МИНИСТЕРСТВО ОБРАЗОВАНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
Белорусский национальный технический университет

Кафедра «Английский язык № 1»

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ENGLISH FOR AUTOMATED ELECTRIC DRIVES

АНГЛИЙСКИИЙ ЯЗЫК. АВТОМАТИЗИРОВАННЫЕ ЭЛЕКТРОПРИВОДЫ

Учебно-методическое пособие
для студентов специальности
1-53 01 05 «Автоматизированные электроприводы»

Рекомендовано учебно-методическим объединением вузов Республики Беларусь по образованию в области автоматизации технологических процессов, производств и управления

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ПРЕДИСЛОВИЕ

Настоящее учебно-методическое пособие предназначено для студентов вузов, обучающихся по специальности 1-53 01 05 «Автоматизированные электроприводы». В то же время, данное издание будет полезно студентам вузов других специальностей, связанных с автоматизацией производства. Предлагаемое учебное пособие подготовлено в соответствии с требованиями типовой программы по иностранным языкам для высших учебных заведений и учебным планом вышеуказанной специальности.

Целью пособия является систематизация знаний студентов по предлагаемой тематике, обогащение их словарного запаса, а также формирование у студентов речевых навыков и развитие умений профессионально ориентированного иноязычного общения в устной и письменной форме в предполагаемых ситуациях профессиональной деятельности.

Пособие состоит из 8 разделов, охватывающих основные тематические области, относящиеся к сфере автоматизации технологических процессов и производств. Каждый раздел имеет единую структуру, включающую следующие ключевые элементы: Switch on (введение в тему в виде проблемных вопросов), Vocabulary (лексические задания на систематизацию и активизацию тематического словаря), Reading (аутентичные тексты с заданиями для различных видов чтения и контроля понимания прочитанного), Grammar (грамматический справочный материал с рядом упражнений, нацеленных на систематизацию грамматических знаний и совершенствование грамматических навыков), Speaking (упражнения на развитие навыков устной речи в ситуациях профессионально ориентированного общения).

Каждый раздел включает упражнения различного уровня сложности. Пособие может использоваться как для организации основной аудиторной, так и внеаудиторной работы.

UNIT 1
ENGINEERING MATERIALS

SWITCH ON

Exercise 1. Write a list of things that are often made of:

steel, cardboard, cotton, wood, glass, copper, leather, aluminium, rubber, concrete, plastics, silicon

Exercise 2. Complete the sentences using the words in the box.

metallic, non-metallic, ferrous, non-ferrous, non-metal, metal

1. Carbon is a ____.
2. Copper is a ____ metal.
3. Aluminium is a common ____.
4. Steel is a widely used ____ metal.
5. Although it is used in steel, carbon is ____.
6. Aluminium is rather light for a ____ material.

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Engineering Materials" and write them down into your personal vocabularies.

Exercise 2. Match the words and word combinations having an opposite meaning.

1. Ferrous	a. Insulator
2. Solid	b. Alloy
3. Conductor	c. To resist corrosion
4. Pure substance	d. Non-ferrous
5. To rust	e. Good
6. Poor	f. Liquid

Exercise 3. Match the alloys with their constituents.

1. Steel	a. An alloy of copper and zinc
2. Brass	b. An alloy of iron and carbon
3. Invar	c. An alloy of copper and tin
4. Bronze	d. An alloy of iron, carbon and chromium
5. Stainless steel	e. An alloy of iron and nickel

Exercise 4. Read the text below and decide whether the sentences are true or false.

1. Various materials have been known since ancient times.
2. The structures and devices the engineers develop are limited by the properties of the materials.
3. All metals are solid substances.
4. Metals have low thermal and electric conductivity.
5. Pure metals are seldom used for certain applications.
6. Examples of alloys include iron, copper, zinc, aluminum.
7. Non-ferrous metals contain iron.
8. Alloys can contain both metallic and non-metallic constituents.
9. The presence of chromium protects stainless steel from rust.
10. Non-metals are good insulators.

ENGINEERING MATERIALS

Materials are the primary part of all things surrounding us. In fact, some materials have given the name to various ages in human history, for example, Stone Age, Bronze Age, Iron Age, Synthetic Materials Age, Smart Materials Age. The materials used for **manufacturing** of engineering products are called engineering materials. The research and development of new engineering materials is a continuous process. Currently many institutions and laboratories are working on the development of new materials to cope with the changing demands of industries.

Engineering materials can be classified according to the branch of engineering like mechanical engineering materials (iron, steel etc.), electrical engineering materials (**conductors**, **insulators**, magnetic materials, etc.), civil engineering materials (cement, stone, etc.) and so on. The

structures, components, and devices that engineers design are limited by the **properties** of the materials that are available and the techniques that can be used for **fabrication**.

Basically, engineering materials can be classified into two categories: metals and non-metals. Most metals are **solid** at room temperature. However, mercury is the only metal that is **liquid** at room temperature. Examples of metals include silver, copper, gold, aluminium, iron, zinc, lead, tin etc. All metals have high thermal and electrical **conductivity**.

Pure metals have very low mechanical **strength**, which sometimes does not match with the mechanical strength required for certain **loads**. To overcome this drawback **alloys** are used. Alloys are the composition of two or more metals or metal and non-metals together. Generally, alloys have better strength and **durability** than their main metals. Examples are steel, **brass**, bronze, **invar** etc.

Metals can be further divided into two groups: **ferrous** and **non-ferrous** metals. All ferrous metals such as **cast iron** and **steel** have iron as a basic **substance**. Non-ferrous metals do not **contain** iron. Non-ferrous metals include silver, copper, gold, aluminium etc. Ferrous metals are prized for their **tensile strength** and durability thanks to a high **carbon** content. However, ferrous metals tend to **rust** when exposed to air and water. There are two exceptions to this rule: **wrought iron** resists rust due to its **purity** and **stainless steel** is protected from rust by the presence of chromium. Most ferrous metals are magnetic which makes them very useful for motor and electrical applications.

The main advantage of non-ferrous metals over ferrous materials is their **malleability**. They also don't contain iron that gives them a higher **resistance** to rust and corrosion. They are non-magnetic, which is important for many electronic and **wiring** applications.

Non-metals are **poor** conductors of heat and electricity. Examples include plastics, rubber, ceramic, leather etc. Non-metals have very high **resistivity** which makes them suitable for insulation purpose in electrical machines.

Exercise 5. Explain why:

1) many scientific laboratories are working now on the development of new materials.

2) the properties of engineering materials are considered to be very important.
3) alloys are used.
4) ferrous metals are very useful for motor and electrical applications.
5) non-ferrous metals have high corrosion resistance.
6) non-ferrous metals are important for electronic and wiring applications.
7) non-metals are suitable for insulation purposes.

Exercise 6. Match the words below to make word combinations found in the text "Engineering Materials".

A	B
tensile, stainless, cast, poor, liquid, pure, carbon, wiring, engineering, normal	**conductors, applications, temperature, content, materials, strength, iron, state, steel, metal**

Exercise 7. Read the groups of derivatives and translate them into Russian.

1) to conduct, conductor, conductivity;
2) to insulate, insulator, insulation;
3) to rust, rust, rusty;
4) pure, purity, to purify;
5) to corrode, corrosion, corroded;
6) to resist, resistance, resistivity, resistant;
7) oxide, oxygen, oxidation, to oxidize.

Exercise 8. Complete the sentences with the words from exercise 7. Sometimes there is more than one possible answer.

1. When steel is exposed to air or water, it ____.
2. Non-ferrous metals can be used to protect steel from ____ by plating it – that is, covering it with a layer of metal.
3. Materials with very high ____, such as plastics, are called electrical ____.
4. A water molecule –H_2O– contains two hydrogen atoms and one ____ atom.

5. An orange coating on the surface of metal is called ____.
6. Aluminium is a very light metal but it's also very soft in its ____ form.
7. Copper has high ____ for electricity and heat.
8. Materials that are good insulators are used to ____ conductors. An example is plastic ____ around electric wires.
9. The main disadvantage of ferrous metals is that they go ____.
10. Aluminium does not ____ easily because it has a protective layer of aluminium ____.

Exercise 9. Find seventeen materials in the puzzle. Read across, down, and diagonally.

X	**L**	**X**	**W**	**O**	**O**	**D**	**Z**	**T**	**I**	**N**
C	**E**	**R**	**A**	**M**	**I**	**C**	**J**	**R**	**M**	**W**
P	**A**	**B**	**N**	**J**	**X**	**C**	**X**	**U**	**X**	**O**
A	**T**	**R**	**X**	**Y**	**I**	**X**	**I**	**B**	**G**	**O**
P	**H**	**X**	**D**	**T**	**L**	**N**	**R**	**B**	**O**	**L**
E	**E**	**X**	**S**	**B**	**I**	**O**	**O**	**E**	**L**	**S**
R	**R**	**A**	**X**	**M**	**O**	**X**	**N**	**R**	**D**	**T**
X	**L**	**X**	**U**	**G**	**L**	**A**	**S**	**S**	**X**	**E**
P	**O**	**L**	**Y**	**S**	**T**	**Y**	**R**	**E**	**N**	**E**
X	**A**	**S**	**I**	**L**	**V**	**E**	**R**	**D**	**X**	**L**

Exercise 10. Study the words and word combinations in bold from the text 'Properties of Materials' and write them down into your personal vocabularies.

Exercise 11. Skim the text and complete the sentences below.

1. Glass is a ____ material but it's an excellent ____ ____.
2. Carbon and alloy steels have the property of ____.
3. Copper is ____ and ____, also it's an excellent ____ material.
4. Rubber is ____.
5. Stainless steel is ____ and ____, therefore it's ____.

Exercise 12. Read the text again and answer the following questions.

1. What happens to a material when it is subjected to tension?
2. What is tensile strength?
3. What kind of materials can extend significantly, but still return to their original shape?
4. What materials are called plastic?
5. Is copper malleable or ductile?
6. Soft materials are wear-resistant, aren't they?

PROPERTIES OF MATERIALS

Different materials exhibit different working properties. When material is subjected to **tension**, its length will increase by a certain amount. Tensile strength (the ability to resist tension) is a very valuable property of ferrous metals such as **carbon** and **alloy steels**.

Some materials can extend significantly, but still return to their original shape. A material's ability to do this is called elasticity. Rubber is an example of a very elastic material. If a material has low elasticity and is weak, it is described as **brittle** – that is, it breaks very easily. Glass and cast iron are the examples of brittle materials.

