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УКРАЇНИ**

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**курсів спеціальності**  
**«Автомобілі і автомобільне господарство»**

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## Передмова

Головною метою навчання іноземної мови спеціального вжитку є оволодіння мовою не лише як інформативним засобом, але й інструментом спілкування у професійно-орієнтованих комунікативних ситуаціях майбутньої фахової діяльності.

Запропонований навчальний посібник складається із IV розділів. Розділи I – III містять автентичні науково-технічні тексти, що призначені для аудиторного читання. Комплекс післятекстових вправ спрямований на розвиток навичок усного мовлення та засвоєння нових лексичних одиниць і термінів, що використовуються у професійній сфері спілкування. У IV розділі подано тексти, які призначені для домашнього читання.

# Contents

<b>Part I.....</b>	<b>5</b>
<b>Lesson 1. Essential parts of an automobile.....</b>	<b>5</b>
<b>Unit 2. Types of Waves.....</b>	<b>8</b>
<b>Unit 3. Speed of Waves.....</b>	<b>10</b>
<b>Unit 4. Interactions of Waves.....</b>	<b>13</b>
<b>Unit 5. Electromagnetic Waves.....</b>	<b>16</b>
<b>Unit 6. Type of Waves.....</b>	<b>19</b>
<b>Part II.....</b>	<b>22</b>
<b>Unit 1. Infrared Rays.....</b>	<b>22</b>
<b>Unit 2. Visible Light.....</b>	<b>25</b>
<b>Unit 3. Wave or Particle?.....</b>	<b>29</b>
<b>Unit 4. Reflection of Light.....</b>	<b>31</b>
<b>Unit 5. Reflection and Mirrors.....</b>	<b>34</b>
<b>Unit 6. Refraction of Light.....</b>	<b>37</b>
<b>Unit 7. Optical Instruments.....</b>	<b>40</b>
<b>Unit 8. Lasers.....</b>	<b>43</b>
<b>Unit 9. Fiber Optics.....</b>	<b>47</b>
<b>Part III.....</b>	<b>52</b>
<b>Unit 1. A Halogen Lamp.....</b>	<b>52</b>
<b>Unit 2. LED Lamp.....</b>	<b>54</b>
<b>Unit 3. Electroluminescent Wire.....</b>	<b>57</b>
<b>Unit 4. Black Light.....</b>	<b>59</b>
<b>Unit 5. Compact Fluorescent Lamp (CFL).....</b>	<b>62</b>
<b>Unit 6. Plasma Lamps. ....</b>	<b>65</b>
<b>Unit 7. Architectural Lighting Design.....</b>	<b>68</b>
<b>Part IV.....</b>	<b>70</b>
<b>Additional reading.....</b>	<b>70</b>

## Part I

### Lesson 1. Essential parts of an automobile.

#### Vocabulary notes:

<b>simultaneously</b> – одночасно;	<b>alternator</b> – генератор;
<b>internal combustion engine</b> – двигун внутрішнього згоряння;	<b>fuel pump</b> – паливний насос;
<b>combustion chamber</b> – камера згоряння;	<b>sparkplug</b> – свічка запалювання;
<b>to ignite</b> – запалювати;	<b>headlights (headlamps)</b> – фари головного світла;
<b>power stroke</b> – (такт розширення) робочий хід;	<b>dashboard</b> – панель інструментів;
<b>timing</b> – (тут) синхронність;	<b>fuse</b> – запобіжник;
<b>drivetrain</b> – силова передача (привідний механізм);	<b>body</b> – кузов;
<b>transmission</b> – трансмісія, коробка передач;	<b>fiberglass</b> – скловолокно;
<b>gear differential</b> – диференціал з шестернями;	<b>bonnet (hood Am.E)</b> – капот;
<b>tank</b> – паливний бак;	<b>grille</b> – решітка радіатора;
<b>injector</b> – форсунка, інжектор;	<b>boot (trunk Am.E) lid</b> – кришка багажника;
<b>exhaust system</b> – вихлопна система (система випуску відпрацьованих газів);	<b>drag</b> – аеродинамічний (лобовий) опір;
<b>frame</b> – рама;	<b>tyre (tire Am.E)</b> – шина;
<b>steering system</b> – система рульового керування;	<b>to pinch</b> – затискати;
<b>suspension system</b> – ходова частина;	<b>brake pad</b> – гальмівна колодка (дискових гальм);
<b>via</b> – через;	<b>caliper</b> – супорт;
	<b>brake shoe</b> – гальмівна колодка (барабанних гальм);
	<b>fuel gauge</b> – показчик рівня палива;
	<b>rotation</b> – оберти;
	<b>leak</b> – протікання

#### Essential parts of an automobile.

Automobiles are made up of many small components that form complex systems, all of which work together for you to drive the car. The car is a complex machine with several systems functioning **simultaneously**. While most modern cars contain computerized systems that are beyond the understanding of all but the most specialized technicians, knowing the basic parts of a car and how they function makes it easier to notice problems, perform basic repairs and drive more responsibly.

#### The Engine

Every car is powered by an engine, and most cars use an **internal combustion engine** that runs on (petrol) gasoline or diesel. Fuel, along with air, is drawn into a **combustion chamber** where it is compressed and **ignited** by a spark. The resulting combustion provides a **power stroke** that, when repeated

rapidly, powers the car. Engines are often referred to by the number of cylinders they have, and each cylinder contains its own combustion chamber. A car's overall power is a function of the size of the engine as well as factors such as the **timing** of the combustion and the type of transmission used.

### **The drive train**

The drive train is the system that generally makes your car move. It includes the engine, which burns fuel to produce the mechanical energy that moves the car, as well as the **transmission**, which changes the **gear differential** to use the power produced by the engine efficiently. It can also include the fuel system, consisting of the **tank**; various filters, fuel **injectors** or carburetors; the **exhaust system**, which removes the engine's waste products; the cooling system, which prevents the engine from overheating, and the braking system, which stops the car.

### **Chassis**

The chassis of the car contains the skeletal **frame** of the car. The most notable components of the chassis are the **steering system**, which allows you to turn the wheels and change direction; the **suspension system**, which keeps the wheels on the ground, prevents a bumpy ride and stabilizes the steering; the frame that supports all the car's parts and keeps them together, and the wheels.

### **The Electrical System**

A car's electrical system is powered by a rechargeable battery that draws its power from the engine itself. The battery – which is charged by the running engine **via** the **alternator** – is used to start the car, providing the initial motion of the engine and powering devices such as the **fuel pump**, starter, car's computer which micromanages many of the sensitive components, as well as the engine's **spark plugs**, **headlights**, interior and **dashboard** lights, and stereo system. Most cars also have additional uses for the electrical system such as power automatic windows or door locks. All of these electrical items are wired to the battery with a series of **fuses** ensuring that the electrical system can continue to function even if one part fails.

### **The body**

Much engineering goes into designing the car's body, which is composed of the metal, plastic or **fiberglass** pieces that cover the **hood**, roof, doors and sides of the car. It also includes the bumpers, windows, **grille** and **trunk lid**. The design of the car body must attempt to minimize **drag** to increase fuel efficiency, as well as be aesthetically appealing to the driver.

### **Brakes and Wheels**

Various types of wheels and **tyres** are useful for driving under specific conditions. All-season tires, for example, have the versatility of being used throughout the year, even if severe conditions occur. A car's brakes are one of its most important safety features and generally come in one of two types: disc or drum. Disc brakes use a disc, which is **pinched** between **brake pads** mounted on **calipers** to slow the motion of the car. Drum brakes use **shoes** that push outward to contact the inside of a spinning cylinder, or drum. Some cars contain

both types of brakes (one type for the front wheels, another for the rear wheels) to take advantage of the best each type of braking system has to offer.

### **Dashboard Instruments**

One of the most visible parts of a car is its instrumentation. Most drivers are aware of the speedometer and **fuel gauge**, but other **dashboard** instruments are equally important. A tachometer, which displays engine speed in **rotations** per minute (RPM), indicates how hard the engine is working. An oil pressure gauge or engine temperature gauge can be useful in diagnosing common problems, such as a **leak** of oil or engine coolant respectively. Stopping a car when oil pressure begins to drop or temperature begins to rise can avoid catastrophic engine failure.

### **Exercise 1. Answer the following questions.**

1. What are the main component parts of an automobile? 2. What is the engine? 3. Explain the operating principle of the engine. 4. What is the drive train and what parts does it consist of? 5. What are some basic components of the chassis? 6. What is the purpose of the vehicle's electrical system? 7. What is the alternator used for? 8. What parts does the car's body consist of? 9. What types of brakes are used in the car? 10. What is a dashboard? 11. Name some dashboard instruments. 12. What do you think is the most important part of the automobile?

### **Exercise 2. Translate the following words and word combinations into Ukrainian.**

complex systems, powered by an engine, runs on petrol, spark, combustion chamber, type of transmission, to use efficiently, the fuel system, overheating, braking system, wheels, bumpy ride, starter, power automatic windows, trunk lid, driving under specific conditions, rotations per minute, oil pressure gauge, engine coolant, catastrophic engine failure

### **Exercise 3. Translate the following words and word combinations into English.**

працювати одночасно, дизельний двигун, згорання, ефективно використовувати, паливна система, запобігати перенагріванню, скелет автомобіля, змінювати напрям руху, ходова частина, колесо, шина, рама, економія пального, зменшити аеродинамічний опір, барабанні гальма, супорт, передні/задні колеса, оберти за хвилину, охолоджувальна рідина, пошкодження двигуна

### **Exercise 4. Match the term with its Ukrainian equivalent.**

- |                                      |                                 |
|--------------------------------------|---------------------------------|
| 1) <b>internal combustion engine</b> | a) двигун внутрішнього згорання |
| 2) <b>power stroke</b>               | b) система рульового керування  |

- |                              |                                  |
|------------------------------|----------------------------------|
| 3) <b>combustion chamber</b> | c) фари ГОЛОВНОГО СВІТЛА         |
| 4) <b>injector</b>           | d) показчик рівня палива         |
| 5) <b>suspension system</b>  | e) запобіжник                    |
| 6) <b>headlights</b>         | f) капот                         |
| 7) <b>fuse</b>               | g) форсунка, інжектор            |
| 8) <b>hood</b>               | h) (такт розширення) робочий хід |
| 9) <b>fuel gauge</b>         | i) ходова частина                |
| 10) <b>steering system</b>   | j) камера згоряння               |

**Exercise 5. Fill in the blanks with appropriate words.**

1. A ... is the part of an engine in which fuel is burned.

- |                    |                       |                      |                        |
|--------------------|-----------------------|----------------------|------------------------|
| a) combustion room | b) combustion chamber | c) combustion camera | d) combustion cylinder |
|--------------------|-----------------------|----------------------|------------------------|

2. In motor vehicles the ... adapts the output of the internal combustion engine to the drive wheels.

- |          |             |               |                 |
|----------|-------------|---------------|-----------------|
| a) frame | b) injector | c) transistor | d) transmission |
|----------|-------------|---------------|-----------------|

3. A spark ... delivers electric current to ignite the mixture of air and fuel in the combustion chamber.

- |         |        |         |         |
|---------|--------|---------|---------|
| a) plug | b) bug | c) drag | d) fuse |
|---------|--------|---------|---------|

4. The ... system removes the engine's waste products.

- |           |         |               |            |
|-----------|---------|---------------|------------|
| a) intake | b) pipe | c) suspension | d) exhaust |
|-----------|---------|---------------|------------|

5. ... system allows a vehicle to follow the desired direction.

- |          |             |               |            |
|----------|-------------|---------------|------------|
| a) Brake | b) Steering | c) Suspension | d) Exhaust |
|----------|-------------|---------------|------------|

6. The car draws its electrical power from ..., which is charged by the running engine via the alternator.

- |            |              |                  |         |
|------------|--------------|------------------|---------|
| a) battery | b) generator | c) power station | d) hood |
|------------|--------------|------------------|---------|

7. The ... system keeps the wheels on the ground, prevents a bumpy ride and stabilizes the steering.

- |            |             |               |             |
|------------|-------------|---------------|-------------|
| a) exhaust | b) steering | c) suspension | d) ignition |
|------------|-------------|---------------|-------------|

8. A ... is a lamp attached to the front of a vehicle to light the road ahead.



- a) rear light            b) front light            c) headlight            d) taillight

9. The ... of an automobile is the vehicle's main storage compartment located at the rear part of the vehicle.

- a) tank            b) boot            c) bank            d) bonnet

10. A ... brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers.

- a) drum            b) hand            c) head            d) disc

### Exercise 6. Translate the following sentences into English.

1. Будь-який автомобіль складається з трьох основних частин: двигуна шасі і кузова. 2. Шасі складається із трансмісії, ходової частини, механізму керування. 3. До механізмів керування належать рульове керування, що призначене для зміни напрямку руху автомобіля та гальмівна система, яка призначена для зниження швидкості автомобіля аж до повної його зупинки. 4. У легкових автомобілях двигун може розташовуватися в його передній або задній частині. 5. Двигун внутрішнього згоряння – найпоширеніший тип двигуна, що використовується у більшості транспортних засобів. 6. Паливна суміш потрапляє в камеру згоряння, де вона стискається та запалюється іскрою. 7. Система охолодження – це система, що призначена для охолодження двигунів та інших частин автомобіля і підтримання їх в оптимальному температурному режимі (operating temperature). 8. До найважливіших елементів шасі автомобілів відносяться трансмісія, рульове керування або механізм керування та гальмівна система. 9. Механізм керування автомобілем складається з двох систем: рульового керування і гальмової системи. 10. Електрообладнання автомобіля (car electrical equipment) служить для запуску двигуна, внутрішнього освітлення автомобіля, освітлення дороги, звукової і світлової сигналізації, а також живить електричним струмом контрольно-вимірювальні прилади і систему запалювання. 11. Кузов кріпиться до рами автомобіля. 12. Дискові гальма, як правило, ефективніші ніж барабанні. 13. Всесезонні шини – це шини, розроблені спеціально для використання протягом усього року при різних погодних умовах. 14. Тахометр – це прилад, що вимірює кількість обертів двигуна за хвилину. 15. Тиск масла – це важливий показник стану двигуна.

## Lesson 2. The Internal Combustion Engine

### *Vocabulary notes:*

**Internal combustion engine** – двигун **camshaft** – карданний вал, внутрішнього згоряння; кулачковий вал;

<b>rotary</b> – обертальний;	<b>combustion chamber</b> – камера
<b>reciprocating</b> – зворотно-поступальний;	згоряння;
<b>crankcase</b> – картер;	<b>flywheel</b> – маховик;
<b>crankshaft</b> – карданний вал;	<b>valve</b> – клапан

### Text A.

Internal combustion is the process of the burning of fuel within the engine. The fuel burns within the engine and provides forces. These forces provide the engine power. Internal combustion engines have stationary, **rotary** and **reciprocating** parts. *Stationary Engine Parts.* The stationary engine parts are the cylinder block, the **crankcase** and the cylinder head. The cylinder block is one of the basic parts of the engine. The process of combustion takes place within the cylinders. The crankcase is a part of the cylinder. It supports the **crankshaft** and the **camshaft** and keeps the lubricating oil near the engine parts. The cylinder heads close the cylinders. The cylinders and the cylinder heads form the **combustion chamber**. The burning of fuel takes place within the combustion chambers.

*Rotary Engine Parts.* Rotary engine parts are the crankshaft, the **flywheel** and the camshaft. The crankshaft changes reciprocating motion of pistons to rotary motion. The camshaft opens the **valves** of the engine.

### **Exercise 1. Answer the following questions.**

1. What process takes place in internal combustion engines? 2. What does the burning of fuel provide? 3. What are the basic parts of the internal combustion engine? 4. What are the stationary engine parts? 5. What does the crankcase support? 6. What is the function of the cylinder heads? 7. What do cylinders and cylinder heads form? 8. Where does the burning of fuel take place? 9. What are the rotary engine parts? 10. What is the function of the crankshaft? 11. What does the camshaft open?

### **Exercise 2. Give Ukrainian equivalents for the following terms and phrases.**

the process of the burning of fuel, within the engine, the engine power, the cylinder head, the cylinder block, keeps the lubricating oil, the combustion chamber, the camshaft, the crankshaft, reciprocating motion of pistons, rotary motion, valves of the engine

### **Exercise 3. Give English equivalents for the following terms and phrases using the text.**

процес внутрішнього згоряння, нерухомі частини, зворотно-поступальні частини, блок циліндрів, один із основних деталей двигуна, відбуватися у

циліндри, утримувати мастило, камера згоряння, маховик, обертання (обертальний рух), поршень, відкривати клапани

**Exercise 4. Match the term with its Ukrainian equivalent.**

- |                         |                              |
|-------------------------|------------------------------|
| 1) engine power         | a) картер                    |
| 2) combustion           | b) розподільний вал          |
| 3) crankcase            | c) клапан                    |
| 4) crankshaft           | d) маховик                   |
| 5) camshaft             | e) зворотно-поступальний рух |
| 6) to lubricate         | f) колінчастий вал           |
| 7) flywheel             | g) поршень                   |
| 8) piston               | h) потужність двигуна        |
| 9) reciprocating motion | i) змащувати                 |
| 10) valve               | j) згоряння                  |

**Exercise 5. Insert the appropriate term.**

- Internal ... engines are commonly used in motor vehicles.  
a) burning                      b) explosion                      c) combustion                      d) blast
- The stationary engine parts are the cylinder block, the ... and the cylinder head.  
a) piston                      b) crankshaft                      c) crankcase                      d) camshaft
- The crankcase supports the crankshaft and the ..., and keeps the lubricating oil near the engine parts.  
a) flywheel                      b) valve                      c) crankshaft                      d) camshaft
- The cylinders and the cylinder ... form the combustion chamber.  
a) block                      b) heads                      c) pistons                      d) valves
- The camshaft opens the ... of the engine.  
a) valves                      b) pistons                      c) heads                      d) flywheels
- Rotary engine parts are the crankshaft, the ... and the camshaft.  
a) pistons                      b) crankcase                      c) cylinders                      d) flywheel
- The combustion chamber is formed by the cylinder heads and ... .  
a) flywheels                      b) cylinders                      c) valves                      d) camshaft
- A... is used to maintain constant angular velocity (частота обертання) of the crankshaft in a reciprocating engine.  
a) flywheel                      b) camshaft                      c) valve                      d) crankcase

## Exercise 6. Insert the necessary word.

1. The ... changes reciprocating motion of pistons to rotary motion.
2. The ... opens the valves of the engine.
3. The ... is one of the basic parts of the engine.
4. The cylinder and the ... form the combustion chamber.
5. The ... of fuel provides forces.
6. The ... keeps the lubricating oil near the engine parts.

(*cylinder head, camshaft, burning, crankcase, crankshaft, cylinder block*).

## Text B. Reciprocating Engine Parts (I)

### *Terms to remember:*

**piston** – поршень;

**ring** – кільце;

**connecting rod**– шатун;

**piston pin**– поршневий палець;

**lubrication**– змащення;

**intake valve**– впускний клапан;

**exhaust valve**– выпускний клапан;

The internal combustion engine has reciprocating parts: **pistons**, **rings**, valves and **connecting rods**. These parts cause engine vibration. The piston moves up and down within the cylinder. The piston head receives the force from the combustion of fuel within the cylinder and transmits it to the **piston pin**, connecting rod and crankshaft. The piston has four rings. Three rings are at the head of the piston and provide good compression. One ring is at the bottom of the piston. It controls the cylinder **lubrication**. The piston rings absorb heat from the piston and transmit it to the cylinder.

The engine has valves. They are **intake valves** and **exhaust valves**. Intake valves allow the fuel to enter the combustion chamber. Exhaust valves allow the gases to pass from the combustion chamber. So the valves open and close the combustion chamber where the burning of fuel takes place. A camshaft opens each valve. The connecting rod links the pistons and the crankshaft. It changes the reciprocating motion of pistons into the rotary motion of the crankshaft.

## Exercise 1. Answer the following questions.

1. What are the reciprocating engine parts?
2. Why does the engine vibrate?
3. Where is the piston placed and what function does it carry out?
4. What parts of the engine provide good compression?
5. What gives an engine the power?
6. What are the two types of valves?
7. What is the function of the intake/exhaust valve?
8. What links the pistons and the crankshaft?

## Exercise 2. Say whether the following statements are true or false.

1. The internal combustion engine has reciprocating parts: pistons, rings, valves and connecting bars.
2. The reciprocating parts of the engine cause vibration.

3. The piston moves up and down within the cylinder.
4. The piston has rings.
5. Intake valves don't allow the fuel to enter the combustion chamber.
6. A crankshaft opens each valve.
7. Exhaust valves allow the gases to pass from the combustion chamber.
8. The valves open and close the combustion chamber where the burning of fuel takes place.
9. The connecting rod links the pistons and the camshaft.
10. The connecting rod changes the reciprocating motion of pistons into the rotary motion of the crankshaft.

**Exercise 3. Give Ukrainian equivalents for the following terms and phrases.**

reciprocating parts, pistons rings, combustion of fuel, piston pin, crankshaft, provide good compression, the cylinder lubrication, absorb heat from the piston, allow the fuel to enter the combustion chamber, camshaft, rotary motion of the crankshaft

**Exercise 4. Translate the following terms and word combinations into English.**

шатун, поршень, зворотно-поступальні частини двигуна внутрішнього згоряння, поршневий палець, колінчастий вал, поршневі кільця, забезпечувати хорошу компресію, поглинати тепло, впускний/випускний клапан, камера згоряння, розподільний вал, змінювати зворотно-поступальний рух на обертальний

**Exercise 5. Match the term with its Ukrainian equivalent.**

- |                       |                          |
|-----------------------|--------------------------|
| 1) connecting rod     | a) колінчастий вал       |
| 2) pin                | b) впускний клапан       |
| 3) crankshaft         | c) камера згоряння       |
| 4) to absorb          | d) зворотно-поступальний |
| 5) intake valve       | e) обертальний           |
| 6) combustion chamber | f) шатун                 |
| 7) camshaft           | g) розподільний вал      |
| 8) reciprocating      | h) випускний клапан      |
| 9) rotary             | i) палець                |
| 10) exhaust valve     | j) поглинати             |

**Exercise 6. Translate the following sentences into English.**

1. Поршні, поршневі пальці, клапани, шатуни – це зворотно-поступальні деталі двигуна внутрішнього згоряння.
2. Зворотно-поступальний рух деталей спричинює вібрацію двигуна.
3. Поршень рухається у циліндрі.
4. Сила, що виробляється під час згоряння паливної суміші, діє на

поршень. 5. Поршень приводить в рух колінчастий вал. 6. У поршня є кільця, які відповідають за компресію у циліндрі та запобігають потраплянню масла в камеру згоряння. 7. Двигун внутрішнього згоряння має впускні та випускні клапани. 8. Через впускний клапан паливна суміш потрапляє в камеру згоряння. 9. Випускні клапани відповідають за виведення відпрацьованих газів з камери. 10. Розподільний вал відкриває клапани. 11. Шатун з'єднує поршень із колінчастим валом. 12. Шатуни перетворюють зворотно-поступальний рух на обертальний.

### Exercise 7. Read and translate the text.

#### *Terms to remember:*

<b>to absorb</b> –поглинати;	<b>gasoline (petrol) engine</b> –
<b>exhaust system</b> – система випуску відпрацьованих газів, вихлопна система;	бензиновий двигун;
<b>fuel mixture</b> – паливна суміш;	<b>mixture</b> суміш;
<b>sparkplug</b> – свічка запалювання;	<b>to reduce</b> – зменшувати;
<b>storage battery</b> – акумуляторна батарея;	<b>wear</b> – зношуваність;
<b>ignition</b> – запалювання;	<b>thermosiphon system</b> –
<b>pump</b> – насос;	термосифонна система

### Reciprocating Engine Parts (Part II)

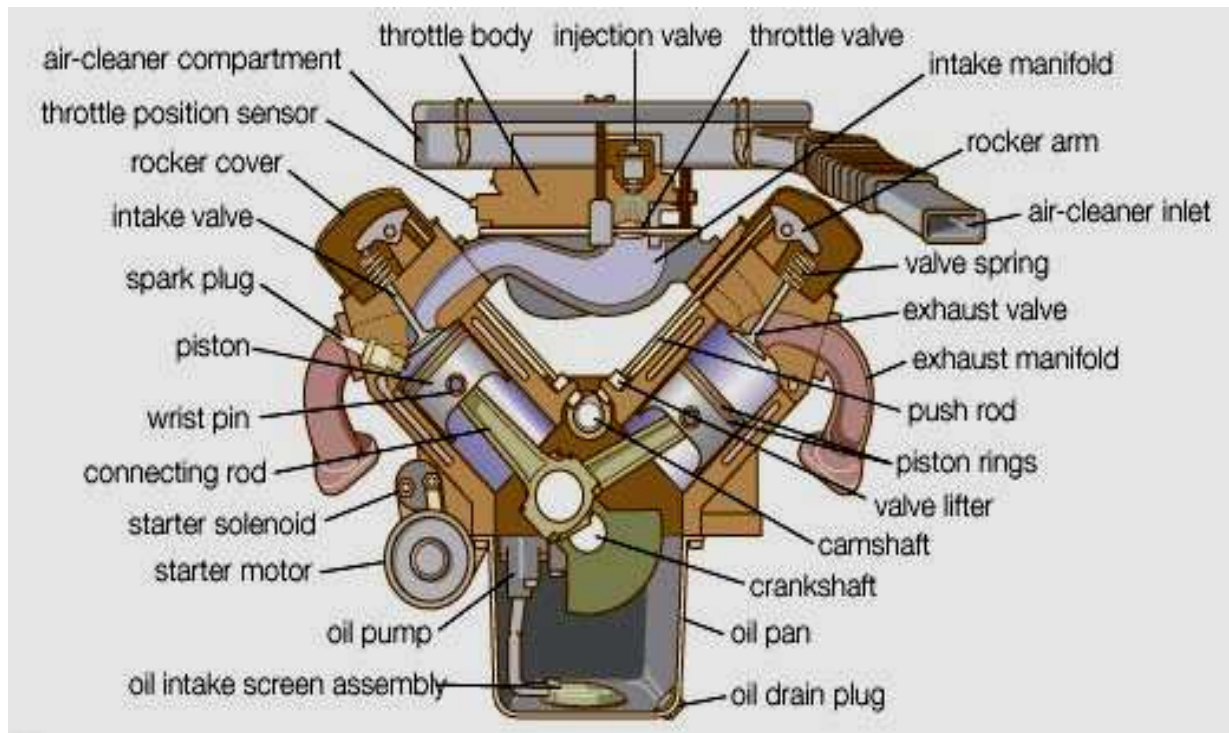
Pistons, rings, valves, connecting rods are reciprocating engine parts. The piston moves within the cylinder and transmits the forces of the expanding gases to the piston pin, connecting rod and crankshaft. Piston rings control the wall lubrication and **absorb** heat from the piston. The engine valves are of two types: intake valves and exhaust valves. The valves open and close the combustion chamber. When the intake valve opens the **fuel mixture** enters the combustion chamber. Through the exhaust valves the burned gases pass into the **exhaust system**.

The connecting rod links the piston and the crankshaft. Additional engine parts are components of four separate systems: electrical, fuel, lubricating and cooling. The electrical system of the engines has a **storage battery**. The battery provides voltage and transmits it to the **spark plugs** for the **ignition**. Spark plugs ignite the **fuel mixture** in the combustion chamber.

The engine has a fuel system. The fuel system of the diesel engine has a **pump**. This pump forces the fuel through injectors into the combustion chamber where the burning of fuel takes place. The **gasoline engine** has no pump, it has a carburettor. The carburettor mixes the fuel and air and transmits this **mixture** to the combustion chamber. The engines have oil pumps. These pumps provide engine lubrication. The oil pumps are of three types. Oil filters are between the pump and other engine parts. The oil filters **reduce** engine **wear**. Cooling

systems come in two types: **thermosiphon** and pump. They use water for the engine cooling.

**Exercise 8. Study the picture below and describe the V-engine operating principle. Ask your classmate to speak about the function of any part of the engine.**



**Terms to remember:**

**air-cleaner compartment (air filter compartment)** – корпус для повітряного фільтра,

**throttle position sensor** – датчик положення дросельної заслінки,

**rocker cover** – кришка клапанного механізму,

**intake valve** – впускний клапан,

**sparkplug** – свічка запалювання,

**piston** – поршень,

**wristpin** – поршневий палець,

**connecting rod** – шатун,

**starter solenoid** – соленоїд стартера,

**oil pump** – масляний насос,

**oil intake screen assembly** – сітчастий фільтр маслозбірника,

**throttle body** – корпус дросельної заслінки,

**injection valve** – інжекторний клапан, нагнітальний клапан,

**throttle valve** – дросельна заслінка,

**intake manifold** – впускний колектор,

**rocker arm** – коромисло,

**air cleaner inlet** – повітряний забірник,

**valve spring** – пружина клапана,

**exhaust valve** – випускний клапан,  
**exhaust manifold** – випускний/вихлопний колектор, колектор вихлопної системи,  
**pushrod** – штовхач (клапана),  
**valve lifter** – кулачок (підйому клапана),  
**oil pan** – піддон картера,  
**oil drain plug** – маслозливна пробка

### Lesson 3. The fuel system

#### *Vocabulary notes:*

<b>fuel tank</b> – паливний бак;	<b>rigid steel</b> – міцна сталь,
<b>filler tube</b> – трубка заливної горловини;	<b>flexible braided steel</b> – гнучка, плетена сталь,
<b>fuel vapor</b> – випари пального;	<b>corrosion-resistant rubber</b> – корозійностійка резина,
<b>baffle</b> – перегородка;	<b>particulate contaminates</b> – дисперсні (механічні) забруднювачі,
<b>sloshing of fuel</b> – коливання, розгойдування пального;	<b>clogging</b> – забивання,
<b>fuel gauge</b> – показник рівня палива;	<b>to spray</b> – розпилювати,
<b>outlet line</b> – випускний трубопровід (канал);	<b>manifold pressure</b> – тиск у колекторі
<b>ignition</b> – запалювання;	

#### **The fuel system**

The fuel system of an automobile moves fuel from the fuel tank to the engine where it is mixed with air and introduced into the combustion chambers. Combustion of the fuel in the cylinders produces the energy that powers the engine. Modern fuel systems are controlled by complex electronics, but their basic operation is simple.

##### ***Fuel Tank***

A vehicle's fuel, either gasoline or diesel, is held in a storage tank which is usually located in the rear of passenger cars. Fuel enters the tank via a **filler tube** that opens on the exterior of the car, and a system of vents allows **fuel vapor** to escape and maintain proper pressure within the tank. **Baffles** inside the tank minimize **sloshing of fuel** when the vehicle is in motion, and a sensor measures the fuel level and displays it on the **fuel gauge** inside the cabin. An **outlet line** directs fuel to the engine, and in most newer cars, the fuel pump is located inside the fuel tank.

##### ***Fuel Pump and Filter***

Fuel is moved from the tank to the engine by the action of a fuel pump. In most modern cars, the fuel pump is powered electrically and begins to operate when the **ignition** switch is activated. Older vehicles may employ a mechanical pump that is powered by the action of the engine. Fuel is pumped through fuel lines, made of **rigid steel**, **flexible braided steel** or **corrosion-resistant rubber**,



to the engine. One or more fuel filters removes **particulate contaminates** from the fuel to avoid **clogging** the fuel system within the engine.

