N2

Motor Trade Theory

Student's Book

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Student's Book

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Contents

Engine measurement

Module 1

Overview of Module 1

When you have completed this module, you will be able to:

Unit 1.1: Taking measurements on the engine block

- Understand where to measure the cylinder bore for size taper and ovality.
- Explain how measurements are taken on the piston.
- Explain how measurements are taken on the crankshaft inside and outside the engine block.
- Explain how measurements are taken on the connecting rod.

Unit 1.2: How to measure a cylinder head

- Explain how measurements are taken on the cylinder head for thickness and warpage.
- Explain how measurements are taken on the cylinder head for wear on the valve guide and valve stem.
- Explain how to check the seating of the valves.
- Explain how to measure valve spring height and spring tension.

An important part of engine manufacturing and maintenance is to correctly measure different engine components. This includes selecting the right measuring tools for the component, taking the right measurements at the right places and being able to come to a meaningful conclusion. The engine specification from the manufacturer tells you what the right dimensions of the components should be, as well as their limits. If a component is still *within* that limit, it is good enough to be used. Never use a component that is *outside* its design limit because it may cause problems in the engine.

Figure 1.1: Components of an engine

Starter activity

1. List all the engine components that you know.
2. Which of these components are difficult to manufacture? Explain your answer.
3. Which of these components are easy to replace? Explain your answer.

Unit 1.1: Taking measurements on the engine block

Introduction to engine measurements

When measuring something, it is good practice to repeat the measurements to ensure you took them correctly. For example, when you measure the diameter of a cylinder, measure at three points on the circumference. This allows you to see the condition of the component as a whole.

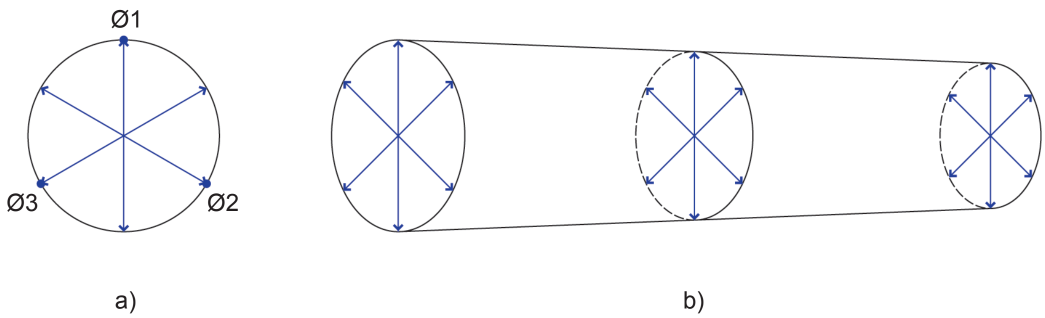

Figure 1.2: Where to measure a cylinder

Figure 1.2 a) shows three different places to measure the diameter of a circle when calculating ***ovality***. These positions are 120° apart. Figure 1.2 b) shows three different places along the length of the cylinder that must be measured when calculating ***taper***. These positions are the top, middle and bottom of the cylinder.

ovality / out-of-round: *the wear that happens over time in a piston engine due to the slightly uneven pressure from left to right; this makes the cylinder slightly oval shaped so that it looks more like the outline of an egg than a circle*

taper: *the gradual narrowing of a cylinder*

bore: *in a piston engine, the bore or cylinder bore or is the diameter of each cylinder*

1.1.1 How to measure a cylinder

A cylinder is the power unit of an engine. This is where the petrol is burned and turned into power.

Ovality, taper and ***bore*** are common features to measure across different engine components. This section explains how to measure ovality, taper and bore on cylinders.

