

[C029/SQP040]

Higher
Automotive Engineering
Specimen Question Paper

Time: 3 hours

NATIONAL
QUALIFICATIONS

70 marks are allocated to this paper.

Attempt **all** questions.

Attempt ALL questions

Marks

1. (a) Describe the benefits of using an anti-lock braking system on a motor vehicle. 3
- (b) Explain the principle of operation of an anti-lock braking system and the role of the Electronic Control Unit (ECU) used on a motor vehicle. 7
- (10)**
2. (a) A vehicle equipped with a five speed gearbox has an overdrive fifth gear of 0.8 to 1, and all other gears are arranged in geometric (Natural) progression. Fourth gear has a ratio of 1 to 1 and first gear has a ratio of 2.68 to 1. Determine:
- (i) the intermediate ratios of the gearbox; 2
- (ii) the overall gear ratio with third gear engaged. The final drive ratio is 2.75 to 1. 1
- (b) The diagram shown in Figure 1, represents the transmission layout of a four wheel drive vehicle.

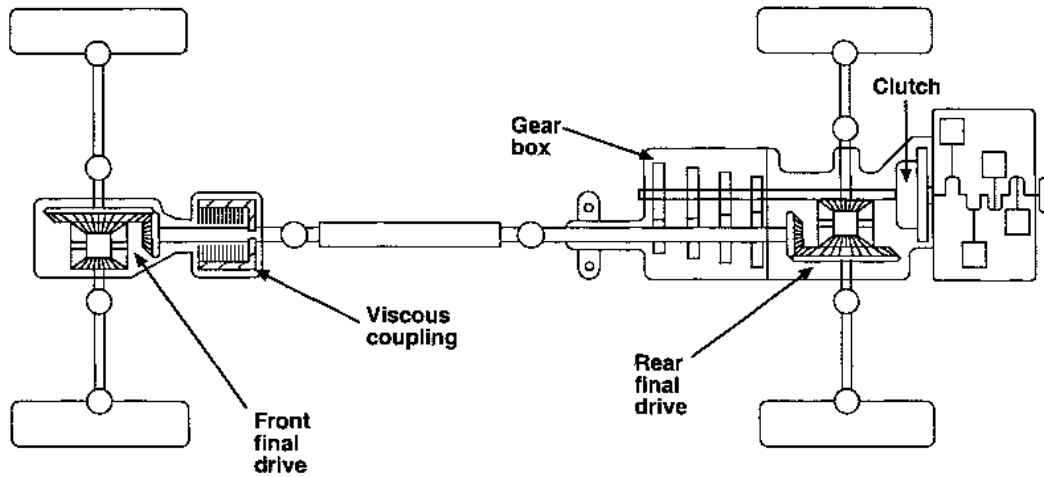


Figure 1 © Heinz Heisler (Advanced Vehicle Technology)

Describe:

- (i) the power flow from the engine through the gearbox to the rear wheels; 2
- (ii) how the viscous coupling transfers the drive to the front wheels; 3
- (iii) when a low ratio is engaged, the effect this would have on the speed of the vehicle and the torque delivered to the road wheels. 2
- (10)**
3. (a) State **three** reasons for using a suspension system on a motor vehicle. 3
- (b) Explain the principle of operation of an active suspension system used to control pitch, roll and bounce. 7
- (10)**

4. Figure 2 and Figure 3 show electronic inductive pulse generator type components.
- (a) (i) Sketch, on Figure 2 on **Worksheet Q4 (a)**, the output signal from the electronic generator shown on Figure 2 below. 1
 - (ii) Sketch, on Figure 3 on **Worksheet Q4 (a)**, the output signal from the electronic generator shown on Figure 3 below. 1
 - (iii) Sketch, on Figure 3 on **Worksheet Q4 (a)** the change required to the signal so that it will be recognised by the Central Processing Unit (CPU). 2
 - (b) Describe the effect on the signal of an increased air gap between component "A" and the reluctor ring shown in Figure 2. 2
 - (c) For the component shown in Figure 3, describe how the signal is generated. 4
- (10)**