### ***Carburetor and Fuel Injectors***

In older cars, fuel is pumped through a carburetor, a mechanism that mixes the fuel with air in the proper proportion before introducing it into the cylinder chambers. Modern cars use a series of electric fuel injectors which **spray** a fine mist of fuel into the chambers; fuel injectors operate more reliably and efficiently than carburetors. Once introduced into the cylinder chamber, fuel is ignited by a spark, producing the explosion that powers the engine.

### ***Emission Control System***

Cars manufactured after 1970 vent fuel vapors from the fuel tank into the engine, allowing the vapors to be burned before being vented into the air, thereby reducing the amount of pollutants released into the atmosphere. Modern cars are also equipped with sensors that monitor the carbon oxide content of exhaust gases, **manifold pressure**, the mass of air flowing into the engine and other parameters in order to adjust the air/fuel mixture to ensure cleaner, more efficient burning of fuel.

## **Exercise 1. Answer the following questions.**

1. What is the function of the vehicle's fuel system? 2. What is the appropriate term for the container where fuel is held? 3. What is the filler tube and where can it be found? 4. What sub-system allows fuel to escape and maintains pressure within the tank? 5. What parts of the tank prevent fuel from sloshing? 6. What function does the fuel gauge carry out? 7. Where is the fuel pump located? 8. How is fuel directed to the engine? 9. What is used to remove particulate contaminates and thus to avoid clogging of the fuel system? 10. What mechanism mixes air with fuel? 11. What process takes place, once the fuel mixture is in the combustion chamber? 12. Why do modern cars employ emission control systems?

## **Exercise 2. Translate the terms and phrases into Ukrainian.**

fuel tank, combustion chambers, controlled by complex electronics, system of vents, maintain proper pressure, fuel level, directs fuel to the engine, fuel pump, powered electrically, ignition switch, fuel lines, fuel injectors, ignited by a spark, amount of pollutants, exhaust gases

## **Exercise 3. Translate the following terms and phrases into English using the text.**

згорання пального, виробляти енергію, трубка заливної горловини, випари пального, перегородка, підтримувати відповідний тиск, вимірювати рівень пального, паливний насос, увімкнути запалювання, паливні трубопроводи,

працювати надійно, запалювати паливну суміш іскрою, викидати в атмосферу, стежити за вмістом оксиду вуглецю, вихлопні газ

**Exercise 4. Match the term with its Ukrainian equivalent.**

- |                      |                              |
|----------------------|------------------------------|
| 1) fuel tank         | a) показник рівня палива     |
| 2) filler tube       | b) перегородка               |
| 3) baffle            | c) тиск у колекторі          |
| 4) fuel gauge        | d) паливний трубопровід      |
| 5) outlet line       | e) трубка заливної горловини |
| 6) manifold pressure | f) паливна форсунка          |
| 7) ignition          | g) іскра                     |
| 8) fuel line         | h) паливний бак              |
| 9) fuel injector     | i) запалювання               |
| 10) spark            | j) випускний трубопровід     |

**Exercise 5. Using the figure describe the operation of the automobile fuel system. Learn some more terms which you may need to work into your explanation:**

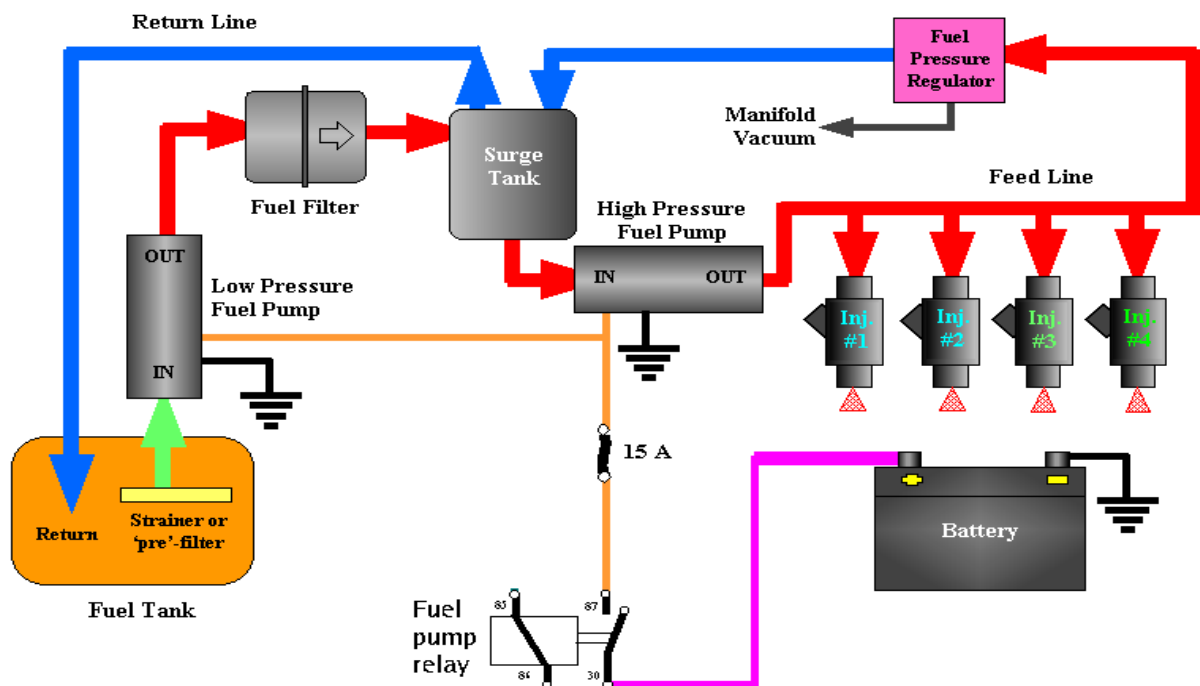
**return line** – зворотний паливний канал/трубопровід,

**strainer** – сітчастий фільтр,

**surge tank** – розширювальний бачок,

**fuel pressure regulator** – регулятор тиску пального,

**fuel pump relay** – реле паливного насоса



## Lesson 4. The Cooling System

### *Vocabulary notes:*

**excess** – надлишковий,  
**exhaust pipe** – вихлопна труба,  
**water jacket** – водяна сорочка,  
**radiator cap** – кришка радіатора,  
**cooling fan** – вентилятор  
охолодження,  
**belt-driven** – з ремінним приводом,  
**hose** – патрубок, рукав,  
**heater core** – радіатор опалення,  
**expansion tank** – розширювальний  
бачок,  
**air-fuel mixture** – повітряно-паливна  
суміш,

**operating temperature** – робоча  
температура,  
**oil film** – масляна плівка,  
**subtracting horsepower** –  
зменшення потужності двигуна,  
**deposit** – нагар, сажа,  
**exhaust emissions** – викид  
відпрацьованих газів,  
**liquid cooling** – рідинне  
охолодження  
**coolant** – охолоджувальна рідина,  
**valve seat** – сідло клапана,  
**pressure** – тиск,  
**leak** – протікання

### **The Cooling System**

The purpose of the engine's cooling system is to remove **excess** heat from the engine, to keep the engine operating at its most efficient temperature, and to get the engine up to the correct temperature as soon as possible after starting. Ideally, the cooling system keeps the engine running at its most efficient temperature no matter what the operating conditions are.

As fuel is burned in the engine, about one-third of the energy in the fuel is converted into power. Another third goes out the **exhaust pipe** unused, and the remaining third becomes heat energy.

A cooling system of some kind is necessary in any internal combustion engine. If no cooling system were provided, parts would melt from the heat of the burning fuel, and the pistons would expand so much they could not move in the cylinders (called "seize").

The cooling system of a water-cooled engine consists of the engine's **water jacket**, a thermostat, a water pump, a radiator and **radiator cap**, a **cooling fan** (electric or **belt-driven**), **hoses**, the **heater core**, and usually an **expansion (overflow) tank**.

Fuel burning engines produce enormous amounts of heat; temperatures can reach up to 4,000 degrees F when the **air-fuel mixture** burns. However, normal **operating temperature** is about 2,000 degrees F. The cooling system removes about one-third of the heat produced in the combustion chamber.

The exhaust system takes away much of the heat, but parts of the engine, such as the cylinder walls, pistons, and cylinder head, absorb large amounts of the heat. If a part of the engine gets too hot, the **oil film** fails to protect it. This lack of lubrication can ruin the engine.

On the other hand, if an engine runs at too low temperature, it is inefficient, the oil gets dirty (adding wear and **subtracting horsepower**), **deposits** form, and fuel mileage is poor – not to mention **exhaust emissions**. For these reasons, the cooling system is designed to stay out of the action until the engine is warmed up.

There are two types of cooling systems; **liquid cooling** and air cooling. Most auto engines are cooled by the liquid type; air cooling is used more frequently for airplanes, motorcycles and lawnmowers.

Liquid cooled engines have passages for the liquid, or **coolant**, through the cylinder block and head. The coolant must have indirect contact with such engine parts as the combustion chamber, the cylinder walls, and the **valve seats**. Running through the passages in the engine heats the coolant (it absorbs the heat from the engine parts), and going through the radiator cools it. After getting "cool" again in the radiator, the coolant comes back through the engine. This continues as long as the engine is running, with the coolant absorbing and removing the engine's heat, and the radiator cooling the coolant.

A cooling system **pressure** tester is used to check the pressure in the cooling system, which allows the mechanic to determine if the system has any slow **leaks**. The leak can then be found and fixed before it causes a major problem.

### **Exercise 1. Answer the following questions.**

1. What is the purpose of the engine's cooling system? 2. What proportion of the energy produced within the engine is converted into power as fuel is burned? 3. What would happen if the engine has no cooling system? 4. What parts does the water cooling system consist of? 5. What is the optimal operating temperature of the engine? 6. How much heat is removed by the cooling system? 7. What are the parts of the engine that absorb heat? 8. How can overheating affect the oil film? 9. What happens if the engine is running at too low temperatures? 10. Describe the process of cooling. 11. What device checks the pressure in the cooling system? 12. What malfunctions can take place if the coolant leaks?

### **Exercise 2. Say whether the following statements are true or false.**

1. The cooling system keeps the engine running at its most efficient temperature.  
2. One third of the heat produced by the burning of fuel is used to produce power.  
3. Without cooling system engine would produce more power.  
4. A cooling fan can be electronic or belt-driven.  
5. The optimal operating temperature of the engine is about 90<sup>0</sup> C.  
6. The cooling system removes about one-third of the heat produced in the combustion chamber.

7. The cylinder walls, pistons, and cylinder head expel large amounts of the heat.
8. If any part of the engine becomes too hot, the oil film cannot protect it.
9. If the engine operates at low temperatures, it loses its efficiency, horsepower, and fuel consumption rises.
10. There are two types of cooling systems: liquid cooling and air cooling.
11. No way should the coolant pass into the combustion chamber, the cylinder walls, and the valve seats.
12. Coolant doesn't absorb the heat from the engine parts.
13. A cooling system pressure tester is employed to monitor the pressure in the fuel system.
14. Leaks in the cooling system can cause severe damages to the engine.

**Exercise 3. Translate the following terms and phrases into Ukrainian.**

to remove excess heat, most efficient temperature, operating conditions, heat energy, internal combustion engine, the heat of the burning fuel, water pump, radiator, combustion chamber, cylinder walls, cylinder head, lack of lubrication, the cylinder block

**Exercise 4. Translate the following terms and phrases into English using the text.**

вихлопна труба, тепла енергія, водяна сорочка, водяний насос, розширювальний бачок, вентилятор охолодження, патрубок, поршні, зношуваність, масляна плівка, нагар, робоча температура, охолоджувальна рідина, сідло клапана, камера згоряння, тиск, протікання

**Exercise 5. Match the terms with their Ukrainian equivalents.**

- |                      |                               |
|----------------------|-------------------------------|
| 1) exhaust pipe      | a) поглинати                  |
| 2) to absorb         | b) вентилятор охолодження     |
| 3) water jacket      | c) радіатор опалення          |
| 4) radiator cap      | d) патрубок                   |
| 5) cooling fan       | e) сідло клапана              |
| 6) hose              | f) розширювальний бачок       |
| 7) heater core       | g) викид відпрацьованих газів |
| 8) expansion tank    | h) водяна сорочка             |
| 9) exhaust emissions | i) кришка радіатора           |
| 10) valve seat       | j) вихлопна труба             |

**Exercise 6. Insert the appropriate terms.**

The water pump pushes **1)** ... through the engine oil cooler and into the cylinder block. The coolant then flows through the cylinder **2)** ... and into the cylinder head(s) where it flows to the hot areas of the cylinder head(s).

Additional **3)** ... that will transfer heat to the coolant are: after coolers, water-cooled exhaust manifolds, water-cooled turbo chargers, water-cooled shields and oil coolers.

After flowing through the cylinder head(s), the coolant goes into the coolant temperature regulator housing. When the **4)** ... is cold, the temperature regulators bypass the radiator and direct the coolant back to the water **5)**... . As the temperature of the bypass coolant flow becomes warmer, the temperature regulators begin to open and permit some of the coolant to flow to the **6)**... .

The regulator opens to **7)** ... the correct engine temperature. The amount that the regulator opens and the percent of coolant flow to the radiator depends on the load on the engine, and the outside air temperature.

The **8)** ... draws air through the radiator and around the tubes that extend from the top to the bottom of the radiator. When the hot coolant goes through the **9)** ... in the radiator, the flow of air around the tubes lowers the temperature of the coolant. The coolant then flows back through the water pump.

Coolant **10)** ... as it is heated. Expansion tanks are used on some applications to contain the increased volume.

- |     |                   |                 |                   |               |
|-----|-------------------|-----------------|-------------------|---------------|
| 1.  | a) coolant        | b) cooling      | c) fuel           | d) oil        |
| 2.  | a) wall           | b) block        | c) hose           | d) valve      |
| 3.  | a) systems        | b) compounds    | c) components     | d) complexes  |
| 4.  | a) weather        | b) engine       | c) temperature    | d) radiator   |
| 5.  | a) station        | b) manifold     | c) jacket         | d) pump       |
| 6.  | a) engine         | b) radiator     | c) expansion tank | d) hose       |
| 7.  | a) maintain       | b) block        | c) use            | d) carry      |
| 8.  | a) exhaust pipe   | b) fan          | c) heater core    | d) valve seat |
| 9.  | a) radiator grill | b) exhaust pipe | c) channels       | d) hoses      |
| 10. | a)explodes        | b) blows        | c) expands        | d) decreases  |

**Exercise 7. Study the picture and describe the operating principle of the cooling system.**

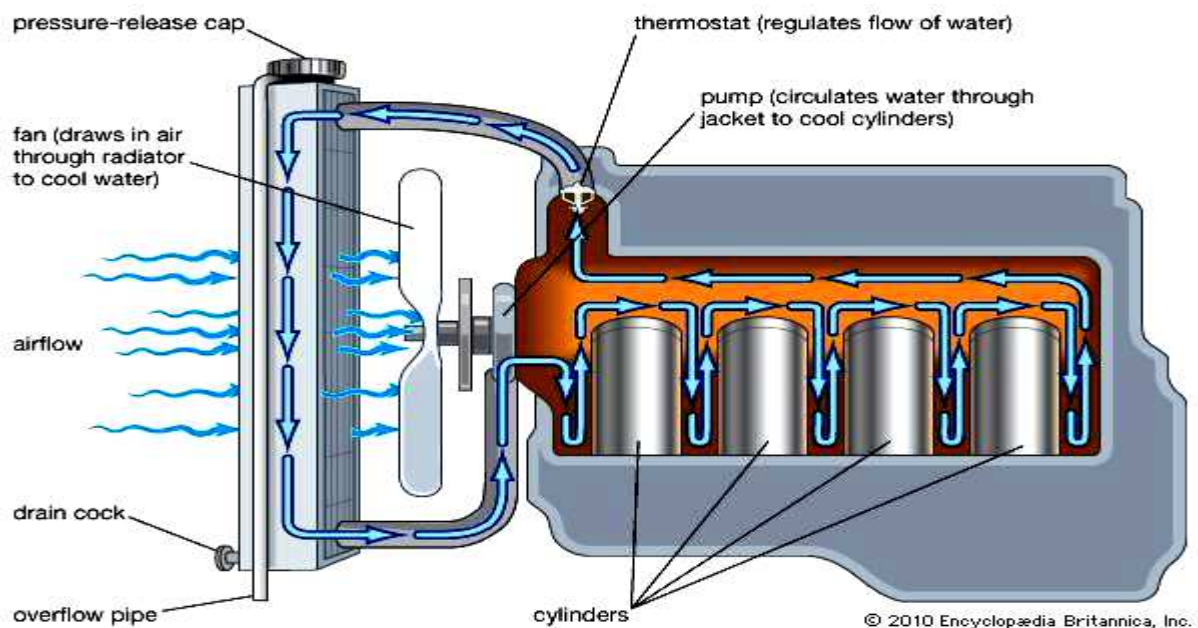
**Terms to remember:**

**pressure-release cap** –

**drain cock** – зливний кран,

**overflow pipe** – дренажний

трубопровід, відвідна трубка



## Lesson 5. Automotive Electrical Systems

### *Vocabulary notes:*

<b>galvanic cell</b> – гальванічний елемент,	<b>belt system</b> – система ремінного/-их приводу/-ів,
<b>lead</b> – свинець,	<b>diode bridge</b> – діодний міст,
<b>sulfuric acid</b> – сірчана кислота,	<b>rectifier</b> – випрямлювач,
<b>to emit</b> – випромінювати, виділяти,	<b>to fluctuate</b> – (тут) змінюватися,
<b>charge</b> – заряд,	<b>connector</b> – клема,
<b>alternator</b> – генератор,	

### **Exercise 1. Read and translate text A. Answer the questions that follows.**

#### **Text A. Automobile Electrical System.**

The heart of all automotive electrical systems is the battery. This component is responsible for storing the electricity that will be used to start the engine and operate all of the electrical accessories contained within the vehicle. Batteries are commonly referred to as SLI (starting, lighting, ignition) because they are designed to provide electricity to the starter, lighting, and ignition systems. The standard battery is made up of six **galvanic cells** that produce 2.1 volts each for a total of 12.6 volts.

Most batteries contain **lead** plates that have been submerged in a mixture of **sulfuric acid** and water. The chemical reaction that results from this design **emits** electrons that produce an electrical current. The battery can be recharged by reversing the chemical reaction, but all batteries lose their **charge** over time due to normal breakdown. When the battery dies, it is important to check its voltage using a Volt Ohm Meter. This will give you a better idea of whether or not the battery is the source of the problem or whether you need to check either the starter or **alternator**.

Automotive electrical systems require an alternator in order to maintain the charge in the battery and run the electrical system while the vehicle is in operation. An alternator is an electromechanical device that transforms mechanical energy into alternating electrical current.

In the automotive industry, the alternator utilizes a **belt system** to convert the mechanical energy produced by the engine into electrical current. Because the alternating current produced cannot be stored in the battery, it is converted to direct current by a **diode bridge** or **rectifier**. It is worth noting that the alternator is not in constant operation while the engine is running. In fact, its operation **fluctuates** to meet the demands of the vehicle. The primary purpose of the alternator is to maintain the voltage level of the automobile and it should really only be operating about half of the time. It is important to understand that the alternator is stressed by many of the electrical components of a vehicle and a dead battery may actually be an indication that the alternator is no longer working.

The starter is one of the most important pieces of automotive electrical systems because it initiates the combustion process within the cylinders. The starter is a motor that uses the flywheel to turn the crankshaft. This process creates compression in the cylinders which in turn allows the engine to operate. Since the starter is the largest consumer of electricity, it receives current directly from the battery. This current is regulated by the key-operated switch within the cab of the vehicle.

Cables and **connectors** are the vital part of all automotive electrical systems because they allow the electrical current to flow from one component to the next. While most people are quick to attribute a malfunction to one of the primary electrical components mentioned above, they often fail to realize that the problem could just as easily be the result of a bad connection. In fact, many problems start as the result of a poor electrical connection. This can be the result of a connection becoming loose or because corrosion has built-up on the battery.

1. What are some basic components of the car electrical system? 2. How much voltage does the storage battery produce? 3. How is electricity produced within the battery? 4. What is an alternator? 5. What is the primary purpose of the alternator? 6. What function does the starter carry out? 7. Name some of the reasons for the electrical system malfunctions.

➤ **Draw a plan and retell the text according to your plan.**

## **Text B. The Ignition System**

### ***Vocabulary notes:***

**motive force** – тягове зусилля;

**storage battery** – акумуляторна батарея;

**complete an electrical circuit** –

замикати електричне коло;

**primary winding** – первинна



<b>timed</b> – синхронний;	обмотка;
<b>discharge</b> – електричний розряд;	<b>ignition coil</b> – котушка запалювання;
<b>induction coil</b> – котушка запалювання;	<b>primary circuit</b> – первинний контур;
<b>distributor</b> – переривник-розподільник запалювання;	<b>surge</b> – спалах напруги;
<b>sparkplug</b> – свічка запалювання;	<b>distributor shaft</b> – вал розподільника запалювання;
<b>successive bursts</b> – послідовні імпульси;	<b>reluctor</b> – зубчасте кільце;
<b>firing order</b> – послідовність роботи циліндрів;	<b>solid-state</b> – напівпровідниковий;
<b>breaker point</b> – контакт переривника;	<b>coil-on-plug</b> – котушка запалювання, що розташована на свічці;
<b>distributor cam</b> – кулачок розподільника;	<b>coil pack</b> – множинна обмотка;
	<b>notch</b> – зубець;
	<b>ignition timing</b> – кут випередження запалювання, <i>фази запалювання</i> , синхронізація запалювання,

## The Ignition System

Ignition system of a gasoline engine produces an electric spark to ignite the fuel-air mixture; the burning of this mixture in the cylinders produces the **motive force**.

The basic components in the ignition system are a **storage battery**, an **induction coil**, a device to produce **timed** high-voltage **discharges** from the **induction coil**, a **distributor**, and a set of **spark plugs**. The storage battery provides an electric current of low voltage (usually 12 volts) that is converted by the system to high voltage (some 40,000 volts). The distributor routes the **successive bursts** of high-voltage current to each spark plug in the **firing order**.

In older automobile ignition systems, the high-voltage pulses are produced by means of **breaker points** controlled by a revolving **distributor cam**. When the points are in contact they **complete an electrical circuit** through the **primary winding** of the **ignition coil**. When the points are separated by the cam, the **primary circuit** is broken, which creates a high-voltage **surge** in the secondary windings of the induction coil. Breaker points have been largely replaced by electronic devices in newer automobiles. Most now use a magnetic device, called a **reluctor**, that is operated by the **distributor shaft** to produce timed electric signals, which are amplified and used to control the current to the induction coil. These newer ignition systems are more reliable than the old, permit better control of the engine, and produce higher-voltage output to the spark plugs.

During the evolution of **solid-state** ignition systems there have been many modifications. Some ignition conversion systems, for example, extend breaker-point life by using transistors – devices in which a small current in the input (the breaker-point circuit) controls much larger current in the output (the coil primary circuit).

Many automobile engines now use a distributor-less ignition system, or direct ignition system, in which a high-voltage pulse is directly applied to coils that sit on top of the spark plugs (known as **coil-on-plug**). The major components of these systems are a **coil pack**, an ignition module, a crankshaft reluctor ring, a magnetic sensor, and an electronic control module. The ignition module controls the primary circuit to the coils, turning them on and off. The reluctor ring is mounted on the crankshaft so that as the crankshaft rotates the magnetic sensor is triggered by **notches** in the reluctor ring. The magnetic sensor provides position information to the electronic control module, which governs **ignition timing**.

**Exercise 1. Answer the following questions.**

1. What does the ignition system produce? 2. What are the basic elements of the ignition system? 3. What function does the distributor carry? 4. How are the high-voltage pulses produced in older automobiles? 5. What device is used to produce timed electric signals in newer motor vehicles? 6. How does the direct-ignition system work? 7. What are the components of the direct-ignition system?

**Exercise 2. Translate the following terms and phrases into Ukrainian.**

electric spark, to ignite the fuel-air mixture, high-voltage discharges, a set of spark plugs, storage battery, to route the successive bursts, spark plug, to be controlled by a revolving distributor cam, secondary windings, to be replaced by electronic devices, to produce timed electric signals, direct-ignition system, electronic control module, to govern ignition timing

**Exercise 3. Translate the following terms and phrases into Ukrainian.**

згоряння суміші, тягове зусилля, котушка запалювання, свічка запалювання, послідовність роботи циліндрів, низька напруга, замикати електричне коло, котушка запалювання, вторинна обмотка, синхронні електричні сигнали, високовольтний вихідний імпульс, система безпосереднього запалювання, магнітний сенсор, синхронізація запалювання

**Exercise 4. Match the term with its Ukrainian equivalent.**

- |                          |  |
|--------------------------|--|
| 1) <b>timed</b>          | a) переривник-розподільник запалювання |
| 2) <b>discharge</b>      | b) контакт переривника                 |
| 3) <b>induction coil</b> | c) котушка запалювання,                |
| 4) <b>distributor</b>    | d) вал розподільника запалювання       |
| 5) <b>sparkplug</b>      | e) кут випередження                    |

- |                      |                         |
|----------------------|-------------------------|
| 6) breaker point     | запалювання,            |
| 7) ignition timing   | f) зубець               |
| 8) ignition coil     | g) електричний розряд,  |
| 9) distributor shaft | h) свічка запалювання,  |
| 10) notch            | i) котушка запалювання, |
|                      | j) синхронний           |

**Exercise 5. Fill in the blanks with the appropriate words.**

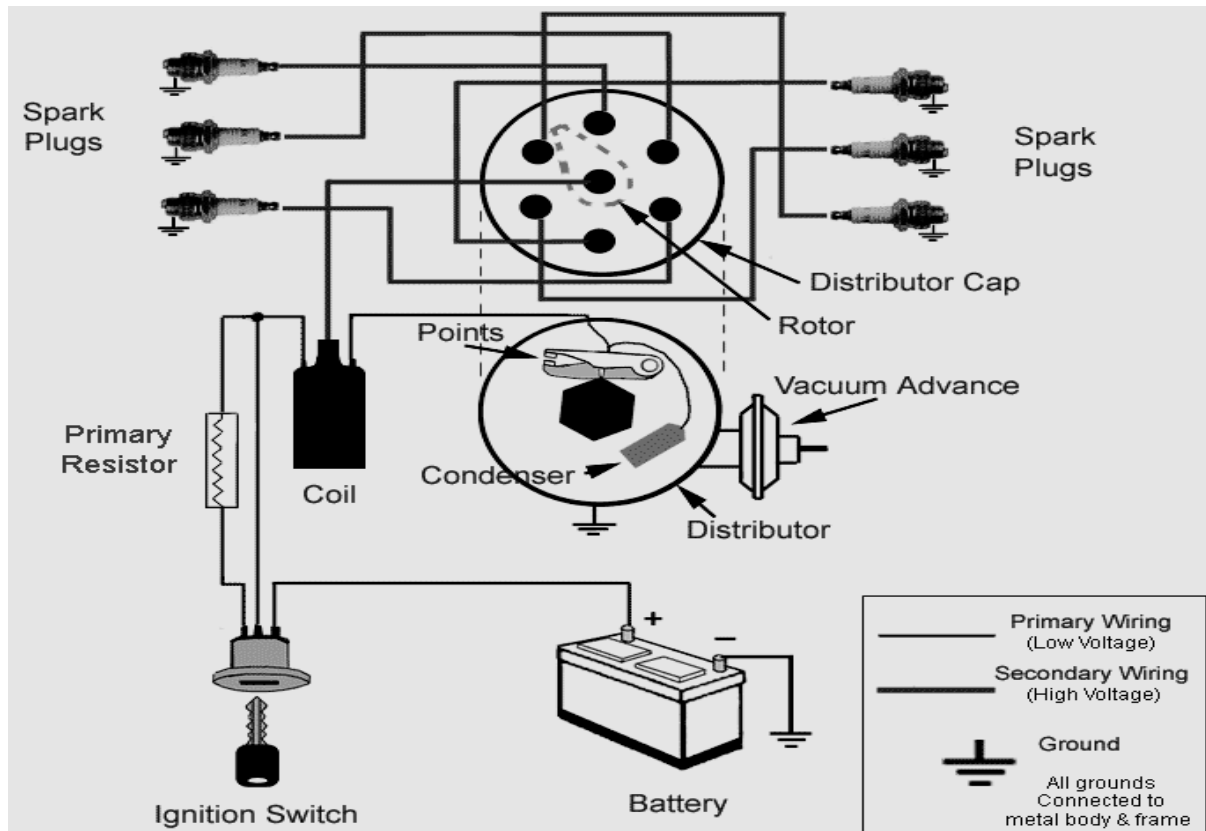
With the universal adaptation of electrical starting for automobiles, and the availability of a large battery to provide a constant source of electricity, magneto systems were abandoned for systems which interrupted current at battery voltage, used an ignition **1)** ... (a transformer) to step the voltage up to the needs of the ignition, and a distributor to route the ensuing pulse to the correct spark **2)** ... at the correct time.

The first reliable battery operated **3)** ... was developed by the Dayton Engineering Laboratories Co. (Delco) and introduced in the 1910, Cadillac. This ignition was developed by Charles Kettering and was a wonder of its day. It consisted of a single coil, points (the switch), a capacitor and a **4)** ... set up to allocate the spark from the ignition coil timed to the correct cylinder. The coil was basically a transformer to **5)** ... the low (6 or 12 V) voltage supply to the high ignition voltage required to jump a spark plug gap.

The points allow the coil to be charged magnetically and then, when they are opened by a cam arrangement, the magnetic field collapses and a large (20 kV or greater) voltage is **6)**... . The capacitor has two functions: 1) it absorbs the back EMF from the magnetic field in the coil to minimize point contact burning and maximize point life; and 2) it forms a resonant circuit with the primary coil of the ignition coil transferring further energy to the secondary side until the energy is exhausted. The Kettering system became the primary ignition system for many years in the automotive industry due to its lower cost, higher reliability and relative simplicity.

- |    |                |               |              |               |
|----|----------------|---------------|--------------|---------------|
| 1. | a) switch      | b) spark      | c) coil      | d) notch      |
| 2. | a) pulse       | b) wire       | c) coil      | d) plug       |
| 3. | a) lubrication | b) ignition   | c) cooling   | d) suspension |
| 4. | a) distributor | b) discharger | c) reluctor  | d) coil pack  |
| 5. | a) direct      | b) transmit   | c) translate | d) convert    |
| 6. | a) made        | b) produced   | c) done      | d) fired      |

**Exercise 6. Study the picture and describe the operating principle of the ignition system.**



## Lesson 6. Transmission

### *Vocabulary notes:*

**clutch** – зчеплення;

**hand lever** – ручний важіль;

**gearstick** – важіль перемикання передач;

**manumatic** – автоматична коробка передач з можливістю ручного перемикання;

**continuously variable transmission** – безступінчаста трансмісія;

**gear ratio** – передавальне число;

**gear** – передача;

**sequential manual transmission** – секвентальна коробка передач;

**flywheel** – маховик;

**clutch disk** – диск зчеплення;

**pressure plate** – корзина зчеплення, нажимний диск;

**throw-out bearing** – вижимний підшипник зчеплення;

**gear pair** – зубчаста пара;

**output shaft** – відомий вал;

**epicyclic gear** – шестерня планетарної передачі, планетарна шестерня;

**brake band** – стрічкове гальмо;

**clutch pack** – пакет фрикційних дисків муфти зчеплення;

**reverse gear** – задня передача;

**power band** – діапазон потужності

## **Automobile Transmission**

A manual transmission, also known as a manual gearbox, a stick shift, or standard transmission is a type of transmission used in motor vehicle applications. It uses a driver-operated **clutch** engaged and disengaged by a foot pedal (automobile) or **hand lever** (motorcycle), for regulating torque transfer from the engine to the transmission; and a **gear stick** operated by foot (motorcycle) or by hand (automobile).