Some materials can change shape significantly, but do not return to their original shape. We say these materials are plastic. A material that can be plastically deformed by **hammering** or **rolling** is malleable. A material that can be stretched into a long length is **ductile**. For example, **mild steel**, copper and tin are malleable as well as ductile.

Some materials conduct heat better than others. Therefore, thermal conductivity varies, depending on the material. Copper is an excellent conductive material. Glass, on the other hand, is an excellent thermal insulator.

The hardness of a material affects its durability – that is, how long it will last. Generally, hard materials are more durable than soft materials because they are more **wear-resistant** like stainless steel.

Exercise 13. In the texts 'Engineering Materials' and 'Properties of Materials' find the adjectives related to the nouns in the box.

durability, malleability, plasticity, elasticity, purity, ductility, conductivity, strength, length, tension, brittleness, hardness

Exercise 14. Match the properties to their definitions.

1)	conductivity	a) the ability of a material to permanently deform in all directions without cracking
2)	strength	b) the ability of a material to withstand wear, especially as a result of weathering
3)	elasticity	c) the ability of a material to conduct heat or electricity
4)	plasticity	d) the ability of a material to withstand a force without breaking or bending
5)	malleability	e) the ability of a material to permanently change in shape
6)	durability	f) the ability of a material to deform, usually by stretching along its length
7)	ductility	g) the ability of a material to bend and then return to its original shape and size

GRAMMAR
DEGREES OF COMPARISON

Exercise 1. Write the opposites using the adjectives in the box.

soft, dangerous, slow, good, elastic, difficult, heavy, conductive, expensive, low

1) ***easier – more difficult***
2) harder
3) cheaper
4) lighter
5) more brittle
6) worse
7) faster
8) higher
9) more insulating
10) safer

Exercise 2. Choose the best option.

1. When pure metals are mixed with ***stronger / more strong*** alloy, they will actually be much ***most durable / more durable***.
2. Since aluminium has a ***lowest / lower*** density than steel a car body made from aluminium will be ***lighter / more lighter*** than the same car body made from steel.
3. A car body made from aluminium will corrode ***little / less*** than one made from steel. However, aluminium is ***the most expensive / more expensive*** than steel.
4. Gold resists corrosion ***gooder / better*** than the other precious metal, silver.
5. Stainless steel is ***more corrosion-resistant / the most corrosion-resistant*** of all steels.
6. Carbon steel has a ***higher / more high*** carbon content in comparison to other types of steel.
7. Gold is often mixed with nickel, zinc, copper and other metals to make it ***the hardest / harder***.
8. Carbon steel is used in ***the tallest / the most tall*** skyscrapers and ***longer / longest*** bridges.

Exercise 3. Study the information about different types of steel. Complete the sentences with the comparative or superlative form of the adjectives in brackets.

Materials / Properties	**Mild steel**	**Stainless steel**	**Tool steel**
1. Carbon content	**0,25 %**	**0,07 – 0,12 %**	**0,7 – 1,5 %**
2. Hardness	**-**	+	+
3. Malleability	+	**- / +**	**- / +**
4. Resistance to corrosion	**-**	+	**-**
5. Resistance to wear	**-**	+	+
6. Resistance to high temperature	**-**	**-**	+
7. High price	**-**	+	+

Example: Mild steel has a ***lower*** carbon content than ***tool steel***. (low)

1. ____ carbon content of the three has ____. (small)
2. Stainless steel and tool steel provide ____ hardness than ____. (good)
3. ____ of the three is ____. (malleable)
4. The ____ the steel the ____ it is worked with. (malleable, easy)
5. Stainless steel is ____ than mild steel and ____. (corrosion-resistant)
6. ____ has ____ resistance to wear. (little)
7. Tool steel is ____ than ____. (wear-resistant)
8. The resistance of ____ to high temperature is ____. (large)
9. Mild steel is ____ than ____ and tool steel. (cheap)
10. Stainless steel and tool steel are much ____ than ____. (expensive)
11. Drills are made of tool steel because it is a lot ____ than ____. (resistant to heat)

Exercise 4. Correct the mistakes if necessary.

1. Almost all metals used in construction are mixed with some alloys to make them more strong and easy to work with.
2. Platinum is hard, but titanium is much hard.
3. Stainless steel provides gooder durability than pure iron.
4. Tungsten is much more durable than silver.
5. Harder metals also have a tendency to be expensiver.
6. The thermal conductivity of copper is about 40 % great than that of aluminium.
7. So, copper is a much most effective thermal conductor than aluminium.
8. The problem of metal micro-cracking is made bad over time.

Exercise 5. Translate the sentences into English

1. Сталь – это самый широко используемый конструкционный материал.
2. Алюминий можно легировать с титаном, чтобы создать более прочные и легкие сплавы.
3. Мы никогда еще не использовали более износостойкий материал, чем этот.
4. Латунь, сплав меди и цинка, является хорошим проводником тепла и электричества.

5. Это самый прочный металл, который я когда-либо видел.

6. Пластик – это самый подходящий изоляционный материал, также он самый дешевый.

7. Хорошая ковкость меди позволяет ей легко вытягиваться, что находит широкое применение в производстве электрических проводов.

8. Самым большим недостатком черных металлов является их более низкое сопротивление коррозии по сравнению с цветными металлами.

9. – Почему черные металлы ржавеют? – Ржавчина появляется из-за химической реакции между железом и кислородом в воздухе. Самый коррозиеустойчивый черный метал – это нержавеющая сталь.

10. Износостойкость инструментальной стали делает ее подходящим материалом для производства режущих инструментов, которые работают при высоких температурах.

11. – Из какого материала изготавливают электродвигатели? – Благодаря своим магнитным свойствам, прочности на разрыв и твердости литейный чугун идеально подходит для производства электродвигателей.

12. Более твердые металлы предоставляют лучшую износостойкость и сохраняются дольше.

SPEAKING

Exercise 1. Make short dialogues about the products and the materials they are made of. Use the prompts below.

A: *What's / what are the ... made of?*

B: *It's / they're made of ...*

A: *Why do they / we use ...?*

B: *Because it's ...*

1) electric wires / copper;
2) cutting tools and drills / tool steel;
3) insulating coating / plastic;
4) turbine blades, springs and household utensils / stainless steel;
5) parts of aircraft and car bodies / aluminium;
6) machine tools and automobile engines / cast iron;
7) ships and containers for chemicals / titanium;
8) electric bulbs / glass;
9) protective coating to iron and steel / zinc.

Exercise 2. Work in pairs. Read the text. Discuss it with your partner using the questions below.

In general, metals and alloys are conductors of electricity. The most common metals used in electrical engineering are copper, aluminium and their alloys. Copper has the highest electrical and thermal conductivity of the common industrial metals. It has good mechanical properties, is easy to solder and is readily available. Cadmium copper, chromium copper and silver copper find wide application in the electrical industry where high conductivity is required.

Cadmium copper is particularly suitable for the contact wires in electric railways, tramways, trolley buses, gantry cranes and similar equipment, and is also used in overhead telecommunications lines and transmission lines. Chromium copper is particularly suitable for high-strength applications such as spot and seam types of welding electrodes. Silver copper is basically used in electrical machines which operate at high temperatures or are exposed to high temperatures in manufacture.

Several aluminium alloys are also good conductors, combining strength with acceptable conductivity. Aluminium is less dense and cheaper than copper. Aluminium and its alloys are used in cables, bus bars and overhead lines.

1. Materials / conductors / are / of / electricity / what?
2. Metals / are /electrical / what / the most / engineering / common / in?
3. Metal / the highest / has / conductivity / thermal / and /which / electrical?
4. Properties / copper / what / have / does?
5. Copper alloys / what / know / you / do?
6. Is / cadmium copper / for / what / suitable?
7. Lines / is / transmission / cadmium copper / also / in / used / isn't it?
8. Used / chromium copper / spot and seam / is / electrodes / types of welding / for?
9. Used / silver copper / where / is?
10. Do / alloys / combine / what / aluminium / properties?
11. Copper / than / cheaper / is / aluminium?
12. Alloys / machines / used / or / aluminium / in cables / are / in electrical?

UNIT 2
FUNDAMENTALS OF ELECTRICITY

SWITCH ON

Exercise 1. Study the difference between "electric" and "electrical".

1. ***Electric*** (adj) refers to something that runs on electricity, is produced by electricity or used for carrying electricity. ***Electric*** is used when the object has been specified. For example, *electric light, kettle, etc.*
2. ***Electrical*** (adj) refers to something relating to electricity or using electricity. ***Electrical*** is used in a more general sense. For example, *electrical equipment, appliances, etc.*

Now decide what can be "electric" and "electrical".

Engineer, wires, current, goods, cooker, charge, motor, engineering, power, energy.

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Electricity" and write them down into your personal vocabularies.

Exercise 2. Match the words with a similar meaning. Check any unknown words in a dictionary.

1.	Like	a.	To raise
2.	To step down	b.	To use
3.	To reverse	c.	Rubbing
4.	To step up	d.	The same
5.	Fission	e.	To lower
6.	To occur	f.	To push away
7.	To repel	g.	Splitting
8.	Friction	h.	To change
9.	To harness	i.	To happen

Exercise 3. Read the text below and decide whether the sentences are true or false.

1. Electricity has been used since ancient times.
2. Thomas Edison invented the electric bulb.

3. Electric power is produced only by burning fossil fuels.
4. A set of transformers at the power plant step up low voltage to high voltage used on the transmission lines.
5. A static charge creates an electric current.
6. Lightning is caused by the build-up of electrical charges on a cloud, also known as static electricity.
7. Opposite charges repel, like charges attract.
8. Electric current is a flow of negatively charged electrons along a conductor.
9. Direct current regularly reverses direction.
10. The frequency of AC is measured in hertz.

ELECTRICITY

Electricity has been known since ancient times, but scientists could not make use of it safely until the eighteenth century. Thomas Edison's invention of the electric **bulb** in 1879 sparked the **demand** for electric **power** that continues to this day.

Major electric **utilities** produce electric power by burning **fossil fuels**, **harnessing** the hydroelectric energy, and initiating and **maintaining nuclear fission**. Electric power is also generated from biomass, wind, solar, geothermal and other **renewable** forms of energy.

An electric power system consists of six main components: the electric **power generating plant**; a set of transformers at the plant to **raise** the generated electricity to high **voltage** used on the **transmission** lines; the transmission lines; the **substations** at which the power is **stepped down** to the voltage that can be distributed to consumers; the **distribution** lines; and the transformers that lower the distributed voltage to the level needed by residential, industrial, and commercial users.