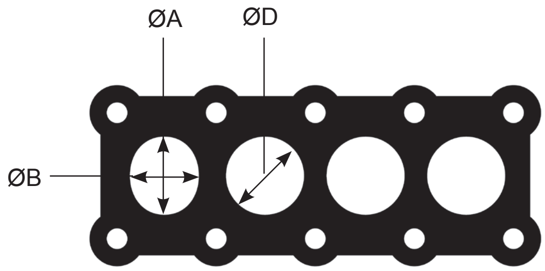

Figure 1.3: Ovality

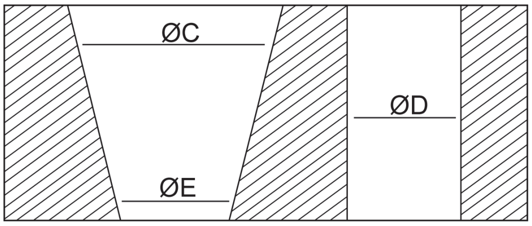

Figure 1.4: Taper

Ovality, also called ***out-of-round***, is the change in the cross section of a pipe or tube from its normal round shape. It shows you how much the diameter of the component has changed. Calculate ovality by subtracting the smaller minor axis from the larger major axis. In Figure 1.3, D is the normal diameter of the cylinder, A is the minor axis and B is the major axis. Therefore, the formula for ovality is ØB – ØA. As you will not always be able to determine the minor and major axes by eye, you must use measuring tools.

Taper occurs when the cylinder becomes more like a cone. The diameter changes along the length of the cylinder. You can calculate taper by measuring the diameters at two to three different places along the length of the cylinder. In Figure 1.4, ØD is the normal diameter of the cylinder. The formula for the taper is ØC – ØE.

Note

Always check the components for cracks, pits or excessive wear before measuring.

Bore refers to the diameter of a cylinder in a piston engine and is measured with a dial bore gauge. It determines how big the pistons must be and is used to calculate the displacement of the engine.

The size of the cylinder bores influences the fuel efficiency and power output of the engine. The larger the cylinders are, the more power the engine has and the more fuel it needs.

To measure and calculate the sizes of cylinders, you will need the following:

- **Dial bore gauge:** Gives an exact reading of a bore size (see Figure 1.5 a).
- **Micrometer:** Used for the precise measurement of very small objects.
- **Pen and paper:** Used to record the measurements.
- **Marking pen:** Used to mark the points that must be measured.
- **Calculator:** Used to calculate the measurements.
- **Manufacturer's specifications:** The required specification for each component.
- **Cleaning materials:** For example, sandpaper, cloth and so on.

a) b) c)

Figure 1.5: a) Dial bore gauge b) Digital vernier measuring the outer diameter c) Digital vernier calliper measuring the inside diameter

Example 1.1

To determine the size of a cylinder:

1. Write down the lower limit of the diameter from the manufacturer's specification. This is the base diameter.
2. Draw a table for each cylinder that you are going to measure. See Table 1.1.

Table 1.1: Sample table to be used in the calculation

	Top	Centre	Bottom
Point A			
Point B			
Point C			

3. Use a marking pen to mark off 120° along the circumference of the first cylinder (Figure 1.6).

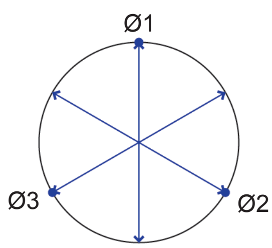

Figure 1.6: Mark the circumference of the cylinder

4. Set the micrometer to the lower limit value and lock it.

To calculate the bore:

14. The bore is the original diameter + the largest variation, which is the largest measured value. If the diameter is 90 mm, the bore size is 90 + 0,0022 = 90,0022 mm.

Table 1.4: The bore is the largest diameter that was measured

	Top (mm)	Centre (mm)	Bottom (mm)	Largest measured diameter (mm)
Point A	90,0022	90,0019	90,0020	90,0022
Point B	90,0011	90,0011	90,0009	90,0011
Point C	90,0012	90,0018	90,0010	90,0018

The bore size is the *largest* diameter in Table 1.4 which is 90,0022 mm.

See it online

If you have Internet access, watch the following YouTube video:

- **Measuring cylinder bore, taper, and out-of-round** (by Justin Miller) www.youtube.com/watch?v=qLzMQtJAljg&t=321s

1.1.2 How to measure a cylinder block

A cylinder block contains all the major components of a combustion engine (see Figure 1.7). It is usually made from an aluminium alloy and houses the pistons, the water cooling system and the crankcase. It is measured for taper, ovality and bore size. As you have already learned how to measure these for a cylinder, you can apply the same steps to measure a cylinder block.

