



# basic education

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Department:  
Basic Education  
**REPUBLIC OF SOUTH AFRICA**

## **SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS**

**MECHANICAL TECHNOLOGY: AUTOMOTIVE**

**2023**

**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  $10 \text{ m/s}^2$ .
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
<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 Electronic)	32	30
<b>TOTAL</b>		<b>200</b>	<b>180</b>

**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.

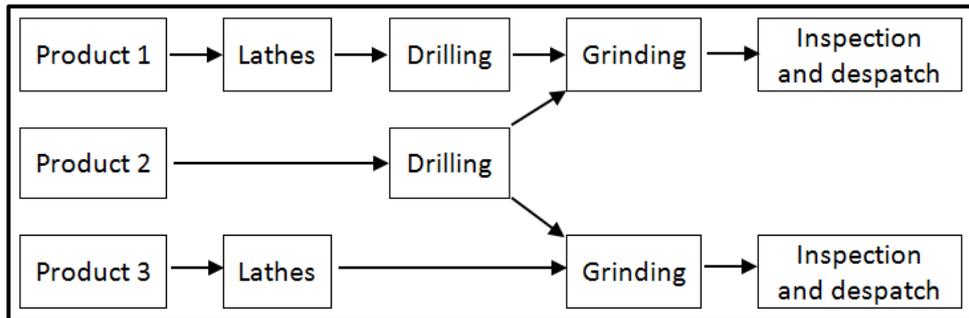
- 1.1 Which ONE of the following safety precautions is applicable to the bench grinder?
- A Oil the surface of the machine.
  - B Remove all guards when grinding.
  - C Wear safety goggles when grinding.
  - D Ensure that the machine is on. (1)
- 1.2 What does the Occupational Health and Safety Act state regarding HIV/Aids awareness?
- A All employers must make sure that the workplace is safe, and that employees are not at risk of contracting HIV.
  - B It does not contain common guidelines on how employers, employees and trade unions should respond to persons with HIV in the workplace.
  - C Employers may demote or promote an employee based on his/her HIV status.
  - D Employers can simply dismiss a person who has HIV. (1)
- 1.3 Which ONE of the following procedures is applicable when applying basic medical treatment?
- A Examine the injured person.
  - B Remove the object from the wound.
  - C Use an oily substance or lotion on a burn.
  - D Phone the insurance company. (1)
- 1.4 Why is steel heated slowly to a certain temperature during heat treatments? To ensure that ...
- A high heat is obtained.
  - B the room temperature is correct.
  - C a uniform temperature is obtained.
  - D the safety process is correct. (1)
- 1.5 Which ONE of the following is an example of case-hardening?
- A Frying pans
  - B Gears
  - C Wheel rims
  - D Chisels (1)
- 1.6 What does the term *quenching rate* during heat treatment mean?
- A Cooling rate
  - B Heating rate
  - C Tempering rate
  - D Hardening rate (1)

**[6]**

**QUESTION 2: SAFETY (GENERIC)**

- 2.1 Which safety precaution must be adhered to after the work on any machine is completed? (1)
- 2.2 Give TWO reasons why the space between the tool rest and the grinding wheel on a bench grinder must not exceed 3 mm. (2)
- 2.3 Identify the workshop layouts shown in FIGURES 2.3.1 and 2.3.2 below.

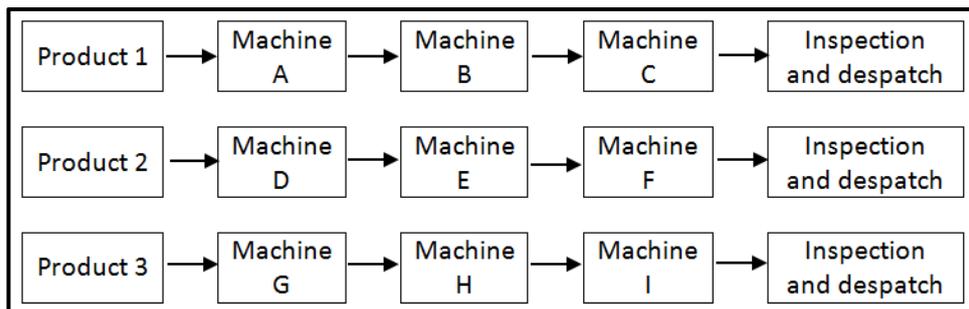
2.3.1



**FIGURE 2.3.1**

(1)

