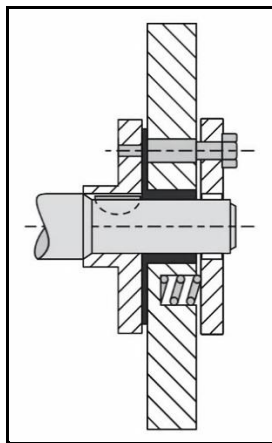


FIGURE 6.2.2

(1)

6.3 State FOUR features, other than vibration dampers, which are built into an engine to improve balance. (4)

6.4 State TWO advantages of using V-type engines compared to in-line (straight) engines in motor vehicles. (2)

6.5 State TWO possible firing orders for a four-cylinder, four-stroke in-line (straight) engine. (2)

6.6 The position of the crank pins in different four-stroke in-line engines are shown in FIGURES 6.6.1 to 6.6.3 below. Identify the number of cylinders for EACH of the crank pin positions below.

6.6.1

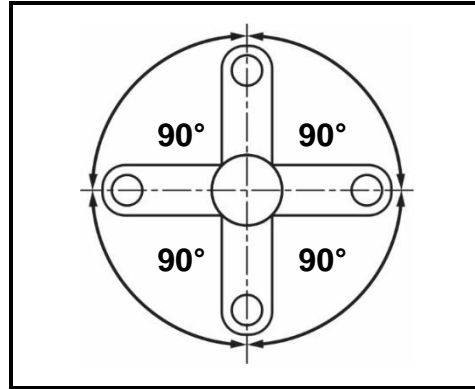


FIGURE 6.6.1

(1)

6.6.2

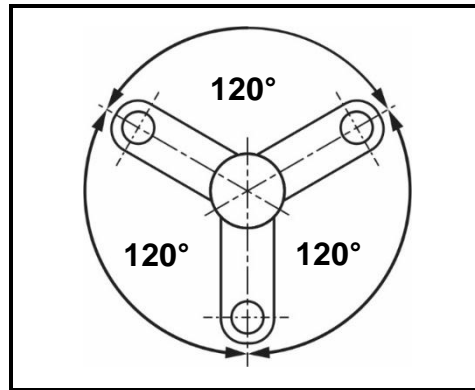


FIGURE 6.6.2

(1)

6.6.3

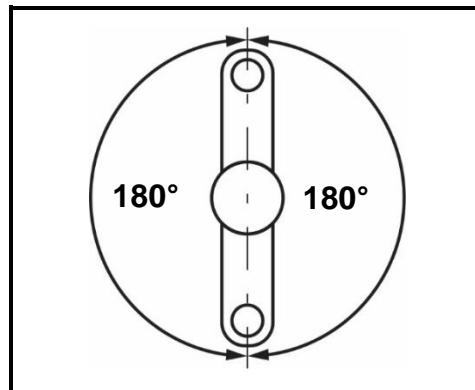


FIGURE 6.6.3

(1)

- 6.7 FIGURE 6.7 below shows a turbocharger that is extensively used in modern vehicles. Answer the questions that follow.