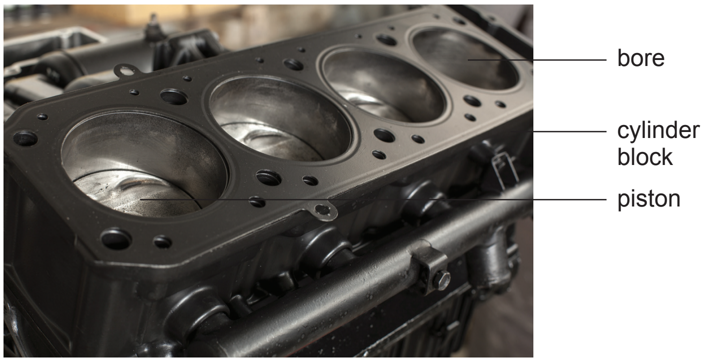

Figure 1.7: Cylinder block

Measure the cylinder bore during engine maintenance before installing the pistons back into the cylinder block. The taper, ovality and bore size determine whether a cylinder is acceptable or if the engine block must be machined. The bore size is the largest measured diameter of the cylinder. You must make sure that the walls of the cylinder are in excellent condition before installing the pistons.

During operation, the pressure differs along the length of a cylinder. Most of the pressure is experienced at the top, close to the surface of the cylinder block. The high pressure applied at the top can make the top of the cylinder deform faster. The ***thrust*** and ***non-thrust surfaces*** also experience higher forces than the rest of the cylinder. Ovality is more likely to happen at these surfaces. Therefore, take measurements at the top and centre, and compare them to the measurements at the bottom. Tapering causes excessive piston ring movement as the piston travels up and down the cylinder.

thrust surface: *when the piston turns the crankshaft, it experiences a resistance force; the force causes the piston to push against one side of the cylinder; this surface of the cylinder experiences larger forces and is likely to wear faster*

non-thrust surface: *adjacent to the thrust surface*

Activity 1.1

1. Define bore. (1)
2. Define taper. (1)
3. Define ovality. (1)
4. State how to calculate ovality (1)
5. State how to calculate taper. (1)
6. Calculate the ovality, taper and bore of a 100 mm diameter cylinder. (12)
   The specifications for the cylinder are as follows:
   - Diameter 100 ± 0,001 mm.
   - Taper < 0,0008 mm.
   - Ovality < 0,0005 mm.

   The measurements that were taken are tabulated below.

	Top	Centre	Bottom	Taper
Point A	0,0020	0,0011	0,0014	
Point B	0,0013	0,0011	0,0010	
Point C	0,0010	0,0016	0,0009	
Ovality				

7. Is the cylinder suitable for use? Give a reason for your answer. (3)

TOTAL: [20]

1.1.3 How to measure a piston

A piston is a component of an engine that transfers power from the expanding gas in the cylinder to the ***crankshaft*** via a piston rod and/or connecting rod (see Figure 1.8).

The piston is measured for ovality, taper, bore as well as piston ***clearance***. We have already explained how to measure ovality, taper and bore. This section will explain how to measure piston clearance.

crankshaft: *a shaft that is driven by a crank (an arm attached at right angles to a rotating shaft), usually from an engine*

clearance: *the amount of space between two objects*

During maintenance, ensure that the piston is in a good condition before installing it back into the cylinder. This means that it must be the correct size and have the right clearances. If the clearance between the piston and the cylinder is too large (the piston is too small), the piston will rock back and forth in the cylinder because it will not be supported. This causes noise in the engine and also causes the piston and cylinder to wear faster. Incorrect sealing in the cylinder can reduce the performance of the engine. Although modern pistons are designed with a little taper and ovality, it must be within the specification.

Figure 1.8: Piston

Piston-to-cylinder clearance is the measurement of the gap between the piston's outside diameter and the cylinder's inside diameter. To measure and calculate the piston's clearance, you will need the following:

- Micrometer.
- Dial bore gauge.
- Pen and paper.
- Calculator.
- The manufacturer's specification.
- Cleaning materials such as sandpaper, cloth and so on.

The steps to measure and calculate the piston-to-cylinder clearance are:

Step 1	Use a micrometer to measure the diameter of the piston.

Step 2	Use a bore gauge to measure the bore of the cylinder.
Step 3	Subtract the piston diameter from the cylinder diameter. The value that you obtain is the piston-to-cylinder clearance.