2.3.2



**FIGURE 2.3.2**

(1)

- 2.4 State ONE type of personal protective equipment that must be worn when working on a hydraulic press machine. (1)
- 2.5 State ONE function of the safety guard on a portable angle grinder. (1)
- 2.6 State ONE safety precaution, other than environmental safety, that must be observed when using a shearing machine/guillotine. (1)
- 2.7 State TWO safety precautions that must be adhered to when storing gas cylinders. (2)

**[10]**

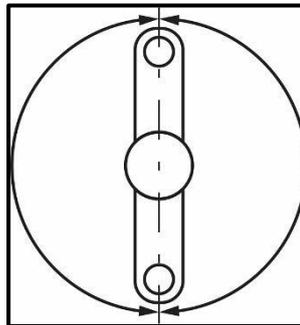
**QUESTION 3: MATERIALS (GENERIC)**

- 3.1 Why is tempering of steel done after hardening? (2)
- 3.2 Give ONE reason for EACH of the following heat-treatment processes on steel:
- 3.2.1 Case hardening (2)
- 3.2.2 Annealing (2)
- 3.3 Explain how to conduct a spark test to identify the type of steel. (2)
- 3.4 Explain how you will conduct the following tests:
- 3.4.1 Filing test (2)
- 3.4.2 Bend test (2)
- 3.5 What sound do the following materials make when performing a sound test?
- 3.5.1 Low-carbon steel (1)
- 3.5.2 High-carbon steel (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, e.g. 4.15 E.

- 4.1 During which test should the crankshaft be locked to prevent the engine from turning?
- A Compression test
  - B Exhaust gas analysis
  - C Cylinder leakage test
  - D Computerised diagnostic scan (1)
- 4.2 Which wheel alignment angles are measured using the bubble gauge?
- A Caster, camber and toe
  - B Caster, camber and king pin inclination
  - C Toe-in, toe-out and Ackermann angle
  - D Camber, Ackermann angle and king pin inclination (1)
- 4.3 FIGURE 4.3 below shows the position of the crankpins in a four-stroke inline engine. Identify the number of cylinders for the crankpin positions shown.

**FIGURE 4.3**

- A Twin-cylinder in-line engine
  - B Three-cylinder in-line engine
  - C Eight-cylinder in-line engine
  - D Five-cylinder in-line engine (1)
- 4.4 An intercooler is used to ...
- A prevent the turbocharger from overheating.
  - B prevent the supercharger from overheating.
  - C cool air that is compressed by the supercharger or turbocharger.
  - D cool the different parts of an engine. (1)

- 4.5 The combustion chamber volume is also known as the ...
- A swept volume.
  - B clearance volume.
  - C total volume.
  - D firing volume.
- (1)
- 4.6 The engine capacity of a four-cylinder 1 600 cm<sup>3</sup> engine is ...
- A 400 ml.
  - B 1,6 ml.
  - C 1 600 ml.
  - D 40 ml.
- (1)
- 4.7 Which ONE of the following determines brake power using a clamping device with the brake arm?
- A Electrical dynamometer
  - B Pröny brake
  - C Chassis dynamometer
  - D Hand brake
- (1)
- 4.8 Which ONE of the following is a cause of high carbon dioxide readings in the exhaust gas?
- A Vacuum leaks
  - B Exhaust system leaks
  - C Nearly ideal air-fuel ratio
  - D Engine overheating
- (1)
- 4.9 The coolant of an engine cooling system is a mixture of ...
- A antifreeze and water.
  - B soluble oil and water.
  - C soap and water.
  - D hydraulic fluid and water.
- (1)
- 4.10 Which ONE of the following components is part of an automatic gearbox?
- A Water pump
  - B Oil pump
  - C Gas pump
  - D Fuel pump
- (1)

