EUROPA REFERENCE BOOKS
for Automotive Technology

Automotive Technology
Basic Worksheets

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Preface

"Automotive Technology – Basic Worksheets" contains worksheets for the following subject areas:

Service, **Repairs**, **Diagnosis**, **Conversions and Retrofits**.

The worksheets are designed to form a foundation for operational situations.

- In each subject area, practical situations serve as an introduction to the topical contents. Comprehensive assignments provide the necessary basic technical knowledge. The learning situations found at the beginning of each topic can then be solved with this basic knowledge.
- Clearly outlined assignments can be solved independently in groups or with an instructor with the help of the "Modern Automotive Technology" textbook as well as the reference table.
- Circuit diagrams, maintenance schedules and work plans as well as functional descriptions are chosen such that they can be processed similarly to comparable job-related workflows.
- With the help of the accompanying ESI-Tronic CD, the student can obtain information and work on customised exercises.
- Content on operational organisation, operational communication and quality management can be found in the Service worksheets in the form of practical tasks.
- An example of a vehicle registration certificate, Part I, for registered vehicles in Europe, can be found on the inside back cover. Such documents are required to identify the vehicle during repair work and in locating spare parts in dealerships and auto parts stores.

The following tasks are given in the four subject areas:

1 Service
Maintaining and inspecting vehicles and systems according to specifications.

2 Repairs
Checking, disassembling, exchanging and assembling simple components and systems.

3 Diagnosis
Identify and eliminate malfunctions

4 Conversions and retrofits
Performing customer-driven conversions

The worksheets, along with other vehicle technology textbooks such as "Modern Automotive Technology", Verlag Europa-Lehrmittel (ISBN 978-3-8085-23025), form a complete unit.

They are intended to help in carrying out practice-orientated lessons.

The Authors — Fall 2015

Contents

Worksheets

1 Service

Maintaining and inspecting vehicles and systems according to specifications

2 Repairs

Checking, disassembling, exchanging and assembling simple components and systems

3 Diagnosis

Identify and eliminate malfunctions

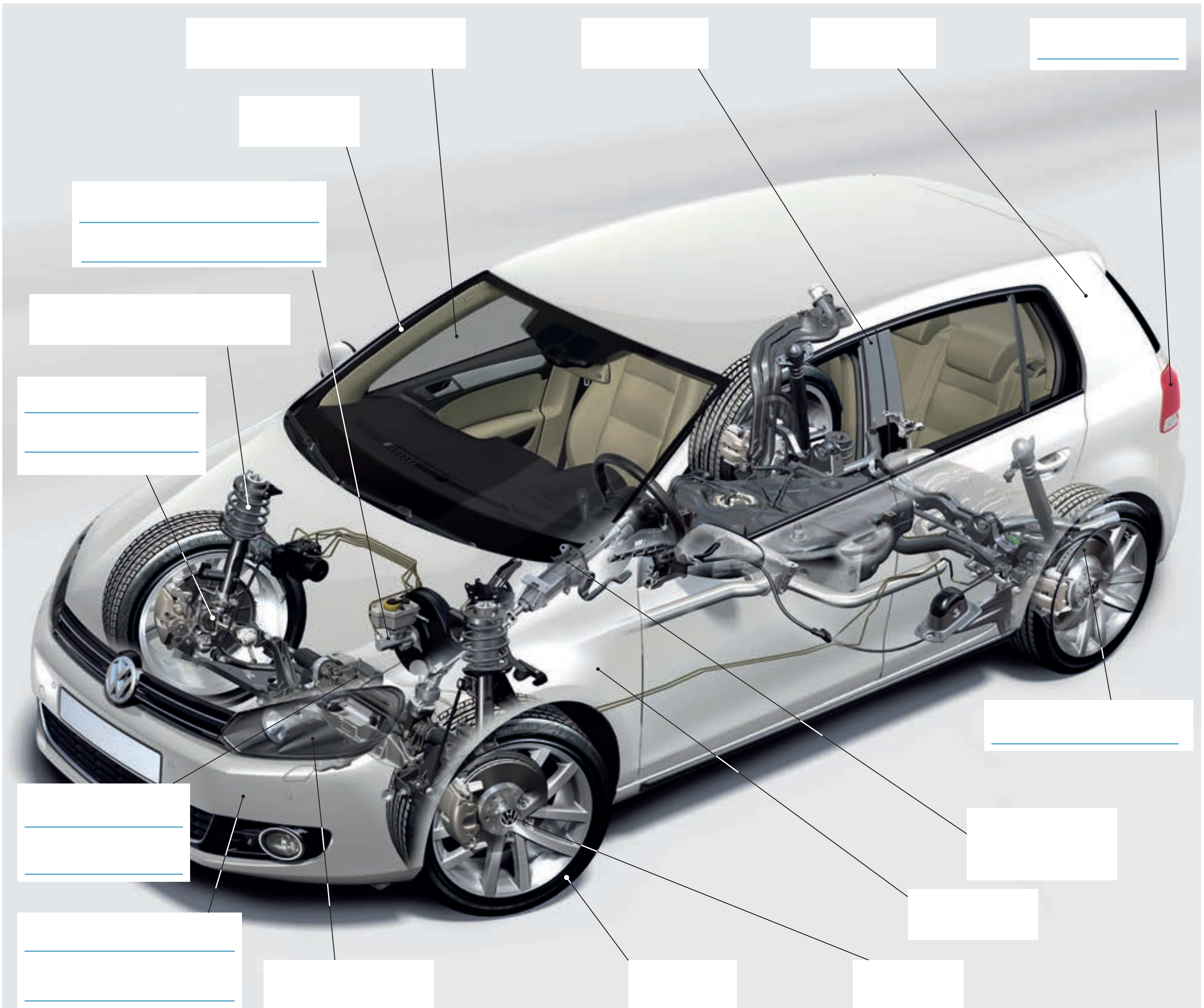
4 Conversions and retrofits

Performing customer-driven conversions

Name:		
Class:	Date:	Sheet No.:

The use of technical terms is required in on- and off-the-job communication.