Electricity is a form of energy associated with **charges**, and both electrons and protons carry a charge. Electrons carry a **negative charge** while protons carry a **positive charge.** As a result, it is moving charges (electrons) that are primarily responsible for electricity. A charge that does not move is called a static charge and creates static electricity. It can be produced by **friction** which is one of the ways to **separate** charges. However, they don't "want" to stay separated.

For example, when you walk across a carpet you can often charge yourself and then touching a metal doorknob, you can **get an electric**

shock. There is always a tendency for charges to return to their original locations, and all that is needed is a pathway for charges to use. Static charges build up on clouds until they can hold no more. At that point, **lightning** can occur. Static electricity is widely used in **xerography**.

It's a well-known fact that opposite charges attract, **like** charges **repel**. A **flow** of negatively charged electrons makes up an electric **current**. If the number of electrons flowing through a conductor **increases**, the amount of current, or **amperage**, increases.

For an electric current to exist in a conductor there must be an **electromotive force** (emf) or **potential difference** between the ends of the conductor. If the source of potential difference is a battery, the current flows in one direction as a **direct current** (DC). If the source is the **mains**, the current **reverses** direction twice every cycle, as **alternating current** (AC). There are several basic units of electricity. An ampere is the **unit measure** of current, a coulomb is the unit measure of charge. An ohm measures **resistance** to the flow of electricity and a volt measures electromotive force.

The majority of electric current used for practical purposes is alternating current. In North America, for example, electric power lines operate at a **frequency** of 60 hertz. Outside of North America, 50 hertz power line is more common.

Exercise 4. Put the words in the correct order and answer the questions.

1. Invented / what / in / was / 1879?
2. Renewable / energy / are / resources / what?
3. Is / power / where / electric / generated?
4. Static / how / produced / is / electricity?
5. Where / electricity / used / static / is?
6. The source / of / what / alternating / is / current?
7. Are / the basic / of electricity / what / units?
8. Frequency / power / operate / do / what / lines / in North America?

Exercise 5. Electricity makes our modern world possible, but how much do you really know about it? Take this quiz and find out.

1. Electricity that reaches our homes through cables is called

a) static electricity;

b) direct current;
c) alternating current.

2. What does a transformer do to an electric current?
a) a transformer adds more watts;
b) a transformer changes voltage;
c) a transformer generates electricity.

3. The build-up of charges on an object is called
a) positive charge;
b) static charge;
c) negative charge.

4. Which type of current is produced by a battery?
a) static;
b) alternating;
c) direct.

5. This is related to the force that causes electric charges to flow.
a) voltage;
b) current;
c) resistance.

6. Lightning is
a) a high-voltage electric current;
b) safe;
c) a large discharge of static electricity.

7. What do like charges do?
a) attract;
b) repel;
c) melt.

8. What is the unit used to measure resistance?
a) ohm;
b) ampere;
c) watt.

9. What do we call a continuous flow of electricity through a conductor?
a) resistance;
b) voltage;
c) current.

10. Most of the energy consumed in Belarus comes from
a) hydropower;
b) natural gas, coal, petroleum;
c) biomass.

Exercise 6. Choose the correct word below.

1. Thomas Edison's (***discovery / invention***) of the electric bulb sparked the demand for electric power.
2. Fossil fuels and nuclear fission are (***renewable / non-renewable***) sources of energy.
3. After the step-up transformer, the current enters a (***distribution / transmission***) line.
4. Electric (***batteries / charges***) are either positive or negative.
5. High voltage is (***stepped up / stepped down***) by transformers to levels appropriate for distribution to consumers.
6. Current in a battery-powered flashlight, is called (***alternating / direct***) current.
7. An electric current is the movement of charged particles measured in (***ohms / amperes***).
8. In order for an electric current to flow, a (***potential difference / high pressure***) must exist between two points.

Exercise 7. Read the groups of derivatives and translate them into Russian.

1) to transmit, transmission, transmitter;
2) to distribute, distribution, distributor;
3) to produce, production, producer;
4) to generate, generation, generator;
5) to operate, operation, operator;
6) to invent, invention, inventor;
7) to consume, consumption, consumer;
8) to charge, charge, charger;
9) to convert, conversion, converter.

Exercise 8. Complete the sentences with the words from exercise 7. Sometimes there is more than one possible answer.

1. The ___ lines carry a lower voltage of electricity than the transmission grid.
2. When the number of electrons in an object become unbalanced, a negative ___ occurs.

3. The electricity we use every day is ___ in power plants.
4. The ___ lines are huge steel towers that can be seen from a distance.
5. In 1831 Michael Faraday built the first ___, then called it dynamo.
6. Solar cells ___ sunlight directly into electricity.
7. The turbine activates a generator to ___ electricity.
8. Our ___ of fossil fuels has doubled every 20 years since 1900.
9. The induction motor has been improved greatly since its ___.
10. Protective clothing must be worn when the machine is in ___.
11. Russia is the world's leading ___ of natural gas.
12. A ___ is a machine that changes alternating current to direct current and vice versa.

GRAMMAR
SIMPLE TENSES

The **Present Simple** is used to describe:

1. Habitual facts or repeated actions.

*He **starts** work at 8 am every day.*

2. Universal truths and permanent characteristics, situations or states.

The earth goes round the sun.

3. Scheduled facts and events.

*The flight **leaves** at 2 p.m. (according to the time-table)*

Time words with the **Present Simple**: ***usually, often, always, sometimes, seldom, rarely, every day (week, year***) etc.

	Positive	Negative	Questions
Present Simple Active	I / you / we / they usually **consume** a lot of electricity. He / she / it usually **consumes** a lot of electricity.	I / you / we / they **do not (don't)** usually **consume** much electricity. He / she / it **does not (doesn't)** usually **consume** much electricity.	**Do** you / we / they usually **consume** a lot of electricity? **Does** he / she / it usually **consume** much electricity?
Present Simple Passive	This device **is** / these devices **are produced / sold by** many companies.	This device **is not** / these devices **are not produced / sold by** many companies.	**Is** this device / **Are** these devices **produced** / **sold** by many companies?

The **Past Simple** is used to describe:

1. A single past action or a past state.

*James Watt **invented** the steam engine in 1765.*

2. A succession of single past actions.

*I **entered t**he office, **looked** around and **came up** to the secretary.*

Time words with the **Past Simple**: ***yesterday, 2 years ago, last year (week, month), in 1997*** etc.

	Positive	Negative	Questions
Past Simple Active	I / you / we / they / he / she / it **carried out / undertook** the test yesterday.	I / you / we / they / he / she / it **did not (didn't) carry out / undertake** the test yesterday.	**Did** you / we / they / he / she / it **carry out / undertake** the test yesterday?
Past Simple Passive	The test **was** / the tests **were carried out / undertaken by** the researchers yesterday.	The test **was not** / the tests **were not carried out / undertaken by** the researchers yesterday.	**Was** the test **/ Were** the tests **carried out / undertaken by** the researchers yesterday?

The **Future Simple** is used to describe:

1. A predicted future action, a happening of which is inevitable.

*Next year he **will be** 18.*

2. An action which the speaker regards as possible, probable or likely to happen in the future.

*I don't think I **will pass** my exams easily.*

3. An action decided on spontaneously, out of circumstances.

*It's hot in the office. I **will turn on** the air conditioning.*

Time words with the **Future Simple**: ***tomorrow, in a week (month, year), next year, in 2030*** etc.

	Positive	Negative	Questions
Future Simple Active	I / you / we/ they / he / she / it **will carry out** the test tomorrow.	I / you / we / they / he / she / it **will not (won't) carry out** the test tomorrow.	**Will** you / we / they / he / she / it **carry out** the test tomorrow?
Future Simple Passive	The test **will be carried out / undertaken by** the researchers tomorrow.	The test **will not (won't) be carried out / undertaken by** the researchers tomorrow.	**Will** the test **be carried out / undertaken by** the researchers tomorrow?

Exercise 1. Complete the sentences using Present Simple Active of the verbs in the box.

stretch, rise, break, rust, melt, conduct

1. If you drop a glass object, it ____.
2. If you pull a copper wire very hard, it ____.
3. If you heat steel bars to 1400°C, they ____.
4. If you put iron into water, it ____.
5. If electric wires made of copper are connected to the power supply, they ____.
6. If a heater warms the air in a room, the temperature ____.

Exercise 2. Complete the sentences with the affirmative or negative Present Simple or Future Simple form of the verb in brackets.

1. Fire ____ (need) oxygen to burn. It usually ____ (not / burn) without oxygen.
2. In a few years a nuclear power plant ____ (produce) enough electrical energy to meet the consumers' demands.
3. Stainless steels ____ (not / rust) but most ferrous metals ____ (corrode) when exposed to air or water.
4. As soon as we check electric wires and cables, we ____ (let) you know.
5. Next year the introduction of new gas turbine generators ____ (reduce) heat loss and ____ (increase) the efficiency of fossil fuel.
6. Alternating current regularly ____ (reverse) direction, while direct current ____ (not / change) direction.
7. – Can you wait for me? It ___ (not / be) very long.
8. I'm sure Misha ____ (get) the job. He ____ (have) a lot of experience.

Exercise 3. Give the Past Simple form and the Past Participle form of the verbs in the box.

Example*: protect – protected – protected (regular verb), choose – chose – chosen (irregular verb)*

a) produce	e) begin	i) invent	m) have
b) do	f) cut	j) melt	n) freeze
c) drive	g) flow	k) be	o) burn
d) get	h) measure	l) keep	p) fall

Exercise 4. Find the past forms of 20 irregular verbs in the puzzle. Read across, down and diagonally.