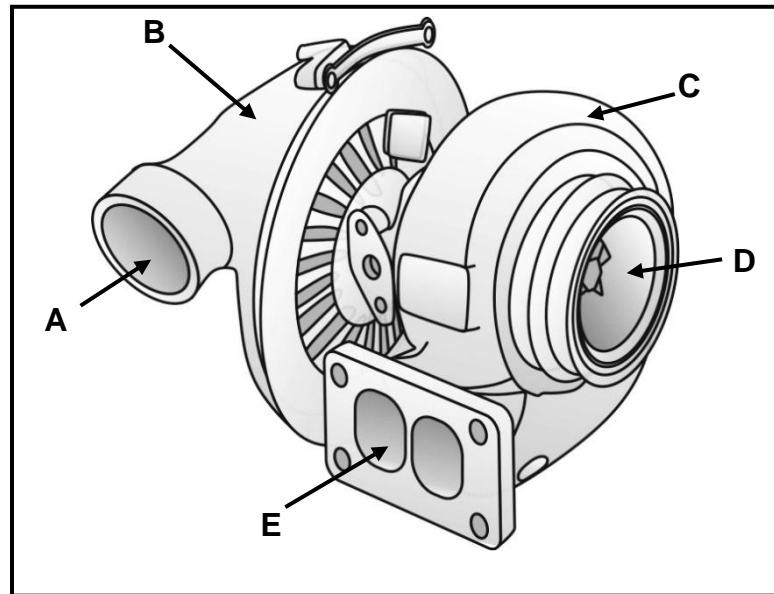


FIGURE 6.7

- 6.7.1 Label parts **A–E**. (5)
- 6.7.2 Name **TWO** types of turbochargers. (2)
- 6.7.3 Give **TWO** reasons why an engine fitted with a turbocharger should idle for a while, before turning off the engine. (2)

6.8 Identify the superchargers shown in FIGURES 6.8.1 to 6.8.3 below.

6.8.1

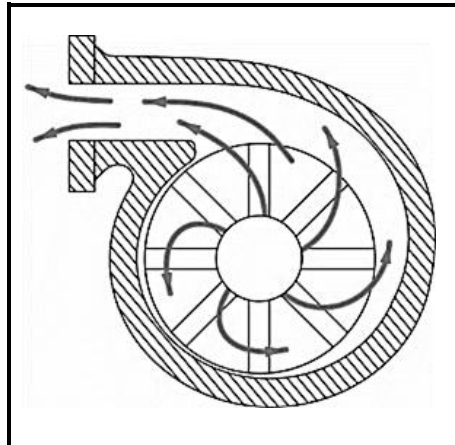


FIGURE 6.8.1

(1)

6.8.2

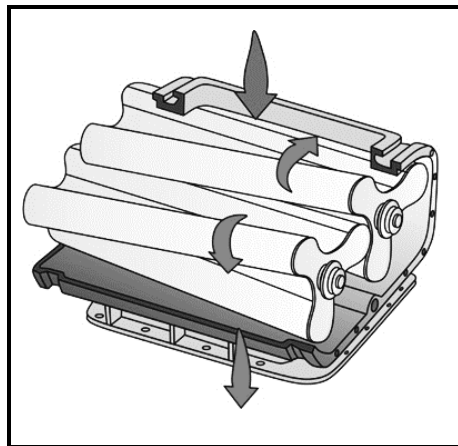


FIGURE 6.8.2

(1)

6.8.3

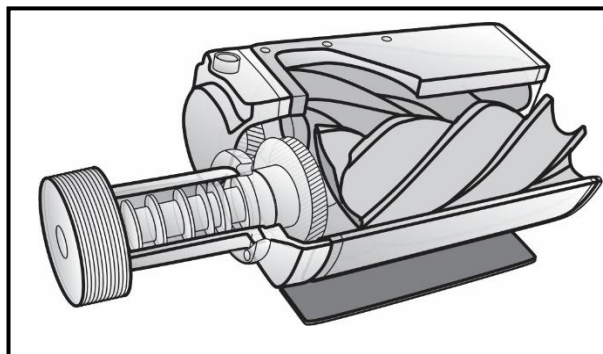
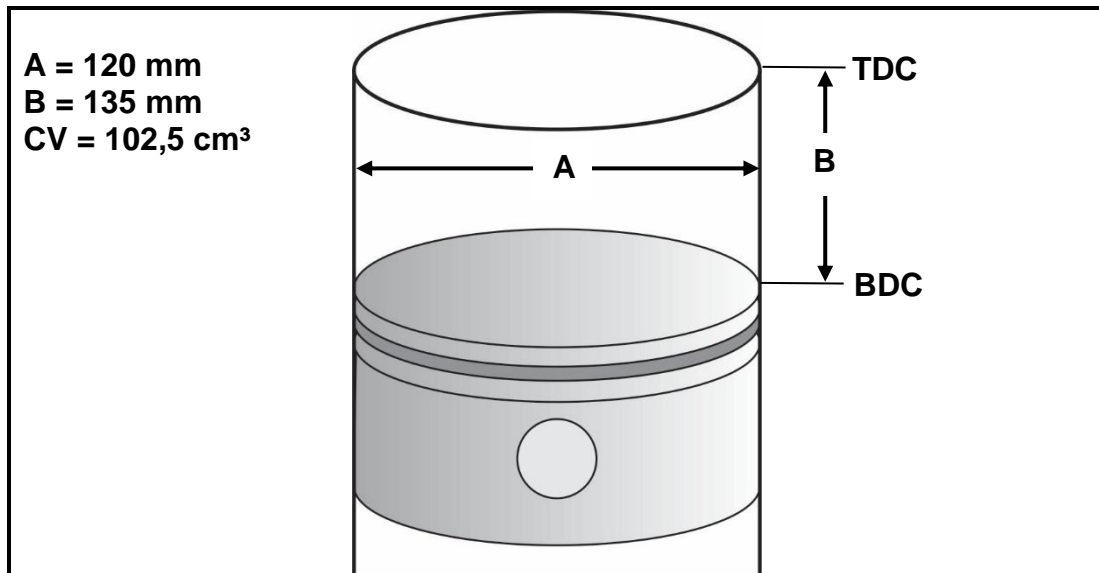