If the piston-to-cylinder clearance is *larger* than the specification, the piston is too small for the cylinder and can cause the engine to operate poorly. If the piston-to-cylinder clearance is *smaller* than the specification, the piston is too big for the cylinder and can cause the engine to ***seize.***

seize (engine): *an engine seizes, or locks, when it does not get enough oil to the moving parts because of a mechanical failure; this will damage the engine*

Use the clearance error equation to determine by how much the measured clearance is larger or smaller than the specified clearance. This is calculated as a percentage.

$$\text{Clearance error} = \frac{\text{measured clearance} - \text{specified clearance}}{\text{specified clearance}} \times 100$$

Activity 1.2

1. Which measuring tools do you use to measure piston clearance? (2)
2. What happens in the engine if the piston clearance is too big? (2)
3. What happens in the engine if the piston clearance is too small? (2)
4. List the steps to measure and calculate the piston-to-cylinder clearance. (4)
5. The specified piston clearance is 0,05 mm and your measured piston clearance is 0,09 mm. Use the specified and measured clearance values to determine what will happen in the engine. (3)
6. You are given the following values for piston diameter and cylinder bore:
   - **Piston diameter:** 66,92 mm.
   - **Cylinder bore:** 67,05 mm.

   Calculate the piston-to-cylinder clearance. (2)

TOTAL: [15]

In the workplace

Always ensure that the components are clean before you start measuring and assembling. Grease and dirt can cause measuring errors.

See it online

If you have Internet access, watch the following YouTube video:

- **Measuring piston size – Jay's Tech Tips** (by That Racing Channel) www.youtube.com/watch?v=u-6tUWAXo-0

1.1.4 How to measure a crankshaft

A crankshaft converts the up and down motion of the piston into the rotational motion of the engine's output shaft (see Figure 1.9). A crankshaft carries the weight of all the components assembled on it. It also carries the forces of the combustion cycle and supports the bearings that allow the crankshaft to rotate.

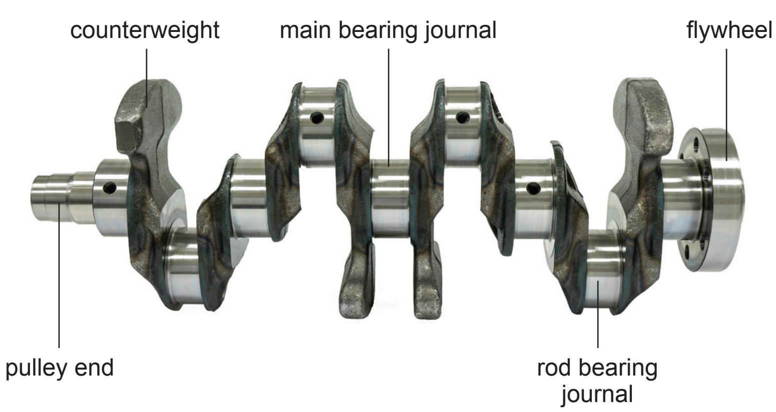

Figure 1.9: Crankshaft

Over time, the bearing wears down and causes the crankshaft to bend slightly. Measuring the ***crankshaft deflection*** ensures that the crankshaft remains within limit. In this section, you will learn how to measure crankshaft deflection and the bearing clearance between the ***crank journal*** and bearing.

crankshaft deflection: *how much a component is displaced under load; it is measured to detect the misalignment of main bearings*

crank journal: *a mechanical device that connects the crankshaft to the connecting rod for each cylinder*

a) How to measure deflection

Determine crankshaft deflection by measuring the distance variations between two adjacent webs. Use a dial bore gauge to measure these variations.

To measure and calculate the crankshaft deflection, you will need the following:

- Micrometer.
- Dial bore gauge.
- Pen and paper.
- Calculator.
- The manufacturer's specification.
- Cleaning materials such as sandpaper, cloth and so on.

The steps to calculate crankshaft deflection are:

Step 1	Turn the engine until the pin of the first cylinder is just past ***bottom dead centre (BDC)***.
Step 2	Put the micrometer at the shaft's centreline and set the micrometer to zero.
Step 3	Rotate the engine 90°. Take the reading of the micrometer.
Step 4	Rotate the engine 90° so that the pin is at ***top dead centre (TDC)*** and take the reading of the micrometer.
Step 5	Rotate the engine again with the pin at 270°. Take the reading.
Step 6	Turn the engine so that the pin is very close to BDC. Take the final reading.
Step 7	Subtract the smallest value from the biggest value.
Step 8	Repeat steps 1 to 7 for the remaining cranks.

bottom dead centre (BDC): *the point where the piston of an engine is nearest to the axis of the crankshaft*

top dead centre (TDC): *the point where the piston in the number one cylinder position of an engine is at its highest point on the compression stroke*

Use Table 1.5 to calculate crankshaft deflection.