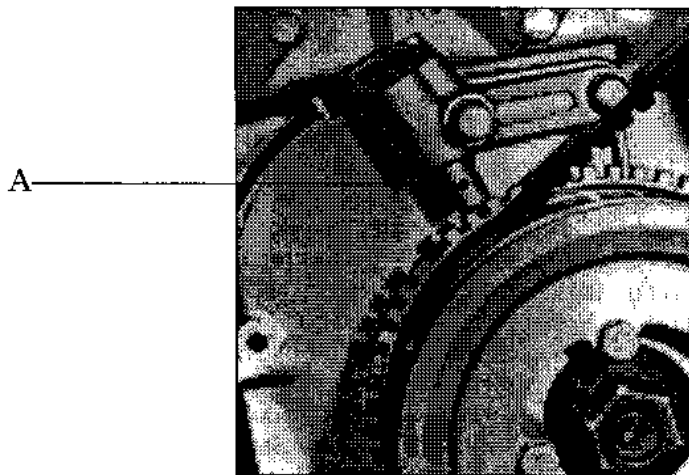


Figure 2

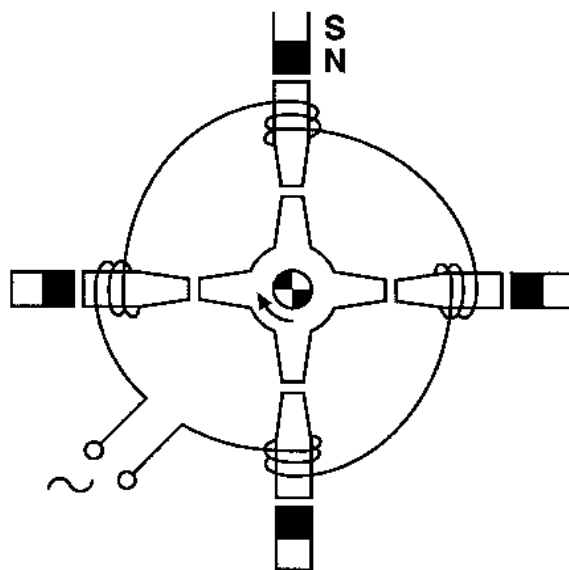


Figure 3

© Robert Bosch

5. (a) Using Table Q5 (a), determine the outputs of X for the AND gate shown in Figure 4.

2



Figure 4

Inputs		Outputs
A	B	X
0	0	
0	1	
1	0	
1	1	

Table Q5(a)

(b) The diagrammatic layout shown in Figure 5, is of an electronic engine management system.

- (i) Identify the components labelled 11, 13, 15, and 17 and state what is being monitored under normal operating conditions by these units.
- (ii) Explain the operation of unit 14 during engine running conditions.

4
4
(10)