H	**W**	**D**	**W**	**R**	**O**	**T**	**E**	**E**
A	**F**	**E**	**I**	**X**	**T**	**H**	**S**	**D**
D	**O**	**O**	**N**	**D**	**T**	**O**	**L**	**D**
C	**U**	**T**	**R**	**T**	**R**	**U**	**O**	**X**
M	**N**	**Z**	**X**	**G**	**O**	**G**	**S**	**K**
E	**D**	**C**	**N**	**C**	**O**	**H**	**A**	**S**
A	**X**	**A**	**L**	**E**	**F**	**T**	**I**	**O**
N	**R**	**M**	**I**	**X**	**U**	**Z**	**D**	**L**
T	**Z**	**E**	**S**	**P**	**O**	**K**	**E**	**D**

Exercise 5. Complete the text with the Past Simple Active form of the verbs in the box.

study, publish, produce, build, use, provide, design, change

Isaac Newton is probably the most important scientist in history. His work on mathematics and physics ____ a basis for modern science, and his ideas ____ the world. Newton ____ his work in two books, Opticks and Principia. These contain his laws of motion and gravity. He ____ these laws to predict the movements of the stars and the planets around the Sun. He also ____ and ____the world's first reflecting telescope. Newton ____at Trinity College, Cambridge. From 1664 to 1696, he ____ most of his important work.

Exercise 6. Use the prompts below to make questions using Present Simple or Past Simple (Active).

Example*: – Tin melts at 230℃. And stainless steel?*

– *Does stainless steel melt at 230°C?*

– *No, it melts at 1400°C.*

1. – Pure iron corrodes easily. And aluminium? – ____? – No, aluminium has a protective layer of aluminium oxide.
2. – Non-ferrous metals have some similar properties. And ferrous metals? – ____? – Yes, they have similar properties too.
3. – The use of copper started in 5,000 BC. And iron? – ____? – No, iron production started in around 1,200 BC.
4. – Direct current flows in one direction. And alternating current? – ____? – No, it regularly reverses direction.
5. – Electricians use a screwdriver and pliers. And mechanics? – ____? – Yes, they do.
6. – Marie Curie made important scientific discoveries. And Michael Faraday? – ____?

– Yes, he discovered electromagnetic induction.

7. – Iron reacts with oxygen. And gold? – ____? – No, gold does not react with oxygen.

Exercise 7. Disagree with the following statements.

Example: *A static charge moves. – I don't agree. A static charge doesn't move.*

1. Michael Faraday designed and built the world's first reflecting telescope.
2. We will run out of fossil fuels soon.
3. In North America, electrical power lines operate at a frequency of 50 hertz.
4. Direct current changes the direction in which it flows very quickly.
5. Newton used the laws of motion and gravity to predict electromagnetic induction.
6. An asteroid will probably hit the Earth in the next hundred years.
7. Nuclear power plants use wind and biomass as fuel.
8. Newton studied at Oxford.

Exercise 8. Replace the active form of the verb in each sentence with the passive form.

1. People use the Internet all over the world.
2. In a few minutes my colleague will ask you some questions.
3. Students take tests at the end of every course.

4. Thomas Edison invented the electric bulb in 1879.
5. Step-up transformers raise the voltage.
6. In the next few weeks the technicians will install a new security system in all our offices.
7. Mr. Jones is ill, so he won't give us a physics test today.
8. The Royal Swedish Academy of Sciences awarded the Nobel prize in Physics in 2017 for the observation of gravitational waves.
9. Albert Einstein predicted the gravitational waves a hundred years ago.

Exercise 9. Read the text and define all the subject, verb and object structures. Then rewrite the text using Present Simple Passive verbs.

Power plants generate most of the world's electric power. Steam turbine generators use the most common fossil fuels. A power plant generates electricity when a loop of conducting wire rotates in a magnetic field. Burning coal or gas produces hot steam, causing a turbine to spin. The spinning motion drives the generating coils within a magnetic field to produce electricity. New gas turbine generators burn natural gas directly in the turbine system. This reduces heat loss and increases the efficiency of the fossil fuels.

Exercise 10. Answer the questions using passive form of the verbs below and *by*. If you need help, some of the answers are given below.

manufacture, protect, discover, convert, heat, form, provide

***Example**: Who was the inventor of the light bulb? The light bulb was invented by Thomas Edison.*

1. Which metal protects stainless steel from rust?
2. How many metals form bronze?
3. Which company was the manufacturer of the first PC?
4. What type of metals provide magnetic properties?
5. Who was the discoverer of the theory of relativity?
6. Which machine converts mechanical energy into electrical energy?

IBM, chromium, generator, Albert Einstein, two (copper and tin), ferrous

Exercise 11. Complete the text with the Past Simple Active or Passive form of the verbs in brackets.

In the year 1821a British scientist Michael Faraday ___ (explain) the conversion of electrical energy into mechanical energy by placing a current carrying conductor in a magnetic field which ___ (result) in the rotation of the conductor due to torque ___ (produce) by the mutual action of electric current and field. Based on his principal the most primitive of machines a DC machine ___ (design) by another British scientist William Sturgeon in the year 1832. But his model ___ (be) very expensive and ___ (not / use) for any practical purpose. Later in the year 1886 the first electric motor ___ (invent) by scientist Frank Julian Sprague. That ___ (be) capable of rotating at a constant speed under a varied range of load, and thus ___ (derive) motoring action.

Exercise 12. Translate he following sentences into English.

1. Электростанции вырабатывают электроэнергию путем сжигания топливных ископаемых, использования возобновляемых источников и поддерживая расщепление ядра.
2. – Трансформаторы понижают или повышают напряжение? – Существуют и понижающие и повышающие трансформаторы.
3. Современные светодиодные лампы обеспечивают низкую потребляемую мощность и большой срок службы.
4. Электрический ток создается потоком отрицательно заряженных электронов, не так ли?
5. Трансформаторы не генерируют энергию, они преобразуют силу тока или напряжения до нужных параметров.
6. В 1826 году немецкий физик Георг Ом открыл закон, выражающий связь между силой тока, напряжением и сопротивлением, известный как закон Ома.
7. – Какая единица измерения заряда? – Я думаю, что заряд измеряется в кулонах.
8. – Где используется статическое электричество? – Насколько я знаю, статическое электричество широко используется в ксерокопировании.
9. – Возрастет ли потребление топливных ископаемых через несколько десятилетий? – Я так не думаю. Вероятно, ископаемое

топливо будет заменено возобновляемыми источниками энергии в некоторых отраслях.

10. На подстанции напряжение понижается посредством трансформаторов до уровней, подходящих для распределения потребителям.

11. Земля имеет огромное магнитное поле, т. к. ядро нашей планеты заполнено расплавленным железом.

12. Одноименные заряды отталкиваются, не так ли?

SPEAKING

Exercise 1. Discuss the following questions with your partner.

1. – what type of current / desktop / makes / run / your / computer? – I think, it's … because …
2. – what type of current / work / smartphone / makes / your? – I'm sure, it's … because …
3. – electrons /used / or protons / are / in electric currents? – Actually, these are … because …
4. – repel / do / charged / positively / particles / negatively / particles / charged? – As I know, … because …
5. – a copper wire / conductor / or glass / is / of electricity / the best? – No doubt, it's … because …
6. – do you happen to know / used / energy / to make / sources / are / electricity / in Belarus / what? – I suppose, these are … because …
7. – do you have any idea / Thomas Edison and Nikola Tesla / what / famous for / are? – As far as I know, …
8. – have / ever / you / a shock / felt / when you touched / after walking / an object /across a carpet? – Yes, I really have. – Can you tell me why this happens? – You know …

Exercise 2. Work in small groups. Describe the process of power supply using the information from the text "Electricity". Group A is using Present Simple Active. Group B is using Present Simple Passive.

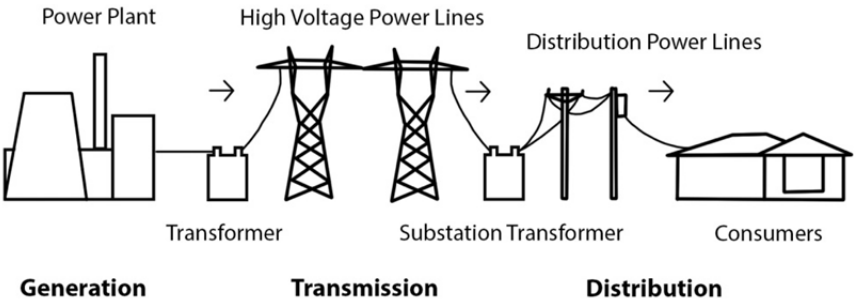

Fig. 1. Electric power system

UNIT 3
ELECTRIC CURRENT

SWITCH ON

Exercise 1. Read the joke below. What is the idea of the joke? What phenomenon is described there? Use the prompts below.

Useful language: ***dangers of electric current, to get electric shock, to be exposed to, to contact the source of electricity***

Last Request

A criminal, sitting in the electric chair, was about to be executed. "Do you have any last requests?" asked the chaplain. "Yes," replied the criminal. "Will you hold my hand?"

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Electric Current" and write them down into your personal vocabularies.

Exercise 2. Match the words having a similar meaning. Check any unknown words in a dictionary.

1.	To provide	a.	To repel
2.	Cell	b.	To store

3.	Supply	c.	To reverse
4.	To convert	d.	Element
5.	To push away	e.	Speed
6.	To accumulate	f.	To give
7.	Rate	g.	Provision
8.	To alternate	h.	To transform

Exercise 3. Agree or disagree with the following statements. Then read the text "Electric Current" and compare your answers with the information given in the text.

1. Electric current is the rate at which electrical energy is transferred.
2. There are two main types of electric current.
3. Alternating current flows continuously in one direction.
4. An Ohm is a unit measure of the amount of current flow.
5. All materials can conduct electric current.

ELECTRIC CURRENT

Electric current is a movement of **electric charges**, usually the flow of electrons along a conductor or the movement of ions through an electrolyte. This is caused by freely moving particles usually charged by a **mains supply** or battery. Current flows from a positive to a negative **terminal**, although electrons actually flow along a wire in the opposite direction. The unit measure of the amount of current flow is the ampere (amp).

Electric current can be either **direct** or **alternating**. Direct current (DC) is a constant flow of electricity which travels in one direction. An example of pure DC is the current produced by an **electrochemical cell**. Another source of DC is the **photovoltaic** or **solar cell.** In these devices photonic energy from sunlight **is absorbed** by electrons and **converted** into electrical energy.

The electricity supplied to homes and other buildings is alternating current (AC). In alternating current the flow of charge carriers **reverses** direction periodically. The rate at which the current alternates is called **the frequency** and is measured in hertz (Hz).

In order for electric current to flow, two conditions must be met. First, **a potential difference** must exist between two points. The term

potential difference means that the force created by a group of electrons in one place is greater than the force of electrons in some other place. The greater force **pushes** electrons **away** from the first place toward the second one.

