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SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: AUTOMOTIVE

MAY/JUNE 2025

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 Electronic)	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 a safety device on the power-driven guillotine?
- A Rear light curtain
 - B Chuck
 - C Cutting table
 - D Blade
- (1)
- 1.2 Which statement forms part of the general responsibilities of the employee according to the Occupational Health and Safety (OHS) Act, 1993 (Act 85 of 1993)?
- A Eliminate hazards in the workplace.
 - B Make provision for maintenance at the workplace.
 - C Report any accidents immediately.
 - D Inform all employees of their scope of work.
- (1)
- 1.3 Which recommendation below is important when applying first aid?
- A Cover the wound with an adhesive plaster.
 - B If necessary, cool wounds with cold water.
 - C Pull out all sharp objects.
 - D Do not check for any broken limbs.
- (1)
- 1.4 Which test determines the ductility of a metal?
- A Sound test
 - B Hardness test
 - C X-ray test
 - D Bending test
- (1)
- 1.5 The spark test is useful for testing the ... content of many metals.
- A magnesium
 - B carbon
 - C aluminium
 - D chrome
- (1)
- 1.6 The hardening temperatures used as a rule during the hardening process is ... above the critical temperature.
- A 10 °C–38 °C
 - B 10 °C–720 °C
 - C 10 °C–268 °C
 - D 10 °C–100 °C
- (1)

[6]

QUESTION 2: SAFETY (GENERIC)

- 2.1 State THREE safety precautions to adhere to when using a manual guillotine.
(NOTE: ALL PPE and environmental factors have been taken care of.) (3)
- 2.2 State THREE examination procedures when performing first aid. (3)
- 2.3 Why must one always leave the acetylene cylinder spindle key on the cylinder valve when working? (1)
- 2.4 State whether EACH of the following is a result of product layout or process layout:
- 2.4.1 Machines are grouped according to their type of operation (1)
 - 2.4.2 Greater flexibility during manufacturing (1)
 - 2.4.3 Handling of material is limited to a minimum (1)
- [10]**

QUESTION 3: MATERIALS (GENERIC)

- 3.1 State the THREE factors that affect the hardness of steel during the heat-treatment process. (3)
- 3.2 State if EACH of the following materials is easy or difficult to cut during a machining test:
- 3.2.1 Cast iron (1)
 - 3.2.2 Cast steel (1)
 - 3.2.3 Mild steel (1)
- 3.3 Give ONE reason why steel is annealed during the heat-treatment process. (1)
- 3.4 Complete the following definition for normalising by filling in the missing words. Write only the words next to the question numbers (3.4.1 to 3.4.4) in the ANSWER BOOK.
- The process of normalising is when an iron base alloy or steel is heated to approximately 56 °C (3.4.1) ... the critical temperature, (3.4.2) ... the metal until it is uniformly heated, followed by (3.4.3) ... it down to (3.4.4) ... temperature in still air, away from draughts. (4)
- 3.5 Why must steel be cooled rapidly during the hardening process? (1)
- 3.6 State TWO manufacturing processes that cause internal stress in steel. (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 The OBD-II scanner is used to scan ...
- A and adjust all engine components.
 - B if the engine leaks gases from the cylinder during the intake stroke.
 - C electronically controlled systems on the vehicle and adjust different actuators.
 - D if the engine leaks gases from the cylinder during the exhaust stroke. (1)
- 4.2 A compression test can only be performed when the engine is ...
- A turning.
 - B locked by the gearbox.
 - C stationary at TDC.
 - D stationary at BDC. (1)
- 4.3 What is the degree of crankshaft rotation between the start of each power impulse in a four-stroke four-cylinder engine?
- A 90°
 - B 120°
 - C 180°
 - D 60° (1)
- 4.4 Which cylinder fires if the valves of cylinder 1 rock (overlap) in a four-stroke four-cylinder engine?
- A Cylinder 1
 - B Cylinder 2
 - C Cylinder 3
 - D Cylinder 4 (1)
- 4.5 The pressure developed on the power stroke is measured with a ...
- A indicator gauge.
 - B indicator diagram.
 - C planimeter.
 - D torque meter. (1)