A conventional, 5-speed manual transmission is often the standard equipment in a base-model car; other options include automated transmissions such as an automatic transmission (often a **manumatic**), a semi-automatic transmission, or a **continuously variable transmission** (CVT).

Manual transmissions often feature a driver-operated clutch and a movable gear stick. Most automobile manual transmissions allow the driver to select any forward **gear ratio** ("gear") at any time, but some, such as those commonly mounted on motorcycles and some types of racing cars, only allow the driver to select the next-higher or next-lower gear. This type of transmission is sometimes called a **sequential manual transmission**. The way a manual transmission works is that the **flywheel** is attached to the engine, the **clutch disk** is between the **pressure plate** and the flywheel. When running, the clutch disk is spinning with the flywheel and when pressure is applied to the clutch pedal the **throw-out bearing** is pushed in. It makes the pressure plate stop applying pressure to the clutch disk and making it stop receiving power from the engine, so the gear can be shifted without any problems and when pressure stops being applied to the clutch pedal the clutch disk starts receiving power from the engine.

Manual transmissions are characterized by gear ratios that are selectable by locking selected **gear pairs** to the **output shaft** inside the transmission. Conversely, most automatic transmissions feature **epicyclic** (planetary) **gearing** controlled by **brake bands** and/or **clutch packs** to select gear ratio. Automatic transmissions that allow the driver to manually select the current gear are called Manumatics. A manual-style transmission operated by computer is often called an automated transmission rather than an automatic.

Contemporary automobile manual transmissions typically use from four to six forward gears and one **reverse gear**, although automobile manual transmissions have been built with as few as two and as many as eight gears. Transmission for heavy trucks and other heavy equipment usually have at least 9 gears so the transmission can offer both a wide range of gears and close gear ratios to keep the engine running in the **power band**. Some heavy vehicle transmissions have dozens of gears, but many are duplicates, introduced as an accident of combining gear sets, or introduced to simplify shifting. Some manuals are referred to by the number of forward gears they offer (e.g., 5-speed) as a way of distinguishing between automatic or other available manual transmissions. Similarly, a 5-speed automatic transmission is referred to as a "5-speed automatic."

**Exercise 1. Answer the following questions.**

1. What function does a vehicle's transmission serve? 2. What types of transmissions do you know? 3. What type of transmission is commonly used on cars nowadays? 4. What devices do manual transmissions feature? 5. What is a sequential manual transmission? 6. How does transmission work? 7. In what type of transmission can a planetary gear set be found? 8. How many gears do most modern motor vehicles have?

**Exercise 2. Translate the following words and word combinations into Ukrainian.**

automatic transmissions, manual gearbox, driver-operated clutch, engaged and disengaged by a foot pedal, torque transfer, conventional, 5-speed manual transmission, semi-automatic transmission, gear stick, operated by computer, forward gears, heavy trucks, planetary gearing, to simplify shifting

**Exercise 3. Translate the following words and word combinations into English using the text.**

звичайна п'ятиступенева коробка передач, вибирати передачу, передавати обертальний момент, 1-ша передача, диск зчеплення обертається з маховиком, перемикає передачу, педаль зчеплення, задня передача, набір шестерень, ручна коробка передач, автоматична коробка передач, секвентальна коробка передач, автоматична коробка передач з можливістю ручного перемикання, безступінчаста трансмісія, зближені передачі.

**Exercise 4. Match the term with its Ukrainian equivalent.**

- |                      |  |
|----------------------|--|
| 1) clutch            | a) планетарна шестерня                     |
| 2) hand lever        | b) ручний важіль                           |
| 3) gear ratio        | c) зубчаста пара                           |
| 4) pressure plate    | d) зчеплення                               |
| 5) throw-out bearing | e) вижимний підшипник                      |
| 6) clutch pack       | f) важіль перемикання передач              |
| 7) output shaft      | g) корзина зчеплення                       |
| 8) gear pair         | h) відомий вал                             |
| 9) gearstick         | i) передавальне число                      |
| 10) epicyclic gear   | j) пакет фрикційних дисків муфти зчеплення |

**Exercise 5. Read and translate the text.**

**More terms to remember:**

**gear train** – блок шестерень;  
**sun gear** – центральна шестерня;

**locking sequences** – послідовність блокування;

<b>internal gear teeth</b> – шестерня із зовнішніми зубцями;	<b>multi-plate clutch</b> – багатодискове зчеплення;
<b>ring gear</b> – вінцева шестерня;	<b>pressure build-up</b> – наростання/збільшення тиску;
<b>torque converter</b> – гідротрансформатор обертового моменту;	<b>kickdown</b> – механізм пониження передачі;
<b>planet carrier</b> – опора планетарної шестерні;	<b>change-down</b> – перехід на нижчу передачу;
<b>output</b> – ефективна потужність;	<b>override system</b> – система ручного управління;
<b>power input</b> – підвід потужності;	

### **Text B. How automatic transmissions work.**

Most modern automatic gearboxes have a set of gears called a planetary or epicyclic **gear train**. A planetary gear set consists of a central gear called the **sun gear**, an outer ring with **internal gear teeth** (also known as the annulus, or **ring gear**), and two or three gears known as planet gears that rotate between the sun and ring gears.

The drive train is coupled to a mechanism known as a **torque converter**, which acts as a fluid drive between the engine and transmission. If the sun gear is locked and the planets driven by the **planet carrier**, the **output** is taken from the ring gear, achieving a speed increase.

If the ring gear is locked and the sun gear is driven, the planet gears transmit drive through the planet carrier and speed is reduced. With **power input** going to the sun gear and with the planet carrier locked, the ring gear is driven, but transmits drive in reverse. To achieve direct drive without change of speed or direction of rotation, the sun is locked to the ring gear and the whole unit turns as one.

The same effect can also be achieved by locking the planet gears to the planet carrier. Most automatic gearboxes have three forward speeds, and use two sets of epicyclic gears. The **locking sequences** of the epicyclic gear train are achieved by hydraulic pressure operating brake bands or **multi-plate clutches**. The bands are tightened round the ring gear to prevent turning, and the clutches are used to lock the sun gear and planets. The correct sequence of **pressure build-up** and release is controlled by a complex arrangement of hydraulic valves in conjunction with sensors that respond to engine load, road speed and throttle opening.

A mechanism linked to the throttle - known as a **kickdown** - is used to effect a **change-down** for rapid acceleration. When you press down the accelerator suddenly to its full extent, a lower gear is selected almost instantly. Most automatic gearboxes have an **override system** so that the driver can hold a low gear as required.

### **Exercise 6. Render the following terms and phrases into Ukrainian.**

modern automatic gearboxes, planetary gear, coupled to a mechanism, to transmit drive, planet carrier, to lock the planet gears, forward speeds, epicyclic gears, hydraulic valves, throttle, rapid acceleration, press down the accelerator, brake bands, direction of rotation

**Exercise 7. Translate the following terms and word combinations into English.**

з'єднаний з механізмом, гідравлічний привід (гідромуфта), збільшення швидкості, передавати тягове зусилля, напрямок обертання, блокувати планетарні шестерні, гідравлічний тиск, правильна послідовність, відкриття дросельної заслінки, тиснути на педаль акселератора, гідротрансформатор обертального моменту, багатодискове зчеплення

**Exercise 8. Match the term with its Ukrainian equivalent.**

- |                      |  |
|----------------------|--|
| 1. gear train        | a) перехід на нижчу передачу               |
| 2. sun gear          | b) підвід потужності                       |
| 3. ring gear         | c) вінцева шестерня                        |
| 4. output            | d) гідротрансформатор обертального моменту |
| 5. power input       | e) ефективна потужність                    |
| 6. locking sequences | f) опора планетарної шестерні              |
| 7. kickdown          | g) блок шестерень                          |
| 8. change-down       | h) центральна шестерня                     |
| 9. torque converter  | i) послідовність блокування                |
| 10. planet carrier   | j) механізм пониження передачі             |

**Exercise 9. Fill in the blanks with appropriate terms.**

**Transmission**

A machine consists of a power source and a power transmission system, which provides controlled application of the power. Often transmission refers simply to the gearbox that uses gears and gear **1**) ... to provide speed and torque conversions from a rotating power source to another device.

The most common use is in motor **2**)... , where the transmission adapts the output of the internal combustion engine to the drive wheels. Such engines need to operate at a relatively high **3**) ... speed, which is inappropriate for starting, stopping, and slower travel. The transmission reduces the higher engine speed to the slower wheel speed, increasing **4**) ... in the process. Transmissions are also used on pedal bicycles, fixed machines, and anywhere rotational speed and torque must be adapted.

Often, a transmission has multiple gear **5**) ... (or simply "gears"), with the ability to switch between them as speed varies. This switching may be done **6**)... (by the operator), or automatically. Directional (forward and reverse) control



may also be provided. Single-ratio transmissions also exist, which simply change the speed and torque (and sometimes direction) of motor 7)... .

In motor vehicles, the transmission generally is connected to the engine crankshaft via a 8) ... and/or clutch and/or fluid coupling, partly because internal combustion engines cannot run below a particular speed. The output of the transmission is transmitted via 9) ... to one or more differentials, which in turn, drive the wheels. While a differential may also provide gear reduction, its primary purpose is to permit the wheels at either end of an 10) ... to rotate at different speeds (essential to avoid wheel slippage on turns) as it changes the direction of rotation.

- |      |                   |                   |               |                 |
|------|-------------------|-------------------|---------------|-----------------|
| 1).  | a) planes         | b) trains         | c) teeth      | d) shafts       |
| 2).  | a) cycles         | b) boats          | c) vehicles   | d) apparatuses  |
| 3).  | a) turning        | b) rotational     | c) revolving  | d) spinning     |
| 4).  | a) drive          | b) strength       | c) power      | d) torque       |
| 5).  | a) ratios         | b) correspondence | c) powers     | d) ability      |
| 6).  | a) electronically | b) automatically  | c) manually   | d) electrically |
| 7).  | a) exhaust        | b) intake         | c) input      | d) output       |
| 8).  | a) crankcase      | b) flywheel       | c) camshaft   | d) rotor        |
| 9).  | a) speed shaft    | b) camshaft       | c) driveshaft | d) crankshaft   |
| 10). | a) tyre           | b) steering wheel | c) axle       | d) driveshaft   |

## Lesson 7. The Suspension

### *Vocabulary notes:*

**spring** – пружина;

**shock absorber** – амортизатор;

**linkage** – тяга;

**bump** – нерівність, лежачий поліцейський;

**rolling** – поперечне розхитування;

**pitching** – поздовжнє розхитування;

**tyre** – шина;

**damper** – демпфер/амортизатор (тут – будь-який пристрій для зменшення механічних коливань);

**anti-roll bar** – стабілізатор поперечної стійкості;

**torsionspring** – торсіон, пружина кручення;

**body roll (motions)** – крени кузова;

**mounting point** – точка кріплення;

**to twist** – скручуватися;

**leaning** – нахил;

**lever** – важіль, плече (важеля);

**magnitude** – величина, сила, інтенсивність;

**rubber bushing** – сайлент блок;

**oscillations** – коливання;

**twin tube design** – двотрубна конструкція/будова;

**axle** – вісь;

**borehole** – отвір;

**compression valve** – клапан ходу стискання;

**pressure tube** – внутрішня трубка амортизатора;

**suspension strut** – стійка підвіски, підвіска;

**suspension arm** – важіль підвіски;

**McPherson strut** – підвіска макферсон, підвіска МакФерсона;

**single unit** – окремий вузол;

<b>rough-road</b> – дорога з поганим покриттям;	<b>tuning ability</b> – налаштування;
<b>coil spring</b> – спіральна/гвинтова пружина;	<b>trailing arm</b> – поздовжній важіль;
<b>leaf spring</b> – ресора;	<b>multi-link</b> – багато важільна (підвіска);
<b>torsion bar</b> – торсіонна балка;	<b>hub</b> – ступиця (колеса);
<b>air spring</b> – пневматична ресора/пневматичний амортизатор;	<b>hub carrier</b> – стійка ступиці;
<b>frame</b> – рама;	<b>steering knuckle</b> – поворотний кулак,
<b>wishbone</b> – поперечний важіль;	поворотна цапфа;
	<b>double-wishbone suspension</b> – двоважільна підвіска;

### The Suspension.

The suspension includes the system of **springs**, **shock absorbers** and **linkages** which connect a vehicle to its wheels. The suspension supports the weight of the vehicle body and also protects the vehicle and any cargo from damage and wear. The purpose of an automobile's suspension system is two-fold: passenger comfort and vehicle control, i.e. the suspension system is the determining factor for active safety and driving pleasure. Comfort is provided by isolating the vehicle's passenger cabin from road **bumps**, vibrations, road noise, etc. Control is achieved by keeping the car body from excessively **rolling** and **pitching**, and maintaining good contact between the **tyre** and the road surface.

Apart from the linkages, the fundamental components of any suspension are springs, **dampers** and stabilizer (also called **anti-roll**) **bars**.

**Stabilizers** A stabilizer is usually a **torsion spring** that resists **body roll** motions. Its purpose is to prevent the car's body from "rolling" in a sharp turn. A stabilizer is generally constructed out of a U-shaped piece of steel that connects to the body at two points. If the left and right wheels move together, the bar just rotates about its **mounting points** and does not bend. If the wheels move relative to each other, the bar is subjected to torsion and forced **to twist**. Some high-priced cars have also begun to use "active" anti-roll bars that can be automatically adjusted by a suspension-control computer. The result is a reduced **leaning** of the body in turns while the **rough-road** ride quality of the vehicle is significantly improved.

**Springs** Today's automotive spring systems are based on one of four basic designs: **coil springs**, **leaf springs** (seldom used today), **torsion bars**, **air springs**

Torsion bar systems are most often found in the automobile. Torsion bars use the twisting properties of a steel bar to provide a coil spring-like performance. One end of the torsion bar is attached to the **frame** of the vehicle, the other end to a **wishbone**, which acts like a **lever** that moves perpendicular to the torsion bar.

Air springs consist of a cylindrical air chamber that is positioned between the wheel and the car body. Air suspension systems, which are typically found in the premium car segment, use compressed air as a spring.

**Air suspension systems** The air suspension replaces the conventional steel spring system. Air suspension systems are able to automatically adapt the damping and spring characteristics of the suspension according to the preferences of the driver. Due to their many advantages, air suspensions systems are more and more specified for future platforms.

**Dampers** Unless there is a damping structure, mechanical springs would release the absorbed energy at an uncontrolled rate. In practice, the unwanted spring motion is dampened by shock absorbers which slow down and reduce the **magnitude** of the vibratory motions by absorbing or dissipating the kinetic energy of the suspension movement. **Rubber bushings** then absorb the rest of the vibrations. The sole purpose of the damper in any suspension system is to control the **oscillations** of the springs, the weight of the vehicle is supported by the spring system.

There are many types of shock absorbers, but the most commonly used is the **twin tube design** which works with a hydraulic fluid (oil). It can be adapted to all types of suspension. The upper mount of the shock absorber connects to the frame of the car (i.e. the sprung weight), while the lower mount connects to the **axle**, near the wheel (i.e. the unsprung weight). The energy of the spring is transferred to the shock absorber through the upper mount into a piston which sits in the inner (pressure) tube filled with hydraulic fluid. **Boreholes** through the piston allow the fluid to leak through a series of **compression valves** as the piston moves up and down in the **pressure tube**.

An automotive **suspension strut** combines the primary function of a shock absorber with the ability to support sideways loads not along its axis of compression, thus eliminating the need for an upper **suspension arm**. The most common suspension strut in an automobile is the **McPherson strut**. Each wheel is attached to the car body by a McPherson strut which combines a shock absorber and a spring in a **single unit**. Such an integrated shock-and-spring module offers better suspension **tuning abilities** and a lower vehicle **step-in height**(посадочна висота) because of the altered suspension geometry.

**Suspension control arms** The typical design elements of any modern suspension system – be it of the McPherson strut, **trailing arm**, **multi-link** or wishbone type - are the suspension control arms. The number of control arms in a vehicle depends on the type of suspension.

The McPherson suspension system, for example, consists of a wishbone (or a lower control arm stabilized by a secondary link) which provides a bottom mounting point for the **hub** of the wheel. This lower arm system controls both the lateral and longitudinal location of the wheel. The upper part of the **hub carrier** (or **steering knuckle**) is rigidly fixed to the strut. The strut suspension includes also a steering arm which connects to the knuckle. The whole assembly is very simple and, since it eliminates the upper control arm, also allows for

more width in the engine compartment. Another common type of a front independent suspension is the double-wishbone suspension. While there are several different possible configurations, this design typically uses two wishbone-shaped arms (вилкоподібні важелі) to locate the wheel. **Double-wishbone suspensions** allow for more control over the motion of the wheel. Because of these characteristics, the double-wishbone suspension is common on the front wheels of larger cars.

### **Exercise 1. Answer the following questions.**

1. What components does the suspension include? 2. What function does the suspension carry? 3. What is the purpose of car's suspension? 4. What are the fundamental parts of the motor vehicle's suspension? 5. What is a stabilizer and what function does it carry out? 6. What are the four common designs for the spring system? Which one is mostly used on modern automobiles? 7. What components does the air spring system consist of? 8. Which suspension system can be adapted to the driver's preference? 9. What devices dampen the unwanted or excessive spring motion? 10. How does the twin tube shock absorber work? 11. What is the most common suspension strut used on most vehicles nowadays? 12. What is a control arm, and what function does it serve? 13. What are the basic components of MacPherson suspension system? 14. What system of suspension is typical for front wheels of larger cars?

### **Exercise 2. Translate the following terms and word combinations into Ukrainian.**

supports the weight of the vehicle body, active safety, driving pleasure, road surface, the fundamental components of any suspension, sharp turn, anti-roll bars, suspension-control computer, rough-road ride quality, steel bar, attached to the frame, cylindrical air chamber, compressed air, release the absorbed energy, vibratory motions, dissipating the kinetic energy, attached to the car body, shock absorber, integrated shock-and-spring module, control arms, secondary link, bottom mounting point, upper part, engine compartment

### **Exercise 3. Translate the following terms and phrases into English using the text.**

пружина, амортизатор, тяги, контакт між шинами та дорожнім покриттям, основні компоненти; **Stabilizers:** крен кузова, крутий поворот, скручуватися, автоматично налаштувати, їзда по дорогах з поганим покриттям; **Springs:** ресора, торсіонна балка, з'єднуватися з рамою, повітряна камера, колесо; **Dampers:** вивільняти поглинуту енергію, небажані пружинні коливання, зменшити силу вібрацій, верхня точка кріплення, поглинати коливання, найпоширеніший тип підвіски, єдиний вузол; **Suspension control arms:** кількість важелів підвіски, поперечний

важіль, ступиця, рульовий важіль (сошка), моторний відсік (відсік двигуна), вилкоподібні важелі

**Exercise 4. Match the terms with their Ukrainian equivalents.**

a)

- |                                       |                          |
|---------------------------------------|--------------------------|
| 1) <b>spring</b>                      | a) тяга                  |
| 2) <b>shock absorber</b>              | b) важіль підвіски       |
| 3) <b>suspension arm</b>              | c) амортизатор           |
| 4) <b>compression valve</b>           | d) двотрубна конструкція |
| 5) <b>twintube design</b>             | e) двоважільна підвіска  |
| 6) <b>oscillations</b>                | f) коливання             |
| 7) <b>linkage</b>                     | g) поздовжній важіль     |
| 8) <b>rubber bushing</b>              | h) пружина               |
| 9) <b>trailing arm</b>                | i) клапан ходу стискання |
| 10) <b>double-wishbone suspension</b> | j) сайлент блок          |

b)

- |                               |                                      |
|-------------------------------|--------------------------------------|
| 1) <b>rolling</b>             | a) крени кузова                      |
| 2) <b>tyre</b>                | b) спіральна/гвинтова пружина        |
| 3) <b>pitching</b>            | c) шина                              |
| 4) <b>body roll (motions)</b> | d) вісь                              |
| 5) <b>anti-roll bar</b>       | e) стабілізатор поперечної стійкості |
| 6) <b>wishbone</b>            | f) торсіон, пружина кручення         |
| 7) <b>torsion spring</b>      | g) поперечний важіль                 |
| 8) <b>coil spring</b>         | h) поперечне розхитування            |
| 9) <b>axle</b>                | i) ресора                            |
| 10) <b>leaf spring</b>        | j) поздовжнє розхитування            |

**Exercise 5. Fill in the blanks with the appropriate words.**

A car's suspension system allows for a smooth ride over **1)** ... roads, while ensuring the tires remain in contact with the ground and that body **2)** ... is minimized. It allows the car to travel smoothly over bumps in the road by **3)** ... and dissipating kinetic energy from the point of contact. Furthermore, a

suspension system allows the car to turn **4)** ... without rolling by shifting the car's center of gravity to maintain balance. A key part of the suspension system is the **5)** ... absorber. Its job is to convert kinetic energy into heat that can be absorbed by the shock's hydraulic **6)**...

Another key component of the suspension is the anti-sway bar (also known as an anti-roll bar), which connects the two sides of a car's suspension along the **7)**... . If one side of the car moves up or down to any extent, the anti-sway bar is able to **8)** ... the roll of the car by distributing the movement to the other side of the car. This means the car won't sway too much in either direction and will remain more level. The anti-sway bar is of particular use when going around corners, especially sharp ones.

- |    |              |             |              |              |
|----|--------------|-------------|--------------|--------------|
| 1. | a) tough     | b) rough    | c) extreme   | d) dangerous |
| 2. | a) jump      | b) build    | c) roll      | d) break     |
| 3. | a) releasing | b) emitting | c) producing | d) absorbing |
| 4. | a) corners   | b) sides    | c) streets   | d) angles    |
| 5. | a) risk      | b) shock    | c) motion    | d) speed     |
| 6. | a) fluid     | b) water    | c) metal     | d) body      |
| 7. | a) wheel     | b) axle     | c) spring    | d) damper    |
| 8. | a) increase  | b) maximize | c) minimize  | d) widen     |

**Exercise 6. Complete the sentences using the correct word.**

- Suspension is the system of springs, shock absorbers and ... that connects a vehicle to its wheels and allows relative motion between the two.  
a) shafts                      b) flywheels                      c) tyres                      d) linkages
- The design of front and ... suspension of a car may be different.  
a) back                      b) rear                      c) side                      d) upper
- The job of a car suspension is to maximize the friction between the ... and the road surface, to provide steering stability with good handling and to ensure the comfort of the passengers.  
a) hub                      b) car body                      c) tyres                      d) damper
- Coil ... compress and expand to absorb the motion of the wheels.  
a) absorbers                      b) linkages                      c) springs                      d) frames
- Torsion ... use the twisting properties of a steel bar to provide coil-spring-like performance.  
a) hubs                      b) knuckles                      c) axles                      d) bars

6. When a car wheel encounters a bump in the road and causes the spring to coil and uncoil, the energy of the spring is transferred to the ... through the upper mount, down through the piston rod and into the piston.

- a) shock absorber    b) steering wheel    c) bushing    d) suspension

7. Dependent front suspensions have a rigid front ... that connects the front wheels.

- a) wheel    b) lever    c) axle    d) borehole

8. The MacPherson ... combines a shock absorber and a coil spring into a single unit.

- a) linkage    b) strut    c) tyre    d) leaf spring

9. Rubber bushings ... the rest of the vibrations.

- a) absorb    b) take over    c) maximize    d) block

10. A stabilizer is usually a torsion spring that resists body ... motions.

- a) jerk    b) shake    c) dance    d) roll

## Lesson 8. Steering

### *Vocabulary notes:*

**rack and pinion steering mechanism**

– рейковий кермовий механізм;

**rack and pinion steering** – кермовий механізм рейкового типу;

**steering wheel** – кермо;

**pinion gear** – ведуча шестерня-вал;

**rack** – зубчаста рейка;

**linear gear** – зубчаста передача шестерня-рейка;

**to mesh** – зчіплюватися;

**circular motion** – обертальний рух;

**linear motion** – прямолінійний рух;

**transverse axis** – поперечна вісь;

**steering torque** – поворотне зусилля;

**swivel pin** – поворотний шкворень;

**ball joint** – шарнірне з'єднання;

**king pin** – поворотний шкворень;

**stub axle** – поворотна цапфа;

**tie rod** – поперечна рульова тяга;

**steering arm** – рульова сошка;

**feedback** – зворотній зв'язок;

**lash** – зазор, люфт;

**recirculating ball mechanism** – гвинтовий механізм;

**utility vehicle** – вантажопасажирський транспортний засіб;

**steering column** – рульова колонка;

**worm gear** – червячна шестерня;

**Pitman arm** – з'єднувальна тяга;

**steering linkage** – рульовий привід;

**friction** – тертя;

**ball bearing** – шариковий підшипник;

**dead spot** – (тут) люфт;

## Steering

Many modern cars use **rack and pinion steering mechanisms**, where the **steering wheel** turns the **pinion gear**; the pinion moves the **rack**, which is a **linear gear** that **meshes** with the pinion, converting **circular motion** into **linear motion** along the **transverse axis** of the car (side to side motion). This motion applies **steering torque** to the **swivel pinball joints** that replaced previously used **kingpins** of the **stub axle** of the steered wheels via **tie rods** and a short lever arm called the **steering arm**.

The rack and pinion design has the advantages of a large degree of **feedback** and direct steering "feel". A disadvantage is that it is not adjustable, so that when it does wear and develop **lash**, the only cure is replacement.

Older designs often use the **recirculating ball mechanism**, which is still found on trucks and **utility vehicles**. This is a variation on the older worm and sector design; the **steering column** turns a large screw (the "**worm gear**") which meshes with a sector of a gear, causing it to rotate about its axis as the worm gear is turned; an arm attached to the axis of the sector moves the **Pitman arm**, which is connected to the **steering linkage** and thus steers the wheels. The recirculating ball version of this apparatus reduces the considerable **friction** by placing large **ball bearings** between the teeth of the worm and those of the screw; at either end of the apparatus the balls exit from between the two pieces into a channel internal to the box which connects them with the other end of the apparatus, thus they are "recirculated".

The recirculating ball mechanism has the advantage of a much greater mechanical advantage, so that it was found on larger, heavier vehicles while the rack and pinion was originally limited to smaller and lighter ones; due to the almost universal adoption of power steering, however, this is no longer an important advantage, leading to the increasing use of rack and pinion on newer cars. The recirculating ball design also has a perceptible lash, or "**dead spot**" on center, where a minute turn of the steering wheel in either direction does not move the steering apparatus; this is easily adjustable via a screw on the end of the steering box to account for wear, but it cannot be entirely eliminated because it will create excessive internal forces at other positions and the mechanism will wear very rapidly. This design is still in use in trucks and other large vehicles, where rapidity of steering and direct feel are less important than robustness, maintainability, and mechanical advantage.

### Exercise 1. Answer the following questions.

1. What type of the steering mechanism is used in modern cars?
2. How does the rack and pinion steering work?
3. What converts circular motion into linear motion?
4. What are some advantages of the rack and pinion design? Disadvantages?
5. What steering mechanisms are mostly used on trucks?
6. Describe the operating principle of the recirculating ball mechanism.
7. What



mechanical device reduces the considerable friction within the recirculating ball mechanism? 8. What are some advantages and disadvantages of the recirculating ball mechanism?

**Exercise 2. Provide Ukrainian equivalents for the following terms and phrases.**

modern cars, to convert circular motion into linear motion, stub axle, lever arm, rack and pinion design, replacement, rotate about its axis, steering linkage, to steer the wheels, mechanical advantage, excessive internal forces, tie rod, feedback

**Exercise 3. Translate the following terms and phrases into English using the text.**

Приводити в рух зубчасту рейку, з'єднуватися з ведучою шестернею, поворотне зусилля, важіль, великий ступінь зворотного зв'язку, зношуватися, зменшувати тертя, кермовий механізм з підсилювачем, допустимий люфт, найменший поворот керма, коробка/редуктор кермового механізму, експлуатаційна надійність

**Exercise 4. Match the terms with their equivalents.**

**A)**

- |                    |                           |
|--------------------|---------------------------|
| 1) steering wheel  | a) прямолінійний рух      |
| 2) stub axle       | b) зубчаста рейка         |
| 3) rack            | c) поворотний шкворень    |
| 4) linear motion   | d) шарнірне з'єднання     |
| 5) transverse axis | e) поворотне зусилля      |
| 6) steering torque | f) кермо                  |
| 7) swivel pin      | g) поперечна рульова тяга |
| 8) ball joint      | h) люфт                   |
| 9) lash            | i) поперечна вісь         |
| 10) tie rod        | j) поворотна цапфа        |

**B)**

- |                |                        |
|----------------|------------------------|
| 1) pinion gear | a) шариковий підшипник |
| 2) to mesh     | b) рульова колонка     |

- |                    |                                     |
|--------------------|-------------------------------------|
| 3) circular motion | c) червячна шестерня                |
| 4) steering arm    | d) зчіплюватися                     |
| 5) steering column | e) обертальний рух                  |
| 6) worm gear       | f) зубчаста передача шестерня-рейка |
| 7) ball bearing    | g) рульова сошка                    |
| 8) linear gear     | h) ведуча шестерня-вал              |

**Exercise 5. Fill in the blanks with appropriate terms.**

Rack-and-pinion **1)** ... is quickly becoming the most common type of steering on cars, small trucks and SUVs. It is actually a pretty simple **2)**... . A rack-and-pinion **3)** ... is enclosed in a metal tube, with each end of the rack protruding from the tube. A rod, called a tie rod, connects to each end of the rack.

The **4)** ... gear is attached to the steering shaft. When you turn the steering **5)**... , the gear spins, moving the rack. The tie **6)** ... at each end of the rack connects to the steering arm on the spindle.