Table 1.5: Sample table to calculate crankshaft deflection

Cylinder number	1	2	3	4	5	6
BDC (start)	0,0	0,0	0,0	0,0	0,0	0,0
90°						
TDC						
270°						
BDC						
Difference						

Table 1.6 shows a typical set of readings.

Table 1.6: Crankshaft deflection calculation table

Cylinder number	1	2	3	4	5	6
BDC	0,0	0,0	0,0	0,0	0,0	0,0
90°	+0,8	+1,0	+1,1	–1,2	–1,0	–1,1
TDC	+1,0	–1,0	+0,5	+1,0	0,0	+1,0
270°	–1,0	–0,4	+1,0	–0,7	+1,0	+1,0
BDC	–0,2	–0,1	0,0	+0,1	0,0	0,0
Difference (micrometres or microns (μm))	2,0	2,0	1,1	2,2	2,0	2,1

Summary of Module 1

Unit 1.1: Taking measurements on the engine block

- How to measure a cylinder.
  - **Ovality:** Subtract the smaller minor axis from the larger major axis.
  - **Taper:** Measure the difference of the diameters at two to three different places along the length of the cylinder.
  - **Bore:** Use a micrometer to measure the bore.
- How to measure a cylinder block.
  - **Ovality:** Subtract the smaller minor axis from the larger major axis.
  - **Taper:** Measure the difference of the diameters at two to three different places along the length of the cylinder.
  - **Bore:** Use a micrometer to measure the bore.
- How to measure a piston.
  - **Ovality:** Aubtracting the smaller minor axis from the larger major axis.
  - **Taper:** Measure the difference of the diameters at two to three different places on the piston.
  - **Bore:** Use a micrometer to measure the bore.
  - **Piston-to-cylinder clearance:** This is the gap between the piston's outside diameter and the cylinder's inside diameter. Measure this with a micrometer and a dial bore gauge.
- How to measure a crankshaft.
  - **Crankshaft deflection:** Measure this with a straight gauge to detect the misalignment of main bearings.
  - **Crankshaft-to-bearing clearance:** This is the distance between the crankshaft journal and diameter of the bearing. It is measured with a micrometer and dial bore gauge.
- How to measure a connecting rod.
  - **Length of connecting rod:** The length of the connecting rod is the distance from the centre of the big end of the rod to the centre of the piston pin bore. It is measured with a micrometer and callipers.
  - **Diameters of the big end and piston pin bores:** Measure the diameter with a dial bore gauge.
  - **Big end bearing clearance:** Measure this with a micrometer and dial bore gauge.

Unit 1.2: How to measure a cylinder head

- **Cylinder head height or thickness:** Measure the height of the cylinder head from the valve cover gasket rail to the head gasket surface with callipers.
- **Cylinder head warpage/flatness:** Measure the cylinder head for warpage or flatness with a straight edge and a feeler gauge.
- **Valve guide and stem clearance:** The clearance between the inner diameter of the valve guide and the outer diameter of the valve stem is critical for the proper operation of an engine and is measured with a ball gauge.
- **Valve seat or seating valve flatness:** Measure this with a square and a feeler gauge.
- **Valve spring free height:** The height before the spring is installed (the length of the spring when there is no load or force applied) is measured using callipers from one end to the other.
- **Valve spring installed height:** This is the height of the spring when the valves have been installed. It can be measured using a mechanic's ruler or a valve spring height micrometer.
- **Valve spring tension:** The spring is mainly responsible for keeping all the valve train components in constant contact with the camshaft lobe. To measure the valve spring tension, you need a spring tester.

Summative assessment for Module 1

1. Indicate whether the following statements are true or false. Choose the answer and write 'True' or 'False' next to the question number (1.1–1.5) in your workbook. Correct the statement if it is false.

1.1 The size of a cylinder does not influence the fuel efficiency and power output of the engine. (2)

1.2 A piston is only measured for ovality, taper and bore. (2)

1.3 The purpose of measuring crankshaft deflection is to detect the misalignment of main bearings. (2)

1.4 The big end bore is the largest diameter measured. (2)

1.5 Piston-to-cylinder clearance is the measurement of the piston's outside diameter and its inside parameter. (2)

1.6 If an engine is subjected to severe overheating or head gasket failure, the cylinder head or block may be broken. (2)

[12]

2. Choose a term from Column B that matches a description in Column A. Write only the letter (A–E) next to the question number (2.1–2.5) in your workbook, for example 2.3 D.