FIGURE 6.8.3

(1)
[28]

QUESTION 7: FORCES (SPECIFIC)

- 7.1 Define *swept volume* of an engine. (2)
- 7.2 A car with a mass of 980 kg is hoisted to a height of 35 m. Calculate the work done in kJ. (3)
- 7.3 FIGURE 7.3 below shows a cylinder. Answer the questions that follow.

**FIGURE 7.3**

- 7.3.1 Name distances **A** and **B**. (2)
- 7.3.2 Calculate the swept volume in cm^3 when **A** = 120 mm and **B** = 135 mm. (4)
- 7.3.3 Calculate the compression ratio of this engine if the clearance volume is $102,5 \text{ cm}^3$. (3)
- 7.4 Calculate the indicated power developed in a four-stroke four-cylinder engine at 1 800 r/min when the diameter of the cylinder is 100 mm and the stroke length is 77 mm. The mean effective pressure is 1 150 kPa. (7)
- 7.5 Name TWO dynamometers used to measure the brake power of an engine. (2)
- 7.6 During a brake power test at 2 500 r/min, the mass reading on the scale showed 120 kg. The length of the brake arm is 500 mm.
- Calculate the following:
- 7.6.1 Torque of the brake arm (4)
- 7.6.2 Power developed by the engine in kW (3)
- 7.6.3 Mechanical efficiency if the indicated power is 196 kW (2)

[32]

QUESTION 8: MAINTENANCE (SPECIFIC)

- 8.1 State THREE gas analyser readings that are caused by a faulty catalytic converter. (3)
- 8.2 State THREE methods to determine the causes of leakages on an internal combustion engine when performing a cylinder leakage test. (3)
- 8.3 The following readings were taken during a compression test:
- Cylinder 1: 11 bar
Cylinder 2: 9 bar
Cylinder 3: 8,2 bar
Cylinder 4: 9,8 bar
- 8.3.1 What is the allowable variation, in percentage (%), between the compression readings? (1)
- 8.3.2 Calculate the maximum variation between the given readings. (2)
- 8.3.3 State TWO possible causes of the low reading in cylinder 3. (2)
- 8.3.4 Explain TWO corrective measures after a wet test is done and the reading in cylinder 3 remains the same. (2)
- 8.4 State TWO possible causes of a low oil pressure reading on an internal combustion engine. (2)
- 8.5 The condition of the oil caused high oil pressure in an internal combustion engine. State TWO corrective measures. (2)
- 8.6 Name THREE checks that must be done on a fuel pressure tester before connecting it to a vehicle's fuel system. (3)
- 8.7 During a cooling system pressure test on an internal combustion engine, the pressure dropped. Name THREE corrective measures to the cooling system. (3)

[23]

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

9.1 Study the cross-sectional view of a double epicyclic gear system in FIGURE 9.1 below. Answer the questions that follow.