- 4.6 Which dynamometer can be used to measure the brake power at the engine but NOT at the wheels?
- A Pröny brake
 - B Manual dynamometer
 - C Eddy current dynamometer
 - D Pressure brake
- (1)
- 4.7 Convert 1 500 millilitres (mℓ) to cm³:
- A 1,5
 - B 15,00
 - C 150
 - D 1 500
- (1)
- 4.8 A rich fuel-air mixture will result in ...
- A low fuel consumption.
 - B high fuel consumption.
 - C a faulty thermostat.
 - D burnt valves.
- (1)
- 4.9 Why is the crankshaft locked during the cylinder leakage test?
- A To limit engine vibrations
 - B To prevent the pistons from moving
 - C To increase cylinder pressure
 - D To prevent the valves from burning
- (1)
- 4.10 Which ONE of the following statements describes how to obtain forward low gear with a single epicyclic gear system?
- A The planet carrier is locked, the sun gear is the driving component and the annulus is the driven component.
 - B The annulus is locked, the sun gear is the driving component and the planet carrier is the driven component.
 - C The planet carrier is locked and the sun gear is the driving component.
 - D The annulus is locked and the sun gear is the driven component.
- (1)
- 4.11 Which ONE of the following is part of the torque converter?
- A Oil pump
 - B Brake bands
 - C Stator
 - D Planetary gears
- (1)



- 4.12 Toe-out on turns ... when referring to wheel alignment angles.
- A allows the vehicle to move straight ahead
 - B ensures better cornering
 - C adjusts the king pin
 - D limits body roll
- (1)
- 4.13 What is *wheel shimmy*?
- A The skidding of the wheels when braking
 - B The side-to-side vibration of the road wheel
 - C The up and down movement of the road wheel that cause vibrations
 - D A heavy spot on a wheel
- (1)
- 4.14 Which ONE of the following is an actuator on the common rail direct injection (CRDI) system?
- A Mass air flow sensor
 - B Accelerator pedal sensor
 - C ECU
 - D Injector
- (1)

[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

- 5.1 State THREE engine faults that can be identified during a cylinder leakage test, but NOT during a compression test. (3)
- 5.2 A compression test is conducted on a spark ignition (petrol) engine. Answer the questions that follow.
- 5.2.1 Where exactly is the compression tester connected to the engine? (1)
- 5.2.2 Which unit of measure is used for compression pressure? (1)
- 5.2.3 Why should all the spark plugs be removed? (1)
- 5.3 A cylinder leakage test is set up on an internal combustion engine before it is tested. Answer the questions that follow.
- 5.3.1 What precaution should be taken before a spark plug is removed? (1)
- 5.3.2 Give TWO reasons why the piston is turned to TDC on the compression stroke. (2)
- 5.4 Explain the difference between *static* and *dynamic* wheel balancing. (2)
- 5.5 State TWO functions of a wheel-weight hammer. (2)
- 5.6 FIGURE 5.6 below shows a wheel alignment tool. Answer the questions that follow.