Column A	Column B
2.1 It detects the misalignment of main bearings.	A. Ovality
2.2 It can be measured from the bottom of the retainer to the cylinder head.	B. Taper
2.3 The change in the cross section of a pipe or tube from its normal round shape.	C. Free length height
2.4 The height of the spring when there is no load or force applied.	D. Installed height
2.5 When the cylinder becomes more like a cone and the diameter changes along the length of a cylinder.	E. Crankshaft deflection

[5]

3. A 100 mm diameter cylinder block is taken for maintenance. The specifications for the cylinder are as follows:

- Diameter 90 ±0,0015 mm.
- Taper < 0,0009 mm.
- Ovality < 0,0006 mm.

3.1 Calculate the ovality. (4)

3.2 Calculate the taper. (4)

3.3 Calculate the bore. (2)

[10]

4. You are given a cylinder with the following measurements. Using the specifications in Question 3, determine if the cylinder is suitable for use. Give reasons for your answer.

	Top	Centre	Bottom	Taper
Point A	0,0012	0,0011	0,0020	
Point B	0,0011	0,0010	0,0010	
Point C	0,0016	0,0009	0,0011	
Ovality				

[4]

5. Calculate the deflection of the crankshaft given the following measurements:

Cylinder number	1	2	3	4	5	6
BDC	0,0	0,0	0,0	0,0	0,0	0,0
90°	+0,8	+1,0	+1,1	–1,2	–1,0	–1,1
TDC	+1,0	–1,0	+0,5	+1,0	0,0	+1,0
270°	–1,0	–0,4	+1,0	–0,7	+1,0	+1,0
BDC	–0,2	–0,1	0,0	+0,1	0,0	0,0
Difference (micrometres)						

[6]

6. 6.1 Explain what will happen in the engine if the piston is too big. (1)
   6.2 Explain what will happen in the engine if the valve seat is not flat. (1)
   6.3 Explain what will happen in the engine if the valve guide is tapered. (1)
   6.4 Explain ovality. (2)
   6.5 Explain taper. (2)
   6.6 Explain piston-to-bearing clearance and how it is calculated. (4)
   6.7 What is the purpose of the valve spring? (2)

[13]

TOTAL: [50]

Practice exam

TIME: 3 HOURS

MARKS: 100

INSTRUCTIONS

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Use only BLUE or BLACK pens.
4. Write neatly and legibly.

QUESTION 1

1.1 List FIVE measurements/checks that must be carried out on a cylinder head. (5)

1.2 Choose a word from COLUMN B that matches the description in COLUMN A. Write only the letter (A–G) next to the question number (1.2.1–1.2.5) in YOUR ANSWER BOOK.

COLUMN A	COLUMN B
1.2.1 A measure of the force applied over a distance.	A. Axial thrust
1.2.2 The difference between the number of teeth on the output gear and the number of teeth on the input gear.	B. Torque
1.2.3 The force or loads that are applied to the shaft in a direction parallel to the axis of the shaft.	C. Gear ratio
1.2.4 To connect tightly with each other and work together.	D. Thrust bearing
1.2.5 A bearing accommodating an axial force.	E. Piston
	F. Crankshaft
	G. Mesh/interlock

$(5 \times 1 = 5)$

1.3 Redraw the table shown below and list FIVE advantages and FIVE disadvantages of spur gears.

	Advantages	Disadvantages
1.3.1		
1.3.2		
1.3.3		
1.3.4		
1.3.5		

(10)

[20]

QUESTION 2

2.1 List FOUR functions of a clutch. (4)

2.2 Explain the operation of a mechanical clutch. (6)

2.3 Figure 1 shows a rear-wheel-drive powertrain set-up.Label items A–F in your ANSWER BOOK.

Glossary

Words and terms

abrasion: *the process of scraping or wearing something away 205*

active ride control (drive assist): *a modern system that uses computers to improve ride control by controlling traction, braking and cornering on slippery roads 97*

actuate: *to set a process in motion 142*

actuator: *a component of a machine that moves and controls a system 58*

advancing the timing: *to energise the spark sooner; this forces the piston down harder in the cylinder after TDC, giving the engine better performance 187*

aftermarket item: *an item that is sold after a vehicle has been bought 104*

atomisation: *to separate something into fine particles 181*

auxiliary tank: *a tank that is secondary to the main fuel tank 171*

axial thrust or force: *the force or loads that are applied to the shaft in a direction parallel to the axis of the shaft 23*