Potential differences usually do not occur in nature. There are certain kinds of devices which can **accumulate** electrons, producing a potential difference. A battery, for example, is a device for producing large masses of electrons at one electrode (a point from which electric current is sent or received) and **a deficiency** of electrons at the other electrode. This difference **accounts for** the battery's ability to generate a potential difference, or **voltage.**

Second, for electric current to flow there must be **a path** along which electrons can travel. Some materials are able **to provide** such a path, and others are not (conductors and insulators respectively). The conductivity of materials is a natural **property** based on their **resistance** to the movement of electrons.

Exercise 4. Make up 5 definitions using the table below. Add the necessary words or prepositions.

Example*:** *Current* ***is a *movement* ***of*** *electric charges.*

Ampere	the rate at which	in one direction
Frequency	the property of materials	between two points
Direct current	the difference in electric charge	to conduct electric current
Potential difference	a flow of electricity	the amount of current flow
Conductivity	a unit measure	the current alternates

Exercise 5. Arrange the words in the following scrambled questions and answer them.

1. Flows / terminal / a positive / to / current / a negative / from / doesn't it?
2. The sources / of / are / direct / what / current?

3. Kind / supplied / current / of / what / to homes / is?
4. Current / reverse / direction / its / does / periodically / alternating?
5. What / the rate / at / which / is / called / current / alternates?
6. Electric / to flow / the conditions / what / are / for / current?
7. Does / mean / the term / difference / potential / what?
8. A battery / used / for / what / is?
9. The difference / conductors / is / what / between / and / insulators?

Exercise 6. Complete the sentences with the words in the box. You may have to change some words slightly.

provide, resistance, a path, convert, electric current, frequency, accumulate, alternating current, solar, property

1. When we speak of ____ ____, we mean the more controlled form of electricity from generators, batteries, ____ or fuel cells.
2. The number of complete ____ ____cycles per second is the____, which is measured in hertz.
3. An electric charge that ____on an object when it is rubbed against another object is called static electricity.
4. Conductivity is the ____to transmit electricity or heat.
5. They will be able to ____ heat into electricity, so anything that heats up will become an energy source.
6. Insulators cannot ____ ____for electric current to flow.
7. Materials that present high ____ and restrict the flow of electrons are called insulators.

Exercise 7. Read the groups of derivatives and translate them into Russian.

1) to alternate, alternating, alternator;
2) to convert, conversion, convertible;
3) charge, to recharge, chargeable;
4) to differ, difference, different;
5) to accumulate, accumulation, accumulator;
6) to resist, resistant, resistance;
7) frequency, frequent, infrequent;
8) electrical, electricity, to electrify.

Exercise 8. Complete the text with the words from exercise 7. You may have to change some words slightly.

An electric current is a movement of ____. Direct current is a flow of ____ in one direction. Current that flows back and forth is called ____ current. Electric current flows easily in the substances called conductors. Materials that ____ the flow of current are called insulators. A good insulator has a very high ____. When ____ energy is needed, batteries and fuel cells are one way to produce it. A fuel cell ____ energy produced by a chemical reaction directly into usable power. If a storage battery no longer produces energy, it can be ____.

Exercise 9. Study the words and word combinations in bold from the text "Electric Circuits" and write them down into your personal vocabularies.

Exercise 10. Match the words having a similar meaning. Check any unknown words in a dictionary.

1. Appliance	a. Fault
2. To confine	b. Damage
3. Malfunction	c. Machinery
4. 4njury	d. Device
5. To fail	e. To limit
6. Equipment	f. Way
7. Path	g. To go wrong

Exercise 11. Scan the text "Electric Circuits" and answer the questions.

1. What is an electric circuit?
2. What components does a complete electric circuit consist of?
3. What are the basic types of electric circuits?
4. In what way can an electric circuit be protected?

ELECTRIC CIRCUITS

The path followed by an electric current is known as an **electric circuit.** The simplest electric circuit contains only three parts, i.e. one **load,**

one **voltage source**, and conductors. Most complete electric circuits contain six parts: 1. an energy source to provide the voltage 2. conductors through which the current can travel, 3. insulators **to confine** the current to the desired paths, 4. a load to control the amount of current and convert the electric energy taken from the energy source 5. a control device, often **a switch**, to start and stop the flow of current and 6. a protection device to break the circuit in case of a circuit **malfunction.**

Basic types of circuits are **a series circuit** and **a parallel circuit.** The series circuit offers a single, continuous path for current flow from the negative side of the **electromotive force** source to the positive one. Different electrical devices like flashlights, doorbells are connected by wires that give only one path to follow.

In a parallel circuit, for example, two or more appliances are placed parallel to each other so that the current has more than one path through which it can flow. If one burns out, the current will flow through the other appliances in a circuit. **Household appliances** are connected by parallel circuits so that the whole circuit does not **fail** if one piece of electrical equipment **burns out**.

Electric circuits have to be protected. If there are too many electrical devices, the conducting wire may **overheat** and cause fire or serious **injuries.** To prevent this, **fuses**, through which all the current in the circuits passes, are built into the circuits. A fuse is an intentionally weakened element that opens the circuit automatically if it is **overloaded**. It has a wire with a low **melting point** and when the fuse heats up, the wire melts and the circuit is broken.

Exercise 12. Mark the sentences as true or false. Correct those which are not right.

1. The required components of a simple circuit include only wires, bulbs and switches.
2. Conductors confine the current to the desired circuits.
3. The series circuit offers more than one path through which the current can travel.
4. Most household appliances are connected by series circuits.
5. If any of the appliances in a parallel circuit fails, current still continues to flow through the other appliances in a circuit.

6. To prevent fire or other serious injuries, switches are built into the circuits.

Exercise 13. Make up the word combinations from columns A and B and find their equivalents in C.

A	B	C
1. Electromotive	point	бытовые приборы
2. Serious	circuit	устройство защиты
3. Melting	source	серьёзные травмы
4. Circuit	force	точка плавления
5. Voltage	malfunction	электродвижущая сила
6. Household	device	последовательная цепь
7. Protection	appliances	источник напряжения
8. Series	injuries	неисправность цепи

Exercise 14. Complete the sentences using information from the text "Electric Circuits".

1. A small wire or device inside a piece of electrical equipment that breaks and stops current if the flow of electricity is too strong is a ____.
2. A complete path through which electric current flows is a____.
3. A circuit in which all parts are connected in succession in order to provide a single path for current is known as _____.
4. Household appliances are connected by _____ circuits.
5. A manual or mechanically actuated device for making, breaking, or changing the connections in an electric circuit is a ____.
6. A substance through which electric charges can easily flow is called a ____.
7. A fuse has a wire with a very low ____.

GRAMMAR
PROGRESSIVE TENSE FORMS

The **Present Progressive** is used to describe:

1. An activity at or around the time of speaking.

*At present we **are using** this system software.*

2. A fixed future plan.

*Next week we **are buying** new equipment.*

Time words with the **Present Progressive**: ***now, right now, at the moment***, ***currently***, ***nowadays*** etc.

	Positive	Negative	Questions
Present Progressive Active	I **am** / he **is** / they **are investigating** the properties of superconductors.	I **am not** / he is **not** / they **are not investigating** the properties of superconductors.	**Is** he / **Are** they **investigating** the properties of superconductors?
Present Progressive Passive	This material **is** / these materials **are being investigated / sold**.	This material **is not** / these materials **are not being investigated / sold**.	**Is** this material / **Are** these materials **being investigated / sold?**

The **Past Progressive** is used to describe:

1. An activity at a definite time in the past (***at 4 pm yesterday, from 3 to 5 yesterday, the whole day yesterday***).

*He **was writing** a report at 5 pm yesterday.*

2. An activity which is a time frame for another activity.

***While** we **were carrying** out the experiment the other team was recording the results.*

	Positive	Negative	Questions
Past Progressive Active	He **was** / they **were investigating** the properties of superconductors.	He **was** not / they **were not investigating** the properties of superconductors.	**Was** he / **Were** they **investigating** the properties of superconductors?
Past Progressive Passive	This material **was** / these materials **were being investigated / sold**.	This material **was not** / these materials **were not being investigated / sold**.	**Was** this material / **Were** these materials **being investigated / sold?**

The **Future Progressive** is used to describe:

1. An activity at a definite time in the future (***at 4pm tomorrow, from 3 to 5 tomorrow, the whole day tomorrow)***. *We **will be discussing** multimedia development at 3 o'clock seminar tomorrow.*

	Positive	Negative	Questions
Future Progressive Active	He / they **will be investigating** the properties of superconductors.	He / they **will not (won't) be investigating** the properties of superconductors.	**Will** he / they **be investigating** the properties of superconductors?

Exercise 1. Say what your groupmates and you are (are not) doing now.

Example:

1. I / to test a new device. — *I **am not testing** a new device right now.*

2. The teacher / to explain a grammar rule. — *The teacher **is explaining** a grammar rule now.*

3. They / to repair an electrical device. — *They **are not repairing** an electrical device now.*

1. We / to have an English class now.
2. I / to study the properties of alloys at the moment.
3. My groupmates / to practice a grammar rule now.
4. They / to carry out the experiment right now.
5. He / to observe the indications of a voltmeter at the moment.
6. We / to sit in the classroom now.
7. The students / to listen to their groupmates at the moment.
8. My neighbor / to measure the value of the current now.
9. I / to perform calculations right now.

Exercise 2. Rewrite the sentences using the Past and Future Progressive (Active) and appropriate time words.

Example: *The students **are measuring** electrical units **now.***
*The students **were measuring** electrical units **at 3 p.m. yesterday.***
*The students **will be measuring** electrical units **at 5 p.m. tomorrow.***

1. The ammeter is indicating + 2 amperes now.
2. We are testing the electromagnetic properties of iron at the moment.

3. The researchers are discussing the results of their investigations now.
4. The battery is producing DC electricity at the moment.
5. I am studying the work of a switching device now.
6. My roommate is replacing a burnt bulb now.

Exercise 3. Think of the questions using the following sentences. Mind the word order.

1. They were still looking through the results of our experiments at 5 o'clock yesterday. (When, What)
2. The generator is converting mechanical energy into electrical energy right now. (General question, What)
3. The Professor will be delivering a lecture on electrical units this time next week. (General question, Who, When)
4. The electrician was repairing a circuit malfunction from 5 till 6 p.m. yesterday. (Who, What)
5. The experiment with electric current is being conducted in the lab at the moment. (General question, What kind, Where)
6. The conductive properties of copper were being tested by my groupmates the whole laboratory practical yesterday. (General question, What properties, When)

Exercise 4. Choose the right tense forms of the verbs (Active or Passive) in the following sentences.