**FIGURE 5.6**

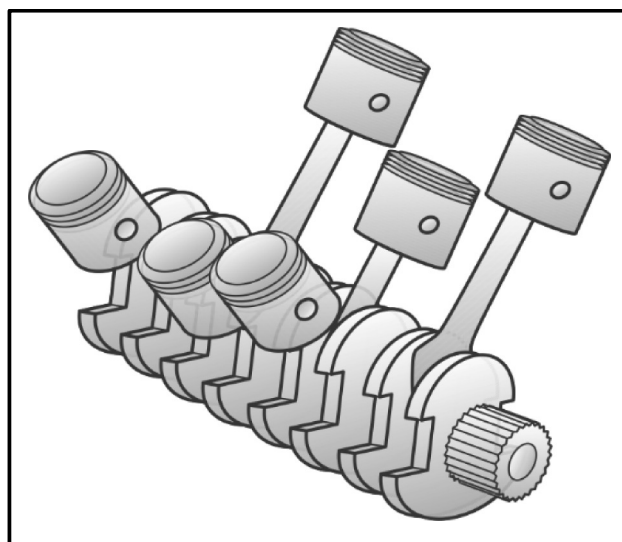
- 5.6.1 Identify the wheel alignment tool. (1)
- 5.6.2 Name THREE angles that are measured with this wheel alignment tool. (3)

- 5.7 Explain the functions of the turn-tables when checking wheel alignment angles. (2)
- 5.8 State THREE methods used to connect the on-board diagnostic (OBD) scanner to a laptop or computer. (3)
- 5.9 State ONE pre-check that must be done on the exhaust gas system of a vehicle to ensure the exhaust gas analyser gives accurate readings. (1)
- [23]**



QUESTION 6: ENGINES (SPECIFIC)

- 6.1 Give THREE reasons why the correct firing order of an internal combustion engine increases the lifespan of the crankshaft. (3)
- 6.2 Explain the following terms with regard to an internal combustion engine:
- 6.2.1 Rotating mass (2)
- 6.2.2 Reciprocating mass (2)
- 6.3 Name TWO types of vibration dampers. (2)
- 6.4 State TWO methods of balancing a crankshaft dynamically. (2)
- 6.5 FIGURE 6.5 below shows the layout of a six-cylinder engine. Answer the questions that follow.

**FIGURE 6.5**

- 6.5.1 Identify the type of engine cylinder layout. (1)
- 6.5.2 State TWO advantages of this engine cylinder layout compared to the in-line engine cylinder layout. (2)
- 6.6 How many power strokes are there in ONE revolution for the engine layouts in QUESTIONS 6.6.1 and 6.6.2 below?
- 6.6.1 Two-stroke one-cylinder engine (1)
- 6.6.2 Four-stroke eight-cylinder engine (1)

- 6.7 FIGURE 6.7 below shows a turbocharger that is fitted to an internal combustion engine. Answer the questions that follow.

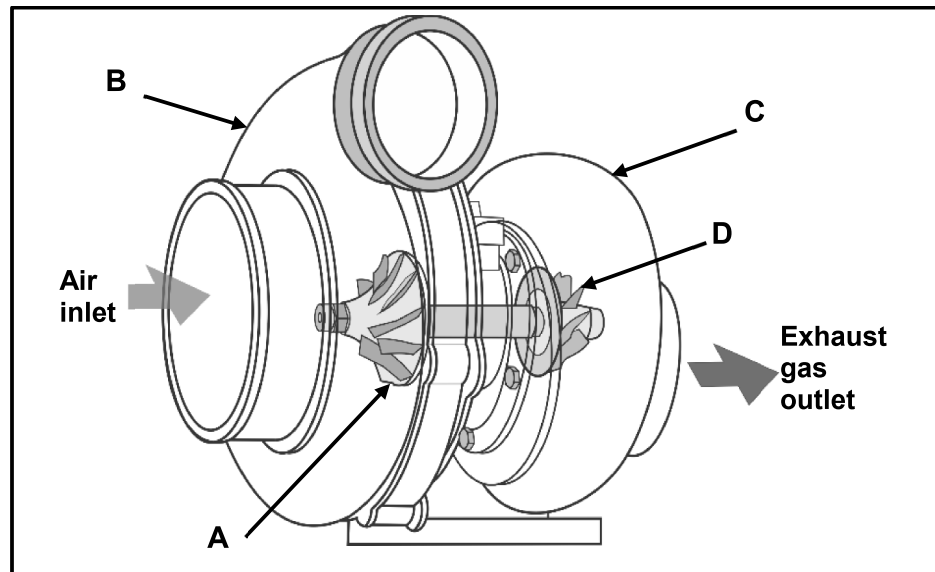


FIGURE 6.7

- 6.7.1 Label **A–D**. (4)
- 6.7.2 What drives this type of turbocharger? (1)
- 6.8 Name TWO parts that are used in a turbocharging system to limit the boost pressure. (2)

- 6.9 FIGURE 6.9 below shows a twin-charging system fitted to an internal combustion engine. Answer the questions that follow.