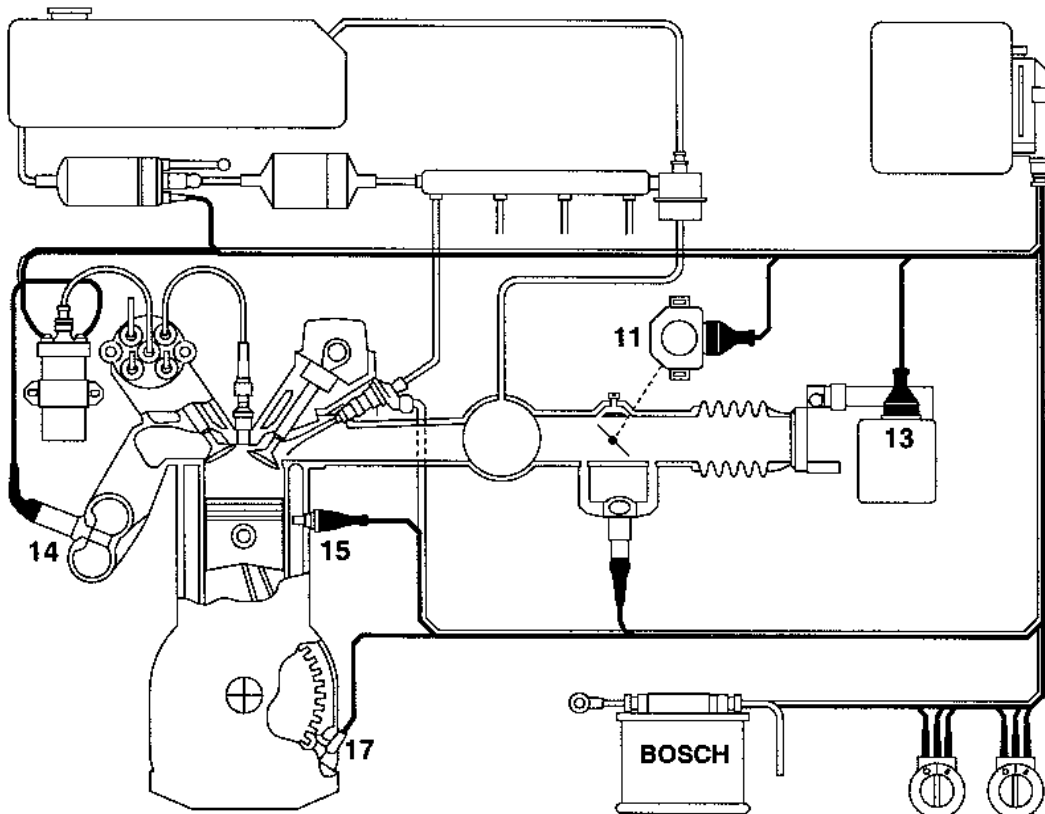


Figure 5

6. (a) Describe the effect on engine emission and efficiency of the following:
- (i) stratified charging; 3
 - (ii) variable valve timing. 3
- (b) (i) In relation to steering, describe the difference between positive and negative offset (Scrub radius). 2
- (ii) Describe what happens when a front tyre deflates suddenly on a vehicle with negative offset steering and describe the effect this would have on the vehicles handling. (Use sketches, if required, to explain your answer.) 2
- (10)**

7. The following table shows the results obtained from a compression test carried out on a 6 cylinder four stroke petrol engine at 48 000 miles as part of a diagnostic fault finding check. The manufacturer's data on the engine is:

Compression ratio = 9.5 : 1
 Cylinder pressure = 12.6 bar

Cylinder	1	2	3	4	5	6
Dry Pressure (bar)	11.7	9.7	6.2	6.2	11.6	11.6
Wet Pressure (bar)	11.8	10.8	6.2	6.2	11.8	11.9

- (a) Determine, from the results obtained, the general condition of the engine. 2
- (b) Before dismantling the engine, determine **one** diagnostic test that could be carried out to establish or support your comments in (a), and explain the procedure for that test. 5
- (c) Outline **three** engine faults which could cause these results. 3
- (10)**

[END OF QUESTION PAPER]

FOR OFFICIAL USE

Centre No.	Subject No.	Grade	Paper No.	Group No.	Marker's No.
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[C029/SQP040]

Higher
Automotive Engineering
Specimen Question Paper
Worksheet Q4(a)

Time: 3 hours

NATIONAL
QUALIFICATIONS

Fill in these boxes and read what is printed below.

Full name of school or college

Town

First name and initials

Surname

Date of birth

Day Month Year

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Candidate number

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Number of seat

To be inserted inside the front cover of the candidate's answer book.

