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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

MECHANICAL TECHNOLOGY: AUTOMOTIVE

2019

MARKS: 200

TIME: 3 hours

This question paper consists of 13 pages and 1 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 Act is the code of good practice with regard to HIV/Aids and employment at the workplace?
- A The Act on safety states that all employees must make sure that the workplace is safe and that employers are not at risk of becoming infected with HIV at work.
 - B The Act contains common guidelines on how employers, employees and trade unions should respond to HIV in the workplace.
 - C Employers may demote employees based on their HIV status (Act 33 of 2000).
 - D Employers can simply dismiss a person who has HIV (Act 34 of 2000). (1)
- 1.2 Which ONE of the following is a reason why oil and grease must NOT be allowed to come into contact with oxygen and acetylene fittings? It will ...
- A cause blockages.
 - B form a flammable mixture.
 - C make the oxygen fittings slippery.
 - D accumulate dust. (1)
- 1.3 Which ONE of the following is an advantage of the process workshop layout?
- A There is high machine utilisation because more than one product is manufactured.
 - B Production is not always continuous.
 - C Transportation costs between process departments may be high.
 - D There may be damage to fragile goods as a result of extra handling. (1)
- 1.4 Which ONE of the following factors is important in the heat treatment of steel?
- A Temperature
 - B Colour
 - C Length
 - D shape (1)
- 1.5 What is the purpose of annealing steel?
- A Harden it
 - B Temper it
 - C Harden the core
 - D Relieve internal stresses (1)

1.6 Which ONE of the following sounds will indicate cast iron when a sound test is carried out?

- A Loud and clear sound
- B Very dull sound
- C High ringing sound
- D High-frequency sound

(1)
[6]

QUESTION 2: SAFETY (GENERIC)

2.1 A welded joint needs to be ground using an angle grinder. State TWO safety measures to be observed when using the angle grinder.

(2)

2.2 Give TWO reasons why it is important to wear welding goggles during gas welding.

(2)

2.3 Name TWO items of personal protective equipment (PPE) that one will use when working with a bench grinder.

(2)

2.4 Explain the difference between the *process workshop layout* and the *product workshop layout*.

(2)

2.5 Describe the employer's responsibility regarding equipment in the workplace.

(2)
[10]

QUESTION 3: MATERIALS (GENERIC)

3.1 Name and describe the FOUR tests used to distinguish between the different types of materials.

(8)

3.2 Give the reason why the following heat-treatment processes are performed on steel:

3.2.1 Tempering

(2)

3.2.2 Normalising

(2)

3.2.3 Hardening

(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.

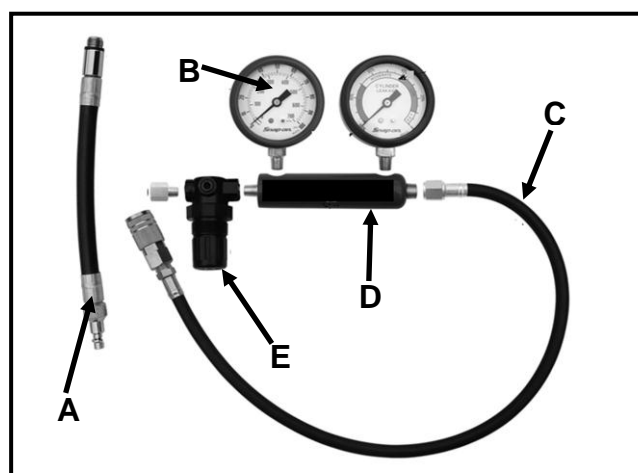
- 4.1 Which ONE of the following safety procedures relates to the cylinder leakage tester?
- A Use water to remove dust around the spark-plug area.
 - B Clean the oil-filler cap.
 - C Exceed the prescribed pressure in the cylinder.
 - D The tester must be well tightened until no hissing sounds can be heard. (1)
- 4.2 Which ONE of the following tests indicates the condition of an engine's piston rings?
- A Cylinder leakage test
 - B Gas analysing test
 - C Fuel test
 - D Torsion test (1)
- 4.3 The ... supercharger is the most efficient and common of all forced-induction systems.
- A twin screw
 - B vane
 - C centrifugal
 - D Roots (1)
- 4.4 What do you understand by the term *boost* with regard to turbochargers?
- A The pressure accumulated by the turbocharger in the inlet manifold
 - B Where the blower is placed before the carburettor
 - C The increase in manifold pressure that is generated in the inlet manifold
 - D Where the blower is placed after the carburettor (1)
- 4.5 What is the unit for turning moment?
- A N/m^2
 - B N.m
 - C N.m^2
 - D N/mm (1)
- 4.6 Which ONE of the following methods is used to raise the compression ratio of an internal combustion engine?
- A Adjust the valve timing on the belt.
 - B Fit a thinner gasket between the cylinder block and the cylinder head.
 - C Fit a thicker gasket between the cylinder block and the cylinder head.
 - D Make sure that there are no holes in the exhaust system. (1)