1. Identify the parts and component groups.

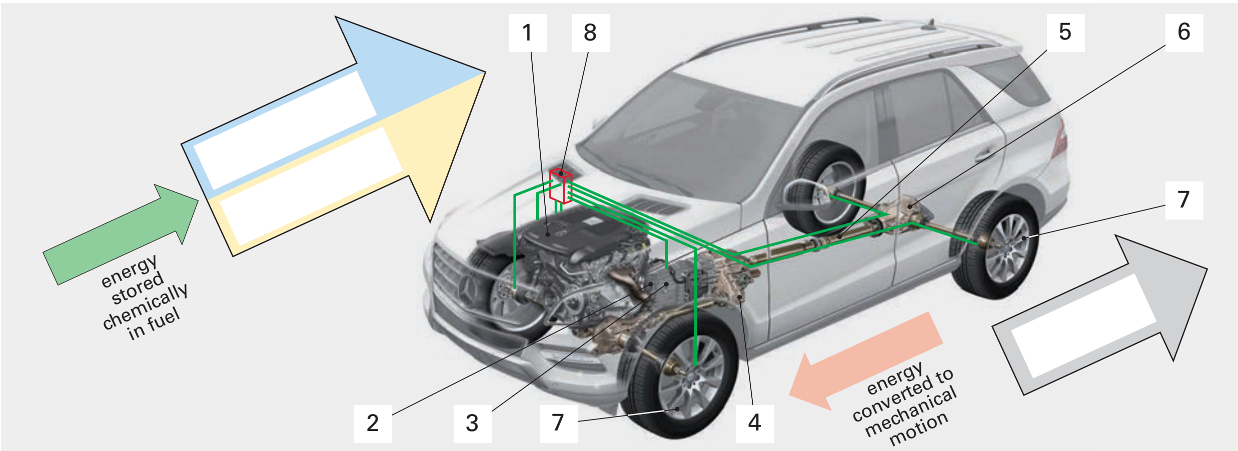


2. Fill in the table with the correct part and its function.

Component-group	Part	Function
Wheel		
Springs, dampers		
Steering		
Lighting-equipment		
Brakes		

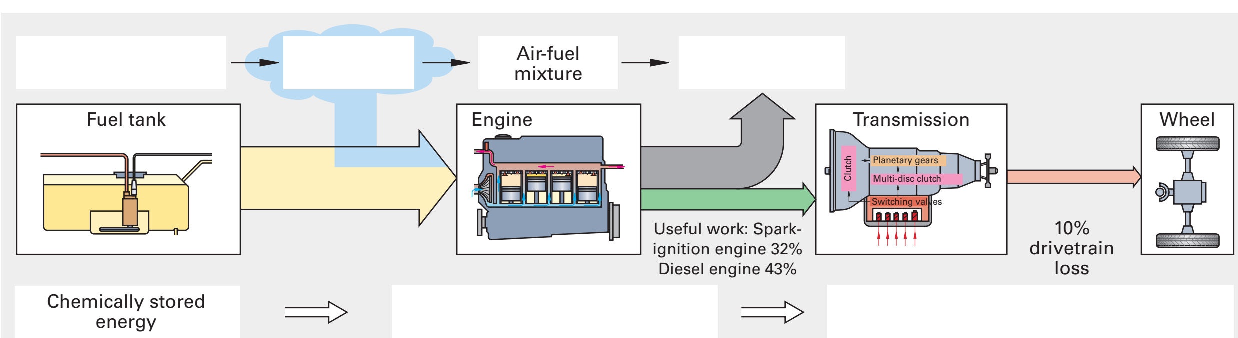
Name:		
Class:	Date:	Sheet No.:

3. Identify the numbered drivetrain subsystems in the table and fill in their functions.



Number labels	Subsystem	Function
1	____________	Converts stored chemical energy into mechanical propulsion.
2	Clutch	____________
3	____________	____________
4	____________	Distributes torque to the front and rear axles in all-wheel-drive vehicles.
5	____________	____________
6	____________	____________
7	____________	____________
8	____________	Collect sensor data, calculate control device parameters, control actuators.

4. In the picture, fill in the vehicle material flow for air, fuel and exhaust and the energy flow.



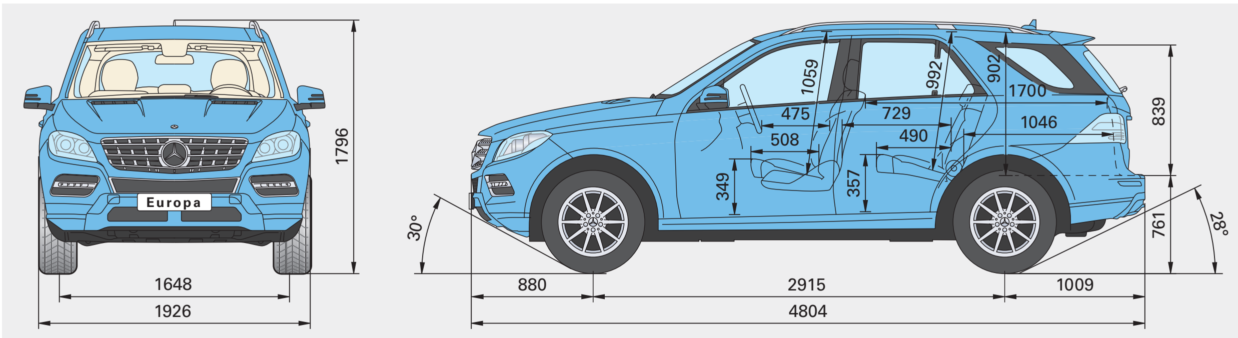
5. How much fuel energy reaches the wheel? How high are the losses? Fill in the table.

Exhaust, cooling, radiation losses in %				Driving power at the wheel in %			
Spark-ignition engine	______	Diesel engine	______	Spark-ignition engine	______	Diesel engine	______

EUROPA LEHRMITTEL	# 1 Service **Motor vehicle classifications, Dimensions**	Name:
		Class: | Date: | Sheet No.:

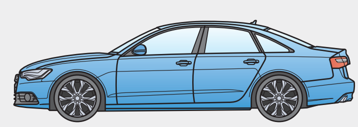
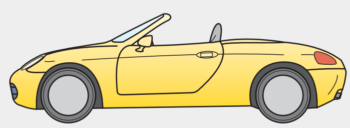
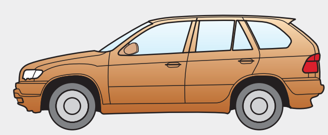
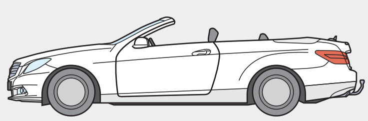
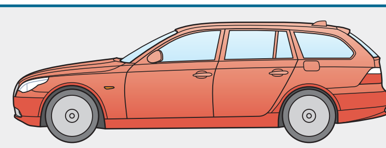
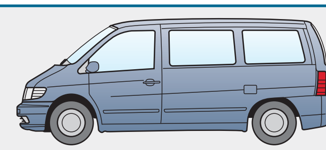
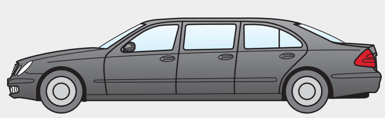
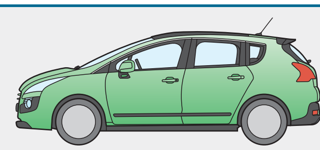
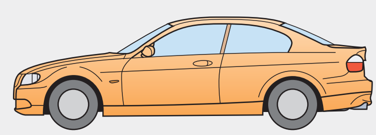
1. **Motor vehicles are divided into the following classifications.**