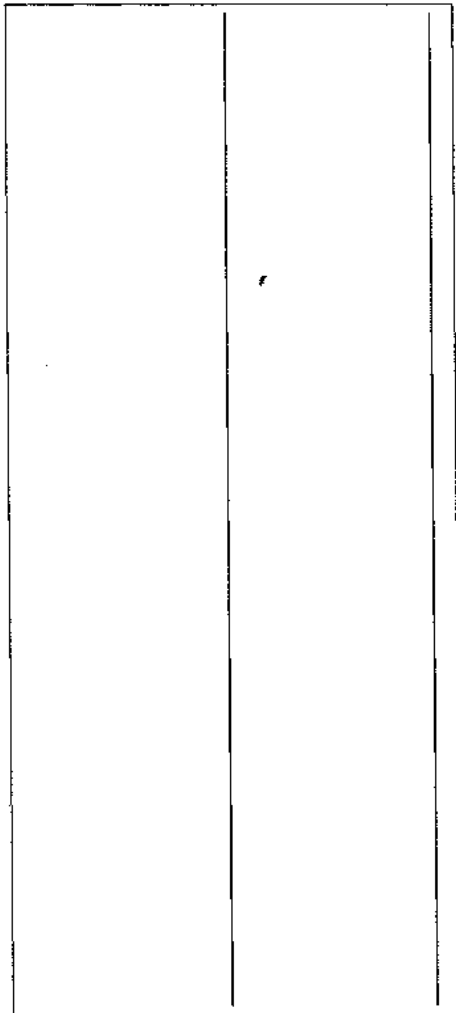


Figure 3

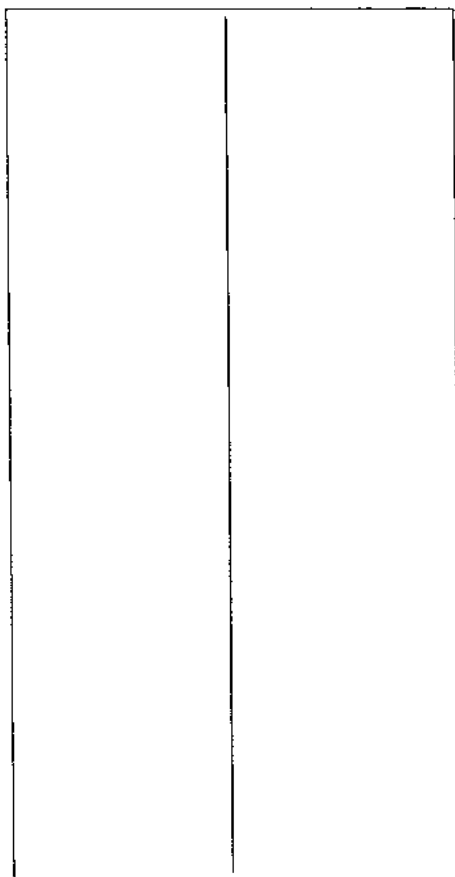


Figure 2

[C029/SQP040]

Higher
Automotive Engineering
Specimen Marking Instructions

NATIONAL
QUALIFICATIONS

1 (a) **Benefits of an Anti-Lock Braking system:** the candidate should include a minimum of three of the following points:

- Prevents road wheels locking up under hard braking conditions therefore preventing skidding
- Stops the vehicle in the shortest distance possible
- Automatically assesses varying road conditions during braking
- Prevents increased stopping distance due to skidding
- In an emergency under heavy braking the driver maintains control of the vehicle.

3

(b) **Operation of an Anti-Lock Braking system:** the candidate can choose the system but should include the following points:

- Sensor and toothed wheel fitted to each road wheel
- 3 phase operation
- One pair of valves per circuit – Pressure reduction, pressure maintenance pressure increase
- Pressure reduction – sensor indicates when the wheel is beginning to skid, ECU closes the input valve and opens the return valve decreasing the pressure, allowing the surplus fluid to return back to the reservoir, thus preventing the wheel locking
- Pressure maintenance – ECU detects that the drop in pressure is sufficient to prevent wheel lock and closes the return valve and allows the pressure to be maintained
- Pressure increase – ECU detects that the wheel is running free, then the input valve is opened and the pressure will increase up to the point where the percentage slip is more than required
- Role of ECU is to monitor the input information in the form of a signal from the wheel sensors, that signal is converted within the processor and activates an actuator, in this case a series of valves.