1. The new properties of engineering materials ***are discussing / are being discussed*** now.
2. While electrical wiring ***was being tested / was testing*** the electrician found a circuit malfunction.
3. At the moment the lecturer ***is demonstrating / is being demonstrated*** interesting data obtained during his experiments.
4. The transformer ***is increasing / is being increased*** the voltage now.
5. We ***were taking / were being taken*** our exam in Physics at that time.
6. The assistant ***is being created / is creating*** a magnetic field right now.
7. Great changes ***are being taken / are taking*** place in the field of electronics nowadays.

8. The quantities we need for our work ***are discussing / are being discussed*** now.

9. The voltmeter ***was connecting / was being connected*** to the circuit when I entered the lab.

Exercise 5. Use one of the given verbs below to fill each gap. Put the verbs in the right tense form (Present, Past or Future Progressive Active).

to write, to make, to study, to connect, to use, to control, to observe, to become

1. The engineer ____the quality of engineering materials the whole day yesterday.
2. The students ____ the properties of conductors at the moment.
3. The professor ____ a report on the latest achievements in the field of electricity from 10 till 11 a.m. tomorrow.
4. Look! You ____ faulty electrical devices in your work.
5. I ____ my coursework when suddenly the light went off.
6. Nowadays hybrid cars ____ very popular.
7. I ____ the indications of electrical devices in the lab at 4 p.m. tomorrow.
8. Now the electrician ____ the appliances by parallel circuits.

Exercise 6. Rewrite the following sentences using the Passive Voice forms.

1. They are still considering the engineer's project**.**
2. Were they setting up the laboratory equipment the whole day yesterday?
3. They are increasingly using these materials in electronics.
4. The engineers were carrying out the tests while the assistants were recording the results.
5. Nowadays many car manufactures are producing electric cars.
6. The students are completing another series of experiments now.
7. Were maintenance technicians repairing the equipment from 9 to 11 a.m. yesterday?

Exercise 7. Correct mistakes in the following sentences. Mind the use of Progressive tense forms.

1. The students are completing the chemical reaction when the teacher came.
2. She was doing research on the properties of this group of alloys now.
3. The samples of this substance are using in the test now.
4. A few students was carrying out some experiments with electrical devices while the assistant were helping them.
5. What you will be doing at 10 a.m. tomorrow? I will probably working in the lab.
6. The engineer is checking the battery at 3 p.m. yesterday.
7. The students are being measuring electrical units now.
8. Were they set up the laboratory equipment all day yesterday?

Exercise 8. Complete the sentences with the correct Progressive tense forms (Active or Passive) of the verbs in brackets.

1. What you (to do) at 9 a.m. tomorrow? – I (to service) electricity meters on customer's property.
2. We (to speak) about the types of electric circuits at 10 o'clock seminar yesterday.
3. The potential difference between two points in a circuit (to measure) by the students now.
4. While we (to have) a fire drill, our colleagues (to learn) first aid.
5. These technologies (to use) in a wide range of micro devices nowadays.
6. At the moment a wind turbine (to generate) about 800 kW.
7. To meet the customer's requirements the manufactures (to make) a number of improvements in the current model of the electric motor.
8. While the generator (to run), mechanical energy (to convert) into electrical energy.
9. You (not to follow) the safety instructions properly. You may get electric shock.
10. They still (to discuss) the advantages of that technology at 8 p.m. yesterday.
11. Look! He (not to wear) a helmet. He may hurt his head.

12. We (to answer) the teacher's questions when the dean of the faculty came in.

Exercise 9. Translate the following sentences into English.

1. – Какие условия существуют для протекания электрического тока? – Во-первых, между двумя точками проводника должна существовать разность потенциалов. Во-вторых, необходим путь для движения электронов.
2. – Ты случайно не знаешь, что Павел чертит на доске? – Если я не ошибаюсь, он чертит простейшую электрическую цепь, которая состоит из источника, нагрузки и проводников.
3. – Разве ты не помнишь основные источники постоянного тока? Мы их обсуждали на прошлой лекции. Это электрохимические батареи, а также фотоэлектрические или солнечные элементы.
4. В последовательной электрической цепи ток имеет только один путь протекания, поэтому недостатком такого соединения является то, что, если хоть один элемент выйдет из строя, ток пропадет во всей цепи.
5. – Что ты делал вчера весь вечер? – Я готовился к экзамену по физике. Я повторял основные понятия и единицы измерения электричества, а также виды электрического тока и электрических цепей.
6. – Вы все еще будете изучать техническую документацию, когда мы вернемся? – Да, конечно, мы также будем составлять инструкции по технике безопасности.
7. – Почему бытовые приборы в квартире необходимо соединять параллельно? – Насколько я знаю, это более эффективно, поскольку, если один из приборов перегорит, все остальные продолжат свою работу.
8. – Где Иван? – Он устанавливает предохранитель в электрическую цепь. Это важное устройство, которое служит для защиты цепи от повреждений и возгорания.
9. Оборудование работало так шумно, что я не мог услышать, что говорил главный инженер.
10. Вчера в 8 часов вечера они все еще обсуждали недостатки и преимущества нового проекта.

11. В данный момент преподаватель объясняет студентам, чем переменный ток отличается от постоянного.

12. В то время как Анна делала презентацию на конференции, ей задавали много вопросов.

SPEAKING

Exercise 1. Work in pairs. Imagine that you are taking your exam in Physics. Your examination card says:

- Electric current, its definition and types.
- A potential difference.
- The components of electric circuits.
- The difference between a series circuit and a parallel circuit.
- The protection of electric circuits.

Your partner is your examiner. Try to answer his questions.

You may start like this: – Well, what is electric current?

– As far as I know, it is …

Exercise 2. Work in pairs. Create a quiz on the topic "Electric Circuits" and check your partner's knowledge.

Exercise 3. Split into 3 groups and get ready to speak on one of the issues given below.

1. Electric current and its types.
2. The conditions for electric current to flow.
3. Electric circuits and their type.

UNIT 4
CONDUCTORS AND INSULATORS

SWITCH ON

Exercise 1. Are the materials listed below good conductors of electricity or electric insulators? Use your general knowledge and complete the table.

Silk, oil, iron, plastic, wood, silver, copper, glass, paper, nickel, rubber, porcelain, gold, air, mercury, wool, aluminum, saltwater

Common conductors	Common insulators

Exercise 2. Match the words with their definitions.

1) a conductor	a) a substance that resists electricity
2) an insulator	b) a substance that is neither a good conductor of electricity nor a good insulator
3) a semiconductor	c) a material which has no resistance to electricity
4) a superconductor	d) a substance that allows electricity or heat to pass through it

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Conductors and Insulators" and write them down into your personal vocabularies.

Exercise 2. Match the words having a similar meaning. Check any unknown words in a dictionary.

1. To increase	a. Sealed
2. leakage	b. Transfer
3. To inhibit	c. To rise
4. Transmission	d. Destruction

5.	Influence	e.	Escape
6.	Waterproof	f.	To prevent
7.	Breakdown	g.	Impact

Exercise 3. Scan the text and mark the issues discussed there.

1. Basic notions of electricity.
2. Conduction and insulation.
3. Electric insulators.
4. The types of electric current.
5. The properties of a good dielectric.
6. Gases as conductors of electricity.
7. The components of electric circuits.

CONDUCTORS AND INSULATORS

In the case of electricity, **conduction** is a transfer of electricity through a substance, **resulting from** an electromotive force or potential difference. In solids, electric current consists of a flow of electrons, so, metals, which have a high free-electron **density**, are good conductors of electricity. Metals allow electrical charges to move easily. While nonmetals, such as rubber or glass, have few free electrons and are poor conductors. These materials may be used as electrical insulators, or dielectrics.

The rate of the electric current is proportional to the potential difference and to the electrical **conductivity** of the substance, which in turn depends on the nature of the substance, its **cross-sectional area**, and its temperature. A material that is a good conductor gives very little **resistance** to the flow of charge. Increasing the cross-sectional area, or **thickness** of a given conductor will increase the current because more electrons will be available for conduction. Increasing the temperature will **inhibit** conduction in a metal because the increased thermal motions of the electrons will tend to **interfere** with their regular flow in an electric current. In a nonmetal, however, an increase in temperature improves conduction because it frees more electrons.

In liquids and gases, current consists not only in the flow of electrons but also in that of ions. Highly ionized water **solutions** of **acids**, **alkalis** and salts are good conductors. Gases at high temperatures tend to become ionized and thus become good conductors, although at ordinary temperatures they tend to be poor conductors.

Insulation is the use of materials or devices to inhibit or **prevent** the conduction of electricity. Dry air is a good insulator, so that conductors used for electric-power transmission require insulating material only at their points of contact with the supporting steel structures to prevent **escape**, or **leakage**, of the current.

Since **wet** materials can become conductors, insulation must often be **waterproof**. Ordinary household wires are commonly insulated by a thin rubber or plastic **coating**. Plastic insulation around electric wires stops people from touching the conductor and – if it is **live** (carrying current) – from getting a dangerous electric shock.

Depending upon the application, the insulating material must be resistant to various types of corrosion resulting from **exposure** to saltwater, oils, or other **influences**. A good dielectric should also have other properties: it must resist **breakdown** under high voltages; it should not itself draw power from the circuit; it must have reasonable physical stability; and none of its characteristics should **vary** much over a wide temperature range.

Exercise 4. Complete the following sentences using information from the text "Conductors and Insulators".

1. Conduction results from ____.
2. Electrical conductivity of the substance depends on ____.
3. A material which gives very little resistance to the flow of charge is ____.
4. Nonmetals are ____.
5. Gases at high temperatures tend to become ____.
6. Dry air is ____.
7. Plastic insulation around electric wires stops people from getting ____.
8. A good dielectric must resist ____.

Exercise 5. Think of the questions to the following answers using information from the text "Conductors and Insulators".

1. It is a transfer of electricity through a substance. (What?)
2. They are poor conductors because they have few free electrons. (Why?)