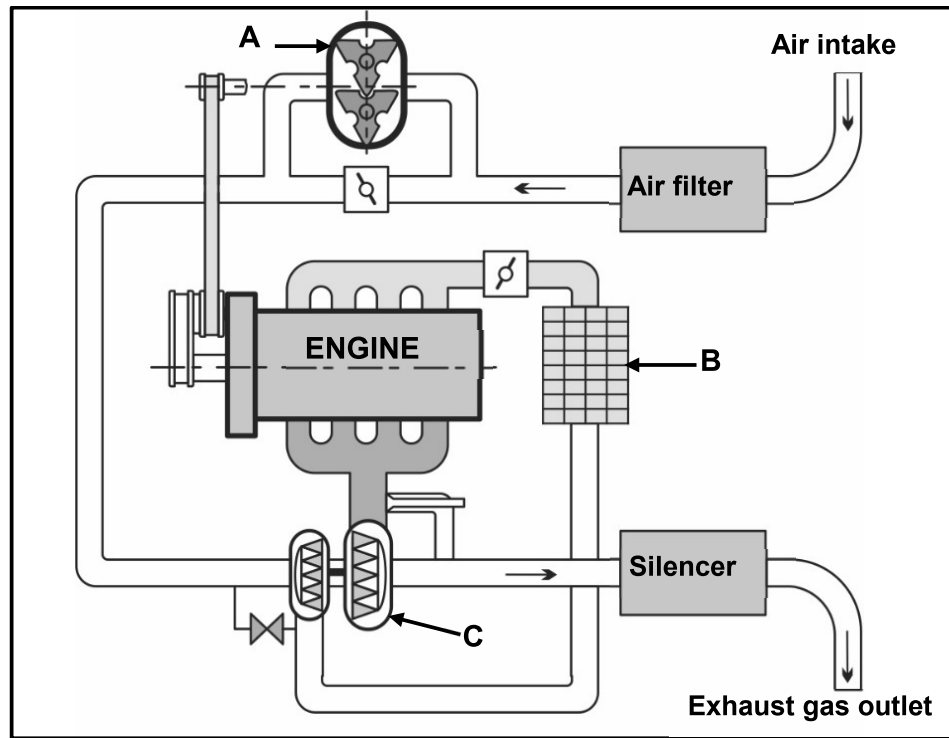


FIGURE 6.9

- 6.9.1 Label A–C. (3)
- 6.9.2 State TWO advantages of using this twin-charging system compared to an engine fitted with one super-charger. (2)
- [28]

QUESTION 7: FORCES (SPECIFIC)

7.1 Define the following terms with regard to an internal combustion engine:

7.1.1 Swept volume (2)

7.1.2 Mechanical efficiency (2)

7.2 State THREE methods to lower the compression ratio in an internal combustion engine. (3)

7.3 The bore of a cylinder is 92 mm and the stroke length of the piston is 85 mm. The compression ratio is 11 : 1.

Calculate the following:

7.3.1 The swept volume in cm^3 (3)

7.3.2 The clearance volume in cm^3 (3)

7.3.3 The new bore diameter if the compression ratio is increased to 12 : 1. The clearance volume and stroke length remain unchanged. (6)