7

(10)

2 (a) The candidate should include the following:

(i) Top gear x cubed root of 1st gear

$$\begin{aligned}
 a &= \text{top gear} &= & 1:1 \\
 a &= \text{3rd gear} &= & 1.389:1 \\
 a &= \text{2nd gear} &= & 1.929:1 \\
 a &= \text{1st gear} &= & 2.68:1
 \end{aligned}$$

2

(ii) Overall Gear Ratio = Third Gear Ratio x Final Drive Ratio

$$= 1.389 \times 2.75$$

$$= 3.82 : 1$$

1

(b) (i) Power Flow: The candidate should include the following:

- Power to rear axle is from the engine flywheel, and pressure plate
- Through the clutch friction disc to the spline drive
- Into the gearbox primary input shaft, through the engaged gear
- Via the spline shaft to the secondary output shaft to the rear axle pinion and crown wheel
- Through 90 degrees to the wheel hubs to the wheels.
- Power to the front wheels is taken via the gearbox secondary output shaft through the propeller shaft to the viscous coupling.

2

(ii) Viscous coupling:

- Into an input set of steel discs splined to the input stub shaft, driven by the propeller shaft
- A second set of output steel discs, equidistant from the input discs, operating in a speed sensitive silicon fluid through which power is transmitted connected to the front output stub shaft
- When the grip to the rear wheel is lost or reduced then power is transmitted to the front output stub shaft, driving the front axle pinion and crown wheel
- Via the front drive shafts to the front hubs and road wheels.

3

(iii) Low Ratio engaged:

- Low gear engaged will result in low vehicle speed and increased torque being delivered to the wheels.

2

(10)

- 3 (a) **Reasons for using a suspension system:** The candidate should include a minimum of three of the following points:
- Large and small road shock/impacts are absorbed
 - Vehicle body is kept on an even keel when travelling over rough ground and cornering
 - Pitch, roll and bounce are minimised
 - Wheels follow the contours of the road more closely resulting in improved tyre grip and traction especially when cornering, braking, accelerating.
- (b) **Operation of active suspension system:** The candidate can select the system eg *Hydropneumatic automatic height correction (Citroen)* but should include the following type of points:
- Front and rear anti roll bars fitted to increase body roll stiffness and activate front and rear height correction valves
 - Fluid pressure source is from an engine driven hydraulic pump which provides a constant flow of fluid at a predetermined pressure. The pressure is fed to the spherically shaped accumulator which uses nitrogen as the spring media and a rubber diaphragm to accommodate the volume of stored fluid.
 - Pitch and Roll – Height correction valves vary the volume of incompressible fluid between the sphere diaphragm and the piston. The increased vehicle weight lowers the body, causing the suspension arms to deflect and at the same time rotate the anti roll bar. Angular rotation of the bar is a measure of the suspension's vertical deflection against the vehicle's normal height. The movement of the bar acts on the height correction valves resulting in levelling of the body.
 - Bounce/rebound – when a wheel meets a hump in the road surface the piston is pushed inwards, displacing fluid from the cylinder to the sphere and in doing so the flexible rubber diaphragm squeezes the nitrogen gas into a small space. If the wheel hits a pot hole then the pressurised gas expands and forces fluid from the sphere into the cylinder and moves the piston outwards.

3

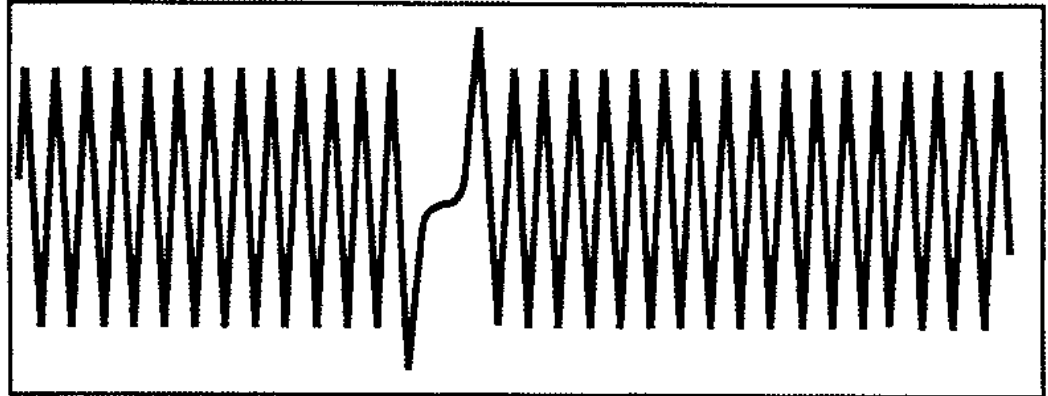
7

(10)