2. **Fill in the dimensions in the table and add mm or degrees.**



Vehicle length		**Rear seat height**			**1648 mm**
Vehicle height			**2915 mm**	**Approach angle**	

3. **Identify the vehicles below and indicate their special features.**

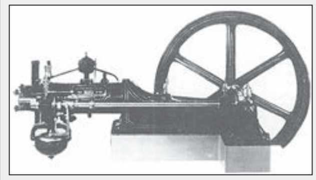
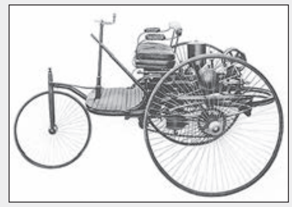
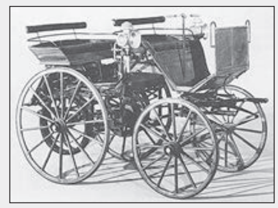
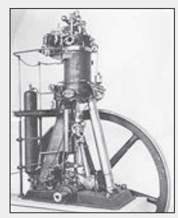
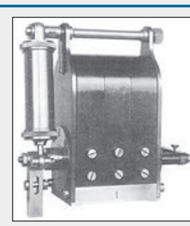
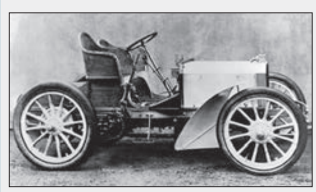
		
		
		
	Crossover	

4. **Which drivetrains are built into today's vehicles?**

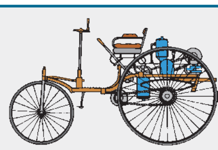
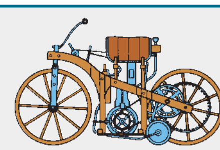
Name:

Class:	Date:	Sheet No.:

1. Which important machines did these individuals invent?

Portrait	Invention	
 Nikolaus August Otto 1832 – 1891		
 Carl Benz 1844 – 1929		
 Gottlieb Daimler 1834 – 1900		
 Rudolf Diesel 1858 – 1913		
 Robert Bosch 1861 – 1942		
 Wilhelm Maybach 1846 – 1929		

2. Use the reference book to determine power, displacement and power density for the pictured vehicles.

				
Power in kW / HP				88 / 120
Displacement in l		2.0		
Power density in kW/l		77.5		146.67

4-stroke spark-ignition engine

Sheet 1

Name:

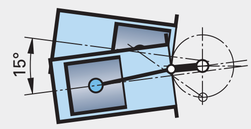
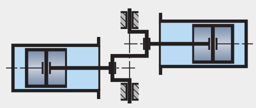
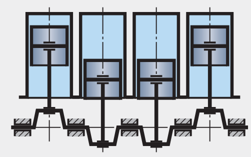
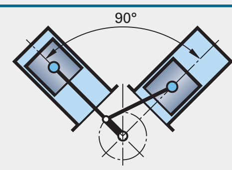
Class: Date: Sheet No.:

Different engine concepts are used for vehicles. Combustion engines can be categorised according to various characteristics.

1. Fill in the table.

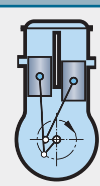
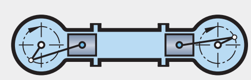
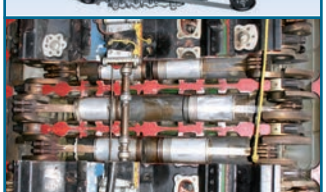
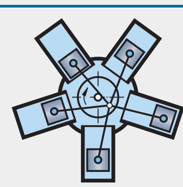
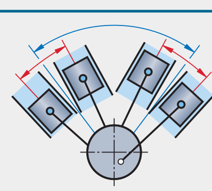
Vehicle					
Engine / Combustion engine categorisation according to type of…					
process				4-stroke	
cylinder motion					
ignition					
cooling					
compressed medium					
injection		direct			
carburetion					
cylinder arrangement				twin-rotor engine	
power control					

2. The cylinder arrangements pictured below are common in 4-stroke piston engines.
   a. Match the engine picture to its construction with an arrow.
   b. Fill in the engine designation and give an example of an application (vehicle).

Figure	Matching	Construction	Description	Example-application
				
				
				
				

3. Other cylinder arrangements are illustrated in the table below. These were or are seldom built.

Fill in the table.

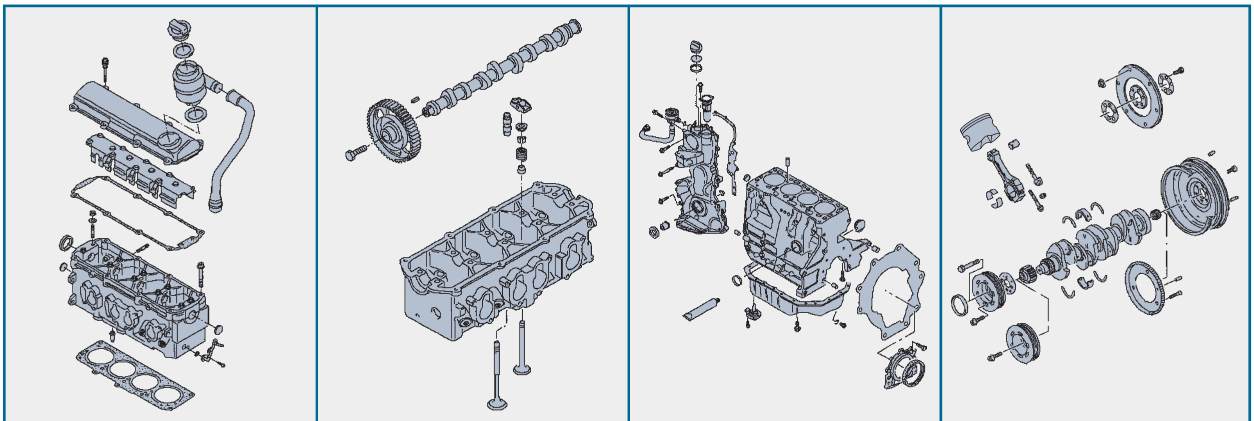
Figure	Matching	Construction	Description	Example application
			Double piston engine with fork connecting rod	Triumph; Puch; Java Motorcycle engines
				Junkers marine, stationary and aircraft engines
				Aircraft engines
				Sports cars

Name:

Class: | Date: | Sheet No.:

As a part of communication within the workshop, it is necessary to be able to identify engine component groups and parts in vehicle engine care and maintenance.