- 4.11 The hydraulic pistons in an automatic gearbox control the ...
- A oil pump.
  - B valve body.
  - C gearshift lever mechanism.
  - D multi-disc clutches. (1)
- 4.12 Feathered tyre wear is caused by ...
- A incorrect toe setting.
  - B incorrect camber setting.
  - C wheel bounce.
  - D worn shock absorbers. (1)
- 4.13 Which component of the alternator controls the charging level of the battery?
- A Stator
  - B Rectifier
  - C Regulator
  - D Slip ring (1)
- 4.14 The amount of fuel injected decreases when the ...
- A engine speed increases.
  - B fuel pressure regulator does not open.
  - C the fuel filter is blocked.
  - D engine is cold. (1)
- [14]**

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

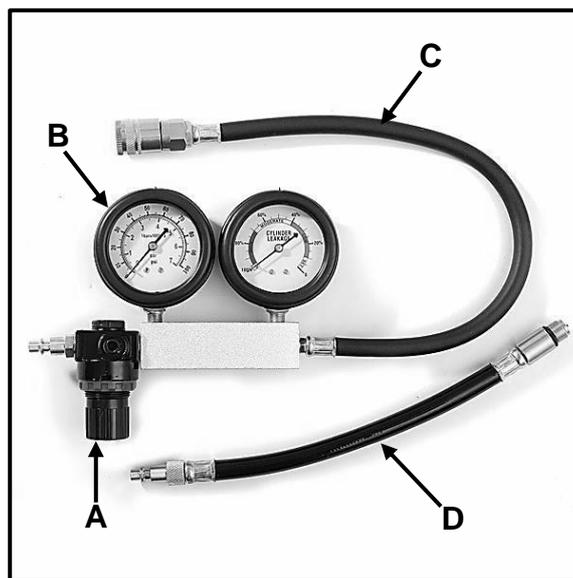
5.1 With reference to the engine cylinder compression test, answer the following questions:

5.1.1 Give a reason for conducting the test. (2)

5.1.2 Name TWO types of compression tests. (2)

5.1.3 Give TWO reasons for low compression in a cylinder. (2)

5.2 FIGURE 5.2 below shows a cylinder leakage tester. Answer the questions that follow.



**FIGURE 5.2**

5.2.1 Label components **A–D**. (4)

5.2.2 Why is pressurised air blown into the cylinder during the cylinder leakage test? (2)

5.3 State THREE precautions when performing an exhaust gas analysis. (3)

5.4 Name THREE vehicle systems that can be scanned by the on-board diagnostic scanner. (3)

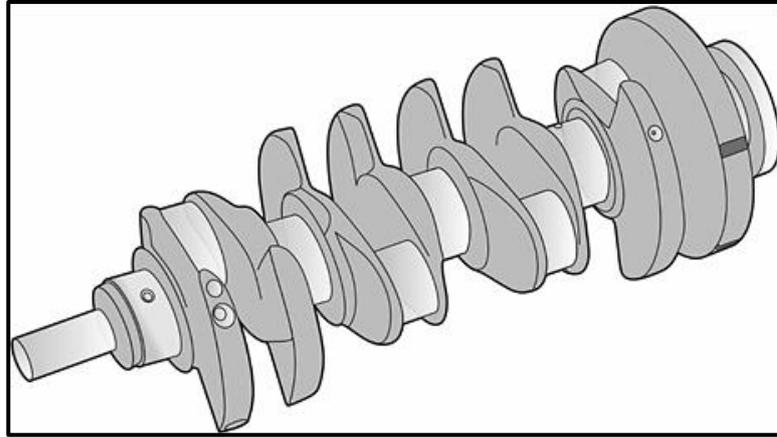
5.5 State TWO faults which could be identified while performing dynamic wheel balancing. (2)

5.6 Describe in THREE steps how to perform dynamic wheel balancing after a wheel has been checked and set up on the wheel balancer. (3)

**[23]**

**QUESTION 6: ENGINES (SPECIFIC)**

- 6.1 FIGURE 6.1 below shows a component of a four-cylinder in-line (straight) engine. Answer the questions that follow.