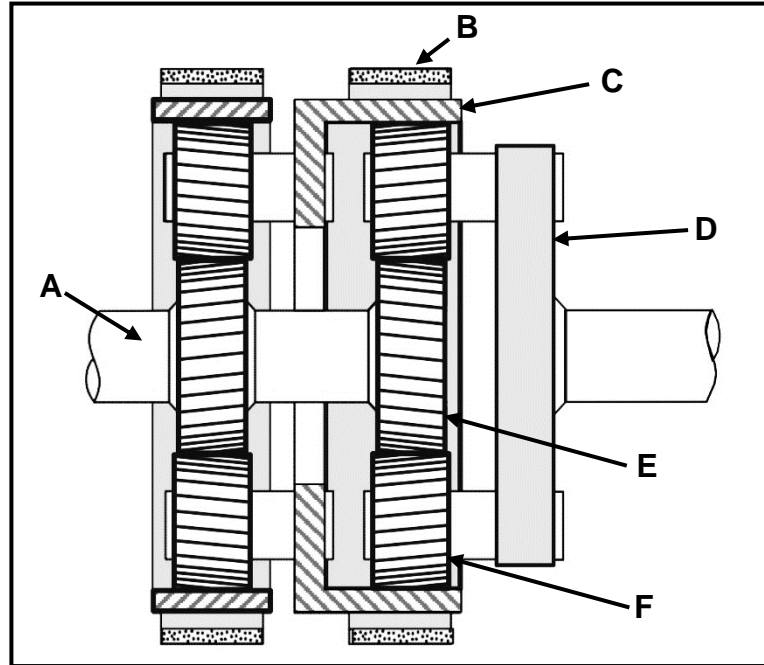


FIGURE 9.1

9.1.1 Label parts **A–F**. (6)

9.1.2 Describe, in detail, the operation of the gear system in FIGURE 9.1 when low gear ratio/gear reduction is obtained.

HINT: Use FIGURE 9.1 to assist you in your answer. (4)

9.2 FIGURE 9.2 below shows a torque converter used in automatic transmissions.

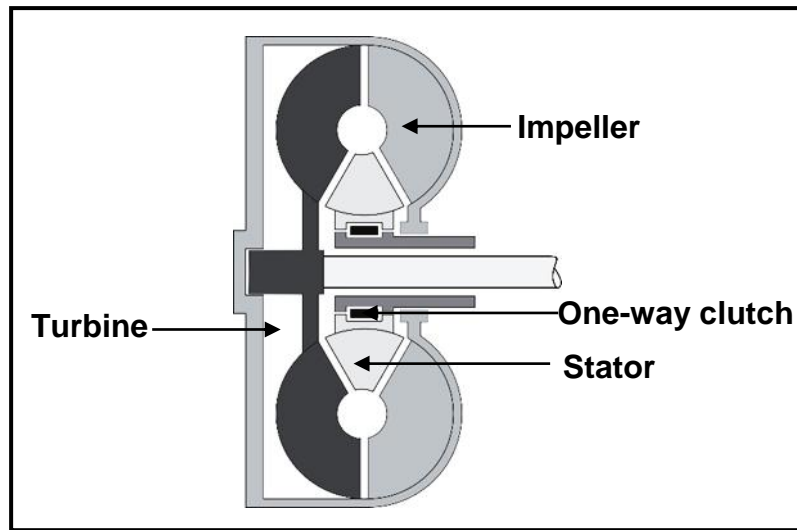


FIGURE 9.2

Identify the part responsible for EACH of the functions in QUESTIONS 9.2.1 to 9.2.4 below.

- 9.2.1 Allows stator to spin freely in the direction of the pump (1)
 - 9.2.2 Rotates the transmission input shaft (1)
 - 9.2.3 Redirects the oil so that it will enter the pump smoothly (1)
 - 9.2.4 The driving member fixed to the torque converter housing (1)
 - 9.3 Name the type of oil used in a torque converter. (1)
 - 9.4 State THREE advantages of epicyclic gear trains. (3)
- [18]**

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

- 10.1 Describe the tyre wear patterns that are a result of the following:
 - 10.1.1 Overinflated tyre (1)
 - 10.1.2 Negative camber (1)
- 10.2 State the purpose of EACH of the following wheel alignment angles:
 - 10.2.1 Toe-in (2)
 - 10.2.2 Negative caster (2)