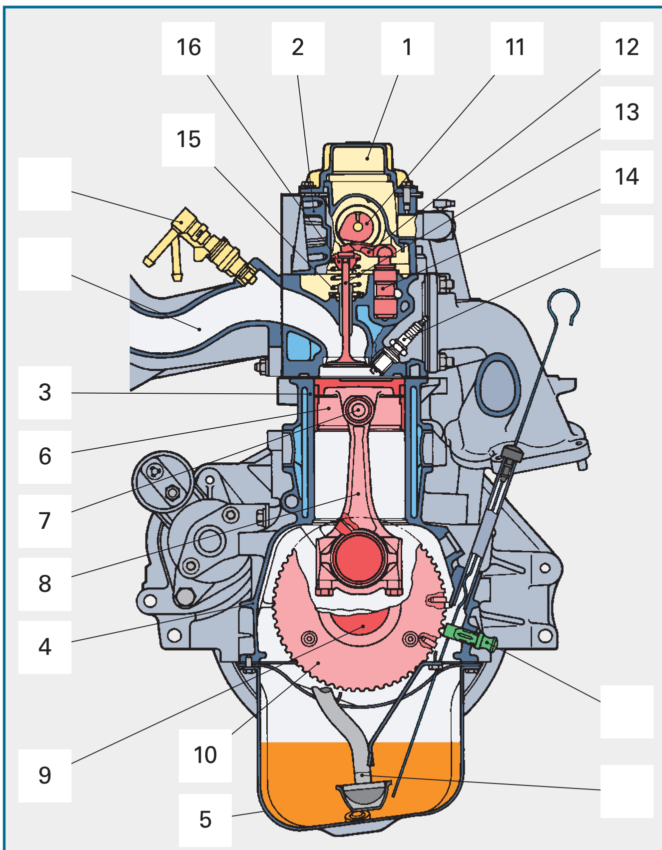
1. Identify the component groups in the exploded views.



________	________	________	________
________	________	________	

2. In the simplified cross-section of a 4-stroke spark-ignition engine, identify the numbered parts and fill in the missing number for the parts given.

3. Mark the crankshaft drive and engine control parts in different colours.



17 Speed sensor	20 Oil-pump strainer/ oil pump
18 Spark plug	21 Fuel injector
19 Intake manifold	

Engine case

1 ________
____

2 ________

3 ________

4 ________

5 ________

Crankshaft drive

6 ________

7 ________

8 ________

9 ________

10 ________

Engine control

11 ________

12 ________

13 ________

14 ________
____

15 ________

16 ________

Situation: You read the following in the magazine "Motor Sport": "...the new turbocharged 4-cylinder 4-stroke engine is a classic short-stroke engine with a 92 mm bore and 60.3 mm stroke. The 1596 cc engine has an 85 kW power output and produces 250 Nm of torque. The compression ratio is 12 to 1. The average fuel economy is 6.1 litres to 100 km..."

1. **Define the following engine-related terminology found in the text and include the respective notation:**

Stroke: ______________________________

Dead centre: ______________________________

____

Displacement: ______________________________

____

Compression space: ______________________________

Crank angle: ______________________________

Compression ratio: ______________________________

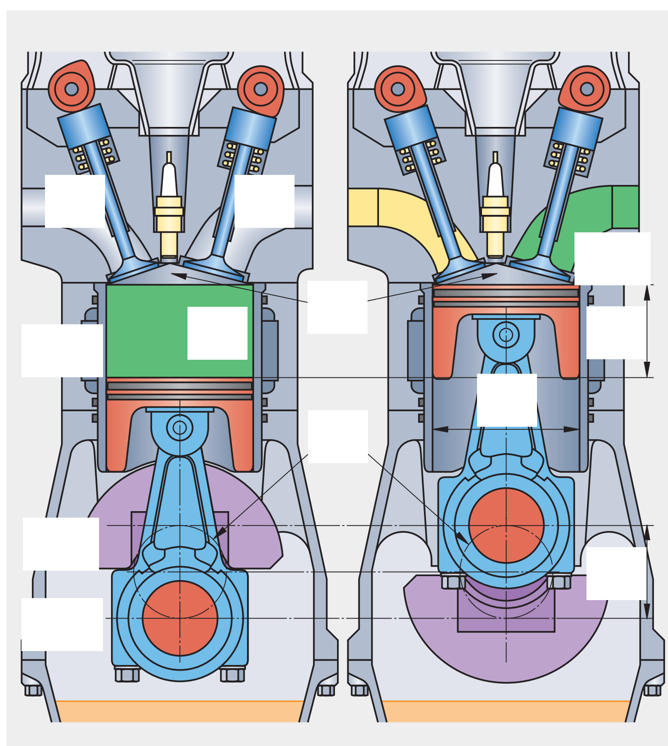
____

2. **Fill in the values corresponding to the terms below that are associated with a 4-stroke engine. An operating cycle consisting of...**

______	strokes	______	crank angle
______	camshaft rotation	______	cam angle
______	crankshaft rotations	______	opening and closing of the inlet and exhaust valves

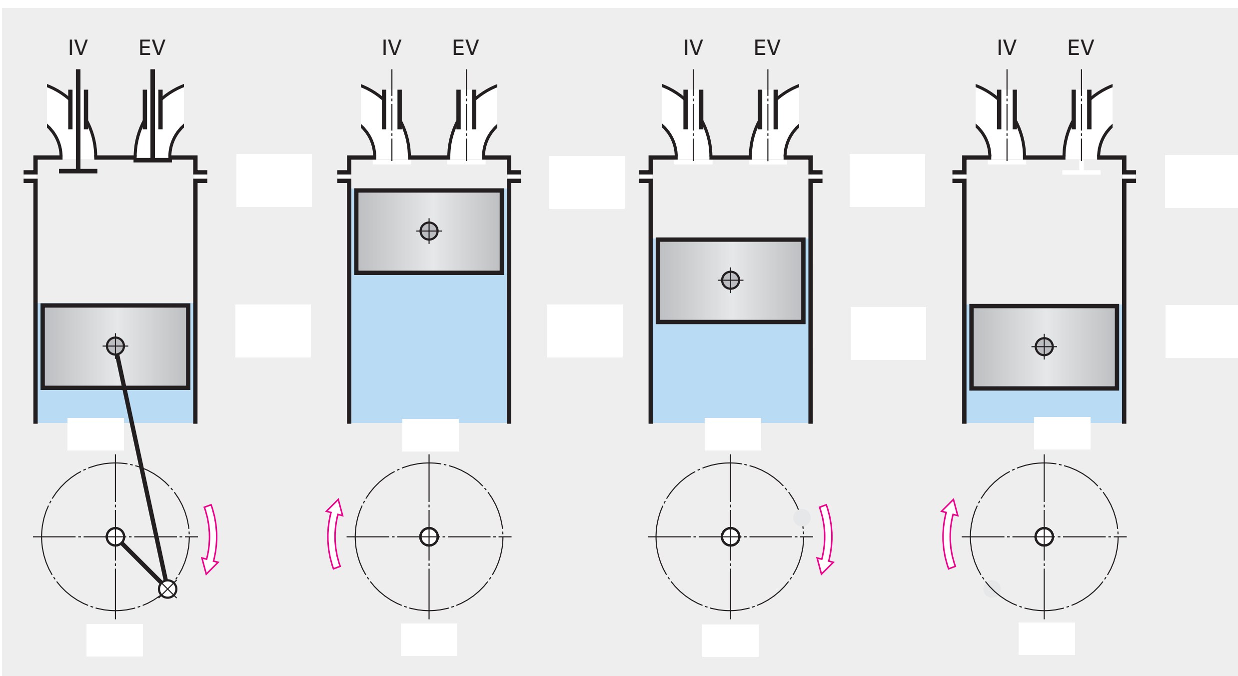
3. **a) Identify the parameters in the table and enter them in the illustration.**
   b) With the part dimensions from the illustration (scale 1:4), calculate V_h.