3. It is a material which gives very little resistance to the flow of charge. (What?)

4. Yes, they are. Water solutions of acids, alkalis and salts are good conductors. (Are?)

5. It is the use of materials to prevent the conduction of electricity. (What?)

6. It must be waterproof because wet materials can become conductors. (Why?)

7. They are commonly insulated by a thin rubber or plastic coating. (What?)

Exercise 6. Complete the sentences with the necessary prepositions below.

with, from, to (3), through, at, in, of, on (upon)

1. A magnetic field results ____ the flow of current ____ the wires or electrical devices and increases ____ strength as the current increases.
2. There are several factors which interfere ____ the resistance of a conductor.
3. This loss is proportional ____ the length ____ the wire.
4. Resistance also depends ____ temperature, usually increasing as the temperature increases.
5. Insulators have very high resistance ____ the movement of electric current.
6. Some people are concerned that daily exposure ____ electric and magnetic fields may cause health problems.
7. A real gas behaves closely to ideal behavior ____ high temperatures and low pressures.

Exercise 7. Unjumble the letters to make the words in bold from the text.

1. Styined
2. Eealkga
3. Pxeoeurs
4. Utniosol
5. Lialka
6. Tgincoa
7. Idca
8. Ertwaroopf

Exercise 8. Match the words that go together in the text "Conductors and Insulators" and translate the word combinations into your language.

1. Cross-sectional	a. Electrons
2. Free	b. Material
3. Liquid	c. Area
4. Insulating	d. Conductor
5. Poor	e. Solution
6. Electric	f. Coating
7. Plastic	g. Density
8. High	h. Range
9. Temperature	i. Wires

Exercise 9. Choose the correct word below.

1. A household wire has a (***coating / a cross-sectional area***) that prevents people from getting an electric shock.
2. Check for voltage (***thickness / leakage***) from every possible source.
3. The electrician warned us about the (***dead / live***) electric cables.
4. The containers are cleaned with a weak (***decision / solution***) of soda.
5. Small holes can sometimes be filled with quick-drying (***windproof / waterproof***) glue.
6. The danger of electric shock (***decreases / increases***) in wet atmosphere.
7. Dielectrics are substances that (***allow / inhibit***) electric current to flow through them.
8. The insulating material must be resistant to various types of corrosion (***resulting in / resulting from***) exposure to saltwater, oils, or other (***influences / insulators***).

Exercise 10. Study the words and word combinations in bold from the text "Semiconductors and Superconductors" and write them down into your personal vocabularies.

Exercise 11. Match the words having a similar meaning. Check any unknown words in a dictionary.

1. Movement	a. To reach
2. Perpetual	b. Including

3.	To approach	c.	To increase
4.	To identify	d.	Motion
5.	Impurity	e.	To display
6.	To enhance	f.	Timeless
7.	Incorporation	g.	To establish
8.	To exhibit	h.	Admixture

Exercise 12. Scan the text "Semiconductors and Superconductors" and answer the questions.

1. What is a semiconductor?
2. What are the types of semiconductors?
3. What are dopants and doping?
4. What is superconductivity?
5. What is absolute zero?

SEMICONDUCTORS AND SUPERCONDUCTORS

A **semiconductor** is a solid material whose electrical conductivity at room temperature is between that of a conductor and that of an insulator. At high temperatures its conductivity **approaches** that of a metal, and at low temperatures it acts as an insulator. In a semiconductor there is a limited movement of electrons, depending upon the crystal structure of the material used. The substances first used for semiconductors were the elements like germanium, **silicon**, and gray tin.

It was found that the **incorporation** of certain **impurities** in them **enhances** their conductive properties. The impurities either add free electrons or create **holes** (electron deficiencies) in the crystal structures of the **host** substances by attracting electrons. Thus, there are two types of semiconductors: the N-type (negative), in which the current carriers (electrons) are negative, and the P-type (positive), in which the positively charged holes move and carry the current.

The process of adding these impurities is called **doping**; the impurities themselves are called **dopants**. Certain chemical **compounds**, including gallium arsenide, indium antimonide, and aluminum phosphide are semiconductors. Semiconductors are used to produce such electronic devices as **diodes**, transistors, and computer memory devices.

Superconductivity is abnormally high electrical conductivity of certain substances when they are cooled below a certain temperature. This temperature, called the critical transition temperature, varies for different materials but generally is near absolute zero. Absolute zero is the temperature at which a thermodynamic system has the lowest energy. It corresponds to 0 K on the Kelvin scale and – 273.15 degrees Celsius on the Celsius scale. Classic superconductivity is **displayed** by some metals, including zinc, magnesium, lead, aluminum, mercury, and cadmium. The **phenomenon** of superconductivity was discovered in 1911. Since then a lot of high-temperature superconductors that **exhibit** lossless electrical flow at temperatures up to nearly 140°K have been **identified**.

An interesting aspect of this phenomenon is the continued flow of current in a superconducting circuit after the source of current is **switched off**. This flow of current looks like the closest thing to **perpetual motion** in nature. Scientists refer to superconductivity as a "macroscopic quantum phenomenon".

Exercise 13. Mark the sentences as true or false. Correct those which are not right.

1. At high temperatures any semiconductor acts as an insulator.
2. The elements like silicon and germanium were first used for superconductors.
3. The incorporation of impurities can affect the conductive properties of materials.
4. Two types of semiconductors are the N-type and the P-type.
5. When we add impurities to a semiconductor we call them dopings.
6. The phenomenon of superconductivity was discovered at the end of the 19th century.
7. Substances become superconductors when their temperature is near absolute zero.
8. There are low-level and high-level superconductors.
9. If a source of current in a superconducting circuit is switched off, the current ceases to flow.

Exercise 14. Link the words in the columns to make true sentences about semiconductors and superconductors.

1. In N-type semiconductors	exhibit	diodes and transistors.
2. Semiconductors	incorporating impurities	are negative.
3. Superconductors	is displayed	is called doping.
4. The process of	the current carriers	high electrical conductivity.
5. At low temperatures	are used to produce	are semiconductors.
6. Classic superconductivity	as aluminum phosphide and gallium arsenide	acts as an insulator.
7. Such chemical compounds	a semiconductor	by zinc, lead and mercury.

Exercise 15. Complete the sentences with the words in the box. You may have to change some words slightly.

exhibit, diode, compound, dopant, switch off, doping, hole, impurity, enhance, silicon

1. Pure water is a ____ containing two elements – hydrogen and oxygen.
2. The conductive properties of a material can be altered by incorporation of ____ in the crystal structure.
3. When we add impurities to a semiconductor we call them ____ and the process itself is called ____.
4. The addition of a substance in order to ____ one property may have unintended effects on other properties.
5. Superconductors ____ the unique ability to conduct current.
6. Switches will simultaneously ____ all unearthed conductors within a circuit.
7. Most ____ used in electronics are made of semiconductor materials such as ____, germanium or selenium.

8. ____ and electrons are the two types of charge carriers responsible for current in semiconductor materials.

Exercise 16. Find seventeen words related to electricity in the puzzle. Read across, down, and diagonally.

C	**Z**	**E**	**D**	**I**	**O**	**D**	**E**	**U**	**L**	**C**	**T**
U	**V**	**L**	**U**	**U**	**W**	**A**	**T**	**T**	**I**	**O**	**R**
R	**O**	**E**	**G**	**H**	**X**	**I**	**I**	**R**	**G**	**N**	**A**
R	**L**	**C**	**O**	**I**	**L**	**U**	**T**	**R**	**H**	**D**	**N**
E	**T**	**T**	**Z**	**I**	**C**	**C**	**A**	**Z**	**T**	**U**	**S**
N	**A**	**R**	**T**	**R**	**E**	**V**	**M**	**B**	**N**	**C**	**F**
T	**G**	**I**	**I**	**L**	**I**	**J**	**P**	**U**	**I**	**T**	**O**
W	**E**	**C**	**E**	**T**	**O**	**X**	**E**	**L**	**N**	**O**	**R**
S	**B**	**I**	**Y**	**J**	**H**	**X**	**R**	**B**	**G**	**R**	**M**
Z	**D**	**T**	**K**	**A**	**M**	**P**	**E**	**R**	**A**	**G**	**E**
M	**K**	**Y**	**I**	**N**	**S**	**U**	**L**	**A**	**T**	**O**	**R**

GRAMMAR
PERFECT TENSE FORMS

We use the **Present Perfect** to talk about past events with a connection to the present (focus on the result but not on the time)
*I **have** already **fixed** the printer fault (now I can print my report).*

Time words with the **Present Perfect**: ***just, already, yet, never, ever, this week, lately, recently, since, for.***

	Positive	Negative	Questions
Present Perfect Active	They **have** just / he **has** just **measured / risen** the temperature of the substance.	They **haven't** / he **hasn't measured / risen** the temperature of the substance yet.	**Have** they / **Has** he **measured / risen** the temperature of the substance?
Present Perfect Passive	The property **has /** the properties **have been investigated** / **found out** recently.	The property **hasn't** / the properties **haven't been investigated / found out** yet.	**Has** the property / **Have** the properties **been investigated / found out**?

We use the **Past Perfect** to describe an activity that happened earlier than another activity in the past or an action completed by a certain time in the past. *By the time we arrived they **had** already **installed** software.*

Time words with the **Past Perfect**: ***by, by the time, after, before, as soon as*** and many of the time words used with the Present Perfect.

	Positive	Negative	Questions
Past Perfect Active	They **had investigated / found out** the new properties **by** the end of the test.	They **hadn't investigated / found out** the new properties **by** the end of the test.	**Had** they **investigated / found out** the new properties **by** the end of the test?
Past Perfect Passive	The new properties **had been investigated / found out** by the end of the test.	The new properties **hadn't been investigated / found out** by the end of the test.	**Had** the properties **been investigated / found out** by the end of the test?

We use the **Future Perfect** to describe an action that will be completed by a certain time in the future. *They **will have reinstalled** the application by 5 pm tomorrow.*

Time words with the **Future Perfect**: ***by next year, by tomorrow, by the time, by 2040, after, before etc.***

	Positive	Negative	Questions
Future Perfect Active	They **will have investigated / found out** the new properties by next month.	They **will not (won't) have investigated / found out** the new properties.	**Will** they **have investigated / found out** the new properties by next month?
Future Perfect Passive	The properties **will have been investigated / found out** by next month.	The properties **will not (won't) have been investigated / found out**.	**Will** the properties **have been investigated / found out** by next month?

Exercise 1. Give Participle II of the following verbs.

to learn	to break	to write	to burn
to apply	to be	to set	to become
to carry	to find	to conduct	to make
to give	to see	to build	to do

Exercise 2. Choose the right form of the verb.