**FIGURE 6.1**

- 6.1.1 Identify the component. (1)
- 6.1.2 What is the main function of the component? (2)
- 6.1.3 Which part of the component is drilled to balance it? (1)
- 6.1.4 Explain *static balance* of this component. (2)
- 6.2 FIGURE 6.2 below shows a vibration damper that is mounted on an internal combustion engine. Answer the questions that follow.

**FIGURE 6.2**

- 6.2.1 Where on an engine is a vibration damper normally mounted? (1)
- 6.2.2 What is the function of a vibration damper? (1)
- 6.3 Name THREE different types of engine cylinder configurations. (3)

- 6.4 Give TWO reasons why the power strokes of an engine are often spaced at equal intervals. (2)
- 6.5 State THREE methods to determine the firing order of an engine. (3)
- 6.6 Answer the following questions about turbochargers:
- 6.6.1 Explain the term *boost*. (2)
- 6.6.2 Name the TWO types of turbochargers. (2)
- 6.7 Answer the following questions about superchargers:
- 6.7.1 Give TWO reasons why superchargers are fitted to engines. (2)
- 6.7.2 Name TWO mechanical drive systems used to turn superchargers. (2)
- 6.8 What does a twin-charging forced induction system consist of? (2)
- 6.9 State TWO advantages of using a twin-charging forced induction system on an engine. (2)
- [28]**

**QUESTION 7: FORCES (SPECIFIC)**

- 7.1 Define *swept volume* of an internal combustion engine. (2)
- 7.2 State THREE methods that can be used to increase the compression ratio of an internal combustion engine. (3)
- 7.3 In an internal combustion engine the bore diameter is 90 mm and the stroke length is 100 mm. The compression ratio is 10,5 : 1.
- Calculate the following:
- 7.3.1 The swept volume of a single cylinder in  $\text{cm}^3$  (3)
- 7.3.2 The original clearance volume of a single cylinder in  $\text{cm}^3$  (3)
- 7.3.3 The new bore diameter in mm if the compression ratio is increased to 11 : 1. The clearance volume and stroke length remain unchanged. (7)
- 7.4 The following data refers to a two-cylinder two-stroke engine which was tested with a Pröny brake:
- |                               |             |
|-------------------------------|-------------|
| Engine speed during the test: | 2 000 r/min |
| Mean effective pressure:      | 900 kPa     |
| Bore diameter:                | 84 mm       |
| Stroke length:                | 86 mm       |
| Brake arm length:             | 0,4 m       |
| Scale reading:                | 25 kg       |
- Calculate the following:
- 7.4.1 Indicated power in kW (7)
- 7.4.2 Brake power in kW (5)
- 7.4.3 Mechanical efficiency (2)
- [32]**

**QUESTION 8: MAINTENANCE (SPECIFIC)**

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

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

FAULTS (DEFECTS)	POSSIBLE CAUSES	CORRECTIVE MEASURES
High oxygen (O <sub>2</sub> ) reading	8.1.1	8.1.2
High hydrocarbon (HC) reading	8.1.3	8.1.4