Notation	Description	Dimension
d	______	______
s	______	______
V_h	______	______
V_C	______	26 cm³
∅-IV	______	______
∅-EV	______	______
∅-Cc	______	______
TDC	______	–
BDC	______	–



4. Identify the individual strokes.
5. Mark the cylinders and the crank circles with TDC and BDC.
6. Mark the direction of cylinder movement with an arrow.
7. Sketch in the connecting rod and crankshaft according to the cylinder's position.
8. Sketch in the valves for each stroke.
9. For each stroke, enter into the table
   – whether the inlet and exhaust valves are open or closed
   – at what crank angle the inlet and exhaust valves open or close
   – the max. temperature in the cylinder
   – the max. pressure in the cylinder.
   Use a reference table.
10. Enter the open and close positions Io, Ic, Eo, Ec in the crank circle of the corresponding stroke.
    Use values from an engine in the reference table.
    Fill the cylinder above the piston with a different colour for each stroke.

1st stroke	2nd stroke	3rd stroke	4th stroke

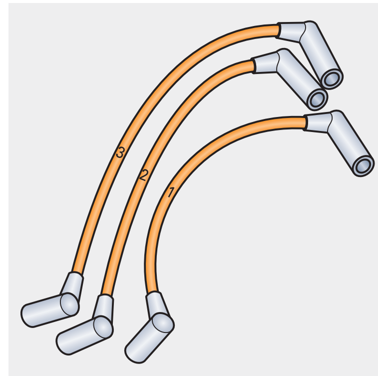


Inlet valve	Inlet valve	Inlet valve	Inlet valve
Exhaust valve	Exhaust valve	Exhaust valve	Exhaust valve
Temperature in cylinder	Temperature in cylinder	Temperature in cylinder	Temperature in cylinder
Pressure in cylinder	Pressure in cylinder	Pressure in cylinder	Pressure in cylinder at Eo

Name:

Class: Date: Sheet No.:

Situation: In the course of servicing a VW Lupo, ignition cables have to be replaced.



1. The new ignition cables are provided with the numbers 1 to 3.
   What do these numbers mean?

   ____

2. The cylinder's numbering and the direction the cylinders are counted are DIN-specified.

   a) Define cylinder 1 according to the standards.

   ____

   ____

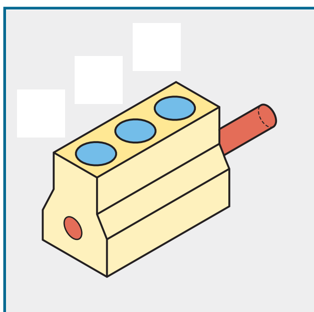
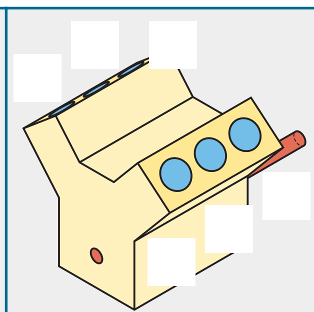
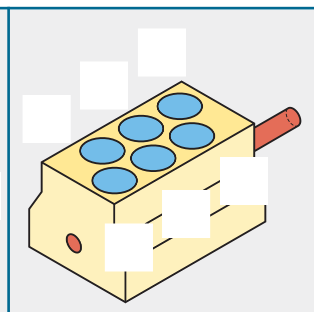
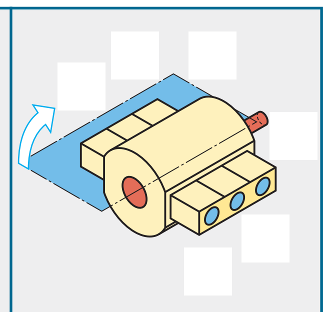
   b) The engine rotates clockwise. What does this mean?

   ____

   ____

3. a) Fill in the cylinder numbering, rotational direction (clockwise) and the construction type of the engine concepts shown according to the DIN Standard.

   b) Indicate the corresponding firing order.

4. What does "firing order" mean?

   ____

   ____

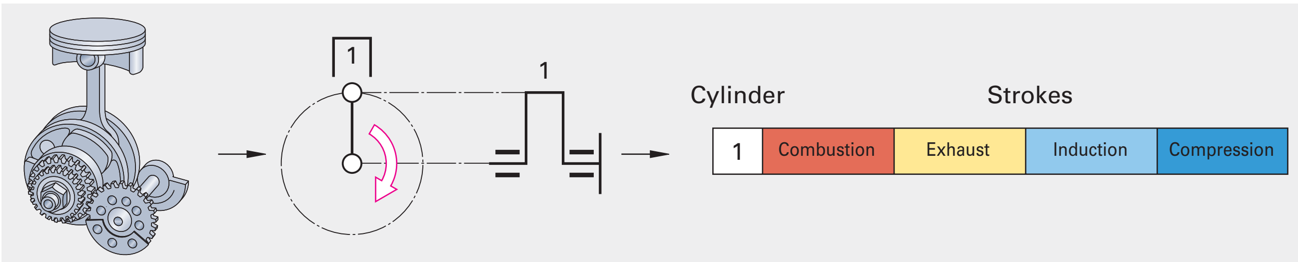
5. Calculate the number of power cycles per minute with an engine speed of 3000 1/min for a 3-cylinder engine and for a 6-cylinder engine.

Given:

6. Describe the term ignition interval and calculate it for a 3-cylinder engine.

$$\text{Ignition interval} = \frac{720°}{z} =$$

7. The crankshaft is cranked according to the ignition interval (figure).
For clarity, the crankshaft is depicted in side and frontal (star diagram) views. The stroke order is shown.