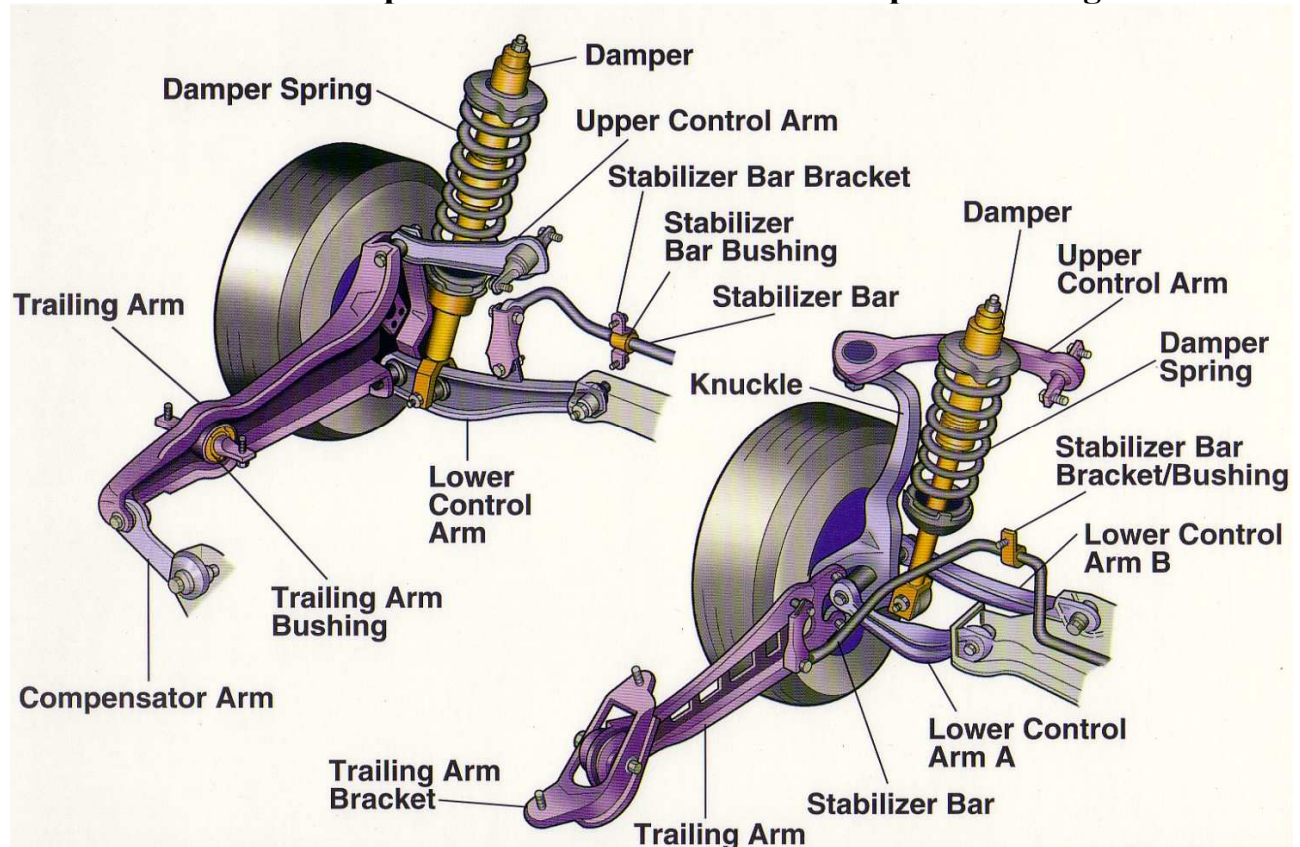
The rack-and-pinion gearset carries two functions:

- It converts the rotational motion of the steering wheel into the **7)** ... motion needed to turn the wheels.
- It provides a gear reduction, making it easier to **8)** ... the wheels.

On most cars, it takes three to four complete revolutions of the steering wheel to make the wheels turn from lock to lock (from far left to far right).

- |                |              |                |               |
|----------------|--------------|----------------|---------------|
| 1. a) driving  | b) motion    | c) suspension  | d) steering   |
| 2. a) device   | b) mechanism | c) block       | d) thing      |
| 3. a) wheel    | b) stub      | c) gearset     | d) suspension |
| 4. a) pinion   | b) satellite | c) planetary   | d) worm       |
| 5. a) tyre     | b) wheel     | c) lever       | d) shaft      |
| 6. a) shaft    | b) linkage   | c) bar         | d) rod        |
| 7. a) circular | b) linear    | c) oscillation | d) vibration  |
| 8. a) rotate   | b) turn      | c) spin        | d) move       |

**Exercise 6. Look at the picture and describe the car suspension design.**



**Lesson 9. The Braking System.**

*Vocabulary notes:*

**master cylinder** – головний циліндр;

**slave cylinder** – робочий циліндр;

**pipe** – трубка;

**hydraulic circuit** – гідравлічна система;

**skid** – занос, блокування коліс;

**partial vacuum** – часткове розрідження;

**inlet manifold** – впускний колектор;

**servounit** – сервомеханізм;

**rod** – шток, важіль;

**to trigger** – приводити в дію

**Exercise 1. Read and translate the text. Answer the questions that follow.**

**Text A. The Braking System**

Modern cars have brakes on all four wheels, operated by a hydraulic system. The brakes may be disc type or drum type.

The front brakes play a greater part in stopping the car than the rear ones, because braking throws the car weight forward on to the front wheels. Many cars therefore have disc brakes, which are generally more efficient, at the front and drum brakes at the rear.

All-disc braking systems are used on some expensive or high-performance cars, and all-drum systems on some older or smaller cars.

***Brake hydraulics***

A hydraulic **brake circuit** has fluid-filled **master** and **slave cylinders** connected by **pipes**. When you push the brake pedal it depresses a piston in the master cylinder, forcing fluid along the pipe. The fluid travels to slave cylinders at each wheel and fills them, forcing pistons out to apply the brakes. Fluid pressure distributes itself evenly around the system. The combined surface 'pushing' area of all the slave pistons is much greater than that of the piston in the master cylinder.

Consequently, the master piston has to travel several inches to move the slave pistons the fraction of an inch it takes to apply the brakes. This arrangement allows great force to be exerted by the brakes, in the same way that a long-handled lever can easily lift a heavy object a short distance.

Most modern cars are fitted with twin **hydraulic circuits**, with two master cylinders in tandem, in case one should fail. Sometimes one circuit works for the front brakes and one for the rear brakes; or each circuit works both for front brakes and one for the rear brakes; or one circuit works for all four brakes and the other for the front ones only. Under heavy braking, so much weight may come off the rear wheels that they lock, possibly causing a dangerous **skid**. For this reason, the rear brakes are deliberately made less powerful than the front.

#### ***Power-assisted brakes***

Many cars also have power assistance to reduce the effort needed to apply the brakes. Usually the source of power is the pressure difference between the **partial vacuum** in the **inlet manifold** and the outside air. The **servo unit** that provides the assistance has a pipe connection to the inlet manifold.

A direct-acting servo is fitted between the brake pedal and the master cylinder. The brake pedal pushes a **rod** that in turn pushes the master-cylinder piston. But the brake pedal also works on a set of air valves, and there is a large rubber diaphragm connected to the master-cylinder piston. When the brakes are off, both sides of the diaphragm are exposed to the vacuum from the manifold.

Pressing the brake pedal closes the valve linking the rear side of the diaphragm to the manifold, and opens a valve that lets in air from outside. The higher pressure of the outside air forces the diaphragm forward to push on the master-cylinder piston, and thereby assists the braking effort.

If the pedal is then held, and pressed no further, the air valve admits no more air from outside, so the pressure on the brakes remains the same. When the pedal is released, the space behind the diaphragm is reopened to the manifold, so the pressure drops and the diaphragm falls back. If the vacuum fails because the engine stops, for example, the brakes still work because there is a normal mechanical link between the pedal and the master cylinder. But much more force must be exerted on the brake pedal to apply them. Some cars have an indirect-acting servo fitted in the hydraulic lines between the master cylinder and the brakes. Such a unit can be mounted anywhere in the engine compartment instead of having to be directly in front of the pedal. It, too, relies on manifold vacuum to provide the boost. Pressing the brake pedal causes

hydraulic pressure build up from the master cylinder, a valve opens and that **triggers** the vacuum servo.

1. What are the main types of brakes used on motor vehicles? 2. Why is it important to supply front wheels with disc brakes? 3. Which type of brakes is more efficient? Why? 4. What elements does a hydraulic brake circuit consist of? 5. Describe the operating principle of a hydraulic brake system. 6. What creates pressure in the hydraulic brake system? 7. Why are the rear brakes made less powerful than the front brakes? 8. What is a power assisted braking system? 9. Describe the operating principle of the power assisted braking system. 10. What function does the servo unit carry out?

**Exercise 2. Find Ukrainian equivalents in the text for the following terms and phrases.**

hydraulic system, front brakes, more efficient, high-performance cars, to force fluid along the pipe, to apply the brakes, heavy braking, dangerous skid, to reduce the effort needed to apply the brakes, master-cylinder piston, to open a valve, to release the pedal, engine compartment, to provide the boost

**Exercise 3. Provide English equivalents for the following terms and phrases using the text.**

гальма дискового типу, легковий автомобіль преміум сегменту (високого класу), головний циліндр, робочий циліндр, тиск рідини рівномірно розподіляється у всій системі, інтенсивне гальмування, розміщений між педаллю гальм і основним циліндром, ніпель (повітряний клапан), механічне з'єднання, моторний відсік, підсилювати, приводити в дію (запускати) сервомеханізм

**Exercise 4. Match the terms with their Ukrainian equivalents.**

**master cylinder**  
**slave cylinder**  
**pipe**  
**hydraulic circuit**  
**partial vacuum**  
**inlet manifold**  
**servounit**  
**rod**  
**air valve**  
**skid**

часткове розрідження  
гідравлічна система  
ніпель  
впускний колектор  
робочий циліндр  
шток, важіль  
занос  
сервомеханізм  
головний циліндр  
трубка

## Exercise 5. Read and translate the text.

### *Some more terms to remember:*

**to straddle** – охоплювати;

**caliper** – супорт;

**braking pad** – гальмівна колодка;

**friction pads** – фрикційні накладки;

**to clamp** – затискати;

**dual-circuit brakes** – двоконтурна гальмівна система;

**return spring** – відтяжна пружина;

**rubber sealing ring** –

ущільнювальне резинове кільце;

**gap** – зазор;

**wear sensor** – датчик зношування;

**leads** – електропроводи;

**to short-circuit** – робити коротке замикання

### Text B. Disc brakes

A disc brake has a disc that turns with the wheel. The disc is **straddled** by a **caliper**, in which there are small hydraulic pistons worked by pressure from the master cylinder.

The pistons press on **friction (braking) pads** that **clamp** against the disc from each side to slow or stop it. The pads are shaped to cover a broad sector of the disc. There may be more than a single pair of pistons, especially in **dual-circuit brakes**. The pistons move only a tiny distance to apply the brakes, and the pads barely clear the disc when the brakes are released. They have no **return springs**.

**Rubber sealing rings** round the pistons are designed to let the pistons slip forward gradually as the pads wear down, so that the tiny **gap** remains constant and the brakes do not need adjustment.

Many later cars have **wear sensors** embedded in the pads. When the pads are nearly worn out, the **leads** are exposed and **short-circuited** by the metal disc, illuminating a warning light on the instrument panel.

## Exercise 6. Answer the following questions.

1. Where a disc brake is positioned? 2. What components does the disc brake consist of? 3. How do the disc brakes work? 4. Do braking pads have return springs? 5. What are rubber sealing rings used for? 6. How can wear sensors be helpful to a driver?

## Exercise 7. Say whether the following statements are true or false.

1. A disc brake employs a disc that spins with the wheel.
2. There are small hydraulic pistons within the caliper.
3. The pistons press the braking pads to slow down or stop the vehicle.
4. Dual-circuit brakes have two pistons.
5. The braking pads have return springs.

6. Wear sensors embedded into the pads alert the driver to stop and change the wheel.

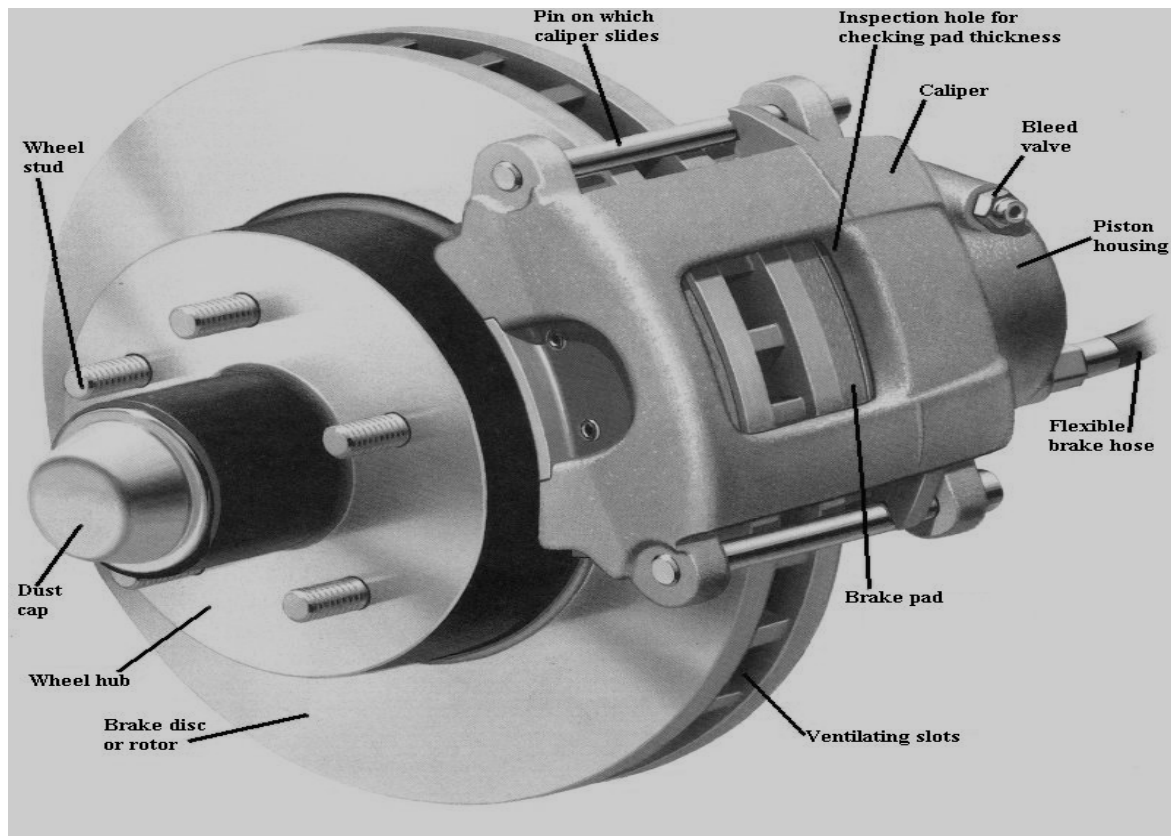
**Exercise 8. Provide English equivalents for the following terms and phrases.**

охоплений супортом, головний циліндр, фрикційні накладки, двоконтурна гальмівна система, задіяти гальма, зношуватися, незначний зазор, не потребувати регулювання, новіші автомобілі, вмонтований у, сигнальна лампочка, панель інструментів

**Exercise 9. Match the terms with their Ukrainian equivalents.**

- |                        |                                  |
|------------------------|----------------------------------|
| 1) caliper             | a) датчик зношування             |
| 2) braking pad         | b) відтяжна пружина              |
| 3) to clamp            | c) двоконтурна гальмівна система |
| 4) rubber sealing ring | d) затискати                     |
| 5) wear sensor         | e) зазор                         |
| 6) dual-circuit brakes | f) супорт;                       |
| 7) return spring       | g) ущільнювальне резинове кільце |
| 8) gap                 | h) гальмівна колодка             |

**Study the picture of a conventional disc brake. Describe the operating principle of the disc brake system.**



## Exercise 10. Read and translate the text.

### *Terms to remember:*

**hollow** – пустотілий;

**backing plate** – опорний щит гальмівного механізму;

**shoe** – гальмівна колодка барабанних гальм;

**friction lining** – фрикційна накладка;

**pivot** – палець;

**leading shoe** – первинна гальмівна колодка;

**leading edge** – робоча сторона;

**trailing shoe** – вторинна гальмівна колодка;

**adjuster** – натяжний гвинт;

**ratchet** – храповий механізм;

**to fade** – втрачати ефективність;

**to be prone to** – мати схильність до

### Text C. Drum brakes

A drum brake has a **hollow** drum that turns with the wheel. Its open back is covered by a stationary **backing plate** on which there are two curved **shoes** carrying **friction linings**.

The shoes are forced outwards by hydraulic pressure moving pistons in the brake's wheel cylinders, so pressing the linings against the inside of the drum to slow or stop it. Each brake shoe has a **pivot** at one end and a piston at the other. A **leading shoe** has the piston at the **leading edge** relative to the direction in which the drum turns.



The rotation of the drum tends to pull the leading shoe firmly against it when it makes contact, improving the braking effect.

Some drums have twin leading shoes, each with its own hydraulic cylinder; others have one leading and one **trailing shoe** - with the pivot at the front. This design allows the two shoes to be forced apart from each other by a single cylinder with a piston in each end. It is simpler but less powerful than the two-leading-shoe system, and is usually restricted to rear brakes.

In either type, return springs pull the shoes back a short way when the brakes are released. Shoe travel is kept as short as possible by an **adjuster**. Older systems have manual adjusters that need to be turned from time to time as the friction linings wear. Later brakes have automatic adjustment by means of a **ratchet**.

Drum brakes may **fade** if they are applied repeatedly within a short time - they heat up and lose their efficiency until they cool down again. Discs, with their more open construction, are much less **prone to** fading.

**Exercise 11. Translate the following terms and phrases into Ukrainian.**

hollow drum, stationary backing plate, curved shoes, hydraulic pressure, braking effect, twin leading shoes, return springs, pull the shoes back, manual adjusters, cool down, prone to fading, relative to the direction, hydraulic cylinder

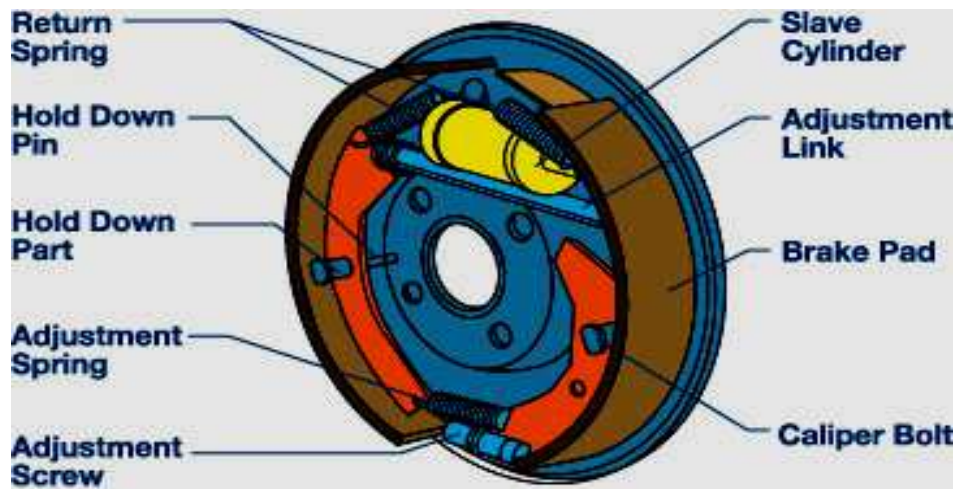
**Exercise 12. Provide English equivalents for the following terms and phrases using the text.**

нерухомий опорний щит гальмівного механізму, відносно руху барабана, спарені первинні гальмівні колодки, ефект гальмування, задні гальма, відтяжна пружина, хід гальмівної колодки, автоматичне регулювання, втратити ефективність, охолоджуватися

**Exercise 13. Match the terms with their Ukrainian equivalents.**

- |                  |                                      |
|------------------|--------------------------------------|
| 1) hollow        | a) гальмівна колодка                 |
| 2) backing plate | b) палець                            |
| 3) shoe          | c) храповий механізм                 |
| 4) pivot         | d) опорний щит гальмівного механізму |
| 5) leading shoe  | e) первинна гальмівна колодка        |
| 6) leading edge  | f) вторинна гальмівна колодка        |
| 7) ratchet       | g) пустотілий                        |
| 8) trailing shoe | h) робоча сторона                    |

**Exercise 14. Study the picture and describe drum brake design and operating principle.**



## **Part II**

### **Lesson 1.The Anti-lock Braking System**

**Anti-lock braking system (ABS)** – антиблокувальна система гальм;  
**tractive contact** – зчеплення, контакт (напр. з дорожнім покриттям);  
**threshold braking** – оптимальне гальмування;  
**cadence braking** – переривчасте гальмування;  
**loose surface** – рихле (дорожнє) покриття;  
**wheel lock** – блокування колеса;  
**front-to-rear brake bias** – розподіл гальмівного зусилля між передніми і задніми колесами;  
**electronic brake force distribution (EBD)** – система розподілу гальмівного зусилля;  
**emergency brake assist** – система контролю під час екстреного гальмування;  
**electronic stability control (ESC)** – система динамічної стабілізації руху;  
**rotational speed** – кількість обертів (за одиницю часу);  
**pedal pulsation** – пульсація педалі (під час спрацювання антиблокувальної системи гальм);  
**hub-mounted sensor** – ступичний датчик;  
**steering wheel angle sensor** – датчик кута повороту руля  
**gyroscopic sensor** – гіродатчик;  
**individual wheel** – окреме колесо;  
**cornering brake control (CBC)** – система контролю гальмування в повороті;  
**traction control system (TCS)** – система регулювання тягового зусилля; антипробуксовувальна система;  
**to lose traction** – втратити зчеплення, контакт; пробуксовувати;

**throttle level** – кількість подачі пального

## **ABS**

**Anti-lock braking system (ABS)** is an automobile safety system that allows the wheels on a motor vehicle to maintain **tractive contact** with the road surface according to driver inputs while braking preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. It is an automated system that uses the principles of **threshold braking** and **cadence braking** which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than a driver could manage.

ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces for many drivers; however, on **loose surfaces** like gravel or snow-covered pavement, ABS can significantly increase braking distance, although still improving vehicle control.

Since initial widespread use in production cars, anti-lock braking systems have evolved considerably. Recent versions not only prevent **wheel lock** under braking, but also electronically control the **front-to-rear brake bias**. This function, depending on its specific capabilities and implementation, is known as **electronic brake force distribution (EBD)**, traction control system, **emergency brake assist**, or **electronic stability control (ESC)**.

Typically ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics. The ECU constantly monitors the **rotational speed** of each wheel; if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster. Conversely, if the ECU detects a wheel turning significantly faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. This process is repeated continuously and can be detected by the driver via **brake pedal pulsation**. Some anti-lock systems can apply or release braking pressure 15 times per second.

The ECU is programmed to disregard differences in wheel rotative speed below a critical threshold, because when the car is turning, the two wheels towards the center of the curve turn slower than the outer two. For this same reason, a differential is used in virtually all roadgoing vehicles.

If a fault develops in any part of the ABS, a warning light will usually be illuminated on the vehicle instrument panel, and the ABS will be disabled until the fault is rectified.

Modern ABS applies individual brake pressure to all four wheels through a control system of **hub-mounted sensors** and a dedicated micro-controller. ABS is offered or comes standard on most road vehicles produced today and is the foundation for electronic stability control systems, which are rapidly

increasing in popularity due to the vast reduction in price of vehicle electronics over the years.

Modern electronic stability control systems are an evolution of the ABS concept. Here, a minimum of two additional sensors are added to help the system work: these are a **steering wheel angle sensor**, and a **gyroscopic sensor**. The theory of operation is simple: when the gyroscopic sensor detects that the direction taken by the car does not coincide with what the steering wheel sensor reports, the ESC software will brake the necessary **individual wheel(s)** (up to three with the most sophisticated systems), so that the vehicle goes the way the driver intends. The steering wheel sensor also helps in the operation of **Cornering Brake Control (CBC)**, since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much.

ABS equipment may also be used to implement a **traction control system (TCS)** on acceleration of the vehicle. If, when accelerating, the tire **loses traction**, the ABS controller can detect the situation and take suitable action so that traction is regained. More sophisticated versions of this can also control **throttle levels** and brakes simultaneously.

### **Exercise 1. Answer the following questions.**

1. What is an ABS? 2. What are the underlying operating principles of the anti-lock braking system? 3. What are the advantages of the ABS? Disadvantages? 4. Name some modern motor car electronic systems that assist or are engaged with the ABS. 5. What physical and electronic components does the ABS consist of? 6. How does the anti-lock braking system work? 7. What is an ECU and how does it operate? 8. Name some of the electronic assistants that are enabled in pair with the ABS.

### **Exercise 2. Provide Ukrainian equivalents for the following terms and word combinations.**

automobile safety system, dry and slippery surfaces, skillful drivers, road surface, uncontrolled skidding, braking distance, four wheel speed sensors, hydraulic valves, brake hydraulics, vehicle instrument panel, brake pressure, electronic stability control systems, steering wheel sensor, acceleration of the vehicle, sophisticated versions

### **Exercise 3. Find English equivalents for the following words and word combinations using the text.**

оптимальне гальмування, некероване пробуксовування, блокування колеса, система розподілу гальмівного зусилля, дії водія, система динамічної стабілізації руху, ступичний датчик, рульове колесо, система контрольованого гальмування в повороті, дорожнє покриття, керованість

автомобіля, швидкість обертання, активувати клапан, панель приборів, шина, пригальмовувати колесо, диференціал, попереджувальний світловий сигнал (сигнальна лампа на щитку приборів)

#### Exercise 4. Match the terms with their equivalents.

- |                                  |                                     |
|----------------------------------|-------------------------------------|
| 1) to maintain tractive contact  | a) датчики швидкості                |
| 2) to lock up                    | b) зменшити тиск рідини             |
| 3) to decrease stopping distance | c) критична межа                    |
| 4) electronic control unit       | d) заблокувати                      |
| 5) hydraulic valve               | e) антипробуксовувальна система     |
| 6) critical threshold            | f) покращити керованість автомобіля |
| 7) speed sensors                 | g) підтримувати зчеплення (коліс)   |
| 8) to improve vehicle control    | h) гідравлічний клапан              |
| 9) traction control system       | i) електронний блок керування       |
| 10) to reduce hydraulic pressure | j) зменшити гальмівний шлях         |

#### Exercise 5. Find pairs of synonyms.

- |                 |                     |
|-----------------|---------------------|
| 1) vehicle      | a) turn             |
| 2) to lock up   | b) instrument panel |
| 3) to monitor   | c) to block         |
| 4) curve        | d) grip             |
| 5) dashboard    | e) to minimize      |
| 6) traction     | f) to apply         |
| 7) to implement | g) automobile       |
| 8) to reduce    | h) to check         |

#### Exercise 6. Insert the necessary words to complete the text.

##### Emergency brake assist

Many drivers are not prepared for the relatively high efforts required for maximum braking, nor are they prepared for the "buzzing" feedback through the brake pedal during ABS operation. If an **1)** ...develops, a slow reaction and less than maximum braking input could result in insufficient time or distance to stop before an accident occurs.

EBA is designed to **2)** ...such "panic stops" and apply maximum braking effort within milliseconds. It interprets braking behaviour by assessing the **3)** ...that the brake pedal is activated.

If the system **4)** ...an emergency, it automatically initiates full braking faster than any driver can move their foot. Emergency stopping distances can be shortened, reducing the likelihood of **5)** ...– especially the common "nose to tail" incident. An electronic system designed to **6)** ... emergency braking

operation and automatically enhance braking effort, and can 7) ...stopping distances by up to 70 ft (21 m) at 125 mph (201 km/h).

Brake Assist detects circumstances in which emergency braking is required by 8) ...the speed with which the brake pedal is depressed. Some systems additionally take into account the rate of which the 9) ... pedal is released, pre-tensioning the brakes when a "panic release" of the accelerator pedal is noted. When panic braking is detected, the Brake Assist system automatically develops maximum brake 10) ...in order to mitigate a drivers tendency to brake without enough force.

- |     |                 |                 |                   |              |
|-----|-----------------|-----------------|-------------------|--------------|
| 1.  | a) problem      | b) accident     | c) emergency      | d) fault     |
| 2.  | a) inspect      | b) detect       | c) protect        | d) reject    |
| 3.  | a) moment       | b) velocity     | c) frequency      | d) rate      |
| 4.  | a) identifies   | b) spots        | c) marks          | d) finds     |
| 5.  | a) crises       | b) disturbances | c) confrontations | d) accidents |
| 6.  | a) find out     | b) recognise    | c) value          | d) sense     |
| 7.  | a) reduce       | b) increase     | c) develop        | d) slow      |
| 8.  | a) calculating  | b) computing    | c) decreasing     | d) measuring |
| 9.  | a) brake        | b) clutch       | c) accelerator    | d) manual    |
| 10. | a) acceleration | b) boost        | c) turbine        | d) power     |

## Lesson 2. The Electronic Stability Program

### Vocabulary notes:

**Electronic stability control** – система динамічної стабілізації руху;

**Electronic stability program** – електронна система курсової стійкості, електронна система стабілізації руху;

**oversteer** – надмірна керованість, стернування (поворотність);

**understeer** – недостатня керованість, стернування;

**vehicle's cornering performance** – проходження віражів, поведінка автомобіля під час проходження повороту;

**vehicle rotation (yaw)** – обертання автомобіля навколо вертикальної осі, відхилення від напрямку руху (рискання);

**lateral acceleration** – бокове прискорення;

**evasive swerve** – об'їзний маневр;

**hydroplaning** – аквапланування;

**high-performance driving** – екстремальне водіння;

**vehicle's handling limits** – межа керованості автомобіля;

**cornering** – проходження поворотів;

**over-ride control** – примусове відключення функції

## Text A. The ESP

**Electronic stability control** (ESC), also referred to as **electronic stability program** (ESP) or **dynamic stability control** (DSC), is a computerized technology that improves the safety of a vehicle's stability by detecting and reducing loss of traction (skidding). When ESC detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go. Braking is automatically applied to wheels individually, such as the outer front wheel to counter **oversteer** or the inner rear wheel to counter understeer. Some ESC systems also reduce engine power until control is regained. ESC does not improve a **vehicle's cornering performance**; instead, it helps to minimize the loss of control. According to Insurance Institute for Highway Safety and the U.S. National Highway Traffic Safety Administration, one-third of fatal accidents could have been prevented by the technology.

During normal driving, ESC works in the background and continuously monitors steering and vehicle direction. It compares the driver's intended direction (determined through the measured steering wheel angle) to the vehicle's actual direction (determined through measured **lateral acceleration**, **vehicle rotation** (yaw), and individual road wheel speeds).

ESC intervenes only when it detects a probable loss of steering control, i.e. when the vehicle is not going where the driver is steering. This may happen, for example, when skidding during emergency **evasive swerves**, understeer or oversteer during poorly judged turns on slippery roads, or **hydroplaning**. ESC may also intervene in an unwanted way during **high-performance driving**, because steering input may not always be directly indicative of the intended direction of travel (i.e. controlled drifting). ESC estimates the direction of the skid, and then applies the brakes to individual wheels asymmetrically in order to create torque about the vehicle's vertical axis, opposing the skid and bringing the vehicle back in line with the driver's commanded direction. Additionally, the system may reduce engine power or operate the transmission to slow the vehicle down.