- 4.7 Which ONE of the following safety measures must be considered while setting up the oil pressure tester? Make sure that ...
- A the tester fits tightly to give an accurate reading.
 - B the adapter fitted to the exhaust system fits well.
 - C you do not open the radiator cap when the engine is hot.
 - D you turn the engine until both valves are closed. (1)
- 4.8 What will be the mechanical efficiency of an engine, if the brake power of the engine is 66 kW and the indicated power is 75 kW?
- A 98%
 - B 146,7%
 - C 88%
 - D 113,64% (1)
- 4.9 What will be the gear ratio of a gear system, if the driver gear has 25 teeth and the driven gear 100?
- A 1 : 4
 - B 4 : 1
 - C 1 : 25
 - D 25 : 1 (1)
- 4.10 The ... system is used to obtain different gear ratios between the driver and driven gear members in an automatic transmission.
- A straight gear
 - B epicyclic gear
 - C rack and pinion
 - D brake gear (1)
- 4.11 What do you understand by the term *torsional vibration* in relation to crankshaft balancing?
- A Rotational movement
 - B Linear movement
 - C Twisting movement
 - D Reciprocating movement (1)
- 4.12 Which ONE of the following statements describes the function of the capacitor in the alternating current charging system? The capacitor ...
- A limits the voltage developed through the magnetic field that produces an electro magnet.
 - B protects the diodes from voltage surge.
 - C permits current to flow in one direction only in the circuit.
 - D absorbs heat generated in the diode. (1)

- 4.13 Which ONE of the following methods is used to increase the output frequency of the alternator?
- A Increase the number of turns of the wire on the stationary coil.
 - B Increase the number of turns of the wire on the rotating coil.
 - C Decrease the magnetic field.
 - D Decrease the rotational frequency at which the magnet rotates.
- (1)
- 4.14 What does it mean if a fuel pump is referred to as a *wet pump*? It means ...
- A that the pump feeds the fuel from the fuel tank at predetermined pressure.
 - B less discharge of pulsation fuel.
 - C that the fuel quantity is controlled precisely by the fuel pump.
 - D that the electrical motor operates immersed in the fuel.
- (1)
[14]

QUESTION 5: TOOLS AND EQUIPMENT (SPECIFIC)

- 5.1 Nelson conducted a compression test on a four-cylinder petrol engine and found that the engine has low compression in one of the cylinders.
- 5.1.1 Name TWO types of compression tests Nelson can perform on the engine. (2)
- 5.1.2 Give TWO possible reasons for low compression in the cylinder. (2)
- 5.2 Explain how static imbalance of a wheel is corrected using a wheel balancing machine. (2)
- 5.3 FIGURE 5.3 below shows a cylinder leakage tester. Answer the questions that follow.

**FIGURE 5.3**

- 5.3.1 Label components A–E. (5)
- 5.3.2 Give TWO reasons why it is necessary to perform a cylinder leakage test on an engine. (2)

- 5.4 The gas analyser is used to determine the carbon monoxide (CO) and carbon dioxide (CO₂) readings of the exhaust gases of an internal combustion engine. Give TWO reasons for a high CO reading. (2)
- 5.5 Study the wheel alignment equipment shown below in FIGURE 5.5 and answer the questions that follow.

**FIGURE 5.5**

- 5.5.1 Identify the wheel alignment equipment shown in FIGURE 5.5. (1)
- 5.5.2 Explain how to take a caster reading on the wheels of a motor vehicle using the wheel alignment equipment in FIGURE 5.5. (5)
- 5.6 Which information is required by the diagnostic scanner before a diagnostic test can be conducted on an internal combustion engine? (2)
- [23]**

QUESTION 6: ENGINES (SPECIFIC)

- 6.1 Proper balancing of all moving engine parts is essential at a high engine speed. Answer the questions that follow.
- 6.1.1 State TWO methods to balance the engine crankshaft. (2)
- 6.1.2 Briefly explain how the balancing is done using EACH of the methods in QUESTION 6.1.1. (2)
- 6.1.3 State TWO factors that cause vibration in an internal combustion engine. (2)
- 6.2 State TWO factors that will determine the firing order in an internal combustion engine. (2)
- 6.3 Explain the function of a vibration damper in an internal combustion engine. (2)

- 6.4 The performance of smaller engines can be improved by using superchargers, as shown in FIGURE 6.4 below. Answer the questions that follow.