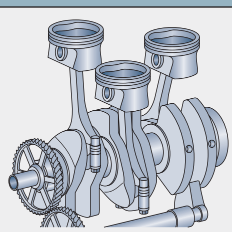
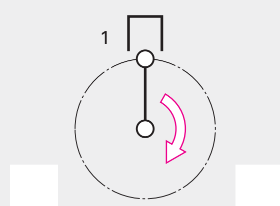
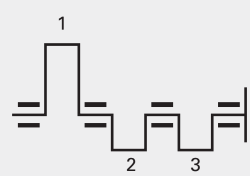
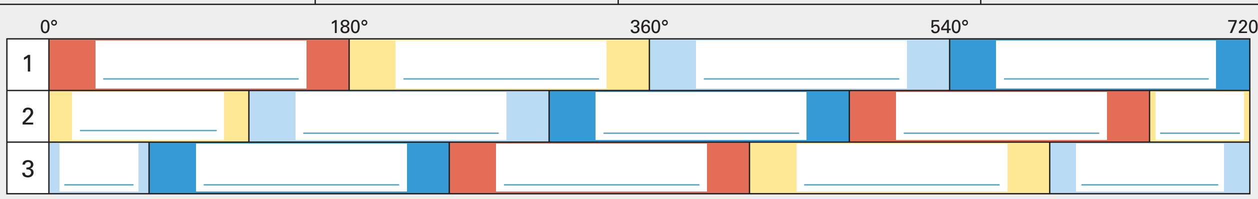
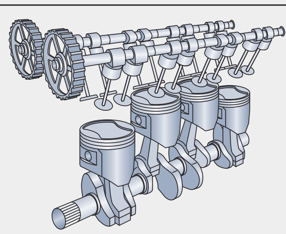
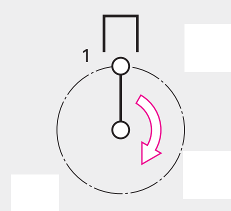
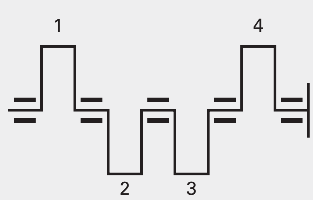
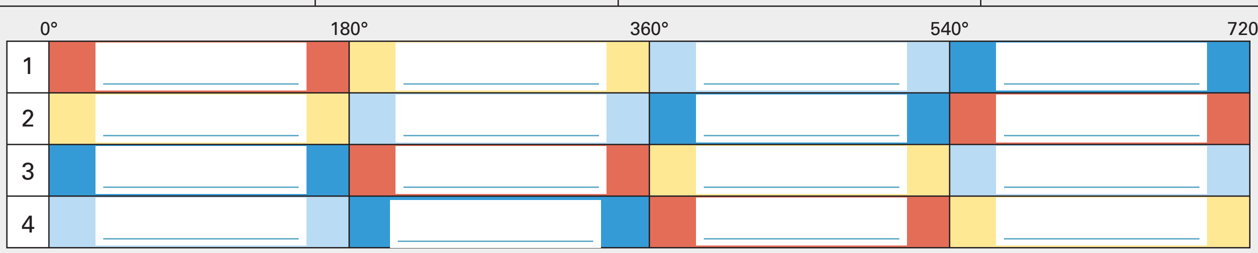
a) Calculate the ignition interval and indicate the firing order.

b) Construct the position of the crank pins (star diagram). Transfer the cylinder numbering to the corresponding crank pin on the star diagram.

Note: Begin with the 1st cylinder. Construct the position of the next crank pin according to the firing order against the direction of rotation by the number of degrees of the ignition interval.

c) Construct the crankshaft side view from the star diagram (with the help of lines).

d) Label the individual stroke of each cylinder.

Engine type	Star diagram	Crankshaft side view	Ignition interval Firing order
			240° Firing order 1 – 3 – 2
			
			
			

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8. The following illustration is a schematic diagram of the crankshaft mechanism for a five-cylinder four-stroke engine.

a) Determine and fill in the firing order.

b) Draw the crank arms for cylinders 2 to 5 onto the crank circle; number the crank pins according to the firing order.

c) Fill in the crankshaft for cylinders 2 to 5; draw the corresponding piston and connecting rod positions.

d) Indicate each piston's direction of movement with arrows.

e) Complete the table with each cylinder's work cycle; indicate the strokes with corresponding colours.

f) Draw the intake and exhaust values in the correct position (the valves should be shown as clearly closed or open).

Timing

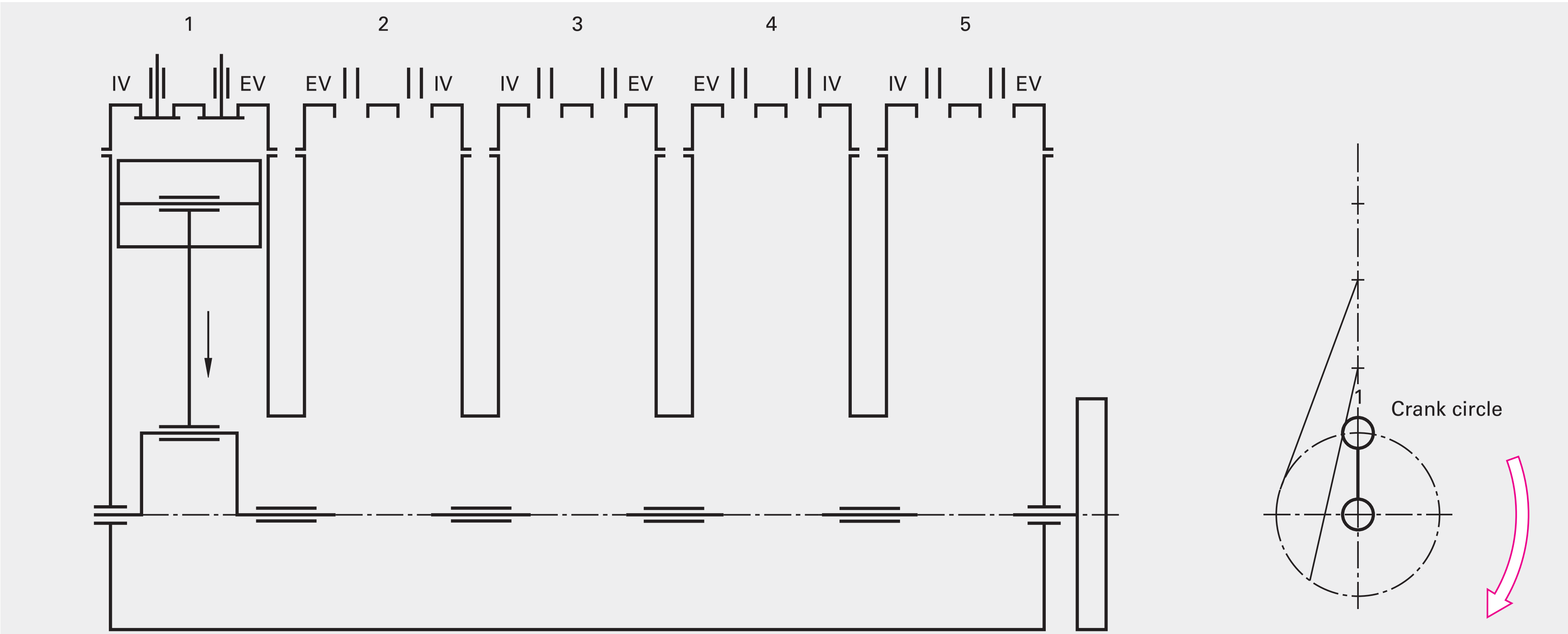
Intake valve opens 6° before TDC
Intake valve closes 44° after BDC