ESC can work on any surface, from dry pavement to frozen lakes. It reacts to and corrects skidding much faster and more effectively than the typical human driver, often before the driver is even aware of any imminent loss of control. In fact, this led to some concern that ESC could allow drivers to become overconfident in their vehicle's handling and/or their own driving skills. For this reason, ESC systems typically inform the driver when they intervene, so that the driver knows that the **vehicle's handling limits** have been approached. Most activate a dashboard indicator light and/or alert tone; some intentionally allow the vehicle's corrected course to deviate very slightly from the driver-commanded direction, even if it is possible to more precisely match it.

Indeed, all ESC manufacturers emphasize that the system is not a performance enhancement nor a replacement for safe driving practices, but

rather a safety technology to assist the driver in recovering from dangerous situations. ESC does not increase traction, so it does not enable faster **cornering** (although it can facilitate better-controlled cornering). More generally, ESC works within inherent limits of the vehicle's handling and available traction between the tires and road. A reckless maneuver can still exceed these limits, resulting in loss of control. For example, in a severe hydroplaning scenario, the wheels that ESC would use to correct a skid may not even initially be in contact with the road, reducing its effectiveness.

Due to the fact that stability control can sometimes be incompatible with high-performance driving (i.e. when the driver intentionally loses traction as in drifting), many vehicles have an **over-ride control** which allows the system to be partially or fully shut off. In simpler systems, a single button may disable all features, while more complicated setups may have a multi-position switch or may never be turned fully off.

### **Exercise 1. Answer the following questions.**

1. What is electronic stability control designed (ESC) for? 2. When is the ESC enabled? 3. Does ESC improve a vehicle's cornering performance? 4. How many fatal accidents could have been prevented with the help of ESC technology according to Insurance Institute for Highway Safety and the U.S. National Highway Traffic Safety Administration? 5. How does ESC work during normal driving? 6. In what road circumstances does the electronic stability control system intervene? 7. Describe the operation of ESC in critical scenario. 8. Why could ESC make drivers overconfident in vehicle's driving? 9. Do you think ESC increase traction or enable faster cornering? 10. What is an over-ride control?

### **Exercise 2. Translate the following terms and word combinations into Ukrainian.**

dynamic stability control (DSC), skidding, loss of steering control, inner rear wheel, understeer, to reduce engine power, vehicle's cornering performance, wheel angle, yaw, slippery roads, hydroplaning, vehicle's handling limits, imminent loss of control, dashboard indicator light, alert tone, safety technology, traction between the tires and road, reckless maneuver, to disable all features

### **Exercise 3. Find English equivalents for the following words and word combinations using the text.**

бокове прискорення, аквапланування, екстремальне водіння, втрата керуваності, автоматично пригальмовувати, кут повороту колеса, стежити за керуванням і напрямком руху транспортного засобу, втручатися, занос, створювати тягове зусилля, зменшити потужність двигуна (обертальний момент), навички водіння, наблизитись до критичної межі керуваності автомобілем, попереджувальний звуковий сигнал, покращення



характеристик, швидше проходження поворотів, зчеплення шин з дорогою, необдуманий маневр, багатопозиційний перемикач

#### Exercise 4. Match the terms with their equivalents.

- |                                     |                                      |
|-------------------------------------|--------------------------------------|
| 1) <b>loss of steering control</b>  | a) бокове прискорення                |
| 2) <b>understeer</b>                | b) коробка передач, трансмісія       |
| 3) <b>vehicle direction</b>         | c) сигнальна лампа на щитку приборів |
| 4) <b>lateral acceleration</b>      | d) допомагати водієві                |
| 5) <b>skidding</b>                  | e) напрямок руху автомобіля          |
| 6) <b>transmission</b>              | f) покращення характеристик          |
| 7) <b>applies the brakes</b>        | g) втрата керування                  |
| 8) <b>dashboard indicator light</b> | h) недостатня керованість            |
| 9) <b>performance enhancement</b>   | i) гальмувати                        |
| 10) <b>to assist the driver</b>     | j) занос, пробуксовування            |

#### Exercise 5. Find pairs of:

##### *a) synonyms*

- |                              |                                 |
|------------------------------|---------------------------------|
| 1) dynamic stability control | a) to interfere                 |
| 2) to reduce                 | b) to minimize                  |
| 3) vehicle rotation          | c) to oversee                   |
| 4) to intervene              | d) to maneuver                  |
| 5) to swerve                 | e) instrument panel             |
| 6) to monitor                | f) electronic stability program |
| 7) dashboard                 | g) to differ                    |
| 8) to deviate                | h) yaw                          |

##### *b) antonyms*

- |                      |                      |
|----------------------|----------------------|
| 1) oversteer         | a) to lose control   |
| 2) inner wheel       | b) to accelerate     |
| 3) to regain control | c) to disable        |
| 4) to reduce         | d) dangerous driving |
| 5) to slow down      | e) to turn on        |
| 6) safe driving      | f) understeer        |
| 7) to activate       | g) to enhance        |
| 8) to shut off       | h) outer wheel       |

Make up sentences with some of the words and phrases.

#### **Text B. Components and design of the ESC.**

ESC incorporates yaw rate control into the anti-lock braking system (ABS). Yaw is a rotation around the vertical axis; i.e. spinning left or right. Anti-lock

brakes enable ESC to brake individual wheels. Many ESC systems also incorporate a traction control system (TCS or ASR (Antriebsschlupfregelung – нім.)), which senses drive-wheel slip under acceleration and individually brakes the slipping wheel or wheels and/or reduces excess engine power until control is regained. However, ESC achieves a different purpose than ABS or traction control.

The ESC system uses several sensors to determine what the driver wants (input). Other sensors indicate the actual state of the vehicle (response). The control algorithm compares driver input to vehicle response and decides, when necessary, to apply brakes and/or reduce throttle by the amounts calculated through the state space (простір станів – фіз.,(set of equations used to model the dynamics of the vehicle)). The ESC controller can also receive data from and put instructions to other controllers on the vehicle such as an all-wheel drive system or an active suspension system to improve vehicle stability and controllability.

The sensors used for ESC have to send data at all times in order to detect possible vehicle's misbehaviour as soon as possible. The sensors have to be resistant to possible forms of interference. **The main sensors come as:**

- Steering wheel angle sensor: determines the driver's intended rotation; i.e. where the driver wants to steer. This kind of sensor is often based on AMR-elements (анізотропні магнетоопірні елементи);
- Yaw rate sensor: measures the rotation rate of the car; i.e. how much the car is actually turning. The data from the yaw sensor is compared with the data from the steering wheel angle sensor to determine regulating action;
- Lateral acceleration sensor: often an accelerometer;
- Wheel speed sensor: measures the wheel speed.

**Other sensors can include:**

- Longitudinal acceleration sensor: similar to the lateral acceleration sensor in design, but can offer additional information about road pitch and also provide another source of vehicle acceleration and speed;
- Roll rate sensor: similar to the yaw rate sensor in design but improves the fidelity of the controller's vehicle model and correct for errors when estimating vehicle behavior from the other sensors alone.

ESC uses a hydraulic modulator to assure that each wheel receives the correct brake force. A similar modulator is used in ABS. ABS needs to reduce pressure during braking, only. ESC additionally needs to increase pressure in certain situations and an active vacuum brake booster unit may be utilized in addition to the hydraulic pump to meet these demanding pressure gradients (баричний градієнт).

The brain of the ESC system is the electronic control unit (ECU). The various control modules are embedded in it. Often, the same ECU is used for diverse systems at the same time (ABS, Traction Control System, climate control, etc.). The input signals are sent through the input-circuit to the digital controller. The desired vehicle state is determined by the steering wheel angle,

its gradient and the wheel speed. Simultaneously, the yaw sensor measures the actual state. The controller computes the needed brake or acceleration force for each wheel and operates the valves of the hydraulic modulator via the driver circuits.

**Exercise 1. Read and translate the statements below. State whether they are true or false.**

1. Yaw is a rotation of a vehicle around its vertical axis.
2. A great number of ESC systems also incorporate a Traction Control System.
3. The ESC system prevents the vehicle from overturning.
4. If emergency develops the ESC system can apply brakes and/or reduce engine power.
5. The ESC controller can also receive data from and direct commands to other controllers on the vehicle such as an all-wheel drive system or an active suspension system to improve vehicle stability.
6. The ESC sensors must be resistant to all forms of interferences.
7. Yaw rate sensor measures the speed of the car.
8. Wheel speed sensor measures the rotation rate of the car.
9. ESC uses a hydraulic modulator to assure that each wheel receives the correct brake force.
10. The electric control unit lies in the core of the ESC system.
11. The same electronic control unit is rarely used for diverse systems at the same time like the ABS, Traction Control System, climate control, etc.
12. ESC uses a hydraulic modulator to assure that each wheel receives the correct brake force.

**Exercise 2. Match the term with its Ukrainian equivalent.**

- |                                      |  |
|--------------------------------------|--|
| 1) yaw rate control                  | a) зменшити подачу палива/оберти         |
| 2) drive-wheel slip                  | b) адаптивна підвіска                    |
| 3) vehicle's response                | c) датчик поздовжнього прискорення       |
| 4) reduce throttle                   | d) (вакуумний) підсилювач гальм          |
| 5) all-wheel drive system            | e) датчик положення керма                |
| 6) steering wheel angle sensor       | f) датчик поперечного нахилу             |
| 7) active suspension system          | g) система контролю кутового прискорення |
| 8) vacuum brake booster              | h) система повного приводу               |
| 9) roll rate sensor                  | i) пробуксовування ведучого колеса       |
| 10) longitudinal acceleration sensor | j) реакція автомобіля                    |

**Exercise 3. Translate the following words and word combination using the text.**

обертання навколо вертикальної осі, дії водія, реакція автомобіля, зменшити подачу палива/оберти, регулятор/контролер, підвіска автомобіля, повний привід, бокове прискорення, розгін, ухил дороги, гідромодулятор, вакуумний підсилювач гальм, електронний блок керування, клапан, сила прискорення.

**Ex. 4. Fill in the blanks with the appropriate words given after the text.**

**Active Yaw Control**

Active Yaw Control is a dynamic **1)** ...control system that sustains longitudinal acceleration and improves lateral stability by controlling torque-bias (перерозподіл обертального моменту) between the rear wheels. Active yaw control increases cornering and traction **2)** ...using a computer controlled rear differential. The torque difference between the rear wheels generates a yawing moment in the proper direction and corrects the yaw-dynamics of the vehicle in motion. The result is a stable **3)** ...with improved handling performance and improved cornering capability. These systems are sometimes referred to as active differentials or vector drives.

The torque variation is controlled by the ECU and is **4)** ...to the wheels through several mechanical components in the differential. The three major components in the computer controlled differential are the **5)** ...mechanisms, the main differential, and the speed increasing/reducing gear train. The clutches are utilized to control the amount of **6)** ...being transferred through the increasing/decreasing gear train, and determine the amount of torque applied to each of the two **7)** ... . The torque-bias is a function of clutch pressure and the amount of clutch pressure is **8)** ...by the processor in the ECU and actuated using hydraulic or electromagnetic components.

The active yaw control strategy is based on the relative wheel speeds. The optimum wheel speed difference is determined by the ECU in order to maintain the **9)** ...wheel position.

If a vehicle with active yaw control begins to **10)** ...in a manner inconsistent with the steering wheel position, torque from the outside wheel will be transferred to the inside wheel. This torque difference will produce a yawing motion in the direction necessary to correct the car's rotation.

- |    |                |              |                |               |
|----|----------------|--------------|----------------|---------------|
| 1. | a) instability | b) stability | c) equilibrium | d) durability |
| 2. | a) performance | b) conduct   | c) action      | d) behaviour  |
| 3. | a) cruiser     | b) ship      | c) engine      | d) vehicle    |
| 4. | a) taken       | b) applied   | c) put         | d) conducted  |
| 5. | a) grasp       | b) clinch    | c) clutch      | d) grip       |
| 6. | a) moment      | b) torque    | c) touch       | d) speed      |

- |     |                |             |              |             |
|-----|----------------|-------------|--------------|-------------|
| 7.  | a) rings       | b) tyres    | c) circles   | d) wheels   |
| 8.  | a) determined  | b) defined  | c) refined   | d) measured |
| 9.  | a) controlling | b) steering | c) directing | d) managing |
| 10. | a) accelerate  | b) revolve  | c) rotate    | d) turn     |

### Lesson 3.The Electronic Valve Timing Control

#### *Vocabulary notes:*

**Electronic Valve Timing Control** – електронна система зміни фаз газорозподілу;

**camshaft** – розподільний/кулачковий вал;

**lobe**– кулачок розподільного валу;

**RPM (Revolutions per minute)** – оберти за хвилину;

**Engine power output** – корисна потужність двигуна;

**actuator** – привід, механізм;

**valve timing** – фази газорозподілу;

**spring-loaded valve** – пружинний клапан;

**crankshaft** – колінчастий вал, колінвал;

**electric solenoid**– електромагніт;

**lifter** – штовхач клапана, кулачок;

**timing chain** – ланцюг газорозподільного механізму;

**intake valve** – впускний клапан;

**exhaust valve** – випускний клапан

#### **Electronic Valve Timing Control**

The valves in an internal combustion engine open and close to both allow the fuel-air mixture to enter the cylinder prior to combustion, as well as to allow the exhaust gases to exit the cylinder after combustion. In most engines, the valves are opened by lobes connected to the camshaft. The shape of these lobes determines the lift, timing and duration of each valve opening. In an engine with fixed valve timing, the timing is not optimal for all engine speeds. For example, if a camshaft is designed to operate the valves for optimal timing at low RPMs, then at higher RPMs each cylinder would be deprived of sufficient fuel and air mixture, limiting the engine power output. Conversely, if optimized for high RPMs, the vehicle would experience rough idling at low RPMs. There are several methods for changing the valve timing, such as using multiple camshafts or eliminating the camshaft altogether; altering the timing of the intake camshaft; and controlling the valve timing with electronic, hydraulic or pneumatic actuators. Variable valve timing can significantly increase both the power and fuel efficiency of an internal combustion engine.

Electronic valve control (EVC) systems attempt to optimize the valve timing over the entire range of possible engine speeds. Most existing systems

manipulate the valve timing using a computer controlled actuator attached to the camshaft. Sometimes two camshafts are used, one to control the intake valves and the other to control the exhaust valves. The camshaft may have two sets of lobes, where one set is designed for low and the other for high RPMs. As the camshaft rotates, the lobes push open the spring-loaded valves, which are then closed by the force of springs. An electronic control unit (ECU) selects which set of lobes to use based on the engine speed. Another approach to variable valve timing employs a cam phasing mechanism to monitor and adjust the rotation of the camshaft relative to the rotation of the crankshaft.

There are other mechanical/electrical methods that come one step closer to eliminating the camshaft altogether. Three of these methods are electro-pneumatic valves (EPV), electro-hydraulic valves (EHV), and electromagnetic valves (EMV). EPV and EHV use electric solenoids to control the flow of compressed air or hydraulic fluid to the valves at the appropriate time. Existing EPV and EHV systems generally eliminate the spring mechanism but still employ the cam. EPV systems are commonly found on Formula One engines and EHV systems are being employed by the engines on all new BMW vehicles. Electromagnetic valves control the valve opening directly with a solenoid and thus eliminates camshafts as well as many other related components including lifters and timing chains. Engines of this design are currently undergoing development and have only made it into prototype stages. Engines with EMV systems are commonly referred to as "camless engines". EMV systems have yet to come to market because of the expense as well as the power required to operate the actuator. EMV systems as opposed to other variable valve timing systems allow for nearly infinite combinations of duration, lift, and phase of both the intake and exhaust valves allowing for greatly improved control over engine performance characteristics reducing emissions, increasing low end torque and increasing peak horsepower.

### **Exercise 1. Answer the following questions.**

1. What are the two types of valves used in the internal combustion engine?
2. What parts of the camshaft are valves opened by?
3. What is fixed valve timing, variable valve timing? Which is better option for a vehicle driving performance and why?
4. What is an electronic valve control system?
5. What solutions are typically used in electronic valve control systems to optimize the valve timing?
6. What is a cam phasing mechanism used for?
7. What are some methods to partially eliminate the camshaft/s?
8. Why could the EMV systems be a revolutionary solution to variable valve timing?

### **Exercise 2. Translate the following words and word combinations into Ukrainian.**

combustion, exhaust gases, fixed valve timing, camshaft, optimal timing, low RPMs, high RPMs, engine power output, rough idling, pneumatic actuator, fuel

efficiency, engine speed, intake valves, exhaust valves, rotation of the camshaft relative to the rotation of the crankshaft, electric solenoid, lifter, timing chain, engine performance characteristics, to reduce emissions, low end torque, peak horsepower

**Exercise 3. Translate the following words and word combinations into English using the text.**

двигун внутрішнього згорання, пальна суміш, електронна система зміни фаз газорозподілу, нерівномірний холостий хід, розподільний вал впускних клапанів, пневматичний привід, обертатися, колінчастий вал, ланцюг газорозподільного механізму, максимальний обертальний момент при низьких обертах двигуна, економія палива, пружинний клапан, штовхач клапана, електронний блок керування, відносно обертів колінчастого валу, впускний клапан, випускний клапан

**Exercise 4. Match the terms with their Ukrainian Equivalents.**

- |                                       |  |
|---------------------------------------|--|
| 1) fuel-air mixture                   | a) фази газорозподілу                    |
| 2) crankshaft                         | b) низькі оберти                         |
| 3) actuator                           | c) ланцюг газорозподільного механізму    |
| 4) electric solenoid                  | d) колінчастий вал                       |
| 5) low RPM                            | e) експлуатаційні характеристики двигуна |
| 6) fuel efficiency                    | f) електромагніт                         |
| 7) timing chain                       | g) електронний механізм                  |
| 8) engine performance characteristics | h) економія палива                       |
| 9) valve timing                       | i) пальна суміш                          |
| 10) electronic actuator               | j) привід, механізм                      |

**Exercise 5. Insert the necessary words to complete the sentences.**

1. In a ... engine, the valve timing is the precise timing of the opening and closing of the valves.

- a) electric                      b) piston                      c) jet                      d) rotor

2. In four-stroke cycle engines and some two-stroke cycle engines, the valve timing is controlled by the ... .

- a) crankshaft                      b) piston                      c) driver                      d) camshaft

3. The ... valve is opened before the exhaust gases have completely left the cylinder.

- a) exhaust                      b) intake                      c) drive                      d) ignition

4. VTEC (Variable Valve Timing and Lift Electronic Control) was initially designed to increase the power ... of an engine to 100 HP/litre.  
 a) output                      b) input                      c) production                      d) development
5. VTEC is an electronic and mechanical system in some Honda engines that allows the engine to have ... camshafts.  
 a) single                      b) triangle                      c) turbo-charged                      d) multiple
6. As the camshaft spins, the ... open and close the intake and exhaust valves in time with the motion of the piston.  
 a) actuators                      b) lobes                      c) switch                      d) crankshaft
7. In single and double overhead cam engines cams are driven by the ... via a belt or chain (called the timing belt or timing chain).  
 a) piston                      b) valve                      c) pushrod                      d) crankshaft
8. The motion of the camshaft controls the action of the engine valves, which then regulates the amount of the air/fuel mixture that ... the engine.  
 a) powers                      b) deforces                      c) forces                      d) charges
9. The valves within an internal combustion engine are used to control the flow of the intake and exhaust gases into and out of the combustion... .  
 a) room                      b) tank                      c) chamber                      d) camera
10. The camshaft is driven by the crankshaft through ... belts, gears or chains.  
 a) time                      b) timing                      c) timed                      d) timeless

## Lesson 4. Cylinder Deactivation Systems

### Vocabulary notes:

- peak performance** – максимальні експлуатаційні характеристики;  
**combustion pressure** – тиск в камері згоряння;  
**to disable the cylinder** – деактивувати циліндр;  
**engine displacement** – робочий об'єм двигуна;  
**throttle valve** – дросельна заслінка;  
**hydraulic lifter** – гідрокомпенсатор;  
**line-up** – модельний ряд;  
**rocker arm** – коромисло клапана;  
**pushrod** – штовхач/штанга клапана;  
**to push/put into a backburner** – відкласти в довгий ящик;  
**variable compression** – зміна ступеня стиснення;  
**pushrod engines** – двигуни з нижнім розташуванням розподільного вала;



**overhead cam engines** – двигуни з верхнім розташуванням розподільного вала

### **Cylinder Deactivation Systems**

Cylinder deactivation systems selectively disable some of the cylinders in an internal combustion engine to improve fuel economy when the full power of the engine is not required. When power requirements from the engine are low, the engine does not run at its peak performance level. The throttle air intake is minimal and the intake of air to the cylinders is more difficult. Not only is more force required to overcome the internal vacuum, but the cylinders are not completely filled with air. With less air in the cylinder, the combustion pressure is reduced. This situation is commonly referred to as pumping loss and can significantly reduce the efficiency of the engine.

Cylinder deactivation effectively decreases the displacement of the engine. As a result, for a given load on the engine, the throttle valve is more open allowing better air flow. Allowing the cylinder pressure to be closer to the optimal level increases the efficiency of the engine.

#### **Cylinder Deactivation History**

The first production cars to implement cylinder deactivation for increased fuel efficiency were from the 1981 Cadillac lineup. GM, in conjunction with Eaton Corporation, designed a six liter engine that had the ability to change from eight to six to four cylinders. Controlling the deactivation of the cylinders was a microprocessor that determined, based on throttle input, which and how many of the cylinders to shut off.

The microprocessor then controlled a solenoid that moved the desired cylinder's valve rocker arms. The arms were moved to a position where the pushrod would not actuate the valves forcing them to remain closed. The microprocessor would also stop the fuel delivery and spark to the deactivated cylinder.

Soon after, Mitsubishi implemented their own type of cylinder deactivation, known as modulated displacement. Based on the same principles as Cadillac's design, Mitsubishi designed a four cylinder engine that was capable of deactivating two of its cylinders. Both designs were not well received by the public and cylinder deactivation was pushed to a back burner. Now, companies including Mercedes-Benz (and DCX), GM, and Honda have brought back the idea of cylinder deactivation along with new ideas that include variable valve timing and variable compression.

#### **Cylinder Deactivation Today**

Engines today have two main designs: the pushrod design and overhead cam design. For both designs, the function of cylinder deactivation is to close both the intake and exhaust valves and stop the fuel injection into the deactivated cylinder. Control over all components of cylinder deactivation comes from the engine control module (ECM). The ECM acquires information from many sensors to decide when to initiate cylinder deactivation.

In pushrod engines, similar to the Cadillac V8 - 6 - 4, the valve rocker or lifter arms are either moved or not allowed to function. Both options are actuated by solenoids to control either the hydraulic lifters or mechanical lifter arms. This control stops the actuation of both the intake and exhaust valves.

On the overhead cam engines, a solenoid regulates the oil pressure to allow separate movement of the two rockers for a single valve. In a standard overhead cam engine, one set of rocker arms controls one valve with the input from the camshaft. Therefore, when cylinder deactivation takes place, the connection between the two hydraulically locked arms are separated.

The U.S. Dept. of Energy estimates that cylinder deactivation systems improve fuel efficiency by about 7.5%. This technology has quickly grown in popularity. Honda has its own system for certain V6 powered Odysseys, Accords, and Pilots. GM has introduced cylinder deactivation on the V6 engines of the Chevrolet Uplander and Impala.

### **Exercise 1. Answer the following questions.**

1. What is the main function of the cylinder deactivation system? 2. When does the engine run at its peak performance level? 3. When does the decompression in the cylinder occur? 4. What may optimize the efficiency of the 6 -12 cylinder engine? 5. What automobile companies were the first to introduce the cylinder deactivation system? 6. What company introduced a modulated displacement as a new type of cylinder deactivation? 7. What are the two types of camshaft arrangement in the internal combustion engine? 8. How does the cylinder deactivation system work in pushrod engines? Overhead engines? 9. What can be the fuel efficiency provided the cylinder deactivation system is enabled?

### **Exercise 2. Translate the following words and word combinations into Ukrainian using the text.**

peak performance, to disable some of the cylinders, throttle air intake, to overcome the internal vacuum, the combustion pressure, pumping loss, the throttle valve, efficiency of the engine, fuel efficiency, six liter engine, throttle input, fuel delivery

### **Exercise 3. Translate the following words and word combinations into English.**

максимальні експлуатаційні характеристики двигуна, внутрішнє розрідження, тиск у циліндрі, коромисло клапана, 6-ти циліндровий двигун, кількість подачі палива (циклова подача), штовхач/штанга клапана, модельний ряд, впускний/випускний клапан, ступінь стиснення, впорскування палива, двигун з нижнім/верхнім розташуванням розподільного вала

**Exercise 4. Match the term with its Ukrainian equivalent.**

- |                        |                           |
|------------------------|---------------------------|
| 1) throttle valve      | a) робочий об'єм двигуна  |
| 2) combustion pressure | b) іскра запалювання      |
| 3) engine displacement | c) коромисло клапана      |
| 4) rocker arm          | d) впорскування палива    |
| 5) pushrod             | e) штовхач/штанга клапана |
| 6) fuel efficiency     | f) клапан                 |
| 7) throttle input      | g) модельний ряд          |
| 8) fuel injection      | h) економія палива        |
| 9) spark               | i) циклова подача палива  |
| 10) valve              | j) дросельна заслінка     |
| 11) lineup             | k) тиск в камері згоряння |

**Exercise 5. Insert the necessary words to complete the sentences.**

1. Cylinder deactivation is used to reduce the fuel ... and emissions of an internal combustion engine.

- a) resolution      b) consumption      c) efficiency      d) economy

2. Cylinder deactivation is achieved by keeping the intake and exhaust ... closed for a particular cylinder.

- a) stroke      b) fuel      c) manifolds      d) valves

3. Cylinder deactivation is applied to relatively large ... engines that are particularly inefficient at light load.

- a) atmospheric      b) displacement      c) supercharged      d) cylinder

4. There are currently two main types of cylinder ... used today, depending on the type of engine.

- a) displacement      b) detonation      c) deactivation      d) disintegration

5. When a cylinder is deactivated, solenoid-controlled oil pressure releases a locking pin between the two ... arms.

- a) rocker      b) fore      c) breaker      d) variable

6. After the price of oil surged in 2008, consumers were looking for a more fuel ... car without sacrificing peak power.

- a) effective      b) consuming      c) reducing      d) efficient

7. An overhead engine uses ... to actuate rocker arms above the cylinder head.

- a) pushrods      b) pistons      c) pins      d) bars

8. In a fuel-injected engine, the throttle ... is placed on the entrance of the intake manifold, or housed in the throttle body.

- a) hose                      b) cap                      c) valve                      d) bar

9. The function of cylinder deactivation is to close both the intake and exhaust valves and stop the ... injection into the deactivated cylinder.

- a) air                      b) fuel                      c) direct                      d) common rail

10. A hydraulic ... is operated either by a rocker mechanism, or in the case of one or more overhead camshafts, directly by the camshaft.

- a) elevator                      b) lifter                      c) brake                      d) pump

### **Exercise 6. Fill in the blanks with the appropriate words.**

In a nutshell, cylinder deactivation is simply keeping the intake and exhaust **1)** ... closed through all cycles for a particular set of cylinders in the engine. Depending on the design of the engine, valve actuation is controlled by one of two common methods:

For **pushrod** designs the hydraulic valve **2)** ... are collapsed by using solenoids to alter the oil pressure delivered to the lifters. In their collapsed state, the lifters are unable to elevate their companion **3)** ... under the valve rocker arms. The valves cannot be **4)** ... and remain closed.

For **overhead cam** designs, generally a pair of locked-together rocker arms is employed for each valve. One rocker follows the **5)** ... profile while the other actuates the valve. When a cylinder is deactivated, solenoid controlled oil pressure releases a locking pin between the two rocker arms. While one arm still follows the camshaft, the unlocked arm remains **6)** ... and unable to activate the valve.

By forcing the engine valves to remain closed, an effective “spring” of air is created inside the deactivated cylinders. Trapped **7)** ... gasses (from previous cycles before the cylinders were deactivated) are compressed as the pistons travel on their upstroke and then decompressed and push back on the pistons as they return on their down stroke. Because the deactivated cylinders are out of phase, (some pistons traveling up while others are traveling down), the overall effect is equalized.

To complete the process, fuel delivery for each deactivated cylinder is cut-off by electronically disabling the appropriate fuel injection **8)** ... . The transition between normal operation and deactivation is smoothed by subtle changes in ignition and camshaft **9)** ... as well as throttle position all managed by sophisticated electronic control systems. In a well-designed and executed system, the switching back-and-forth between both modes is seamless – you really don’t feel any difference and have to consult the **10)** ... gauges to know that it's happened.

- |                  |               |                |             |
|------------------|---------------|----------------|-------------|
| 1. a) strokes    | b) valves     | c) manifolds   | d) lines    |
| 2. a) devices    | b) elevators  | c) openers     | d) lifters  |
| 3. a) pushrods   | b) pins       | c) stiff       | d) pistons  |
| 4. a) introduced | b) involved   | c) deactivated | d) actuated |
| 5. a) cam        | b) crank      | c) come        | d) can      |
| 6. a) speechless | b) motionless | c) still       | d) static   |
| 7. a) input      | b) intake     | c) exhaust     | d) output   |
| 8. a) plugs      | b) nozzles    | c) tanks       | d) openings |
| 9. a) timing     | b) steering   | c) directing   | d) managing |
| 10. a) trash     | b) hash       | c) dash        | d) brush    |

## Lesson 5. Electric Power Steering

### *Vocabulary notes:*

**torque** – обертальний момент;

**electric power steering** – електропідсилювач керма (система підсилення керування з електричним підсилювачем);

**hydraulic power steering** – гідро підсилювач керма; (система підсилення керування з гідравлічним підсилювачем);

**hose** – шланг, патрубок, рукав;

**drive belt** – ремінь приводу;

**pulley** – шків;

**variable power assist** – підсилювач (керма) зі змінним коефіцієнтом підсилення;

**steering gear** – шестерня рульового механізму, рульовий механізм;

**forms of EPS: 1) column assist type (C-EPS); 2) pinion assist type (P-EPS); 3) direct drive type (D-EPS); 4) rack assist type (R-EPS)** – варіанти конструкції електропідсилювача керма: 1) з розташуванням приводу на кермовій колонці; 2) рейкового типу; 3) безпосереднього типу; 4) з розташуванням приводу на кермовій рейці;

**power assist unit** – підсилювач;

**pinion shaft** – вал зубчатого колеса (шестерні конічного типу);

**fail-safe mechanism** – запобіжний механізм;

**steer-by-wire** – сервопривід;

### **Electric Power Steering**

Power steering systems supplement the torque that the driver applies to the steering wheel. Traditional power steering systems are hydraulic systems, but electric power steering (EPS) is becoming much more common. EPS eliminates many HPS components such as the pump, hoses, fluid, drive belt, and pulley. For this reason electric steering systems tend to be smaller and lighter than hydraulic systems.

EPS systems have variable power assist, which provides more assistance as the speed of a vehicle decreases and less assistance at higher speeds. They do not need any significant power to operate when no steering assistance is required. For this reason, they are more energy efficient than hydraulic systems.