7.4 The following data refers to a two-stroke two-cylinder petrol engine:

Engine speed during test: 3 000 r/min
Cylinder diameter: 83 mm
Stroke length: 80 mm
Mean effective pressure: 450 kPa
Brake power: 16 kW @ 3 000 r/min

Calculate the following:

7.4.1 Torque in Nm (4)

7.4.2 Indicated power in kW (7)

7.4.3 Mechanical efficiency in % (2)

[32]



QUESTION 8: MAINTENANCE (SPECIFIC)

- 8.1 TABLE 8.1 below shows the results of a gas analysis on an internal combustion engine. Complete TABLE 8.1 by stating ONE cause and ONE appropriate corrective measure for EACH given fault.

NOTE: Write only the answer next to the question numbers (8.1.1 to 8.1.4) in the ANSWER BOOK.

FAULTS (DEFECTS)	CAUSE	CORRECTIVE MEASURE
High hydrocarbon (HC) reading	8.1.1	8.1.2
High oxygen (O ₂) reading	8.1.3	8.1.4

TABLE 8.1

(4)

- 8.2 Explain, step by step, how to perform a wet compression test. (5)

- 8.3 State ONE corrective measure for each of the following faults detected when performing a cylinder leakage test:

8.3.1 Bubbles in radiator (1)

8.3.2 Hissing sound at the exhaust pipe (1)

8.3.3 Hissing sound at the dipstick (1)

- 8.4 Give ONE reason for EACH of the following corrective measures after performing an oil pressure test on an internal combustion engine:

8.4.1 Change the oil (1)

8.4.2 Clean the oil pick-up screen (1)

8.4.3 Replace the oil pump (1)

8.4.4 Replace the oil filter (1)

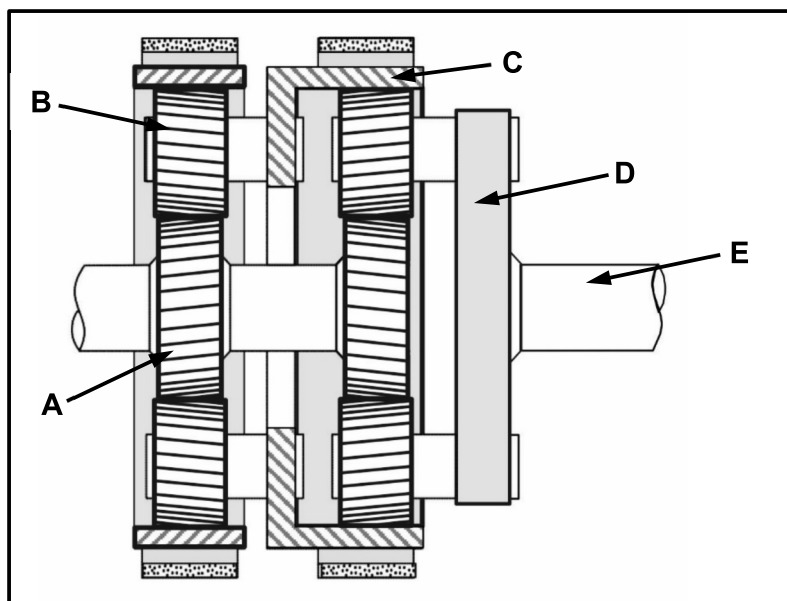
- 8.5 State THREE manufacturer's specifications that are required to perform the fuel pressure test. (3)

- 8.6 Explain FOUR precautions that must be adhered to when performing a cooling system pressure test. (4)

[23]

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

- 9.1 State the differences between the construction of an automatic gearbox and a manual gearbox with regard to the following components:
- 9.1.1 Type of clutch (2)
- 9.1.2 Type of gear system (2)
- 9.2 Name the type of torque converter in which slippage is prevented. (1)
- 9.3 Which rotating components of the torque converter are described below.
- 9.3.1 The driving component (1)
- 9.3.2 The driven component (1)
- 9.4 FIGURE 9.4 below shows the epicyclic gear system of an automatic gearbox. Answer the questions that follow.