Exhaust valve opens 40° before BDC
Exhaust valve closes 10° after TDC

Cyl.	Strokes				
1	Combustion				
2					
3					
4					
5					

Firing order 1 – 2 – 4 – 5 – 3

Ignition interval =



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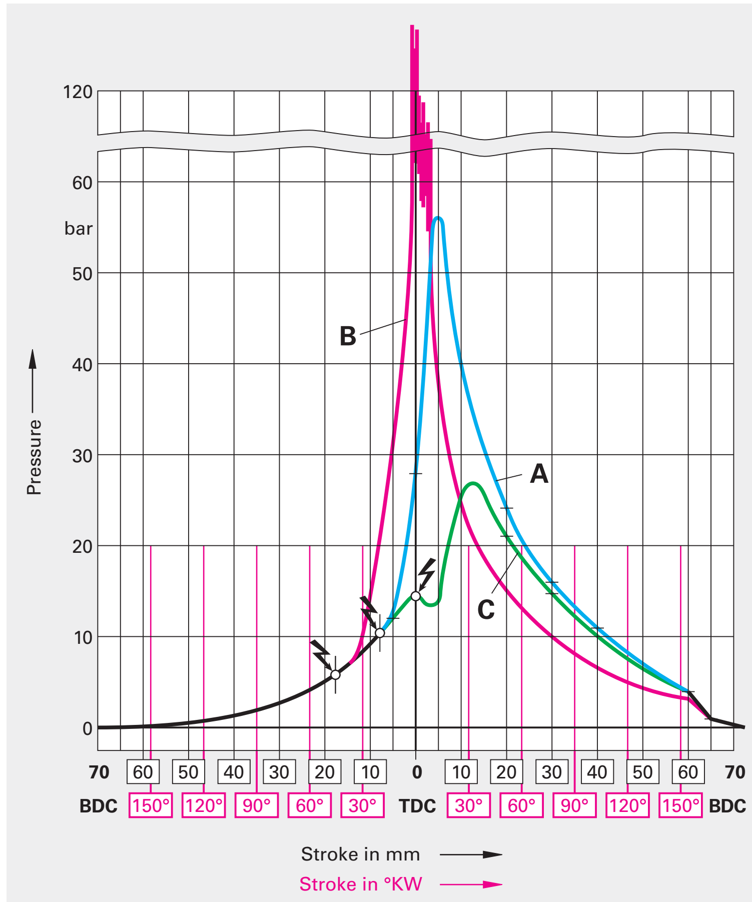
Situation: A spark-ignition engine was optimised on a test stand. Several ignition points were set and the pressure profile recorded. Engine characteristics: Bore x Stroke = 89.9 mm × 70 mm, ε = 10.

1. Evaluate the ignition point in the table with "right", "too late" or "too early". Give the ignition point in crankshaft angle. Describe the effect on the combustion process with "knocking", "adverse", or "optimal".

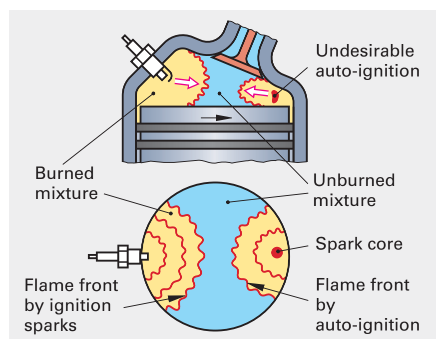
	Curve A	Curve B	Curve C
Ignition point			
in °CA			
Effect on combustion			



2. Indicate the maximum piston pressure on the curve at which the engine properly operates.

3. Explain the process "knocking combustion".

4. What factors cause knocking?



5. What is shown in a PV diagram for a combustion engine?

6. Cylinder pressure relative to the piston stroke can be carried over for the power cycle of a four-stroke engine into a PV diagram.
   a) Divide the axes according to the given scaling and label them. The cylinder pressure should be on the y-axis and piston stroke on the x-axis.
   Scaling: Pressure scale 0.4 bar ≙ 1mm; Stroke scale 1 mm ≙ 0.5 mm piston stroke.
   b) Fill in the missing table values for normal combustion and enter the respective points on the curve. The missing values can be found in Figure 1. Draw the PV diagram for a spark-ignited engine. Indicate the effective work with hatch marks.
   c) Mark the valve opening points in the diagram: IVo mm before TDC, IVc 20 mm after BDC, EVo 10 mm before BDC, EVc 6 mm after TDC.
   d) Mark the curves of the 4 strokes in different colours and give the respective stroke names.

e) Mark the ignition point in the diagram with an arrow.

f) Draw the curves for compression and combustion in retarded (late) ignition.

Piston stroke in mm	0 (TDC)	5	10	20	30	40	50	60	65	70 (BDC)
Induction 0° … 180° p_e in bar	0	– 0.3	– 0.3	– 0.3	– 0.3	– 0.3	– 0.3	– 0.3	– 0.3	– 0.3
Compression 180° … 360° p_e in bar	28.0		9.2	5.0	2.4	1.2	0.6	0	– 0.1	– 0.3
Combustion 360° … 450° p_e in bar			40.0		16.0		7.0	4.0	1.0	0.3
Exhaust 540° … 720° p_e in bar	0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

7. Calculate the missing values for the engine in the table. In the diagram, draw the combustion type with the corresponding ignition point.

   Note: the middle indexed pressure is the average of all pressures within the work cycle.

	Middle pressure in bar	Piston force in N	Indexed work in J/kJ
Normal ignition	18.7		
Late ignition	10.9		

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Situation: You are to carry out work on the engine pictured below.