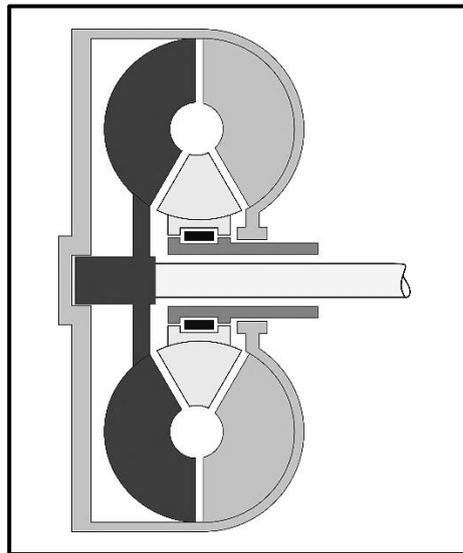
**TABLE 8.1**

- (4)
- 8.2 Explain why the following procedures are conducted on an internal combustion engine during a compression test:
- 8.2.1 Remove the high-tension lead. (1)
- 8.2.2 Unplug the fuel-injection system. (1)
- 8.2.3 Fully open the throttle valve. (1)
- 8.2.4 Record the readings. (1)
- 8.3 State the cause of and suggest an appropriate corrective measure for the following cylinder leakage test results:
- 8.3.1 Hissing sound at the air intake (2)
- 8.3.2 Hissing sound at the dipstick (2)
- 8.4 State THREE causes of a high oil-pressure reading on an internal combustion engine. (3)
- 8.5 A fuel pressure test is conducted on an engine.
- 8.5.1 State TWO manufacturer's specifications required before the fuel pressure test can be conducted. (2)
- 8.5.2 Where on the vehicle is the fuel-pressure tester inserted? (1)
- 8.5.3 Why may the rubber pipe on the fuel pressure tester not be worn away? (1)
- 8.6 State FOUR causes of pressure drop during a cooling system pressure test. (4)

**[23]**

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

- 9.1 A vehicle is fitted with an automatic gearbox. Explain how the following problems are solved:
- 9.1.1 The vehicle needs to be towed over a long distance (1)
  - 9.1.2 Slippage occurs inside a torque converter (1)
  - 9.1.3 The automatic gearbox oil overheats (1)
  - 9.1.4 Gearshift lever position is selected before starting the vehicle (1)
  - 9.1.5 Identify the correct type of oil to use in the gearbox (1)
- 9.2 FIGURE 9.2 below shows a torque converter.

**FIGURE 9.2**

Which components of the torque converter are described in QUESTIONS 9.2.1 to 9.2.3 below?

- 9.2.1 The driving member that is driven by the crankshaft (1)
  - 9.2.2 It is splined to the gearbox input shaft (1)
  - 9.2.3 It increases the torque under load (1)
- 9.3 Which component of the valve body is directly connected to the gear lever in an automatic transmission? (1)
- 9.4 State TWO advantages of the epicyclic gear system in the transmission of a motor vehicle. (2)