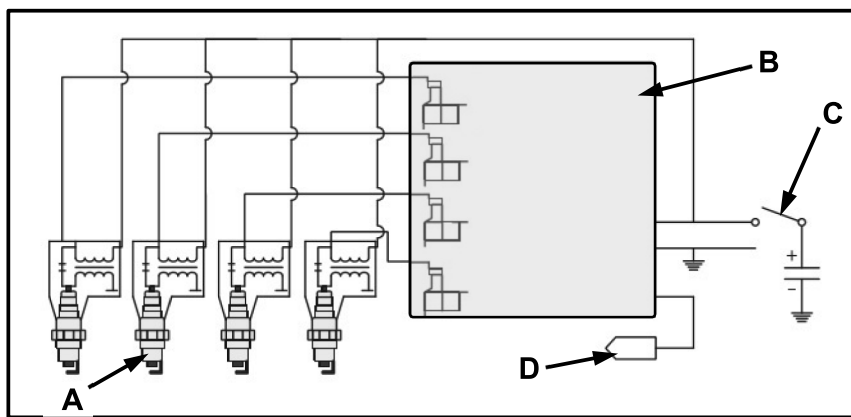
**FIGURE 9.4**

- 9.4.1 Label **A–E**. (5)
- 9.4.2 State TWO advantages of epicyclic gear trains. (2)
- 9.5 State TWO functions of EACH of the following components found in an automatic gearbox:
- 9.5.1 Valve body (2)
- 9.5.2 Oil pump (2)

[18]

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

- 10.1 State FOUR pre-checks to do before conducting wheel alignment on a vehicle. (4)
- 10.2 Draw a neat labelled sketch to illustrate negative caster on a front wheel. (4)
- 10.3 State where the following sensors are found on a vehicle:
- 10.3.1 Manifold absolute pressure sensor (MAP) (1)
- 10.3.2 Camshaft position sensor (CMP) (1)
- 10.3.3 Lambda (oxygen) sensor (1)
- 10.4 What are the TWO basic functions of sensors fitted to an engine? (2)
- 10.5 FIGURE 10.5 below shows a diagram of a coil on plug (COP) ignition system. Answer the questions that follow.

**FIGURE 10.5**

- 10.5.1 Label A–D. (4)
- 10.5.2 Name TWO components found in the conventional ignition system that are not needed in a COP ignition system. (2)
- 10.6 Name TWO environmentally friendly gases that leave the catalytic converter. (2)
- 10.7 State TWO advantages of the adaptive speed control system compared to the conventional speed control system. (2)

- 10.8 FIGURE 10.8 below shows the rotor of an alternator. Answer the questions that follow.

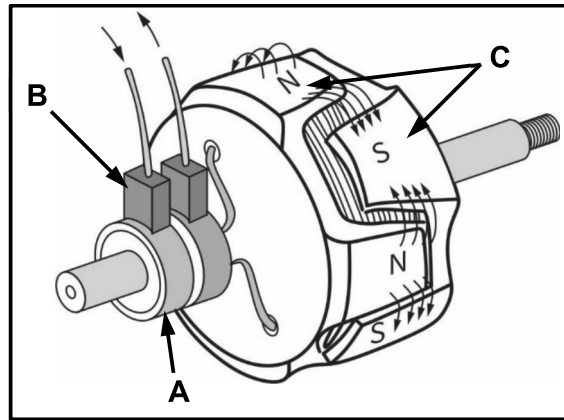


FIGURE 10.8

- 10.8.1 Label **A–C**. (3)
- 10.8.2 What is the function of the rotor? (2)
- 10.9 State TWO advantages of an electric fuel pump fitted to an internal combustion engine. (2)
- 10.10 State TWO functions of a check (one-way) valve in the fuel system. (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. $BP = 2\pi NT$

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

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

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