1. How can you tell that it is a diesel engine?

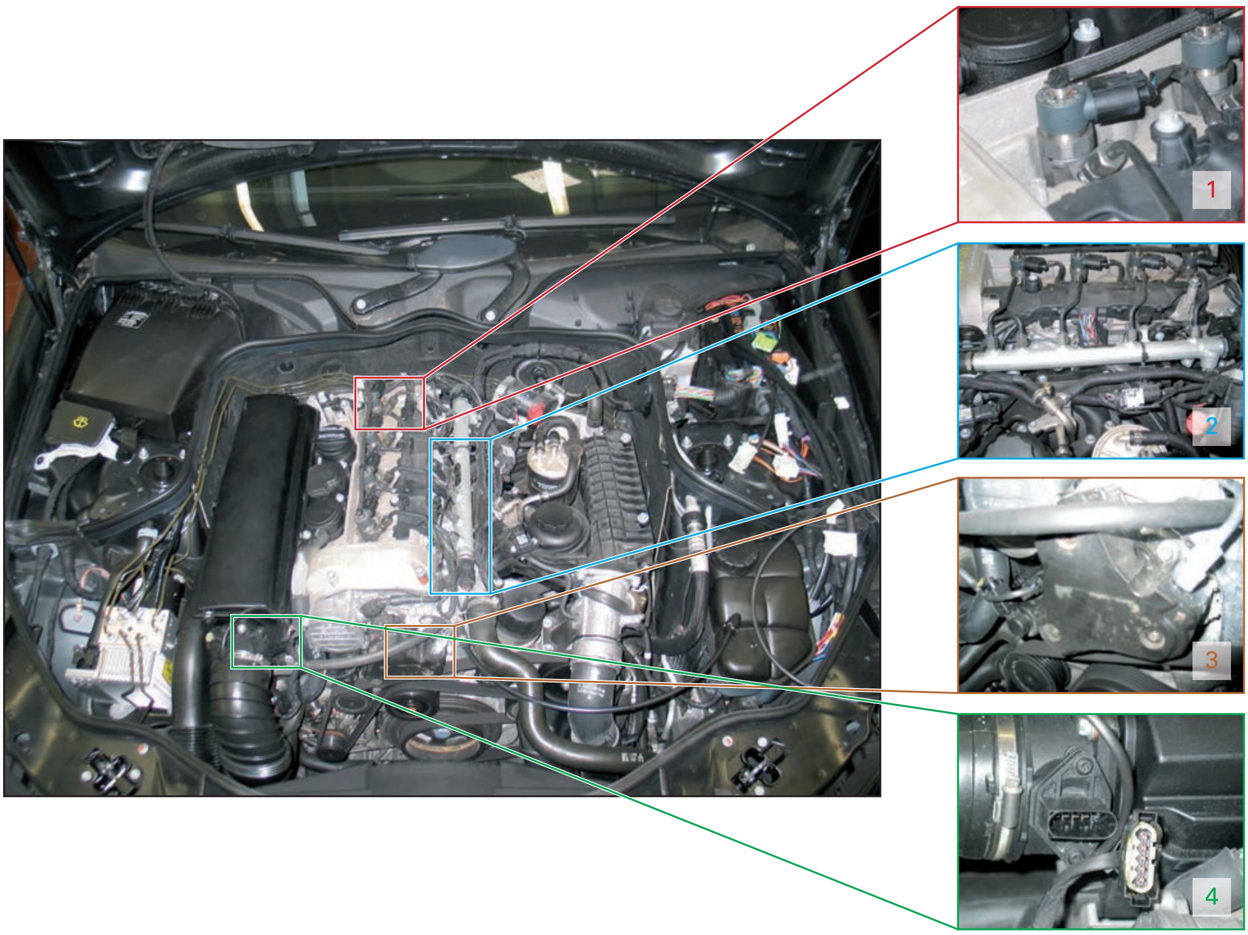
___

2. a) Match the numbers on the pictures to their respective part names.

___	Rail	___	Air flowmeter	___	pressure pump	___	injector

b) Components that send information to the control unit are called sensors. Components that receive commands from the control unit are called actuators. To which component group do the red and green marked components belong?

red = ___ green = ___



3. a) Fill in the missing vehicle data with help from a reference table.

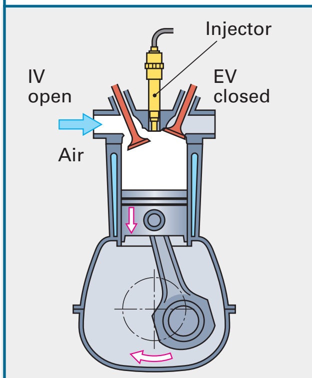
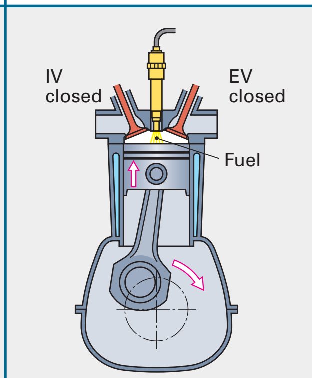
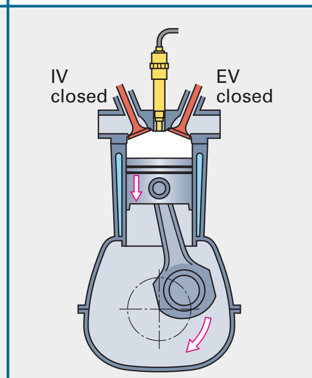
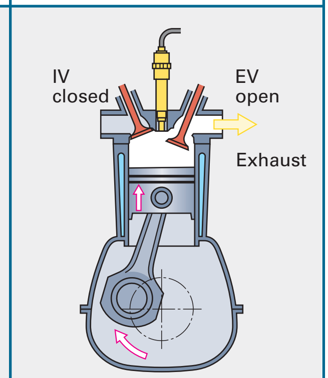
Vehicle		Smart cdi 0.6	VW Golf 1.9 TDI	Audi Q7 3.0 TDI
Effective power / Nominal speed	kW / 1/min			
Max. torque / speed	Nm / 1/min			
CO_2 emissions	g/km			
Fuel consumption	l/100 km			

b) Diesel vehicles are hugely popular. Today, 50% of registered new vehicles are diesel. Give reasons for this development.

___

___

4. a) In line 1 of the table, name the individual strokes for a turbocharged diesel engine.
b) Fill the cylinder space above the piston in a different colour for each stroke.
Air Compressed air Burned fuel-air mixture Exhaust
c) Enter the max. cylinder pressure and temperature for each stroke.
d) In line 5 of the table, fill in the essential processes for each stroke.

1st stroke	2nd stroke	3rd stroke	4th stroke
			
Cylinder pressure	Cylinder pressure	Cylinder pressure	Cylinder pressure
Cylinder temperature	Cylinder temperature	Cylinder temperature	Cylinder temperature

5. The pressure profile during the 4 strokes of a work cycle in a running engine is recorded with a pressure sensor.
a) The curves were recorded for a spark-ignited engine and a diesel engine, both at full load. Match each process to its respective pressure profile.
b) Mark the 4 strokes: Induction Compression Combustion Exhaust
c) In the diagram, mark the ignition point for the spark-ignited engine and the injection process start for the diesel engine.
d) In the illustration, the pressure profile of a naturally aspirated diesel engine is shown. How would the PV diagram differ with a turbocharged engine?