### ***How the system works***

The EPS electronic control unit (ECU) calculates the assisting power needed based on the torque being applied to the steering wheel by the driver, the steering wheel position and the vehicle's speed. The EPS motor rotates a steering gear with an applied force that reduces the torque required from the driver.

There are four forms of EPS based on the position of the assist motor. They are the column assist type (C-EPS), the pinion assist type (P-EPS), the direct drive type (D-EPS) and the rack assist type (R-EPS). The C-EPS type has a power assist unit, torque sensor, and controller all connected to the steering column. In the P-EPS system, the power assist unit is connected to the steering gear's pinion shaft. This type of system works well in small cars. The D-EPS system has low inertia and friction because the steering gear and assist unit are a single unit. The R-EPS type has the assist unit connected to the steering gear. R-EPS systems can be used on mid- to full-sized vehicles due to their very relatively low inertia from high reduction gear ratios.

Unlike a hydraulic power steering system that continuously drives a hydraulic pump, the efficiency advantage of an EPS system is that it powers the EPS motor only when necessary. This results in reduced vehicle fuel consumption compared to the same vehicle with an HPS system. These systems can be tuned by simply modifying the software controlling the ECU. This provides a unique and cost effective opportunity to adjust the steering "feel" to suit the automotive model class. Additional advantages of EPS is its ability to compensate for one-sided forces such as a flat tire. It is also capable of steering in emergency maneuvers in conjunction with the electronic stability control.

In current-day systems, there is always a mechanical connection between the steering wheel and the steering gear. For safety reasons, it is important that a failure in the electronics never result in a situation where the motor prevents the driver from steering the vehicle. EPS systems incorporate fail-safe mechanisms that disconnect power from the motor in the event that a problem with the ECU is detected.

The next step in electronic steering is to remove the remaining mechanical components and to convert to pure electronic steering, which is referred to as steer-by-wire (SBW). This functions by transmitting digital signals to one or more remote electric motors instead of a rack and pinion assembly, which in-turn steers the vehicle. The 2014 Infinity Q50 is the first commercial vehicle to implement SBW. Although there is normally no direct mechanical linkage, the Q50 has a mechanical back-up. Under a failure, a clutch engages to restore the driver's mechanical control. As with throttle control systems, it is likely that

SBW will become the standard once the electronic controls prove to be safer and more reliable than the current hybrid systems.

**Exercise 1. Answer the following questions.**

1. What are the two types of power steering? Which system is smaller, lighter and more energy efficient? 2. How does the EPS system work? 3. What are the forms of EPS based on the position of the assist motor? 4. What are the operating principles of column assist type, direct drive type, rack assist type of electric power steering? 5. How is the EPS system different from the HPS system? 6. What are some other advantages of EPS over HPS? 7. Does a driver lose control of a vehicle should any failure in electronics occur? 8. What is steer-by-wire option? Do you think it is advantageous? Why?

**Exercise 2. State whether the following sentences are true or false.**

1. Power steering systems boost the torque that the driver applies to the steering wheel.
2. EPS systems are considered to be traditional ones.
3. EPS systems do not need any significant power to operate when no steering assistance is required.
4. There are four forms of EPS based on the position of the assist motor.
5. In the P-EPS system, the power assist unit is connected to the steering gear's pinion steering column.
6. The D-EPS system has low inertia and friction because the steering gear and assist unit are a single unit.
7. R-EPS systems can be used on mid- to full-sized vehicles.
8. In current-day systems there is not a mechanical connection between the steering wheel and the steering gear.
9. For safety reasons the EPS systems incorporate fail-safe mechanisms that disconnect power from the motor in the event that a problem with the ECU is detected.
10. Introduction of steer-by-wire option will eliminate the mechanical components within steering mechanism.
11. SBW will become the standard as soon as the electronic controls become safer and more reliable than the current hybrid systems.

**Exercise 3. Translate the following words and word combinations into Ukrainian.**

power steering systems, steering wheel, hose, fluid, drive belt, pulley, variable power assist, energy efficient, electronic control unit, steering wheel position, steering gear, torque sensor, steering column, single unit, vehicle fuel consumption, emergency maneuvers, mechanical connection, failure in the electronics, to result in, to transmit digital signals, commercial vehicle

**Exercise 4. Find English equivalents for the following terms in the text.**

гідравлічний підсилювач керма, ремінь приводу, шків, енергоефективний (економний), підсилювач зі змінним коефіцієнтом підсилення, датчик обертового моменту, високий ступінь силового зусилля, гідравлічний насос, спущена шина, сервопривід, запобіжний механізм, вал зубчатого колеса, передавати сигнал, механічне щеплення важільного типу

**Exercise 5. Match the terms with their Ukrainian equivalents.**

- |                         |                                 |
|-------------------------|---------------------------------|
| 1) drive belt           | a) шестерня рульового механізму |
| 2) steering gear        | b) сервопривід                  |
| 3) power assist unit    | c) рульова колонка              |
| 4) fail-safe mechanism  | d) регулятор                    |
| 5) steer-by-wire        | e) зменшити обертове зусилля    |
| 6) fluid                | f) тертя                        |
| 7) to reduce the torque | g) ремінь приводу               |
| 8) steering column      | h) запобіжний механізм          |
| 9) controller           | i) (робоча) рідина              |
| 10) friction            | j) підсилювач                   |

**Exercise 6. Insert the necessary words to complete the sentences.**

1. The steering ... is the part of the steering system that is manipulated by the driver.

- a) gear                      b) wheel                      c) shaft                      d) controller

2. Modern vehicles are fitted with a steering ... which is an anti-theft device.

- a) lock                      b) timer                      c) dog                      d) actuator

3. Power steering provides some ... of forces acting on the front wheels to give an ongoing sense of how the wheels are interacting with the road.

- a) feel                      b) backup                      c) reaction                      d) feedback

4. The power-steering system ... still permits the vehicle to be steered using manual effort alone.

- a) failure                      b) break                      c) corruption                      d) collision

5. Many modern cars use rack and ... steering mechanisms.

- a) beam                      b) pinion                      c) bar                      d) crankshaft

6. A hydraulic power steering (HPS) uses hydraulic pressure supplied by an engine-driven ... to assist the motion of turning the steering wheel.

- a) pump                      b) servomechanism                      c) belt                      d) pulley



7. Four-wheel steering is a system employed by some vehicles to improve steering... , increase vehicle stability while maneuvering at high speed, or to decrease turning radius at low speed.

- a) response                      b) feedback                      c) answer                      d) reaction

8. In EPS the amount of ... is easily tunable to the vehicle type, road speed, and even driver preference.

- a) addition                      b) help                      c) torque                      d) assistance

9. Sensors detect the position and torque of the steering... , and a computer module applies assistive torque via the motor, which connects to either the steering gear or steering column.

- a) rack                      b) column                      c) spoke                      d) assistance

10. The aim of steer-by-... technology is to completely do without as many mechanical components (steering shaft, column, gear reduction mechanism, etc.) as possible.

- a) rack                      b) column                      c) wire                      d) sense

### **Exercise 7. Fill in the blanks with appropriate terms.**

#### **Passive rear wheel steering**

Many modern vehicles have passive rear steering. On many vehicles, when **1)** ... , the rear wheels tend to steer slightly to the outside of a turn, which can reduce stability. The passive steering system uses lateral forces generated in a turn (through suspension geometry) and the bushings to correct this tendency and **2)** ... the wheels slightly to the inside of the corner. This **3)** ... the stability of the car, through the turn. This effect is called compliance understeer and it is present on all suspensions. Typical methods of achieving compliance understeer are to use a Watt's Linkage on a live rear axle, or the use of toe control bushings on a twist beam suspension. On an independent **4)** ... suspension it is normally achieved by changing the rates of the rubber bushings in the suspension. Some suspensions typically have compliance oversteer due to geometry, such as Hotchkiss live axles or a semi-trailing arm but may be mitigated by revisions to the pivot points of the leaf spring or trailing **5)** ... .

Passive rear wheel steering is not a new concept, as it has been in use for many years, although not always recognised as such.

- 1) a) cornering                      b) overtaking                      c) swerving                      d) accelerating  
2) a) rotate                      b) brake                      c) steer                      d) curve  
3) a) decreases                      b) corrupts                      c) approves                      d) improves  
4) a) back                      b) front                      c) side                      d) rear  
5) a) bar                      b) couple                      c) rack                      d) arm

## Lesson 6. The Hill Hold Control

### *Vocabulary notes:*

**Hill Hold Control** – система контролю утримання автомобіля на схилі;

**steep incline** – крутий схил;

**brake pedal travel sensor** – датчик ходу гальмівної педалі;

**master cylinder pressure sensor** – датчик тиску в головному циліндрі;

**gradient of the incline** – крутизна схилу;

**exit criteria of the system** – критерій деактивації системи;

**entrance criteria** – критерій активації;

**two-position clutch switch** – двопозиційний перемикач зчеплення;

**longitudinal acceleration sensor** – датчик поздовжнього прискорення;

**rolling** – скочування;

**gear engagement** – включення передачі;

### **The Hill Hold Control**

When starting a vehicle from a stationary position on a **steep incline**, a driver has to coordinate the application and release of the clutch, brake and accelerator pedals in a manual transmission car. This unsafe situation can be a frustrating experience. Hill hold control systems assist the driver in these situations by keeping the brakes activated until torque from the engine is applied to wheels.

There are basically three types of hill-hold systems used in vehicles today.

#### **Basic-Level System:**

The sensors used in the most basic hill-hold systems are a **brake pedal travel sensor**, a **master cylinder pressure sensor**, wheel speed sensors and throttle position sensor. Hill hold takes place after the vehicle comes to a complete stop with the driver's foot on the brake which is determined by the brake pedal travel sensor. The required torque to be applied for the hill hold function is calculated based on the amount of torque required to keep the vehicle stationary. The torque applied is a function of the pressure applied to the brakes, which is determined by the master cylinder pressure sensor. When the brake pedal is released, Hill Hold Control is activated maintaining the appropriate brake pressure until the throttle is applied.

The limitation of the basic-level system is that it's independent on the **gradient of the incline**. Therefore, if the conditions required to activate Hill Hold Control (entrance criteria) are satisfied, then the system will be activated whether the surface has a positive, negative or zero gradient. The '**exit criteria of the system**' is based only on throttle position.

#### **Medium-Level System**

This is a balance between a basic-level system and an up-level system. The sensors used in this system are a brake pedal travel sensor, **two-position clutch**

**switch** (for manual transmission vehicles), **longitudinal acceleration sensor** and wheel speed sensor. The system also requires inputs when the driver activates reverse gear as well as the throttle position, both of which are obtained from the vehicle.

The **entrance criteria** of a mid-level system is different when the vehicle is on an incline and when it's on a decline. In the case, when a vehicle is on an incline, 4 conditions must be satisfied:

1. The vehicle must come to a complete stop;
2. The incline must be sufficiently steep to require the use of hill hold control as determined by the longitudinal acceleration sensor;
3. The clutch must be completely depressed or close to full travel (manual transmissions only).

When on a decline, an additional condition is required. The reverse gear must be engaged. This indicates to the system that the driver is trying to back up a hill without **rolling** forward. The exit criteria or deactivation of hill hold control is based on either of two independent conditions. The first is an indication that the driver wants to move the vehicle. This may be indicated by the following:

1. The clutch pedal being released to the point of **gear engagement** (which is detected by the second clutch switch);
2. An appropriate amount of throttle being applied for the vehicle to start moving (a higher amount of throttle must be applied when the vehicle is moving up a steeper incline).

The second is the brake being applied in any of the following conditions:

1. When the vehicle is stopped on a positive incline and the clutch is released (indicating neutral is engaged);
2. The clutch is pressed and reverse gear is engaged while the vehicle is stopped on an incline;
3. The vehicle is stopped on a decline and the clutch is released.

If the brake is applied in any of the above conditions, it means that the driver wants to let the vehicle roll in the direction of the slope. Hill hold control is deactivated by reducing the torque applied on the wheels to stop the car at a rate proportional to the slope. This gives the mid-level system a very natural feel.

### **Up-Level System**

The up-level system is similar to the mid-level system, except that it has the following extra features:

1. A clutch travel sensor for determining the speed with the clutch pedal is pressed or released (to allow the system apply and release the brakes accordingly);
2. An additional hill-descent feature that enables the system to reverse the vehicle when going downhill.

Different manufacturers implement hill hold in different ways. Subaru has a mechanical version of hill hold control on their cars. Bosch has an electronic

control that activates the brakes for 2 seconds to give the driver time to start the vehicle.

**Exercise 1. Answer the following questions.**

1. What is the Hill Hold Control System used for? 2. What types of hill-hold systems are used in vehicles today? 3. What sensors are used in the most basic hill-hold systems? 4. When is the hill-hold control system activated? 5. Is the system dependent on the gradient of the incline? 6. When is the hill-hold system deactivated? 7. What sensors does the medium-level hill-hold system include? 8. What conditions must be met for the medium-level system to be activated? 9. When is the medium-level system disengaged? 10. What is the up-level hill-hold system different from medium-level one?

**Exercise 2. Say whether the following statements are true or false.**

1. There are four types of hill-hold systems used in vehicles today.  
2. The sensors used in the most basic hill-hold systems are a brake pedal travel sensor, a master cylinder pressure sensor, wheel speed sensors and a throttle position sensor.  
3. The limitation of the basic-level system is that it's dependent on the gradient of the incline.  
4. The 'exit criteria' of the basic-level system is based only on throttle position.  
5. To activate the middle level system a driver has to stop the vehicle, make sure that the slope is steep enough and depress the clutch pedal.  
6. The up-level system is similar to the mid-level system but it has two extra features.  
7. Different manufacturers implement the hill hold control system in different ways.

**Exercise 3. Translate the following words and word combinations into Ukrainian.**

stationary position, release of the clutch pedal, wheel speed sensors, brake pedal travel sensor, pressure applied to the brakes, master cylinder, manual transmission, reverse gear, to back up a hill, rolling forward, slope, hill-descent feature, to start the vehicle.

**Exercise 4. Translate the following words and word combinations into English using the text.**

крутий спуск, задня передача, педаль акселератора, датчик ходу гальмівної педалі, датчик тиску в головному циліндрі, крутизна схилу, автомобілі з механічною коробкою передач, датчик швидкості обертання колеса, задня передача, деактивація системи, скотитися, додаткові опції, задіяти гальма.

**Exercise 5. Match the terms with their Ukrainian equivalents.**

1. **rolling**

a) двопозиційний перемикач

- |                                   |   |
|-----------------------------------|---|
|                                   | зчеплення                                       |
| 2. reverse gear                   | b) відпустити педаль зчеплення                  |
| 3. to keep the vehicle stationary | c) скочування                                   |
| 4. master cylinder                | d) включення передачі                           |
| 5. two-position clutch switch     | e) рухатись заднім ходом                        |
| 6. to back up                     | f) крутий схил                                  |
| 7. gear engagement                | g) головний циліндр                             |
| 8. to release the clutch pedal    | h) задня передача                               |
| 9. steep slope                    | i) датчик ходу гальмівної педалі                |
| 10. brake pedal travel sensor     | j) утримувати автомобіль в нерухомому положенні |

**Exercise 6. Fill in the blanks with the appropriate words.**

- Hill Descent Control is an electronically controlled feature that assists drivers during certain off road manoeuvres by controlling the speed at which a vehicle proceeds down ... hills.  
a) flat                      b) steep                      c) step                      d) mountainous
- The driver can speed up or slow down the vehicle with the ... pedal or brake pedal respectively.  
a) reverse                      b) hand                      c) clutch                      d) throttle
- Hill Descent Control works in sync with the vehicle's Anti-lock Braking System (ABS) and Traction Control System (TCS) to ensure that no individual wheel loses ... on loose or slippery surfaces and prevents the wheels from locking if you jam the brakes.  
a) friction                      b) traction                      c) control                      d) tyre
- The job of the wheel speed sensor is to constantly monitor and report the ... speed of each tire to the ABS control module.  
a) rotational                      b) torque                      c) acceleration                      d) rolling
- ... transmissions often feature a driver-operated clutch and a movable gear stick.  
a) Automatic                      b) Manual                      c) Variable                      d) Semi-automatic
- The term ... refers to any mechanism by which the power or speed of an engine is regulated.  
a) energy                      b) torque                      c) throttle                      d) booster
- Sensors may ... when a vehicle is following too closely and slow down the vehicle, straighten up seat backs, and tighten seat belts, avoiding and/or preparing for a crash.

a) detect                      b) calculate                      c) evaluate                      d) investigate

8. The term 4×4 was in use to describe North American military ...-wheel-drive vehicles as early as the 1940s.

a) two                      b) five                      c) four                      d) single

9. The more weight presses on a tire, the more ... it has.

a) traction                      b) torque                      c) speed                      d) acceleration

10. Accelerator pedal is a pedal that controls the ... valve.

a) throttle                      b) torque                      c) intake                      d) exhaust

## **Lesson 7. Four-wheel-drive System**

### ***Vocabulary notes:***

**drivetrain** – трансмісія, силова передача;

**simultaneously** – одночасно;

**off-road vehicle** – позашляховик;

**transfer case** – роздавальна коробка

**locking hub** – ступиця

**drive shaft** – карданний вал

**to spin** – крутитися, обертатися;

**traction** – тягове зусилля

**viscous coupling** – віскомуфта

**front-axle** – передня вісь, передній міст;

**gear set** – редуктор

**concrete** – бетон

**jerky turn** – різкий поворот

**drivetrain** – трансмісія, редукторна передача, привід на ведучі колеса;

**low range** – понижена передача, нижчий діапазон передач;

**gear ratio** – передавальне число;

**output speed** – швидкість на відомому валу;

**hub** – ступиця;

**half-shaft** – піввісь;

**wear and tear** – зношення, спрацювання;

**sliding collar** – муфта вільного ходу; повзаюча обойма (шестерні);

### **Four-wheel-drive System**

Four-wheel drive, all-wheel drive, AWD, 4WD, or 4×4 ("four by four") is a four-wheeled vehicle with a **drivetrain** that allows all four wheels to receive torque from the engine **simultaneously**.

While many people typically associate the term 4x4 with **off-road vehicles** and Sport utility vehicles, powering all four wheels provides better control than

normal road cars on many surfaces and is an important part in the sport of rallying.

The main parts of any four-wheel-drive system are the two differentials (front and rear) and the **transfer case**. In addition, part-time systems have **locking hubs** and both types of systems may have advanced electronics that help them make even better use of the available traction.

**Differentials** A car has two differentials, one located between the two front wheels and one between the two rear wheels. They send the torque from the **driveshaft** or transmission to the drive wheels. They also allow the left and right wheels to **spin** at different speeds when you go around a turn.

When you go around a turn, the inside wheels follow a different path than the outside wheels, and the front wheels follow a different path than the rear wheels, so each of the wheels is spinning at a different speed. The differentials enable the speed difference between the inside and outside wheels.

There are several different kinds of differentials used in cars and trucks. The types of differentials used can have a significant effect on how well the vehicle utilizes available **traction**.

**Transfer Case** This is the device that splits the power between the front and rear axles on a four-wheel-drive car.

While the differentials handle the speed difference between the inside and outside wheels, the transfer case in an all-wheel-drive system contains a device that allows for a speed difference between the front and rear wheels. This could be a **viscous coupling**, center differential or other type of **gearsset**. These devices allow an all-wheel-drive system to function properly on any surface.

The transfer case on a part-time four-wheel-drive system locks the **front-axle** driveshaft to the rear-axle driveshaft, so the wheels are forced to spin at the same speed. This requires that the tires slip when the car goes around a turn. Part-time systems should only be used in low-traction situations in which it is relatively easy for the tires to slip. On dry **concrete**, it is not easy for the tires to slip, so the four-wheel drive should be disengaged in order to avoid **jerky turns** and extra wear on the tires and **drivetrain**.

Some transfer cases, more commonly those in part-time systems, also contain an additional set of gears that give the vehicle a **low range**. This extra gear ratio gives the vehicle extra torque and a super-slow **output speed**. In first gear in low range, the vehicle might have a top speed of about 5 mph (8 kph), but incredible torque is produced at the wheels. This allows drivers to slowly and smoothly creep up very steep hills.

### **Locking Hubs**

Each wheel in a car is bolted to a **hub**. Part-time four-wheel-drive trucks usually have locking hubs on the front wheels. When four-wheel drive is not engaged, the locking hubs are used to disconnect the front wheels from the front differential, **half-shafts** (the shafts that connect the differential to the hub) and driveshaft. This allows the differential, half-shafts and driveshaft to stop

spinning when the car is in two-wheel drive, saving **wear and tear** on those parts and improving fuel-economy.

Manual locking hubs used to be quite common. To engage four-wheel drive, the driver actually had to get out of the truck and turn a knob on the front wheels until the hubs locked. Newer systems have automatic locking hubs that are engaged when the driver switches into four-wheel drive. This type of system can usually be engaged while the vehicle is moving.

Whether manual or automatic, these systems generally use a **sliding collar** that locks the front half-shafts to the hub.

### ***Advanced Electronics***

On many modern four-wheel and all-wheel-drive vehicles, advanced electronics play a key role. Some cars use the ABS system to selectively apply the brakes to wheels that start to skid – this is called brake-traction control.

### **Exercise 1. Answer the following questions.**

1. What is an All-Wheel Drive vehicle? 2. What are the main parts of any four-wheel-drive system? 3. How many differentials does a typical personal car have? 4. What function do differentials carry out? 5. Does a differential allow the individual wheels to spin at different speed? 6. What is a transfer case? 7. What are some devices within the transfer case of a four-drive vehicle that allow wheels to spin at different speed and to function properly on any road surfaces? 8. What device allows drivers to slowly and smoothly creep up very steep hills? 9. What are locking hubs used for? 10. What is a brake-traction control?

### **Exercise 2. Say whether the following statements are true or false.**

1. Four-wheel drive is a four-wheeled vehicle with a drivetrain that allows all four wheels to receive torque from the engine at the same time.
2. The main parts of any four-wheel-drive system are the three differentials and the transfer case.
3. The differentials transmit the torque from the driveshaft or transmission to the drive wheels.
4. The types of differentials used in a car can have a significant effect on how well the vehicle utilizes available traction.
5. A transfer case is the device that splits the power between the front and rear axles on a two-wheel-drive car.
6. The transfer case on a part-time four-wheel-drive system locks the front-axle driveshaft to the rear-axle driveshaft, so the wheels are forced to spin simultaneously.
7. Some transfer cases also contain an additional set of gears that give the vehicle a low range.
8. Each wheel in a car is bolted to a driveshaft.



9. When four-wheel drive is not engaged, the locking hubs are used to disconnect the front wheels from the front differential, half-shafts and driveshaft.
10. With manual locking hubs the driver actually had to get out of the truck and turn a knob on the front wheels to engage four-wheel drive.
11. All-wheel-drive system can usually be engaged while the vehicle is moving.
12. Some cars use the ABS system to selectively apply the brakes to wheels that start to skid

**Exercise 3. Translate the following words and phrases into Ukrainian.**

four-wheeled vehicle, to receive torque, advanced electronics, better use of the available traction, rear wheels, drive wheels, to go around a turn, truck, gearset, to function properly on any surface, rear-axle driveshaft, to avoid jerky turns, extra wear, additional set of gears, gear ratio, to disconnect the front wheels from the front differential, to turn a knob

**Exercise 4. Translate the following words and phrases into English.**

Повний привід, трансмісія, обертовий момент, тягове зусилля, ведучі колеса, вантажівка, передня/задня вісь, напів-вісь, центральний диференціал, кардан, понижена передача, передаточне число, ступиця; повний привід, що підключається; активувати систему, постійний повний привід

**Exercise 5. Translate the following sentences into English.**

1. Повний привід – це конструкція трансмісії автомобіля, коли обертальний момент, що створюється двигуном, передається на всі колеса.
2. Повний привід покращує керованість автомобіля на усіх видах дорожнього покриття, а також дозволяє ефективніше використовувати тягове зусилля.
3. Роздавальна коробка служить для розподілу обертального моменту між ведучими мостами і включення-виключення переднього ведучого моста.
4. Карданний вал застосовується для передачі обертального моменту від коробки передач (роздавальної коробки) до ведучих мостів.
5. Віскомуфта – це механізм, що використовується для автоматичного блокування диференціалу.
6. Піввісь – це вал, що передає обертальний момент ведучим колесам.
7. Як правило понижена передача має низьке передавальне число, що дозволяє транспортному засобу максимально використовувати обертальний момент двигуна.

**Exercise 6. Match the terms with their equivalents.**

1) drivetrain

a) передній міст

- |                            |                               |
|----------------------------|-------------------------------|
| 2) <b>simultaneously</b>   | b) понижена передача          |
| 3) <b>off-road vehicle</b> | c) передавальне число         |
| 4) <b>driveshaft</b>       | d) привід на ведучі колеса    |
| 5) <b>front-axle</b>       | e) швидкість на відомому валу |
| 6) <b>gear ratio</b>       | f) піввісь                    |
| 7) <b>output speed</b>     | g) карданний вал              |
| 8) <b>rear axle</b>        | h) задній міст                |
| 9) <b>half-shaft</b>       | i) одночасно                  |
| 10) <b>low range</b>       | j) позашляховик               |

### Exercise 7. Insert the appropriate words into the text.

#### Difference between 4WD and AWD

4WD is selected manually and is commonly used on Pickup **1)**... .Under normal driving conditions a 4WD vehicle is **2)** ... by 2WD (two-wheel drive); i.e. the **3)** ... is being transferred from the engine to the transmission, **4)**... , differential, and to the rear wheels. The front wheels of the vehicle are just being pushed along by the **5)** ... wheels which are being driven. When you manually press 4WD button, it activates a mechanism called a transfer **6)**... . It allows traction to be **7)** ... from the engine to the transmission through its own driveshaft and to the front wheels. In 4WD the front wheels are now being driven just the same as the rear wheels are. In an AWD vehicle it operates under the same basic principles as the 4WD system, but with the AWD system all **8)** ... wheels are driven all the time without you having to activate it.

- |                  |              |                |                   |
|------------------|--------------|----------------|-------------------|
| 1. a) carts      | b) tricks    | c) trucks      | d) tracks         |
| 2. a) activated  | b) shifted   | c) driven      | d) moved          |
| 3. a) traction   | b) might     | c) energy      | d) torque         |
| 4. a) driveshaft | b) crankcase | c) camshaft    | d) take-off shaft |
| 5. a) front      | b) rear      | c) back        | d) side           |
| 6. a) case       | b) box       | c) gear        | d) bearing        |
| 7. a) imported   | b) passed    | c) transported | d) transferred    |
| 8. a) two        | b) four      | c) rear        | d) front          |

## Lesson 8. The Navigation Systems

### *Vocabulary notes:*

**destination** – пункт призначення, кінцевий пункт маршруту;

**Global Positioning System (GPS)** – система глобального позиціонування, супутникова система навігації,

**foliage** – листяний покрив;

**proximity beacons** – радіочастотний маяк;

**intersection** – перехрестя;

**short range radio signal** – низькочастотний сигнал;

**top view** – вид зверху;

**emergency notifications** – інформування про аварійні ситуації

**visible** – видимий;

**pre-stored map**– попередньо-запрограмовані карти;

**a locus of points**– геометричне місце точок;

**incoming signals** – вхідні сигнали

### Navigation Systems

Navigation systems help the driver of a vehicle to locate a particular **destination** and identify the best route for getting to that destination. Most automotive navigation systems use **Global Positioning System (GPS)** signals and electronic maps to identify the vehicle's current position relative to the desired destination. Portable navigation systems powered through the cigarette lighter or batteries, can be easily moved from one vehicle to another. Built-in navigation systems have the advantage that they can access information about the vehicle's speed and direction to help navigate in situations where a GPS signal is temporarily blocked by buildings, traffic, **foliage**, etc.

Although the vast majority of automotive navigation systems rely on GPS signals, **proximity beacons** provide another form of radio-positioning. Proximity beacons are devices installed at key **intersections** and other strategic roadside locations that communicate their location along-with other information to receivers in passing vehicles via very **short range radio**, microwave or infrared **signals**. The reception of a proximity beacon signal provides an occasional basis for confirming vehicle position.

Vehicle navigation systems generally offer the option of a **top view** (or bird's eye view) that shows the position of the vehicle on a traditional map; or a forward view that shows the road ahead as it would be viewed by the driver.

Some navigation systems are integrated with real-time traffic information and **emergency notifications** that are transmitted to the vehicle wirelessly (e.g. at cell phone or FM radio frequencies).

#### The Global Positioning System

For instance the U.S. military has 27 satellites orbiting the earth, 24 that are used for the GPS system and 3 as back-ups in case of a failure. They travel around the earth twice every day and are arranged in such a way that at least 4 satellites are **visible** from any point on the earth at any time. To use GPS, a vehicle must have a GPS receiver. The GPS receiver has a **pre-stored map** or almanac of the position of each satellite (which is updated based on information sent out by the satellite). The GPS receiver finds its distance from one satellite. Now, the receiver might be at any point on the surface of a sphere (say, Sphere A) with a radius equal to the distance from this satellite. Now, if the receiver measures its distance from a second satellite, it obtains another sphere (say, Sphere B) of probable positions. Sphere A and Sphere B will intersect to form a **locus of points** that would be a circle. So, we now have a circle of probable positions. Now, the receiver does the same with a third satellite. The result is 3

spheres that will give only 2 possible locations of the GPS receiver. Only one of these two positions can be on earth.

The GPS satellite communicates with satellites by high-frequency, low-power radio signals. Radio signals travel at the speed of light and the GPS receiver measures the distance between itself and the satellite by finding the time taken for a radio signal to travel between the satellite and itself. However, to be able to measure this, the satellite and the receiver require extremely accurate clocks. The satellites have an atomic clock; most commercial receivers employ an ordinary quartz clock. The receiver measures **incoming signals** from 4 or more satellites, which is more information than necessary just to establish position. The additional information is used to update the receiver's quartz clock to maximize the accuracy of its position calculations.

**Exercise 1. Answer the following questions.**

1. How do navigation systems assist drivers nowadays? 2. What advantages do built-in navigation systems have over portable ones? 3. What do most navigation systems rely on? 4. What wave ranges do proximity beacons use for sending signals? 5. What types of view are offered by car navigation systems? Which is more preferable to you personally? 6. Explain in a just few words how a GPS work. 7. What devices does one need to locate any object on the earth? 8. What is a GPS receiver? 9. What purpose is an atomic clock used in a satellite for?

**Exercise. 2. Say whether the following statements are true or false.**

1. Navigation systems assist the driver of a vehicle to locate a particular destination and chose the best route for getting to that destination.  
2. Most automotive navigation systems use Global Prognostication System (GPS) signals and electronic maps to figure out the vehicle's current position relative to the desired destination.  
3. GPS signal may be temporarily blocked or screened by buildings, heavy traffic, tall trees etc.  
4. Proximity beacons is another form of radio-positioning.  
5. Some navigation systems are integrated with real-time traffic information and emergency notifications that are transmitted to the vehicle wirelessly.  
6. To use GPS, a vehicle must have a GPS receiver.  
7. The GPS satellite communicates with satellites by high-frequency, low-power radio signals.  
8. Radio signals travel at the speed of sound and the GPS receiver measures the distance between itself and the satellite.  
9. The satellites employ an atomic alarm clock and most commercial receivers use an ordinary Swiss sand clock.  
10. The receiver takes incoming signals from 4 or more satellites which is more information than necessary to establish its position on the earth.