10.3 FIGURE 10.3 below shows the king pin inclination, as seen from the front. Answer the questions that follow.

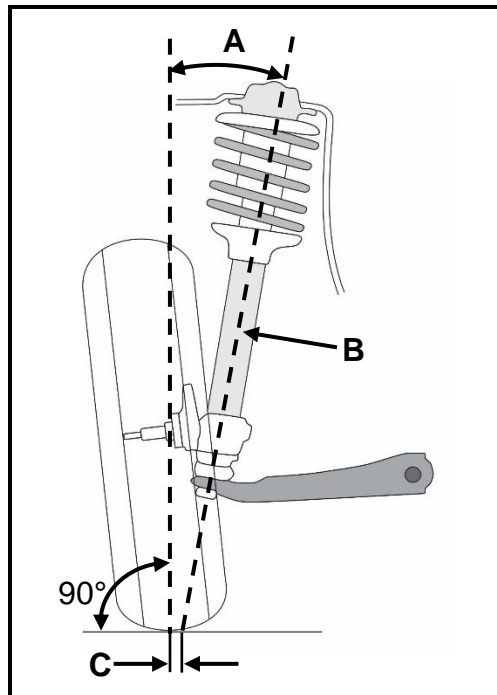


FIGURE 10.3

- 10.3.1 Label parts **A–C**. (3)
- 10.3.2 Define *king pin inclination*. (2)
- 10.3.3 Can the king pin inclination be adjusted on the suspension? (1)
- 10.4 State TWO characteristics/effects of unbalanced wheels. (2)
- 10.5 Name THREE sensors found on an air-intake system. (3)
- 10.6 State TWO functions of the speed control system. (2)

10.7 FIGURE 10.7 below shows the rotor of an alternator. Answer the questions that follow.

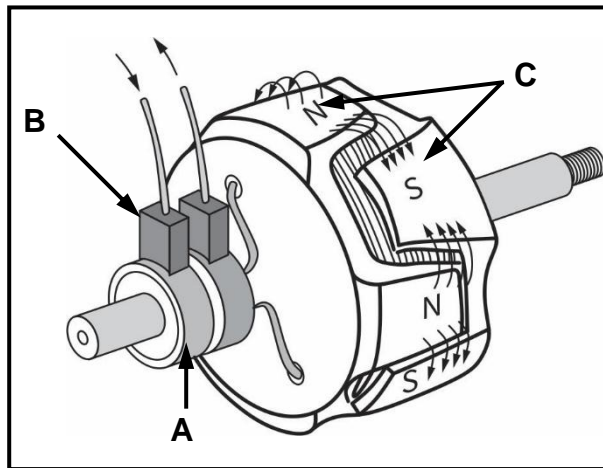


FIGURE 10.7

10.7.1 Label parts **A–C**. (3)

10.7.2 Describe the function of the rectifier in the alternator. (2)

10.7.3 State TWO methods of increasing the output frequency of the alternator. (2)

10.8 Name the TWO chemical processes that take place in the catalytic converter. (2)

10.9 Label **A** and **B** of the piezo injector shown in FIGURE 10.9 below.

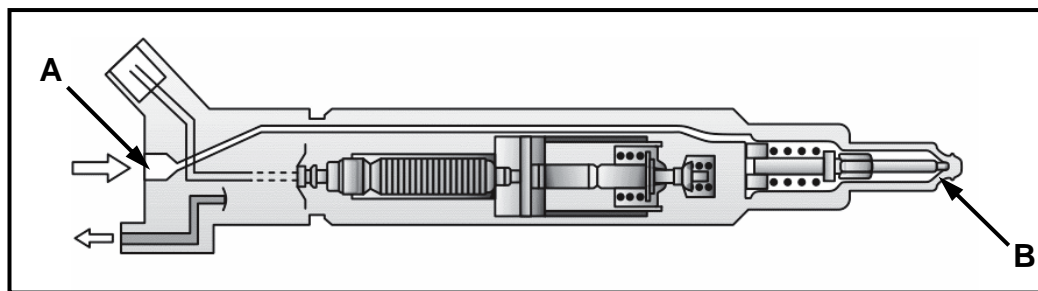


FIGURE 10.9

(2)

10.10 State TWO functions of the check valve in the fuel system. (2)

(2)

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

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:

$SV = \text{Swept volume}$

$CV = \text{Clearance volume}$

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

Where:

$D = \text{Bore diameter}$

$L = \text{Stroke length}$

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

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