axle: *a shaft that passes through the centre of a wheel and transmits power to it 65*

backlash: *the amount of clearance between mated gear teeth; also known as slop 127*

bearing: *a ring-shaped machine component that allows very smooth, low friction rotation of the shaft that it holds 28*

bonding agent: *a chemical that is used to glue two materials together 152*

bore: *in a piston engine, the bore or cylinder bore or is the diameter of each cylinder 2*

bottom dead centre (BDC): *the point where the piston of an engine is nearest to the axis of the crankshaft 8*

bushing: *a plain cylindrical bearing that is inserted into a housing and is used as the interface for rotary motion 89*

calliper: *a vehicle brake component that houses the pistons that act on the brake pads in a disc brake system 123*

camshaft lobe: *lobes, also called cams, push against the valves to open them as the camshaft rotates 15*

chassis: *the base frame and outer shell of a vehicle 98*

clearance: *the amount of space between two objects 6*

clutch shaft: *the shaft that goes into the flywheel 51*

coaxial position: *mounted on a common axis; this means that the output shaft is mounted along the same axis as the input shaft 27*

combustion: *the process of burning something 25*

commutator: *a part of the motor shaft that makes electrical contact between the armature and brushes of a motor 213*

compression stroke: *the stroke in an engine in which the air-fuel mixture is compressed before ignition 187*

cone clutch: *a friction clutch in which the frictional surfaces are cone shaped 32*

contact points follower: *part of the ignition points that rides on the distributor shaft and is acted upon by the cam lobes 188*

control arm bushing: *located between the control arm and the chassis; used to damp the vibrations between the wheel and the frame 123*

control arm: *hinged suspension link that connects the chassis and the suspension upright of the wheel 123*

corrode: *to slowly destroy or damage something by chemical action 101*

couple: *to join or connect 89*

crank journal: *a mechanical device that connects the crankshaft to the connecting rod for each cylinder 8*

crankshaft deflection: *how much a component is displaced under load; it is measured to detect the misalignment of main bearings 8*

crankshaft: *a shaft that is driven by a crank (an arm attached at right angles to a rotating shaft), usually from an engine 6*

CV joint: *constant velocity joints allow a drive shaft to transmit power at a variable angle at a constant rotational speed and without a significant increase in friction or play 65*

differential: *part of the front or rear axle of a vehicle that splits the engine torque two ways, allowing each output to spin at a different speed 22*

differential assembly: *a group of components at the rear end of the prop shaft that distributes power to the rear axle 65*

dog clutch: *a type of clutch with teeth that couples two rotating shafts by pushing the one side of the clutch against the other 31*

driveline: *the system that connects the gearbox to the axle 65*

drivetrain: *a group of components that deliver power to the driving wheels 64*

driving thrust: *the forward driving force that makes the car move 99*

dry clutch: *a clutch that does not need lubrication oil 51*

ECU: *the engine control unit that controls various actuators, including the fuel injection system, in an internal combustion engine 175*

end float: *the amount by which a steering shaft can move lengthwise 126*

free play: *the pedal movement before the thrust bearing comes into contact with the clutch release levers 55*

friction modifier: *mild anti-wear agent added to lubricant for the purpose of minimising light surface contacts 152*

fuel line: *a thin hose, usually made of rubber; where flexing occurs or rigid metal where it does not; it is used to transport fuel from one area to another, such as from the fuel tank to the fuel filter 167*

gasket: *a mechanical seal that fills the space between two or more mating surfaces to prevent leaking 13*

gear: *a toothed wheel or disc used to change the speed and direction of transmitted motion of an object 21*

gear ratio: *the number of revolutions made by the driving gear compared to the number of revolutions by the driven gear of a different size; for example, if one gear makes four revolutions while the other gear makes one revolution, the gear ratio is 4:1 22*

gearbox: *a set of gears and its casing that transmits power from an engine to the axle in a vehicle 22*

ground line: *the point where the bottom of the tyre is in contact with the ground 134*

hand primed: *manually removing air from the pump and suction line to create pressure, causing the fuel to flow into the carburettor 171*

helical: *an object having a three-dimensional spiral shape 15*

HID light: *high-intensity discharge lamp; light is produced by an electric arc between tungsten electrodes 202*

horizontal movement: *side to side movement 98*