9.5 FIGURE 9.5 below shows the gear system of an automatic gearbox. Answer the questions that follow.

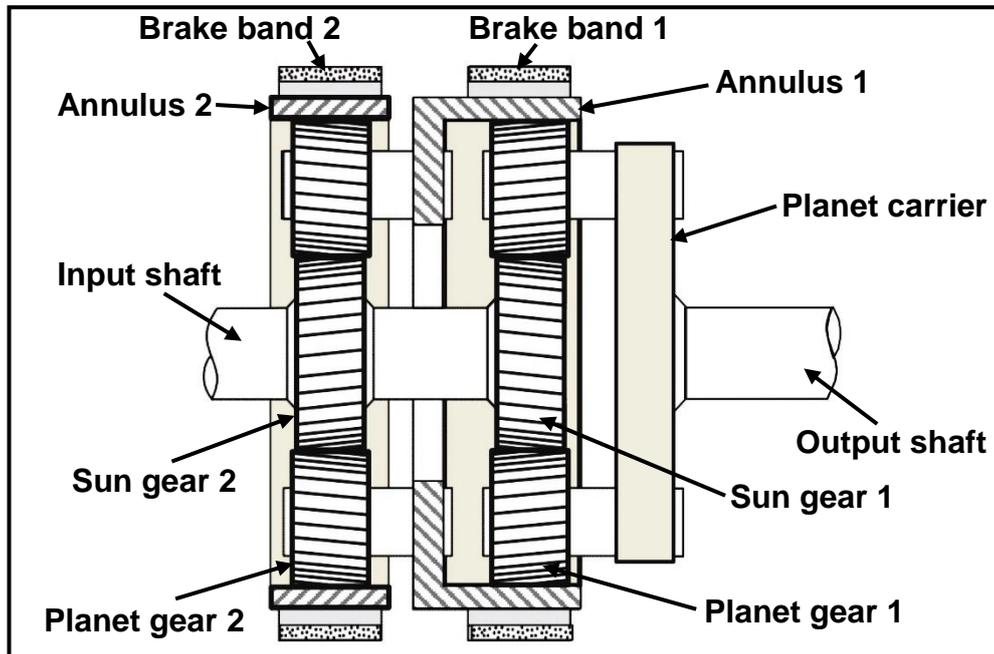


FIGURE 9.5

9.5.1 Identify the gear system in FIGURE 9.5 above. (1)

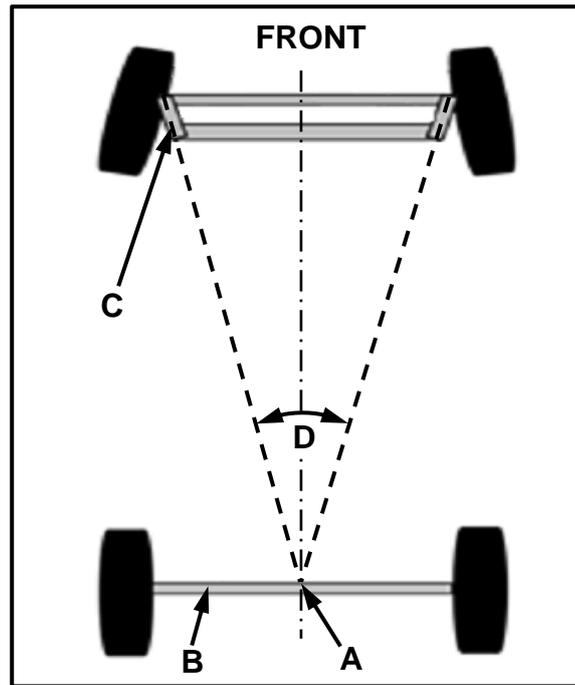
9.5.2 Explain, in the CORRECT sequence, how reverse gear is obtained in this gear system. Use the labels in FIGURE 9.5 to assist you in your explanation. (5)

9.6 Which component circulates the oil through an automatic gearbox? (1)  
[18]

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

10.1 State TWO features required for a well-designed steering system. (2)

10.2 FIGURE 10.2 below shows a wheel alignment angle. Answer the questions that follow.



**FIGURE 10.2**

10.2.1 Label A–C. (3)

10.2.2 Identify angle D. (1)

10.2.3 What is the purpose of wheel alignment angle D? (2)

10.3 Wheel bounce (hop) and wheel wobble (shimmy) are symptoms of unbalanced wheels.

Answer the questions below.

10.3.1 Draw a neat labelled sketch to show wheel bounce (hop). (2)

10.3.2 Draw a neat labelled sketch to show wheel wobble (shimmy). (2)

10.3.3 Explain the difference between *wheel wobble* and *wheel bounce*. (2)

10.4 Name TWO materials that are used to coat the monolith in a catalytic convertor. (2)

- 10.5 State TWO functions of EACH of the following sensors:
- 10.5.1 Lambda (2)
  - 10.5.2 TPS (2)
  - 10.5.3 MAF (2)
- 10.6 Briefly explain the operation of the common rail direct-injection system (CRDI). (3)
- 10.7 Explain how current is generated in an alternator. (3)
- 10.8 State TWO tests performed on an alternator stator by using a multimeter. (2)
- 10.9 State TWO positions where an electrical fuel pump is placed in a modern motor vehicle. (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.  $\text{Brake power with Pröny brake} = 2 \times \pi \times N \times F \times R$

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

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

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