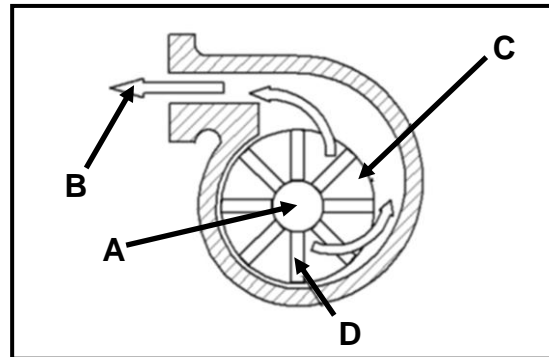


FIGURE 6.4

- 6.4.1 Identify the type of supercharger shown in FIGURE 6.4. (1)
- 6.4.2 Label parts **A–D** of the supercharger above. (4)
- 6.5 State TWO advantages of a motor vehicle fitted with a supercharger. (2)
- 6.6 Explain how a turbocharger on an internal combustion engine operates. (7)
- 6.7 State TWO disadvantages of turbochargers when compared with superchargers. (2)
- 6.8 Explain the effect of high altitude on the performance of an internal combustion engine. (2)

[28]

QUESTION 7: FORCES (SPECIFIC)

- 7.1 Define the term *compression ratio* of an engine. (2)
- 7.2 The bore and stroke of an engine is 84 mm and 90 mm respectively and they have a compression ratio of 8,5 : 1.
- Calculate:
- 7.2.1 The swept volume (3)
- 7.2.2 The original clearance volume in cm^3 (3)
- 7.2.3 The compression ratio is increased to 9,5 : 1. What would be the new bore diameter, if the clearance volume remains unchanged? (6)

- 7.3 The following data was recorded during a Pröny brake test on a four-stroke four-cylinder petrol engine:

Brake arm length:	300 mm
Balance reading:	125 kg
Crankshaft revolutions:	2 400 r/min
Mean effective pressure:	950 kPa
Bore diameter:	120 mm
Stroke length:	140 mm

Calculate:

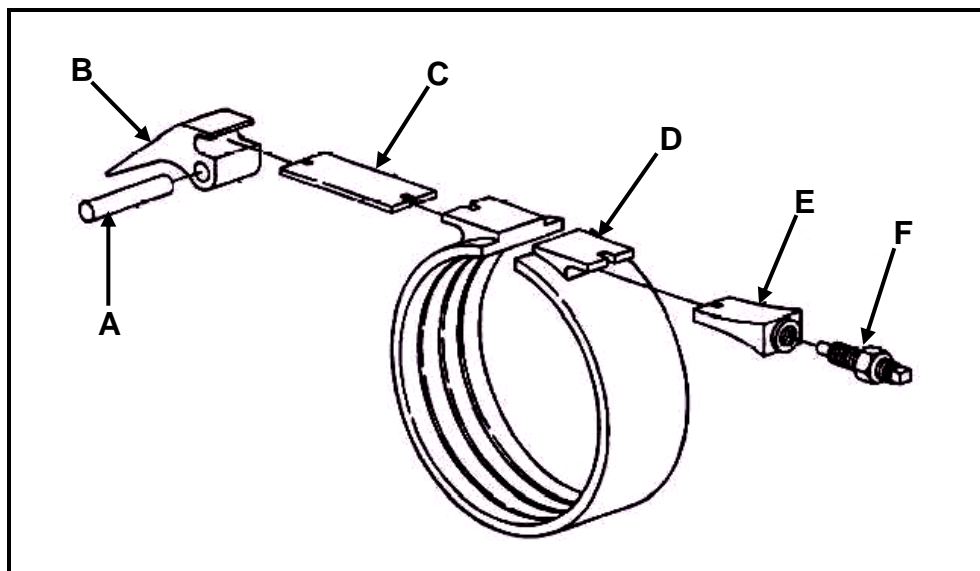
- | | | |
|-------|-----------------------|-------------|
| 7.3.1 | Torque | (3) |
| 7.3.2 | Indicated power | (9) |
| 7.3.3 | Brake power | (3) |
| 7.3.4 | Mechanical efficiency | (3) |
| | | [32] |

QUESTION 8: MAINTENANCE (SPECIFIC)