4 (a) (i) Output signals:

Signal from inductive crankshaft pulse generator

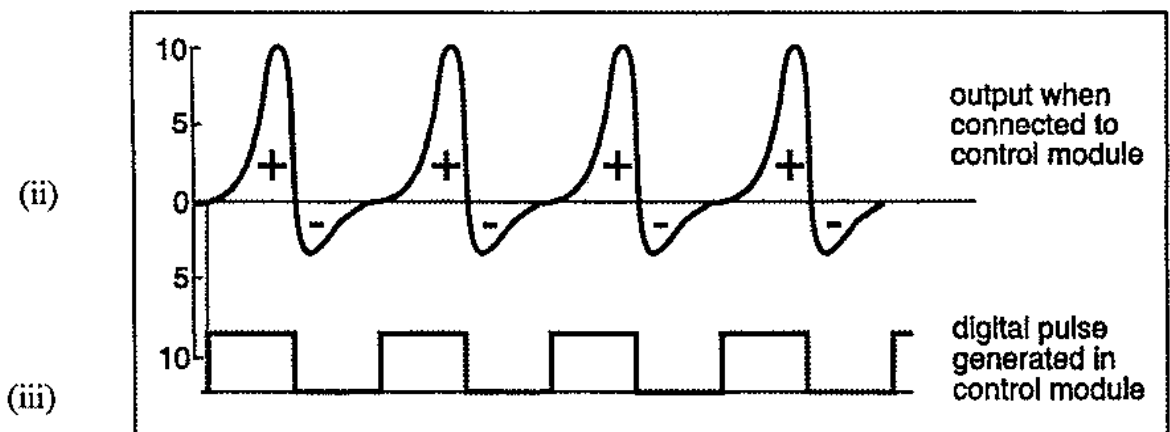
Figure 2



Signals from distributor inductive pulse generator

1

Figure 3



(b) The effect of an increased air gap between component A and the reluctor ring - (inductive pulse generator) - will result in a weak signal being generated resulting in poor performance or an incorrect signal resulting in incorrect positioning of TDC.

1, 2

2

(c) **Generation of signal and information contained:** the candidate should include the following points:

- In Figure 3 the signal from the distributor inductive pulse generator is an AC output generated by a stator and a rotor (trigger wheel) consisting of an annular coil and permanent magnet, the number of teeth corresponding to the number of cylinders of the engine. The AC output signal is sent to the amplifier.
- Each time the arms pass in front of the pick up teeth the magnetic field is diverted and a current is induced into the pick up coil and this is used to trigger the amplifier.

4 (c) continued

- The signal shows the AC output on a time base. The top of the wave is positive and the bottom negative. The distance between the peaks indicates the dwell angle, current limiting time and output stage conductive.

4

(10)

5 (a) Outputs for X for AND gate:-

Inputs		Outputs
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

2

(b) (i) **Condition monitored by:** the candidate should include the following points:

- 11 - Throttle valve sensor/potentiometer senses the position of the throttle valve
- 13 – Air flow sensor detects the volume of air. Monitors the volumetric flow rate M³/H of the air being drawn into the engine
- 15 – Water temperature sensor/temperature sensitive resistor controls the warm up enrichment
- 17 – TDC reference marker and speed sensor provides the engine speed and position signals enabling the ECU to calculate the ignition timing pulses.