### Exercise 3. Translate the following words and phrases into Ukrainian.

to locate a particular destination, to identify the best route, automotive navigation systems, to identify the vehicle's current position relative to the desired destination, built-in navigation systems, can access information, temporarily blocked, the vast majority of automotive navigation systems, proximity beacons, radio-positioning, strategic roadside locations, real-time traffic information, 27 satellites orbiting the earth, to travel at the speed of light, extremely accurate clocks, incoming signals

### Exercise 4. Translate the following words and phrases into English.

визначити місцеперебування, найкращий маршрут, портативні системи, отримувати доступ до інформації, низькочастотний сигнал, перетинатися, геометричне місце точок, високочастотні радіосигнали, надточний годинник, вхідний сигнал, додаткова інформація

### Exercise 5. Match English words and word combinations with their Ukrainian equivalents.

- |                           |                                       |
|---------------------------|---------------------------------------|
| 1) destination            | a) супутникова система навігації      |
| 2) GPS                    | b) інформування про аварійні ситуації |
| 3) proximity beacons      | c) вхідний сигнал                     |
| 4) accuracy               | d) видимий                            |
| 5) emergency notification | e) пункт призначення                  |
| 6) incoming signal        | f) вихідний сигнал                    |
| 7) outgoing signal        | g) точність                           |
| 8) visible                | h) радіочастотний маяк                |

### Exercise 6. Fill in the blanks with the appropriate words.

An automotive navigation system is a satellite navigation system designed for use in 1) ... . It typically uses a GPS navigation 2) ... to acquire position data to locate the user on a road in the unit's map database. Using the road database, the unit can give directions to other locations along roads also in its database.

Many systems can give information on nearby points of interest (POIs), such as restaurants, cash machines and gas stations. Some navigation devices use this 3) ... to store the location of known speed traps or speed cameras, and can alert the driver in much the same way as a radar detector. GPS may also be integrated into actual radar detection devices to enhance accuracy, and in some cases, implement a logic system where the system only 4) ... if the driver is traveling above the speed limit or in the direction to be 'caught.' Unlike radar 5) ... , GPS-based speed trap warnings are currently legal in many countries.

Some systems feature internet connectivity, either via Bluetooth to a mobile phone (in this case the device can also typically be used for hands-free calling), or with a built in GSM SIM card. This connectivity can be used to 6) ... traffic information, to find fuel prices, as well as to search for local distances.

The radio dispatching of taxicabs have been phased out in several countries in favor of GPS technology plus some form of mobile networking with onboard computers. The central dispatch computer keeps 7) ... of all vehicles in its fleet, and automatically selects the nearest cab to respond to a passenger 8) ... .

Advanced car security vehicle tracking systems can relay the vehicle's location via cellular phone services in case of loss or 9) ... . The technology can also be used to manage fleet vehicles known as automatic vehicle location.

In Taipei, GPS receivers have several 10) ... on city buses. They enable automatic station approach announcements, provides ETA (Electronic Travel Aid) information for passengers waiting at bus stops or using mobile devices. Finally, GPS data is recorded along with video surveillance footage, which is helpful when investigating traffic incidents.

- |     |               |                 |                   |                  |
|-----|---------------|-----------------|-------------------|------------------|
| 1.  | a) ships      | b) automobiles  | c) locomotives    | d) mobile phones |
| 2.  | a) instrument | b) gauge        | c) box            | d) device        |
| 3.  | a) future     | b) disadvantage | c) feature        | d) thing         |
| 4.  | a) wakes up   | b) alerts       | c) alarms         | d) gets up       |
| 5.  | a) grabbers   | b) detectors    | c) trappers       | d) investigators |
| 6.  | a) upgrade    | b) downdate     | c) update         | d) upstream      |
| 7.  | a) track      | b) monitor      | c) eyes           | d) search        |
| 8.  | a) ask        | b) recall       | c) request        | d) offer         |
| 9.  | a) robbery    | b) theft        | c) burglary       | d) blackmail     |
| 10. | a) deviations | b) informations | c) investigations | d) applications  |

### **Part III**

#### **Texts for home reading**

##### **Principles of Engine Operation**

Engines operate on cycles. There are four strokes of the piston in one cycle of engine operation. There are two outward strokes toward the crankshaft and two inward strokes away from the crankshaft. When the piston is at the end of the stroke away from the crankshaft (inward stroke) this is top dead centre (TDC). When the piston is at the end of the outward stroke (toward the crankshaft) this is bottom dead centre (BDC). The piston movement from TDC to BDC is an engine stroke. The four strokes in a cycle of the internal combustion engine are: intake, compression, power and exhaust.

**Intake.** During the intake stroke the piston moves to BDC and the intake valve opens. This movement of the piston draws a mixture of air and fuel into the cylinder (in a diesel this movement of the piston draws in air only)

**Compression.** When the piston reaches BDC it moves toward the cylinder head (inward motion). The valves do not open and the piston compresses the fuel mixture between the piston and the cylinder head (in a diesel the piston compresses air only).

**Power.** When the piston reaches TDC, an electric spark ignites the fuel mixture in the combustion chamber of the gasoline engine (in a diesel engine the heat of the highly compressed air ignites the fuel). When the air-fuel mixture burns it moves the piston with great force. There are higher pressures in the diesel engines and because of these pressures the diesel engines have heavier piston pins, connecting rods and crankshafts than the gasoline engines.

**Exhaust.** The exhaust stroke takes place when the piston moves up. The exhaust valve opens and the piston forces out the gases. The new cycle will begin in the cylinder. Because of the four strokes we call this engine a four stroke cycle engine. The four-stroke-cycle engine with spark ignition is the most common type of the internal combustion engine.

### **The Thermostat**

An additional device usually used in the cooling system is a thermostat. It controls the temperature of the water near cylinders. It is useful when an engine is started up or when it has to idle (run slowly) for a long time.

The thermostat is an automatic valve located in the pipe. Connecting the cylinder head to the top of the radiator the thermostat reduces the flow of water to the radiator, and so a necessary working temperature is reached in the cylinder block. When the engine is cold the thermostat prevents circulation through the radiator. When the engine cooling water reaches a temperature of about 75 °C, the thermostat valve opens and the water can flow into the radiator for cooling.

The flow of water may be stopped or has limited movement (according to the temperature of the water). As the volume of water within the cylinder block is less than that within the whole cooling system, it causes the rapid warming-up of the water. The water in the cylinder block is circulated by means of the water pump. When the thermostat is closed there is a by-pass in the system allowing this internal circulation. On some engines the thermostat opens and closes this by-pass. This internal circulation prevents engine damage.

The thermostat is an important unit in the cooling system and it should be checked at least once a year. A faulty thermostat must be replaced with a new one. A cold or overheated engine cannot work properly. The necessary working temperature of an engine is about 90 °C.

## The Fall of the Carburetor

For most of the existence of the internal combustion engine, the carburetor has been the device that supplied fuel to the engine. On many other machines, such as lawnmowers and chainsaws, it still is. But as the automobile evolved, the carburetor got more and more complicated trying to handle all of the operating requirements. For instance, to handle some of these tasks, carburetors had five different circuits:

**Main circuit** - Provides just enough fuel for fuel-efficient cruising;

**Idle circuit** - Provides just enough fuel to keep the engine idling;

**Accelerator pump** - Provides an extra burst of fuel when the accelerator pedal is first depressed, reducing hesitation before the engine speeds up;

**Power enrichment circuit** - Provides extra fuel when the car is going up a hill or towing a trailer;

**Choke** - Provides extra fuel when the engine is cold so that it will start

In order to meet stricter emissions requirements, catalytic converters were introduced. Very careful control of the air-to-fuel ratio was required for the catalytic converter to be effective. Oxygen sensors monitor the amount of oxygen in the exhaust, and the engine control unit (ECU) uses this information to adjust the air-to-fuel ratio in real-time. This is called closed loop control -- it was not feasible to achieve this control with carburetors. There was a brief period of electrically controlled carburetors before fuel injection systems took over, but these electrical cars were even more complicated than the purely mechanical ones.

At first, carburetors were replaced with throttle body fuel injection systems (also known as single point or central fuel injection systems) that incorporated electrically controlled fuel-injector valves into the throttle body. These were almost a bolt-in replacement for the carburetor, so the automakers didn't have to make any drastic changes to their engine designs.

Gradually, as new engines were designed, throttle body fuel injection was replaced by multi-port fuel injection (also known as port, multi-point or sequential fuel injection). These systems have a fuel injector for each cylinder, usually located so that they spray right at the intake valve. These systems provide more accurate fuel metering and quicker response.

## Turbochargers

A turbocharger, or turbo (colloquialism), from the Greek "τὺρβη" ("turbulence") is a forced induction device used to allow more power to be produced by an engine of a given size. A turbocharged engine can be more powerful and efficient than a naturally aspirated engine because the turbine forces more air, and proportionately more fuel, into the combustion chamber than atmospheric pressure alone.

Turbochargers were originally known as turbo superchargers when all forced induction devices were classified as superchargers; nowadays the term



"supercharger" is usually applied to only mechanically driven forced induction devices. The key difference between a turbocharger and a conventional supercharger is that the latter is mechanically driven from the engine, often from a belt connected to the crankshaft, whereas a turbocharger is powered by a turbine that is driven by the engine's exhaust gas. Compared to a mechanically-driven supercharger, turbochargers tend to be more efficient but less responsive. Twin charger refers to an engine which has both a supercharger and a turbocharger.

In most piston engines, intake gases are "pulled" into the engine by the downward stroke of the piston (which creates a low-pressure area), similar to drawing liquid using a syringe. The amount of air which is actually inhaled, compared with the theoretical amount if the engine could maintain atmospheric pressure, is called volumetric efficiency. The objective of a turbocharger is to improve an engine's volumetric efficiency by increasing density of the intake gas (usually air).

The turbocharger's compressor draws in ambient air and compresses it before it enters into the intake manifold at increased pressure. This results in a greater mass of air entering the cylinders on each intake stroke. The power needed to spin the centrifugal compressor is derived from the kinetic energy of the engine's exhaust gases.

A turbocharger may also be used to increase fuel efficiency without increasing power. This is achieved by recovering waste energy in the exhaust and feeding it back into the engine intake. By using this otherwise wasted energy to increase the mass of air, it becomes easier to ensure that all fuel is burned before being vented at the start of the exhaust stage.

The control of turbochargers is very complex and has changed dramatically over the 100-plus years of its use. Modern turbochargers can use wastegates, blow-off valves and variable geometry, as discussed in later sections.

The reduced density of intake air is often compounded by the loss of atmospheric density seen with elevated altitudes. Thus, a natural use of the turbocharger is with aircraft engines. As an aircraft climbs to higher altitudes, the pressure of the surrounding air quickly falls off. At 5,486 metres (17,999 ft), the air is at half the pressure of sea level, which means that the engine will produce less than half-power at this altitude.

### **Wankel Engine.**

The Wankel engine is a type of internal combustion engine using an eccentric rotary design to convert pressure into rotating motion. Over the commonly used reciprocating piston designs the Wankel engine delivers advantages of: simplicity, smoothness, compactness, high revolutions per minute and a high power to weight ratio. The engine is commonly referred to as a rotary engine, though this name applies also to other completely different designs. Its four-stroke cycle occurs in a moving combustion chamber between

the inside of an oval-like epitrochoid-shaped housing and a rotor that is similar in shape to a Reuleaux triangle with sides that are somewhat flatter.

The engine was invented by German engineer Felix Wankel. He received his first patent for the engine in 1929, began development in the early 1950s at NSU and completed a working prototype in 1957. NSU subsequently licensed the design to companies around the world, who have continually improved the design.

Thanks to the compact design and unique advantages, over the most common internal combustion engine in use employing reciprocating pistons, Wankel rotary engines have been installed in a variety of vehicles and devices including: automobiles, motorcycles, racing cars, aircraft, go-karts, jet skis, snowmobiles, chain saws, and auxiliary power units.

In the Wankel engine, the four strokes of a typical Otto cycle occur in the space between a three-sided symmetric rotor and the inside of a housing. In each rotor of the Wankel engine, the oval-like epitrochoid-shaped housing surrounds a rotor which is triangular with bow-shaped flanks (often confused with a Reuleaux triangle, a three-pointed curve of constant width, but with the bulge in the middle of each side a bit more flattened). The theoretical shape of the rotor between the fixed corners is the result of a minimization of the volume of the geometric combustion chamber and a maximization of the compression ratio, respectively. The symmetric curve connecting two arbitrary apexes of the rotor is maximized in the direction of the inner housing shape with the constraint that it not touch the housing at any angle of rotation (an arc is not a solution of this optimization problem).

The central drive shaft, called the eccentric shaft or E-shaft, passes through the center of the rotor and is supported by fixed bearings. The rotors ride on eccentrics (analogous to crankpins) integral to the eccentric shaft (analogous to a crankshaft). The rotors both rotate around the eccentrics and make orbital revolutions around the eccentric shaft. Seals at the corners of the rotor seal against the periphery of the housing, dividing it into three moving combustion chambers. The rotation of each rotor on its own axis is caused and controlled by a pair of synchronizing gears. A fixed gear mounted on one side of the rotor housing engages a ring gear attached to the rotor and ensures the rotor moves exactly 1/3 turn for each turn of the eccentric shaft. The power output of the engine is not transmitted through the synchronizing gears. The force of gas pressure on the rotor (to a first approximation) goes directly to the center of the eccentric, part of the output shaft.

The best way to visualize the action of the engine in the animation at left is to look not at the rotor itself, but the cavity created between it and the housing. The Wankel engine is actually a variable-volume progressing-cavity system. Thus there are 3 cavities per housing, all repeating the same cycle. Note as well that points A and B on the rotor and e-shaft turn at different speeds—Point B circles 3 times as often as point A does, so that one full orbit of the rotor equates to 3 turns of the e-shaft.

As the rotor rotates and orbitally revolves, each side of the rotor is brought closer to and then away from the wall of the housing, compressing and expanding the combustion chamber like the strokes of a piston in a reciprocating engine. The power vector of the combustion stage goes through the center of the offset lobe.

While a four-stroke piston engine makes one combustion stroke per cylinder for every two rotations of the crankshaft (that is, one-half power stroke per crankshaft rotation per cylinder), each combustion chamber in the Wankel generates one combustion stroke per driveshaft rotation, i.e. one power stroke per rotor orbital revolution and three power strokes per rotor rotation. Thus, power output of a Wankel engine is generally higher than that of a four-stroke piston engine of similar engine displacement in a similar state of tune; and higher than that of a four-stroke piston engine of similar physical dimensions and weight.

Wankel engines also generally have a much higher redline than a reciprocating engine of similar power output. This is in part because the smoothness inherent in circular motion, but especially because they do not have highly stressed parts such as a crankshaft or connecting rods. Eccentric shafts do not have the stress-raising internal corners of crankshafts. The redline of a rotary engine is limited by tooth load on the synchronizing gears. Hardened steel gears are used for extended operation above 7000 or 8000 rpm. Mazda Wankel engines in auto racing are operated above 10,000 rpm. In aircraft they are used conservatively, up to 6500 or 7500 rpm. However, as gas pressure participates in seal efficiency, racing a Wankel engine at high rpm under no load conditions can destroy the engine.

National agencies that tax automobiles according to displacement and regulatory bodies in automobile racing variously consider the Wankel engine to be equivalent to a four-stroke engine of 1.5 to 2 times the displacement; some racing series ban it altogether.

### **Engine Lubrication System Technology**

There are basically two types of oil systems in vehicles, both of which sound like types of walruses or something: wet sump and dry sump.

Most cars use a wet sump system. (The more you say it, the weirder it sounds. Wet sump.) That means the oil pan is at the bottom of the engine, and the oil is stored there. Remember Oliver the oil molecule's lounge? It's kind of like he has a table next to the dance floor at the club. And in this strange metaphor, the dancers are pistons and bearings.

The advantage of a wet sump system is its simplicity. The oil is close to where it will be used, there aren't too many parts to engineer or repair, and it's relatively cheap to build into a car.

Some cars, especially high-performance cars, use a dry sump system. That means the sump isn't underneath the engine -- in fact, it can be located anywhere within the engine compartment. After Oliver does his job in the engine, he

doesn't just drip into the lounge. He goes to the VIP room away from the dance floor.

A dry sump system gets you a couple of bonuses: First, it means the engine can sit a little lower, which gives the car a lower center of gravity and improves stability at speed. Second, it keeps extra oil from soaking the crankshaft, which can lower horsepower. And, since the sump can be located anywhere, it can also be any size and shape.

Two-stroke engines, by the way, use a completely different type of technology. Scooters, lawn mowers and other two-stroke machines have the oil mixed right in with the gasoline. When the gasoline evaporates in the combustion process, the oil is left behind to do its slick business.

Sometimes you have to do this yourself, measuring the correct amounts before filling the tank. But sometimes, as in most motor scooters, there's an injection system that takes oil from the reservoir and mixes it with the gasoline for you in just the right proportions.

### **Electrical system**

The electrical system comprises a storage battery, generator, starting (cranking) motor, lighting system, ignition system, and various accessories and controls. Originally, the electrical system of the automobile was limited to the ignition equipment. With the advent of the electric starter on a 1912 Cadillac model, electric lights and horns began to replace the kerosene and acetylene lights and the bulb horns. Electrification was rapid and complete, and, by 1930, 6-volt systems were standard everywhere.

Increased engine speeds and higher cylinder pressures made it increasingly difficult to meet high ignition voltage requirements. The larger engines required higher cranking torque. Additional electrically operated features—such as radios, window regulators, and multi-speed windshield wipers—also added to system requirements. To meet these needs, 12-volt systems replaced the 6-volt systems in the late 1950s around the world.

The ignition system provides the spark to ignite the air-fuel mixture in the cylinders of the engine. The system consists of the spark plugs, coil, distributor, and battery. In order to jump the gap between the electrodes of the spark plugs, the 12-volt potential of the electrical system must be stepped up to about 20,000 volts. This is done by a circuit that starts with the battery, one side of which is grounded on the chassis and leads through the ignition switch to the primary winding of the ignition coil and back to the ground through an interrupter switch. Interrupting the primary circuit induces a high voltage across the secondary terminal of the coil. The high-voltage secondary terminal of the coil leads to a distributor that acts as a rotary switch, alternately connecting the coil to each of the wires leading to the spark plugs.

Solid-state or transistorized ignition systems were introduced in the 1970s. These distributor systems provided increased durability by eliminating the frictional contacts between breaker points and distributor cams. The breaker

point was replaced by a revolving magnetic-pulse generator in which alternating-current pulses trigger the high voltage needed for ignition by means of an amplifier electronic circuit. Changes in engine ignition timing are made by vacuum or electronic control unit (microprocessor) connections to the distributor.

The source of energy for the various electrical devices of the automobile is a generator, or alternator, that is belt-driven from the engine crankshaft. The design is usually an alternating-current type with built-in rectifiers and a voltage regulator to match the generator output to the electric load and also to the charging requirements of the battery, regardless of engine speed.

A lead-acid battery serves as a reservoir to store excess output of the generator. This provides energy for the starting motor and power for operating other electric devices when the engine is not running or when the generator speed is not sufficiently high for the load.

The starting motor drives a small spur gear so arranged that it automatically moves into mesh with gear teeth on the rim of the flywheel as the starting-motor armature begins to turn. When the engine starts, the gear is disengaged, thus preventing damage to the starting motor from overspeeding. The starting motor is designed for high current consumption and delivers considerable power for its size for a limited time.

Headlights must satisfactorily illuminate the highway ahead of the automobile for driving at night or in inclement weather without temporarily blinding approaching drivers. This was achieved in modern cars with double-filament bulbs with a high and a low beam, called sealed-beam units. Introduced in 1940, these bulbs found widespread use following World War II. Such units could have only one filament at the focal point of the reflector. Because of the greater illumination required for high-speed driving with the high beam, the lower beam filament was placed off centre, with a resulting decrease in lighting effectiveness. Separate lamps for these functions can also be used to improve illumination effectiveness.

Dimming is automatically achieved on some cars by means of a photocell-controlled switch in the lamp circuit that is triggered by the lights of an oncoming car. Lamp clusters behind aerodynamic plastic covers permitted significant front-end drag reduction and improved fuel economy. In this arrangement, steerable headlights became possible with an electric motor to swivel the lamp assembly in response to steering wheel position. The regulations of various governments dictate brightness and field of view requirements for vehicle lights.

Signal lamps and other special-purpose lights have increased in usage since the 1960s. Amber-coloured front and red rear signal lights are flashed as a turn indication; all these lights are flashed simultaneously in the “flasher” (hazard) system for use when a car is parked along a roadway or is traveling at a low speed on a high-speed highway. Marker lights that are visible from the front, side, and rear also are widely required by law. Red-coloured rear signals are

used to denote braking, and cornering lamps, in connection with turning, provide extra illumination in the direction of an intended turn. Backup lights provide illumination to the rear and warn anyone behind the vehicle when the driver is backing up. High-voltage light-emitting diodes (LEDs) are under development for various signal and lighting applications.

## **Suspension Types**

### ***Dependent Rear Suspensions***

If a solid axle connects the rear wheels of a car, then the suspension is usually quite simple -- based either on a leaf spring or a coil spring. In the former design, the leaf springs clamp directly to the drive axle. The ends of the leaf springs attach directly to the frame, and the shock absorber is attached at the clamp that holds the spring to the axle. For many years, American car manufacturers preferred this design because of its simplicity.

The same basic design can be achieved with coil springs replacing the leaves. In this case, the spring and shock absorber can be mounted as a single unit or as separate components. When they're separate, the springs can be much smaller, which reduces the amount of space the suspension takes up.

### ***Independent Rear Suspensions***

If both the front and back suspensions are independent, then all of the wheels are mounted and sprung individually, resulting in what car advertisements tout as "four-wheel independent suspension." Any suspension that can be used on the front of the car can be used on the rear, and versions of the front independent systems described in the previous section can be found on the rear axles. Of course, in the rear of the car, the steering rack -- the assembly that includes the pinion gear wheel and enables the wheels to turn from side to side -- is absent. This means that rear independent suspensions can be simplified versions of front ones, although the basic principles remain the same.

## **Specialized Suspensions: Formula One Racers.**

The Formula One racing car represents the pinnacle of automobile innovation and e-volution. Lightweight, composite bodies, powerful V10 engines and advanced aerodynamics have led to faster, safer and more reliable cars.

To elevate driver skill as the key differentiating factor in a race, stringent rules and requirements govern Formula One racecar design. For example, the rules regulating suspension design say that all Formula One racers must be conventionally sprung, but they don't allow computer-controlled, active suspensions. To accommodate this, the cars feature multi-link suspensions, which use a multi-rod mechanism equivalent to a double-wishbone system.

Recall that a double-wishbone design uses two wishbone-shaped control arms to guide each wheel's up-and-down motion. Each arm has three mounting positions -- two at the frame and one at the wheel hub -- and each joint is hinged

to guide the wheel's motion. In all cars, the primary benefit of a double-wishbone suspension is control. The geometry of the arms and the elasticity of the joints give engineers ultimate control over the angle of the wheel and other vehicle dynamics, such as lift, squat and dive. Unlike road cars, however, the shock absorbers and coil springs of a Formula One racecar don't mount directly to the control arms. Instead, they are oriented along the length of the car and are controlled remotely through a series of pushrods and bell cranks. In such an arrangement, the pushrods and bell cranks translate the up-and-down motions of the wheel to the back-and-forth movement of the spring-and-damper apparatus.

### **The Future of Power Steering**

Since the power-steering pump on most cars today runs constantly, pumping fluid all the time, it wastes horsepower. This wasted power translates into wasted fuel.

You can expect to see several innovations that will improve fuel economy. One of the coolest ideas on the drawing board is the "steer-by-wire" or "drive-by-wire" system. These systems would completely eliminate the mechanical connection between the steering wheel and the steering, replacing it with a purely electronic control system. Essentially, the steering wheel would work like the one you can buy for your home computer to play games. It would contain sensors that tell the car what the driver is doing with the wheel, and have some motors in it to provide the driver with feedback on what the car is doing. The output of these sensors would be used to control a motorized steering system. This would free up space in the engine compartment by eliminating the steering shaft. It would also reduce vibration inside the car.

General Motors has introduced a concept car, the Hy-wire, that features this type of driving system. One of the most exciting things about the drive-by-wire system in the GM Hy-wire is that you can fine-tune vehicle handling without changing anything in the car's mechanical components -- all it takes to adjust the steering is some new computer software. In future drive-by-wire vehicles, you will most likely be able to configure the controls exactly to your liking by pressing a few buttons, just like you might adjust the seat position in a car today. It would also be possible in this sort of system to store distinct control preferences for each driver in the family.

In the past fifty years, car steering systems haven't changed much. But in the next decade, we'll see advances in car steering that will result in more efficient cars and a more comfortable ride.

### **Traction Control System (TCS)**

A Traction Control System (TCS), in German known as Antriebschlupfregelung (ASR), is typically (but not necessarily) a secondary function of the anti-lock braking system (ABS) on production motor vehicles, designed to prevent loss of traction of driven road wheels. When invoked it

therefore enhances driver control as throttle input applied is mismatched to road surface conditions (due to varying factors) being unable to manage applied torque.

**Intervention consists of one or more of the following:**

- Reduces or suppress spark sequence to one or more cylinders;
- Reduce fuel supply to one or more cylinders;
- Brake force applied at one or more wheels;
- Close the throttle, if the vehicle is fitted with drive by wire throttle;
- In turbo-charged vehicles, a boost control solenoid can be actuated to reduce boost and therefore engine power.

Typically, traction control systems share the electro-hydraulic brake actuator (but does not use the conventional master cylinder and servo), and wheel speed sensors with the anti-lock braking system.

The basic idea behind the need of a traction control system is the difference between traction of different wheels evidencing apparent loss of road grip that compromise steering control and stability of vehicles. Difference in slip may occur due to turning of a vehicle or differently varying road conditions for different wheels. At high speeds, when a car tends to turn, its outer and inner wheels are subjected to different speed of rotation that is conventionally controlled by using a differential. A further enhancement of the differential is to employ an active differential that can vary the amount of power being delivered to outer and inner wheels according to the need (for example, if, while turning right, outward slip (equivalently saying, 'yaw') is sensed, active differential may deliver more power to the outer wheel, so as to minimize the yaw (that is basically the degree to which the front and rear wheels of a car are out of line.) Active-differential, in turn, is controlled by an assembly of electromechanical sensors collaborating with a traction control unit.

When the traction control computer (often incorporated into another control unit, like the anti-lock braking system module) detects one or more driven wheels spinning significantly faster than another, it invokes the ABS electronic control unit to apply brake friction to wheels spinning with lessened traction. Braking action on slipping wheel(s) will cause power transfer to wheel axle(s) with traction due to the mechanical action within a differential. All-wheel drive AWD vehicles often have an electronically controlled coupling system in the transfer case or transaxle engaged (active part-time AWD), or locked-up tighter (in a true full-time set up driving all wheels with some power all the time) to supply non-slipping wheels with (more) torque. This often occurs in conjunction with the powertrain computer reducing available engine torque by electronically limiting throttle application and/or fuel delivery, retarding ignition spark, completely shutting down engine cylinders, and a number of other methods, depending on the vehicle and how much technology is used to control the engine and transmission. There are instances when traction control is undesirable, such as trying to get a vehicle unstuck in snow or mud. Allowing one wheel to spin can propel a vehicle forward enough to get it unstuck, whereas both wheels



applying a limited amount of power can't get the same effect. Many vehicles have a traction control shut off switch for just such circumstances.

Traction control is not just used for improving acceleration under slippery conditions. It can also help a driver to corner more safely. If too much throttle is applied during cornering, the drive wheels will lose traction and slide sideways. This occurs as understeer in front wheel drive vehicles and oversteer in rear wheel drive vehicles. Traction control can prevent this from happening by limiting power to the wheels. It cannot increase the limits of grip available and is used only to decrease the effect of driver error or compensate for a driver's inability to react quickly enough to wheel slip.

Automobile manufacturers state in vehicle manuals that traction control systems should not encourage dangerous driving or encourage driving in conditions beyond the drivers' control.

### **Airbag Deployment Systems**

Airbags are passive safety devices that are mandatory on all vehicles sold in the United States. Airbags are a critical part of the Supplemental Restraint System (SRS) in most vehicles. The objective of the airbag, which is deployed when the vehicle suddenly decelerates (as in a collision), is to prevent the vehicle occupants from hitting any rigid surfaces and cushion the forces on their heads and upper or lower bodies. Airbags are typically made of nylon fabric and are hidden behind panels at various locations in the vehicle, including the steering wheel.

Depending on the crash severity, the rate at which the airbags are deployed is decided by the airbag control unit. In event of a crash, the crash sensor (an accelerometer) sends a signal to the airbag control unit. This control unit triggers the inflation device, which generates nitrogen gas by igniting a mixture of sodium azide ( $\text{NaN}_3$ ) and potassium nitrate ( $\text{KNO}_3$ ). From crash detection to complete deployment of the airbag, takes about 0.05 seconds. The airbag speed is about 200 mph, which itself can be harmful in certain cases, this has given rise to adaptive airbag systems that employ multiple inflators to produce either low-level or high-level deployments. These systems can adjust the airbag pressure depending on factors such as seat position, size of passenger, crash severity and seat belt use.

In the front passenger seat, most systems use a weight sensor to determine if the seat is unoccupied in which case deployment of the passenger air bag will be inhibited. The weight sensor can also discriminate between children and adults who may be occupying the seat. The U.S. Federal Motor Vehicle Safety Standard 208 requires airbag deployment systems to detect whether a child is seated in the front passenger seat. Typically, air bag deployment will be suppressed if a sensor identifies a low-weight condition. Additionally some systems can detect child's safety seats that are equipped with special sensors as defined by the technical specification ISO/TS 22239.

In 2010, 20% of all new vehicles sold in the U.S. were required to have side impact protection. This target increases 20% each year and will be 100% in 2014. Side-curtain airbags are likely to play a major role in helping vehicles to meet these requirements. The required response time for side-impact airbags is 0.005 to 0.010 seconds. Some car makers install pressure sensors in the door cavities that instantly detect deformations caused by side impact collisions.

In 2013, Volvo was the first automotive manufacturer to introduce a Pedestrian Airbag System in its V40 model. It uses a pedestrian contact sensing system. When impact with a pedestrian is sensed, the hood opens from the back and an airbag is inflated over the windshield-wiper area.

### **Variable Valve Timing**

There are a couple of novel ways by which carmakers vary the valve timing. One system used on some Honda engines is called VTEC.

VTEC (Variable Valve Timing and Lift Electronic Control) is an electronic and mechanical system in some Honda engines that allows the engine to have multiple camshafts. VTEC engines have an extra intake cam with its own rocker, which follows this cam. The profile on this cam keeps the intake valve open longer than the other cam profile. At low engine speeds, this rocker is not connected to any valves. At high engine speeds, a piston locks the extra rocker to the two rockers that control the two intake valves.