- | | | |
|-------|--|-------------|
| 8.1 | State THREE manufacturers' specifications that could be used to conduct an oil pressure test. | (3) |
| 8.2 | Give TWO reasons why an exhaust pressure test is conducted. | (2) |
| 8.3 | Explain how a pressure test is conducted on a radiator cap. | (4) |
| 8.4 | List FOUR manufacturer's specifications that must be obtained before a fuel pressure test can be carried out. | (4) |
| 8.5 | Due to engine power loss in a vehicle the mechanic/technician conducts a compression test according to certain procedures. Explain why the following procedures are conducted: | |
| 8.5.1 | Remove the high-tension lead | (2) |
| 8.5.2 | Unplug the fuel-injection system | (2) |
| 8.5.3 | Open the throttle valve fully | (2) |
| 8.5.4 | Record the readings | (2) |
| 8.6 | Explain how a wet compression test is conducted on an internal combustion engine after a dry compression test has been done on the engine. | (2) |
| | | [23] |

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

- 9.1 Name TWO methods used to cool the oil in the automatic transmission of a motor vehicle. (2)
- 9.2 State TWO advantages of an automatic gearbox when compared with a manual gearbox. (2)
- 9.3 What is the main purpose of an automatic transmission gearbox when compared with a manual gearbox? (2)
- 9.4 Explain the influence of the gear ratio on the torque of a motor vehicle. (2)
- 9.5 State TWO advantages of the torque converter in the automatic transmission of a motor vehicle. (2)
- 9.6 FIGURE 9.6 below shows a component of an automatic gearbox. Answer the questions that follow.

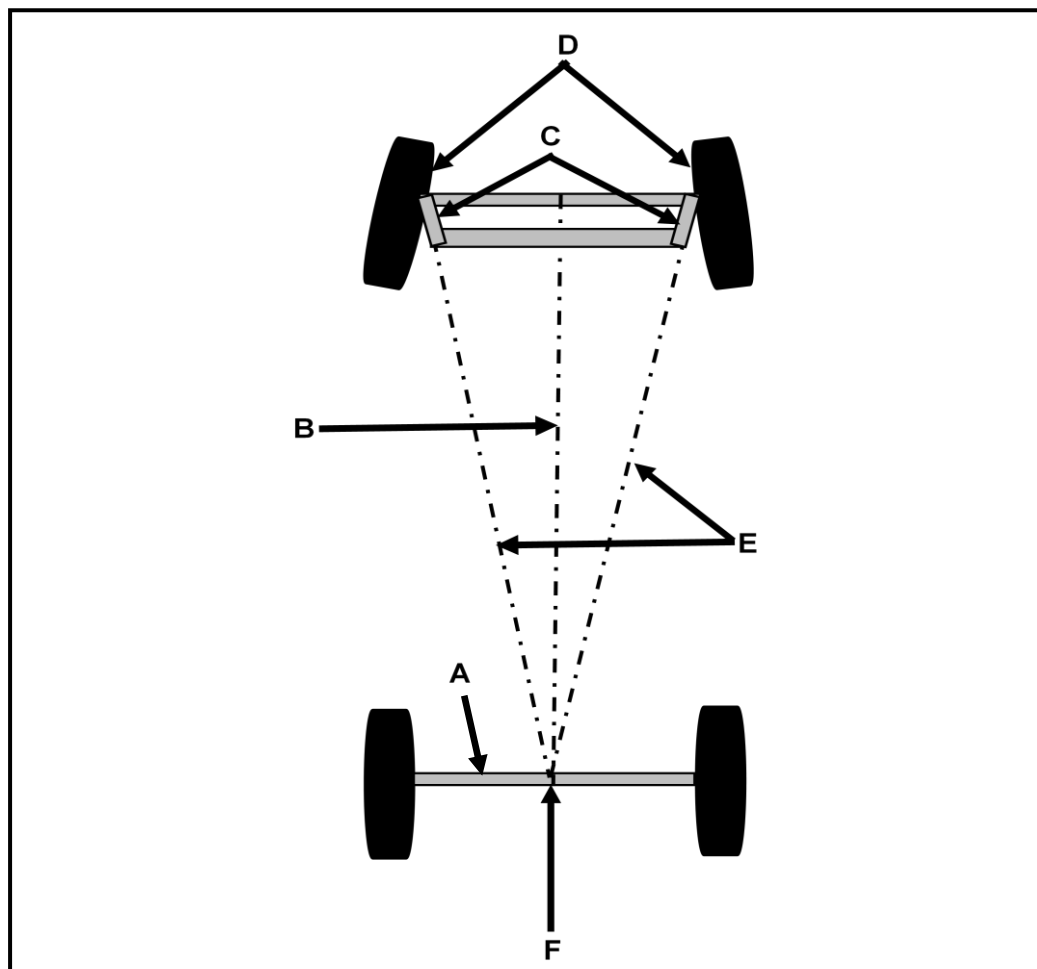
**FIGURE 9.6**

- 9.6.1 Identify the component shown in FIGURE 9.6. (1)
- 9.6.2 Label parts A–F. (6)
- 9.6.3 State the function of the component in FIGURE 9.6. (1)