4

(ii) **Operation of Lambda sensor:**

- Unit 14 – Lambda sensor, monitors the level of oxygen in the exhaust gases, operating on the closed loop systems to give the most efficient level of exhaust gas conversion, fitted into the exhaust downpipe it monitors the exhaust gas, and supplies a small voltage proportional to the exhaust oxygen content to the engine management unit (ECU). As the air/fuel mixture weakens, the exhaust oxygen content increases and the voltage from the sensor to the ECU also increases. If the mixture becomes richer, the oxygen content will decrease and the voltage supplied to the ECU from the sensor will also decrease. The ECU uses the signal voltage to determine the air/fuel ratio that should be delivered to the engine, and the injector duration is adjusted to maintain that ratio.

4

(10)

6 (a) (i) **Stratified Charging:** the candidate should include the following points:

- Used for control of fuel economy and exhaust emissions
- Layer of mixture next to piston to cushion the effect of the explosion on the piston
- Rich mixture fed into cylinder via a separate pipe past the inlet valve to create a swirling action of the gas
- Weak mixture enters cylinder in normal way, also through the inlet valve
- A vortex comprising of alternative layers of rich and weak mixtures is formed in the cylinder
- Rich proportion of the mixture is directed over the spark plug so that it can be ignited and this in turn ignites the weak mixture.

3

(ii) **Variable valve timing:** the candidate should be able to identify the following:

- Valve timing designed to produce an overlap between the commencement of the inlet valve opening and the closure of the exhaust valve
- Valve overlap designed to make use of the outgoing exhaust gases to create a depression in the cylinder which helps to induce into the cylinder a fresh charge into the combustion chamber when the piston is in the ineffective crank angle position
- The benefits gained are only recognisable at the upper range of the engine speeds and there are no effects at low starting speeds. Efficiency of the engine is increased at high speeds by the effect produced by the improved cylinder charging, but the emissions in the exhaust are slightly increased due to some of the inlet charge being lost out of the exhaust valve because of the increased overlap period.

3

(b) (i) **Positive and Negative offset:** the candidate should include the following points

- Positive offset – obtained by having centre line of the wheel meet the swivel axis line at a point just below the road surface
- Negative offset is when the swivel axis line meets the centre line of the wheel well above the road.

2

(ii) **Front tyre deflation:**

- On a vehicle with negative offset, when tyre failure occurs, the deflated tyre has the tendency to shorten the offset to rob the deflated tyre of leverage to change the direction of the vehicle, especially when the brakes are applied and as a result the vehicle is brought to rest in a straight line and under control.

2

(10)

7 (a) **General condition of engine:** the candidate should include the following points:

- Cylinders 1, 5 and 6 are relatively unaffected by wear and the results indicate that the rings and bore wear are minimal
- Cylinder 2 indicates that the piston rings/cylinder are worn
- Cylinders 3 and 4 indicate that there is a pressure leak between the cylinders – head gasket is blown – crack or fissure in head/block or both, valve, valve seats
- Engine requires dismantling to establish cause of pressure loss in cylinders 3 and 4.

2

(b) **One other test:** cylinder leakage test

In terms of procedure the candidate should include the following points:

- Run the engine to working temperature, if possible
- Remove spark plugs and remove the HT distributor lead
- Set cylinder 3 to TDC on the compression stroke
- Engage top gear and hand brake of vehicle
- Set cylinder leakage tester to zero by connecting tester to the main pressure line of 5 to 10 bar, and rotating the regulator clockwise until the gauge reads zero. Momentarily release the air output connection and check that the gauge returns to zero then re lock the regulator.
- Open valve and note reading on gauge
- Listen into the cylinder 4 for an air escape
- Listen into the exhaust tail pipe, oil filler cap, inlet manifold for air escape
- Look into the cooling system expansion bottle for air bubbles indicating air loss
- Loss of more than 20 percent indicates unacceptable loss.

5

(c) **Three possible causes are:**

- Cylinder head studs loose between 3 and 4 resulting in blown cylinder head gasket
- Loss of coolant resulting in blown cylinder head gasket or crack in the head/block
- Corrosion of head/block resulting in blown cylinder head gasket or crack in the head/block
- Blocked water jacket resulting in blown cylinder head gasket
- Any other acceptable engine fault that could cause the fault will be acceptable.

3

(10)

[END OF MARKING INSTRUCTIONS]

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