Some cars use a device that can advance the valve timing. This does not keep the valves open longer; instead, it opens them later and closes them later. This is done by rotating the camshaft ahead a few degrees. If the intake valves normally open at 10 degrees before top dead center (TDC) and close at 190 degrees after TDC, the total duration is 200 degrees. The opening and closing times can be shifted using a mechanism that rotates the cam ahead a little as it spins. So the valve might open at 10 degrees after TDC and close at 210 degrees after TDC. Closing the valve 20 degrees later is good, but it would be better to be able to increase the duration that the intake valve is open.

Ferrari has a really neat way of doing this. The camshafts on some Ferrari engines are cut with a three-dimensional profile that varies along the length of the cam lobe. At one end of the cam lobe is the least aggressive cam profile, and at the other end is the most aggressive. The shape of the cam smoothly blends these two profiles together. A mechanism can slide the whole camshaft laterally so that the valve engages different parts of the cam. The shaft still spins just like a regular camshaft -- but by gradually sliding the camshaft laterally as the engine speed and load increase, the valve timing can be optimized.

Several engine manufacturers are experimenting with systems that would allow infinite variability in valve timing. For example, imagine that each valve had a solenoid on it that could open and close the valve using computer control rather than relying on a camshaft. With this type of system, you would get maximum engine performance at every RPM. Something to look forward to in the future...

## **Cylinder Deactivation Reborn**

The idea of cylinder deactivation is becoming increasingly popular as car manufacturers strive to reduce fuel consumption. Cylinder deactivation effectively creates a variable displacement engine, which means you can enjoy the on-demand power of a large capacity engine together with the fuel economy of a smaller engine.

Cylinder deactivation is used to reduce the fuel consumption and emissions of an engine during light load operation.

In typical light load driving you use only around 30 percent of an engine's maximum power. In these conditions, the throttle valve is nearly closed and the engine needs to work to draw air. This causes an inefficiency known as pumping loss.

Mercedes says that some large capacity engines need to be throttled so much at light load that the cylinder pressure at Top Dead Centre is approximately half that of a small 4 cylinder engine. Low cylinder pressure means low fuel efficiency.

The use of cylinder deactivation at light load means the throttle valve can be opened further to provide the same power output. This reduces pumping losses and increases pressure in each cylinder. Fuel consumption can be improved by around 20 percent in highway conditions.

So how is cylinder deactivation achieved?

Well, put simply, it involves keeping the intake and exhaust valves closed for a particular cylinder. We will examine ways to keep the valves closed as we look at each manufacturer's system. By keeping the intake and exhaust valves closed, it creates an 'air spring' in the combustion chamber – the trapped exhaust gasses (kept from the previous charge burn) are compressed during the piston's upstroke and push down on the piston during its down stroke. The compression and decompression of the trapped exhaust gasses have an equalising effect – overall, there is virtually no extra load on the engine.

In the latest breed of cylinder deactivation systems, the engine management system is also used to cut fuel delivery to the disabled cylinders. The transition between normal engine operation and cylinder deactivation is also smoothed using changes in ignition timing, cam timing and throttle position (thanks to electronic throttle control).

In most instances, cylinder deactivation is applied to relatively large displacement engines that are particularly inefficient at light load. In the case of a V12, up to 6 cylinders can be disabled.

## **The VTEC engine.**

VTEC (Variable Valve Timing and Lift Electronic Control) is a valve train system developed by Honda to improve the volumetric efficiency of a four-stroke internal combustion engine. The VTEC system uses two camshaft profiles and hydraulically selects between profiles. It was invented by Honda

engineer Ikuo Kajitani, and was the first system of its kind.[citation needed] Different types of variable valve timing and lift control systems have also been produced by other manufacturers (MIVEC from Mitsubishi, AVCS from Subaru, VVT-i/VVTL-i from Toyota, VANOS from BMW, VarioCam Plus from Porsche, NeoVVL from Nissan, etc.).

VTEC was initially designed to increase the power output of an engine to 100 HP/litre or more while maintaining practicality for use in mass production vehicles. Some later variations of the system were designed solely to provide improvements in fuel efficiency.

Japan levies a tax based on engine displacement, and Japanese auto manufacturers have correspondingly focused their research and development efforts toward improving the performance of smaller engine designs through means other than displacement increases. One method for increasing performance into a static displacement includes forced induction, as with models such as the Toyota Supra and Nissan 300ZX which used turbocharger applications and the Toyota MR2 which used a supercharger for some model years. Another approach is the rotary engine used in the Mazda RX-7 and RX-8. A third option is to change the cam timing profile, of which Honda VTEC was the first successful commercial design for altering the profile in real-time.

The VTEC system provides the engine with multiple camshaft profiles optimized for both low and high RPM operations. In basic form, the single cam profile of a conventional engine is replaced with two profiles: one optimized for low-RPM stability and fuel efficiency, and the other designed to maximize high-RPM power output. The switching operation between the two cam lobes is controlled by the ECU which takes account of engine oil pressure, engine temperature, vehicle speed, engine speed and throttle position. Using these inputs, the ECU is programmed to switch from the low lift to the high lift cam lobes when the conditions mean that engine output will be improved. At the switch point a solenoid is actuated which allows oil pressure from a spool valve to operate a locking pin which binds the high RPM cam follower to the low RPM ones. From this point on, the valves open and close according to the high-lift profile, which opens the valve further and for a longer time. The switch-over point is variable, between a minimum and maximum point, and is determined by engine load. The switch-down back from high to low RPM cams is set to occur at a lower engine speed than the switch-up (representing a hysteresis cycle) to avoid a situation in which the engine is asked to operate continuously at or around the switch-over point.

The older approach to timing adjustments is to produce a camshaft with a valve timing profile that is better suited to high-RPM operation. The improvements in high-RPM performance occur in trade for a power and efficiency loss at lower RPM ranges, which is where most street-driven automobiles operate a majority of the time. Correspondingly, VTEC attempts to combine high-RPM performance with low-RPM stability.

## **Transmission Control**

The Transmission Control Module (TCM) is a device that controls modern automatic transmissions based on various inputs. The basic function of this unit is to receive signals from various sensors as well as data provided by engine control module (ECM), process this input, calculate how and when to shift gears in the transmission and generate the output signals required to drive the actuators that accomplish this shifting. The software controlling the TCM is designed to optimize vehicle performance, shift quality and fuel efficiency.

The electronic sensors monitor the gear position selection, vehicle speed, throttle position and a number of other parameters. Based on this data, the control unit adjusts the current supplied to solenoids in the transmission that control the position of various valves and gears.

The gear position selector switch communicates to the TCM which gear has been selected by the operator. The crankshaft position sensor provides information to the TCM to determine the existing rotational speed of the engine. This information helps the TCM to determine when to change gears. The Throttle position sensor tells the TCM how far the throttle is open which indirectly indicates the engine load. This input is used to determine the best time to change a gear. The turbine speed sensor determines the speed of the torque converter. The TCM uses this information to find the slippage across the torque converter, which helps it decide when to activate the torque converter lock-up clutch. The torque converter lock-up clutch increases the efficiency of the transmission by eliminating the hydraulic and pumping losses associated with the torque converter when cruising on the highway. The transmission fluid temperature sensor is used to ensure that the automatic transmission fluid is at the correct temperature. If the automatic transmission fluid is hot, then the transmission is downshifted. The brake pedal position sensor helps to ensure that the driver has applied the brake before shifting into park or reverse. The TCM may also downshift the transmission if the vehicle is going downhill in order to utilize the compression braking of the engine. Inputs from the traction control system instruct the transmission to downshift when one or more tires are losing traction.

Thanks to electronic transmission controls, modern automatic transmissions are much more fuel efficient than their purely mechanical/hydraulic predecessors. They also exhibit smoother shifting, reduced engine emissions, greater reliability and improved vehicle handling.

On some vehicles, the functions of the TCM and ECM are combined in a single module called the Powertrain Control Module or PCM.

## **Cruise control**

Cruise control is a system that automatically controls the speed of an automobile. The driver sets the speed and the system takes over the throttle of the car to maintain the speed. The system thereby improves driver comfort in steady traffic conditions. In congested traffic conditions, where speeds vary

widely, these systems are no longer effective. Most cruise control systems do not allow the use of cruise control below a certain speed.

In modern designs, the cruise control may need to be turned on before use — in some designs it is always "on" but not always enabled (not very common), others have a separate "on/off" switch, while still others just have an "on" switch that must be pressed after the vehicle has been started. Most designs have buttons for "set", "resume", "accelerate", and "coast" functions. Some also have a "cancel" button. Alternatively, depressing the brake or clutch pedal will disable the system so the driver can change the speed without resistance from the system. The system is operated with controls easily within the driver's reach, usually with two or more buttons on the steering wheel spokes or on the edge of the hub like those on Honda vehicles, on the turn signal stalk like in many older General Motors vehicles or on a dedicated stalk like those found in, particularly, Toyota and Lexus. Earlier designs used a dial to set speed choice.

The driver must bring the vehicle up to speed manually and use a button to set the cruise control to the current speed. The cruise control takes its speed signal from a rotating driveshaft, speedometer cable, wheel speed sensor from the engine's RPM, or from internal speed pulses produced electronically by the vehicle. Most systems do not allow the use of the cruise control below a certain speed (normally around 40 km/h (25 mph)). The vehicle will maintain the desired speed by pulling the throttle cable with a solenoid, a vacuum driven servomechanism, or by using the electronic systems built into the vehicle (fully electronic) if it uses a 'drive-by-wire' system.

All cruise control systems must be capable of being turned off both explicitly and automatically when the driver depresses the brake, and often also the clutch. Cruise control often includes a memory feature to resume the set speed after braking, and a coast feature to reduce the set speed without braking. When the cruise control is engaged, the throttle can still be used to accelerate the car, but once the pedal is released the car will then slow down until it reaches the previously set speed.

On the latest vehicles fitted with electronic throttle control, cruise control can be easily integrated into the vehicle's engine management system. Modern "adaptive" systems (see below) include the ability to automatically reduce speed when the distance to a car in front, or the speed limit, decreases. This is an advantage for those driving in unfamiliar areas.

The cruise control systems of some vehicles incorporate a "speed limiter" function, which will not allow the vehicle to accelerate beyond a pre-set maximum; this can usually be overridden by fully depressing the accelerator pedal. (Most systems will prevent the vehicle accelerating beyond the chosen speed, but will not apply the brakes in the event of overspeeding downhill.)

On vehicles with a manual transmission, cruise control is less flexible because the act of depressing the clutch pedal and shifting gears usually disengages the cruise control. The "resume" feature has to be used each time after selecting the new gear and releasing the clutch. Therefore cruise control is

of most benefit at motorway/highway speeds when top gear is used virtually all the time.

### **Idle Stop-Start Systems**

The Idle Stop-Start System is a low cost method for increasing fuel economy and decreasing emissions. The system turns off an internal combustion engine when the vehicle stops at a stop light or during stop and go traffic where the vehicle would normally idle for a minimum of three to five seconds, then the engine is restarted when the driver is ready to proceed. An electronic control unit determines an appropriate time to turn off the engine based on data from various sensors. An auto start/stop system can reduce CO<sub>2</sub> emissions by up to 3.5%. The system is currently available on most hybrid vehicles and on BMW's EfficientDynamics vehicles.

In hybrid vehicles, the system works very efficiently due to the availability of the large rechargeable battery used to assist in powering the engine. The picture below demonstrates how the system works on a full hybrid 2007 Toyota Prius. When the vehicle comes to a complete stop at a stop; the engine is turned off. Notice how the energy monitoring computer shows no flow of energy. When the brake pedal is released, the electric power from the battery is used to start the engine and assist in the initial acceleration. The yellow arrows show the flow of the electric energy to the wheels. When engine power is required, the engine is quickly started and assists the electric motor in powering the vehicle.

The concept is simple; however numerous parameters must be monitored and controlled in order to ensure the driver's comfort whenever the engine turns off. The system must monitor the state of charge (SOC) of the battery, so that the engine can be started again. Also, the air conditioning system must be shut down when the engine is off or being started. The system monitors the cabin climate to ensure the driver's thermal comfort. If the cabin temperature has not reached the operator's set value the auto start/stop system will not initiate. In addition, the engine temperature is monitored to avoid cold starts. This ensures complete combustion and optimal operation of the catalytic converter, thus reducing emissions.

### **Automatic Braking Systems**

A study conducted by the German Association of Insurance revealed that 50% of rear-end collisions occur without any braking and as much as 70% percent occur with braking that is insufficient to stop the vehicle in time. Furthermore, nearly 75% of all accidents that result in injuries happen within city limits at speeds below 20 mph. Active braking systems are well suited for avoiding or minimizing the damage caused by accidents under these conditions.

Active braking systems monitor conditions ahead of the vehicle. If a crash appears to be imminent, these systems will automatically apply an appropriate braking pressure. Continental's Emergency Brake Assist system, for example, uses three laser beams level with the rear-view mirror to scan the road for

obstacles up to eight meters ahead. The system is capable of preventing collisions if the speed differential between the two vehicles is less than 10 mph. At speeds greater than 10 mph, the system can reduce the severity of impact.

The Volvo XC60 implements a dual-mode detection technology from Continental that is capable of detecting pedestrians as well as other vehicles and applying full brake pressure at 2 to 18 mph. The system uses an infrared laser located behind the rear-view mirror and high resolution cameras for image detection. The combination of the two sensing technologies enables the system to more accurately assess the situation to further aid in accident prevention. The Highway Loss Data Institute found that Volvo XC60s equipped with this feature had 27% fewer claims, and were involved in fewer claims valuing up to \$6,999 compared to other midsize luxury SUVs. This shows that the system appears to be effective at reducing the number of low speed collisions.

Most of the automatic braking systems do not brake until the last minute, after warning the driver using acoustic as well as visual warning. This braking is usually activated later than a normal driver who is concentrating on the road would brake. Hence the system is less likely to interfere with normal driving and drivers are less likely to become dependent on the system for braking.

### **Blind Spot Detection**

A person seated in the driver's seat of a typical car or truck depends on the rear view mirror and two side mirrors to see vehicles approaching from behind. However, vehicles or other objects on either side and slightly behind a car may be in an area that is outside the field of view of these mirrors. This region is called the vehicle's blind spot. Driver's education classes emphasize the importance of checking for vehicles in the blind spot before attempting to make a lane change. Nevertheless, hundreds of thousands of collisions occur every year during lane changes.

Blind spot detectors use radar or image sensors to monitor a vehicle's blind spots and alert the driver when other vehicles are present. The alert indication is normally a yellow or red light located in or near the side mirrors that illuminates when a vehicle enters the blind spot associated with that particular side of the vehicle. Some models will provide an additional haptic warning that vibrates the driver's seat and/or steering wheel should he use the turn signals to indicate his intention to change lanes even though there is a vehicle in his blind spot.

With the 2011 model year, Infiniti introduced two models offering a feature called "Blind Spot Intervention". In addition to warning the driver about a vehicle in the blind spot, this system actually helps to prevent the car from changing lanes when a collision is likely to occur. The system applies mild braking to the wheels on the opposite side of the vehicle to pull the vehicle back to its original lane when it determines that changing lanes is likely to cause a collision with a vehicle in the blind spot.

***Other Blind Spot Detection Methods.*** Bosch's "Side View Assist" uses ultrasonic sensors for blind spot detection.



Multi-radius mirrors having a 40-degree field of view have been a popular option for consumers in Europe and Japan for more than 20 years. But in the US, this cannot be the solution, since government regulations permit only flat mirrors, having a 15-degree field of view.

A different blind-spot detection device has been developed by Advanced Technology Products of Toronto, Ontario. The system uses a patented passive infrared sensor technology, which the company claims can sense thermal energy radiating from the tires of a moving vehicle. This temperature difference is used to trigger a flashing red light to warn the driver of the hazard.

Michigan-based Magna Donnelly Corp. has developed panoramic vision displays involving three cameras, which can give an image of both sides and of the back of the vehicle, covering a 70-degree field of view with almost no blind spots. The three cameras replace the exterior and interior rear-view mirrors.

### **Navigation Systems**

Navigation systems help the driver of a vehicle to locate a particular destination and identify the best route for getting to that destination. Most automotive navigation systems use Global Positioning System (GPS) signals and electronic maps to identify the vehicle's current position relative to the desired destination. Portable navigation systems powered through the cigarette lighter or batteries, can be easily moved from vehicle to another. Built-in navigation systems have the advantage that they can access information about the vehicle's speed and direction to help navigate in situations where a GPS signal is temporarily blocked by buildings, traffic, foliage, etc.

Although the vast majority of automotive navigation systems rely on GPS signals, proximity beacons provide another form of radio-positioning. Proximity beacons are devices installed at key intersections and other strategic roadside locations that communicate their location along-with other information to receivers in passing vehicles via very short range radio, microwave or infrared signals. The reception of a proximity beacon signal provides an occasional basis for confirming vehicle position. One such system is described here.

Vehicle navigation systems generally offer the option of a top view (or bird's eye view) that shows the position of the vehicle on a traditional map; or a forward view that shows the road ahead as it would be viewed by the driver.

Some navigation systems are integrated with real-time traffic information and emergency notifications that are transmitted to the vehicle wirelessly (e.g. at cell phone or FM radio frequencies).

### **The Global Positioning System**

The U.S. military has 27 satellites orbiting the earth, 24 that are used for the GPS system and 3 as back-ups in case of a failure. They travel around the earth twice everyday and are arranged in such a way that at least 4 satellites are visible from any point on the earth at any time. To use GPS, a vehicle must have a GPS receiver. The GPS receiver has a pre-stored map or almanac of the

position of each satellite (which is updated based on information sent out by the satellite). The GPS receiver finds its distance from one satellite. Now, the receiver might be at any point on the surface of a sphere (say, Sphere A) with a radius equal to the distance from this satellite. Now, if the receiver measures its distance from a second satellite, it obtains another sphere (say, Sphere B) of probable positions. Sphere A and Sphere B will intersect to form a locus of points that would be a circle. So, we now have a circle of probable positions. Now, the receiver does the same with a third satellite. The result is 3 spheres that will give only 2 possible locations of the GPS receiver. Only one of these two positions can be on earth.

The GPS satellite communicates with satellites by high-frequency, low-power radio signals. Radio signals travel at the speed of light and the GPS receiver measures the distance between itself and the satellite by finding the time taken for a radio signal to travel between the satellite and itself. However, to be able to measure this, the satellite and the receiver require extremely accurate clocks. The satellites have an atomic clock; most commercial receivers employ an ordinary quartz clock. The receiver measures incoming signals from 4 or more satellites, which is more information than necessary just to establish position. The additional information is used to update the receiver's quartz clock to maximize the accuracy of its position calculations.

### **"Sure-footed all-wheel-drive handling."**

That's the kind of lingo you're likely to hear in car ads and marketing material, and it has prompted me to shout at televisions, print ads, and the occasional car-company rep: All-wheel drive doesn't help handling!

It's disingenuous to say or infer that AWD enhances cornering prowess, or that it'll help a driver avoid a fallen tree or dodge Bambi. When it comes to handling, all-wheel drive is overrated (not to mention heavy and gas-sucking), especially in foul weather.

"I'd rather have a Camry on four new snow tires than the best all-wheel-drive vehicle on all-season tires," said one tester who requested anonymity.

Before you start flaming, I'm not anti-AWD. Rather, I'm just incensed by those who fudge its ability beyond all recognition. AWD is great at aiding accelerating on slick surfaces and keeping a vehicle moving on snowy roads. Rally racers like AWD because it helps their over-powered cars accelerate on gravel and dirt paths. I co-drove an AWD car to victory in a 24-hour race, and in the rain I enjoyed how the car accelerated off the corners.

However, my experience—hard-earned from wrecking more than one AWD vehicle during snow-handling tests for a tire company—is that AWD is counter-productive when the roads are slick. At the same time AWD doesn't improve your handling, it does offer an overly optimistic sense of available traction, and it provides the potential to be going so much faster when you need to stop. (Note to those from warm climes: Snowbanks are not puffy and cushiony.) The laws of physics mean a vehicle's cornering power is the job of the tires and suspension.

"In the snow, it is all about the tires," says automotive engineer Neil Hannemann, whose resume includes helping to develop the original Dodge Viper, creating a proof-of-concept vehicle for the original all-wheel-drive Chrysler minivan, and driving ice racers on frozen lakes. Having power to four wheels rather than two sounds like it would help the car handle, which is why you see those ads that infuriate me. But good tires beat AWD.

Some disagree, saying AWD helps bad-weather handling because it quells power on oversteer, the fishtailing rear-drive cars experience when a ham-footed driver is too rough on the accelerator. It is true that AWD is excellent at preventing the tail from stepping out under power. But this is not "improving handling." It's really aiding acceleration.

And it's true that some advanced AWD systems now on the market help the car turn a little bit if the driver is assertively pushing the accelerator; they do it by dragging the inside wheel and diverting more force to the outside wheel. But my experience, and that of the test drivers I consulted, found little more than a small benefit. Once the tires' grip limit is reached, no more can be created. (For nitpickers and engineers: Yes, more aerodynamic downforce will increase grip, but I'm talking about road-going vehicles at highway-legal speeds, where that kind of performance edge isn't really applicable.)

There are more advanced AWD systems on the horizon. These torque-vectoring differentials are advanced versions of the current systems that cause one or more tires to turn faster or slower. The goal of these systems is to harness the grip all four tires have to offer.

Even so, we're talking about minor improvements. If you're looking for the peace of mind in knowing that you'll be able to get home if an unexpected snowstorm hits, AWD may be a good choice for you. However, if you think that AWD will help your car better grip slippery corners or dodge an indecisive squirrel, you're sadly mistaken. A good set of snow tires is a better investment if you live where it snows frequently or if the highway department is poor at plowing roads.

### **Transmission**

In a front-engined rear-wheel-drive car, power is transmitted from the engine through the clutch and the gearbox to the rear axle by means of a tubular propeller shaft. The rear axle must be able to move up and down on the suspension according to variations of the road surface. The movement causes the angle of the propeller shaft, and the distance between the gearbox and the rear axle, to change constantly.

To allow for the constant movement, splines on the front end of the propeller shaft slide in and out of the gearbox as the distance changes; the shaft also has universal joints at each end, and sometimes in the middle. The universal joints allow the propeller shaft to be flexible, while constantly transmitting power. The last part of the transmission is the final drive, which incorporates the differential and is sometimes called the differential. The differential has three functions: to

turn the direction of drive through 90 degrees to the rear wheels; to allow either rear wheel to turn faster than the other when cornering; and to effect a final gear reduction.

A pinion gear inside the differential is driven by the propeller shaft and has its gears bevelled - cut at an angle. It meshes with a bevelled crown wheel so that the two gears form a 90 degree angle. The crown wheel usually has about four times as many teeth as the pinion gear, causing the wheels to turn at a quarter the propeller-shaft speed. The drive is transmitted from the differential to the rear wheels by means of half shafts, or drive shafts.

At the differential end of each half shaft, a bevelled pinion gear is connected to the crown wheel by means of an intermediate set of bevel pinions.

### ***Driving through the front wheels***

Front-wheel-drive cars use the same transmission principles as rear-wheel-drive cars, but the mechanical components vary in design according to the engine and gearbox layout.

Transverse engines are normally mounted directly above the gearbox, and power is transmitted through the clutch to the gearbox by a train of gears. In-line engines are mated directly to the gearbox, and drive passes through the clutch in the normal manner. In both cases, drive passes from the gearbox to a final-drive unit. In a transverse-mounted engine, the final-drive unit is usually located in the gearbox. In an in-line engine, it is usually mounted between the engine and the gearbox.

Power is taken from the final-drive unit to the wheels by short drive shafts. To cope with suspension and steering movement in the wheels, the drive shafts use a highly developed type of universal joint called a constant-velocity (CV) joint. A CV joint uses grooves with steel ball bearings in them instead of the 'spider' found in a universal joint, and transmits power at a constant speed, regardless of the angle and the distance between the final-drive unit and the wheels.

Some cars, such as earlier Minis, also have drive-shaft couplings which are 'spider' joints, and do the same job as universal joints in rear-wheel-drive cars, allowing up-and-down movement of the suspension. They are usually made of rubber bonded to metal.

### ***Rear engine driving rear wheels***

Some cars, such as VW Beetles and smaller Fiats, have rear-mounted engines and gearboxes, driving the rear wheels. Power is transmitted through the clutch to the gearbox, passing to the wheels through drive shafts. The layout is similar to some frontwheel-drive cars, except that no allowance need be made for steering movement of the wheels. Sometimes the shafts are connected to the flanges at the gearbox by 'doughnut' couplings. The shafts and flanges are bolted on either side of the couplings, and drive is transmitted through the flexible rubber.

## Quiz

1. Almost all cars convert gasoline into motion with a \_\_\_\_\_-stroke combustion cycle.

a) two	b) three	c) <i>four</i>	d) six
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2. In a multi-cylinder car engine, what are the three ways in which the cylinders can be arranged?

a) <i>Inline, V and flat</i>	b) Stacked, Z and inline	c) Flat, T and parallel	d) Opposite, S and flat
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3. The "big three" engine problems are: lack of spark, lack of compression and \_\_\_\_\_.

a) _____ cracked cylinder	b) <i>bad fuel mix</i>	c) oil leak	d) misfiring pistons
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4. What's one component a gasoline engine has that a diesel engine doesn't?

a) turbine	b) intercooler	c) alternator	d) <i>spark plugs</i>
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5. What's the system that opens and closes a car's valves?

a) rotor	b) <i>camshaft</i>	c) carburetor	d) timing belt
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6. What are the two components of a car's cooling system?

a) carburetor and water pump	b) coil and radiator	c) <i>radiator and water pump</i>	d) oil and turbine
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7. What engine component is absent in a fuel-injected car?

a) muffler	b) turbocharger	c) <i>carburetor</i>	d) muffler
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8. The catalytic converter is part of which engine system?

a) Air-intake	b) Valve train	c) Cooling	d) <i>Emission control</i>
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9. The three most important factors in car aerodynamics are drag, lift and \_\_\_\_\_.

a) <i>down force</i>	b) up force	c) side force	d) roll force
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10. What's the drag coefficient of most cars today?

a) <i>down force</i>	b) up force	c) side force	d) roll force
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11. What does ABS stand for?

- a) Anti-hijack braking system;
- b) American braking system;
- c) Awesome braking system;

d) *Anti-lock braking system*

12. Where are drum brakes typically located?

a) front brakes	b) <i>rear brakes</i>	c) truck brakes only	d) fork lift brakes
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13. What prevents or reduces injury to passengers?

a) ABS	b) ESP	c) Traction control	d) <i>Rigid frames</i>
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14. What's the primary advantage of anti-lock braking systems (ABS)?

- a) They allow you to stop easier;
- b) *They allow you to steer while braking;*
- c) They prevent locking;
- d) None of the above

15. What kind of gas inflates an airbag?

a) Hydrogen	b) <i>Nitrogen</i>	c) Helium	d) Oxygen
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16. Which type of engine has the highest compression ratio?

a) Infinite	b) Petrol	c) Steam	d) <i>Diesel</i>
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17. A bump or imperfection on the roadway causes the vehicle's wheel to move up and down perpendicular to the road surface. What is this motion called?

- a) Horizontal acceleration;
- b) Lateral acceleration;
- c) *Vertical acceleration;*
- d) Roll acceleration

18. What is the most common type of spring used in modern car suspensions?

a) Leaf springs	b) <i>Coil springs</i>	c) Air springs	d) Water springs
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19. What term describes the ability of a vehicle to travel a curved path?

a) Acceleration	b) <i>Road holding</i>	c) Angling	d) <i>Cornering</i>
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20. What is loosely defined as the mass between the road and the suspension springs?

a) <i>Unsprung mass</i>	b) Sprung mass	c) Spring mass	d) Leaf mass
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21. A car engine's job is to:

- a) Convert fuel into heat;
- b) *Convert fuel into motion;*
- c) Convert fuel into exhaust;
- d) Convert fuel into flame

22. A car uses a four-stroke engine. The four strokes are:

a) Compression, decompression and exhaust	b) Injection, burning, decompression, exhaust
c) Injection, rotation, ignition and exhaust	d) <i>Intake, compression, ignition and exhaust</i>

23. A crankshaft's job in an engine is to:

a) Deliver fuel to the cylinders	b) <i>Change linear motion into rotational motion</i>
c) Deliver a person from point A to point B	d) Keep cylinder heads in place

24. In a car engine's cylinder, valves let fuel in and exhaust out. The \_\_\_\_\_ moves these valves.

a) <i>camshaft</i>	b) timing belt	c) distributor	d) silencer
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25. A turbocharger is:

a) A set of gears that makes the wheels turn faster	b) <i>A turbine that compresses the air traveling into the engine</i>
c) A pair exhaust pipes that thrust the vehicle ahead	d) An injector that delivers fuel to the engine faster

26. What are the key parts of the camshaft?

a) Pistons	b) <i>Lobes</i>	c) Cylinders	d) Valves
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27. Which of these is not a type of camshaft?

a) Pushrod	b) A single overhead crank
c) A single overhead cam	d) <i>Platinum overhead cam</i>

28. In single and double overhead cam engines, what keeps the cams rotating?

a) Timing belt	b) Timing chain	c) <i>Crankshaft</i>	d) Wheels
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29. How do pushrod engines differ from overhead engines?

a) Pushrod valves are located in the head.	b) The valves are spring loaded.
c) <i>The camshaft is located inside the engine block.</i>	d) The valves are positioned upside down

30. Why is the camshaft important to engine performance?

a) It regulates the amount of fuel and air that enters the engine.	b) It monitors the pistons.
c) <i>It controls the action of the engine valves.</i>	d) It rotates the crankshaft

31. What's the most persistent flaw in camshaft design?

a) Corrosion	b) <i>Imperfect timing</i>
c) Valve clogging	d) Metal fatigue

32. To make the best use of the fuel, the spark should occur before the piston reaches the top of the \_\_\_\_\_ stroke.

a) exhaust	b) intake	c) <i>compression</i>	d) power
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33. A manual transmission is connected to the engine through the: \_\_\_\_\_.

a) differential	b) <i>clutch</i>	c) belt	d) gear stick
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34. What connects the gears to the drive shaft in a manual transmission?

a) layshaft	b) clutch	c) belt	d) <i>collar</i>
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35. In a manual transmission, how does the collar engage a gear?

a) with magnets	b) <i>with dog teeth</i>
c) with electronics	d) with hydraulics

36. What do manual transmissions in modern passenger cars use to eliminate the need for double-clutching?

a) elite motor oil	b) <i>synchronizers</i>	c) equalizers	d) flywheel
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37. What two things do automatic transmissions lack that manual transmissions have?

a) clutch pedal and gears	b) <i>clutch pedal and gear shift</i>
c) clutch pedal and steering wheel	d) clutch pedal and gear stick

38. What creates the different gear ratios in an automatic transmission?

a) a series of four gears	b) <i>planetary gearset</i>
c) a series of two gears	d) planetary hydraulics

39. When the piston reaches a point just before top dead center, the ... ignites the fuel mixture.

a) alternator	b) <i>spark plug</i>	c) valve	d) flywheel
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40. The connecting rod connects the piston to the... .

a) crankcase	b) camshaft	c) valve	d) <i>crankshaft</i>
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