[18]

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

- 10.1 State FIVE factors to be taken into account before attempting a wheel alignment adjustment or check. (5)
- 10.2 Explain the purpose of toe-out on turns. (2)
- 10.3 Define *dynamic balance* of a tyre and wheel assembly. (1)
- 10.4 Give TWO reasons why a motor vehicle is equipped with a speed control system. (2)
- 10.5 State TWO disadvantages of the speed control system. (2)
- 10.6 What is the purpose of a diode in an alternator? (2)
- 10.7 State TWO advantages of an electric fuel pump. (2)
- 10.8 State TWO criteria that a fuel injector needs to comply with. (2)
- 10.9 FIGURE 10.9 below shows a wheel alignment angle. Answer the questions that follow on the next page.

**FIGURE 10.9**

- 10.9.1 Identify the wheel alignment angle shown in FIGURE 10.9. (1)
- 10.9.2 Label **A–F** in FIGURE 10.9. (6)
- 10.9.3 Define the *alignment angle* as shown in FIGURE 10.9. (2)

10.10 FIGURE 10.10 below shows a component of an alternator. Answer the questions that follow.

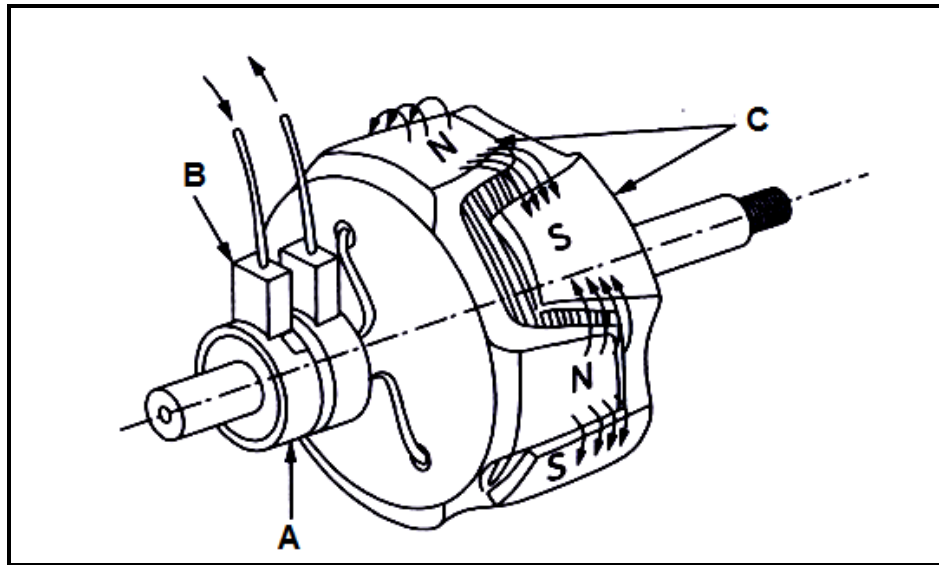


FIGURE 10.10

- 10.10.1 Identify the component shown in FIGURE 10.10. (1)
- 10.10.2 Label **A–C** in FIGURE 10.10. (3)
- 10.10.3 State the function of the component in FIGURE 10.10. (1)
- [32]**

TOTAL: 200

FORMULA SHEET FOR MECHANICAL TECHNOLOGY (AUTOMOTIVE)

$$\text{Force} = m \times a \quad \text{where } m = \text{mass}$$

$$a = \text{acceleration}$$

$$\text{Work} = \text{force} \times \text{distance} (F \times d)$$

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

$$\text{Torque} = \text{force} \times \text{radius}$$

$$\text{Indicated power} = P \times L \times A \times N \times n$$

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

$$\text{Brake power} = 2 \pi N \times T$$

where $N = \text{revolutions per second}$
 $T = \text{torque}$

$$\text{Brake power (Pröny brake)} = F \times 2 \times \pi \times R \times N$$

where $F = \text{force}$
 $R = \text{length of brake arm}$
 $N = \text{revolutions per second}$

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

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

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

where $L = \text{length of stroke}$
 $D = \text{diameter of bore}$

$$\text{clearance volume} = \frac{\pi \times D^2}{4} \times l$$

where $D = \text{diameter of bore}$
 $l = \text{clearance}$

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