1. The properties of superconductors ***have / has*** been investigated by several groups of researchers lately.
2. ***Have / has*** you already carried out the calculations?
3. He ***have / has worked*** at this problem for 2 years.
4. New types of sensors ***has / have*** been developed recently.
5. The students ***have / has*** already considered the chemical properties of metals.
6. The desirable properties of transistors ***have / has*** been improved recently.
7. I ***hasn't / haven't*** understood the law of electromagnetic induction yet.
8. We ***has / have*** never seen such an advanced production line.
9. ***Have / has*** she obtained all the necessary data?
10. The course project ***has / have*** been written by final year students for several months.

Exercise 3. Choose the correct form of the verb.

a. Present, Past or Future Perfect Active

1. After the teacher ***has drawn / had drawn / will have drawn*** a series circuit, he started his explanation.
2. The students already ***had measured / will have been measured / have measured*** the potential difference between two points in a circuit.
3. The engineers ***have been carried out / will have carried out / had carried*** out all the necessary calculations before the experiment begins.
4. The scientists ***will have experimented / had experimented / have been experimented*** with superconductors by that time.
5. Misha ***has prepared / will have prepared / had prepared*** the report by next week.

6. The electrician ***haven't installed / hasn't installed / won't have installed*** a fuse into the circuit yet.

7. Researchers ***have tried / have been tried / will have tried*** to discover the principles of electricity since 1600s.

b. **Present, Past or Future Perfect Passive.**

1. All the household appliances ***will have connected / had been connected / have been connected*** by parallel circuits by 6 p.m. yesterday.

2. Fuses ***has been used / will have been used / have been used*** as essential safety devices from the early days of electrical engineering.

3. After electricity ***has generated / had been generated / will have been generated*** it was sent into a system of cables and wires called transmission grid.

4. The circuit malfunction ***has been fixed / will have been fixed / had been fixed*** by 3 p.m. tomorrow.

5. The source of current just ***had been switched off / has been switched off / will have been switched off*** to prevent a short circuit.

6. Superconductive properties ***have identified / will have been identified / has been identified*** by the time we complete the research.

7. After the results ***have been obtained / will have obtained / had been obtained*** they checked the circuit again.

Exercise 4. Arrange the words in the following sentences in the correct order.

1. In the system / the engineers / have / yet / increased / the pressure?
2. The transformer / has / the voltage / or / increased / decreased?
3. Been / connected / the contacts / of the circuit / have?
4. They / engineering / known / about /materials / these / have / for a long time.
5. You / ever / of superconductors / studied / have / the properties?
6. Electromagnets / have / powerful / been / recently / developed.
7. Since / he / been / morning / has / in the laboratory.
8. By / time / everything / had / arranged / been / that.
9. The students / have / studied / semiconductors / will / next / by / term / the types of.
10. They / just / have/ of this / the conductive / material / enhanced / properties.

Exercise 5. Transform the sentences using the verbs either in the Active or Passive Voice.

1. The electrical engineer has already solved all the technical problems.
2. A series of experiments with electric circuits had been performed by the students by the end of the term.
3. He has recharged these batteries since 2 o'clock.
4. When you come I will have prepared sodium hydroxide solution.
5. A new type of an electric drive has been developed by our engineers recently.
6. To prevent overheating they have installed a fuse into the circuit.
7. They have changed the diameter of the wire to obtain better results.

Exercise 6. Correct the mistakes in the following sentences. Mind the use of Perfect tense forms.

1. These engineering materials have already find a wide application in industry.
2. Ivan have just unplugged the microwave oven to work on electrical wiring.
3. The students will have studied the theory of semiconductors by the end of last week.
4. The resistance of the circuit have been change in order to control the current flow.
5. You have insulated the wire properly?
6. After he will have determined the number of amperes and volts he could find the resistance of the coil.
7. Since that time it have been become the usual thing to speak of the current as flowing from positive to negative.

Exercise 7. Complete the sentences with the correct tense forms (Active or Passive) of the verbs in brackets.

1. We already (to speak) about the difference between AC and DC at the seminar.
2. The students (to study) the electricity basics by the end of next year.
3. The students of our group (not to pass) all the exams yet.
4. You ever (to get) a shock from static electricity?

5. The engineer (to prepare) the necessary measuring devices before the experiment started?

6. The ability of semiconductors to change their state (to make) them the cornerstone of electronics.

7. All the articles on engineering materials (to translate) by next Tuesday.

8. The substance (to cool) until it approached absolute zero.

9. Why you (not to put on) rubber gloves? You must follow safety rules to avoid the injury.

10. The scientist (to prove) the practical importance of his invention recently.

11. He (to change) the level of conductivity of this material by the end of the experiment.

12. The flow of current just (to increase).

13. After the report (to complete) it was given to the supervisor.

Exercise 8. Work in pairs. Ask your partner what these people

a) have done recently (lately / already etc.)

b) had done by certain time in the past (by 7 p.m. yesterday / by that time etc.)

c) will have done by certain time in the future (by 5 p.m. tomorrow / by the end of next month etc.)

1. The Professor (to tell the students about electric generators / to deliver a lecture on superconductors / to publish the results of the experiment).

2. The engineers (to test new engineering materials / to introduce new methods of work / to investigate the properties of the substance under test).

3. The students (to study the conductivity of liquids and gases / to take part in the scientific and technical conference / to perform a series of experiments with semiconductors).

4. The scientist (to complete his research / to improve the previous results / to succeed in creating a new superconductor).

5. You (to complete the coursework / to pass all the exams / to develop new specialist skills).

6. The electrician (to check the transformer operation / to fix a faulty wiring / to insulate bare wires).

Exercise 9. Translate the following sentences into English.

1. Мы только что протестировали, что дистиллированная вода не проводит электричество. Но, например, высоко ионизированные водные растворы солей являются хорошими проводниками.
2. – От чего зависит скорость электрического тока? – Насколько я знаю, она пропорциональна разности потенциалов и электропроводности вещества.
3. – Вы уже изучали свойства полупроводников? – Да, полупроводник – это вещество, электропроводность которого имеет промежуточное значение между электропроводностью проводников и диэлектриков.
4. Металлы, в отличие от неметаллов, имеют высокую плотность свободных электронов, поэтому хорошо проводят электричество.
5. Электрик только что заизолировал эти провода, чтобы исключить получение удара электрическим током от проводов под напряжением.
6. – Вы когда-нибудь ремонтировали электронные устройства? – Нет, это требует специальных навыков и оборудования.
7. С помощью сверхпроводников недавно были созданы чрезвычайно мощные электромагниты, т. к. чем сильнее ток, тем сильнее магнитное поле.
8. К концу месяца я уже закончу свою курсовую работу по теме «Проводники и изоляторы».
9. Электропроводность этого полупроводника значительно улучшилась, после того как к нему добавили определенные примеси.
10. – Ты уже прочитал эту статью? О чем она? – В ней сообщается о процессе легирования полупроводников с целью изменения их свойств.
11. Явление высокотемпературной сверхпроводимости было открыто сравнительно недавно. С момента открытия первого высокотемпературного сверхпроводника в 1986 году, количество таких соединений значительно возросло.
12. На протяжении многих лет сверхпроводники применяются в медицине в магнитно-резонансной томографии и научно-исследовательском оборудовании.
13. Профессор рассказал студентам об интересных свойствах сверхпроводимости до того, как начался эксперимент.

14. Открытие сверхпроводников с температурой перехода в сверхпроводящее состояние при комнатной температуре будет настоящим прорывом в передаче электричества без потерь.

SPEAKING

Exercise 1. Interview your partner about different materials and their conductivity. Put the words in questions in the correct order.

Dialogue 1

– Do / to know / what / you / happen / is / conduction?
– As far as I know, it is a …
– I see. I wonder / metals / are / or / nonmetals / conductors / electricity / of / if / good?
– Of course, … are good conductors because …
– Well, what / gases / and / about? Do / conduct / they / electricity?
– If I'm not mistaken, their conductivity depends on …

Dialogue 2

– What / between / is / the difference / and / conductors / insulators?
– You know, insulators, unlike conductors …
– Ok, and you / what /insulating / know / do /materials?
– Actually, these are …
– Can you tell me what / should / these / possess / properties / materials?
– Depending upon the application, insulators should …

Dialogue 3

– What / semiconductors / for / are / used?
– They are used to …
– Do / types / you / semiconductors / know / any /of?
– If I remember right, there are …
– By the way, can / the conductive /of semiconductors / properties / be enhanced?
– It was found that …

Dialogue 4

– You / ever / have / heard / superconductivity /about?
– Yes, of course, superconductivity is …

– This / was / phenomenon / when / discovered?
– As far as I remember it …
– Materials / what / display / property / this?
– Well, classic superconductivity is displayed by …

Exercise 2. Run any Internet search engine and prepare a talk on one of the following issues.

1. Aluminium and copper as the most common conductors used in industry.
2. The ways of enhancing electrical conductivity.
3. The discovery of superconductivity.
4. Technological applications of superconductivity.

UNIT 5
MAGNETIC MATERIALS

SWITCH ON

Exercise 1. Test your knowledge of magnets and magnetism with a simple magnet quiz.

1. What is a magnet?
a) a household appliance;
b) an object that can pull certain types of metal toward itself;
c) a charged particle.
2. Which material will not be attracted to a magnet?
a) iron;
b) nickel;
c) copper.
3. Which is not associated with magnets?
a) north pole;
b) east pole;
c) south pole.
4. The Earth is a huge ___ because the core of our planet is filled with molten iron.
a) magnet;

b) electromagnet;
c) particle.

5. Which is true?

a) the north pole of one magnet will attract the north pole of another magnet;
b) the south pole of one magnet will stick to the south pole of another magnet;
c) the north pole of one magnet will attract the south pole of another magnet.

6. All the magnets on the Large Hadron Collider (LHC) are

a) particles;
b) electromagnets;
c) semiconductors.

7. Which of the following is not an application of electromagnet?

a) motors and generators;
b) electric bells;
c) fridge magnets.

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Magnetic Materials" and write them down into your personal vocabularies.

Exercise 2. Match the words and word combinations having an opposite meaning.

1. To disappear	a. To turn on
2. Rare	b. Temporary
3. To attract	c. To lose
4. Permanent	d. To appear
5. Soft	e. Artificial
6. To turn off	f. To demagnetize
7. To retain	g. Common
8. Natural	h. Hard
9. To magnetize	i. To repel

Exercise 3. Scan the text "Magnetic Materials" and answer the questions.

1. What is the difference between gravity and magnetism?
2. Which is the strongest permanent magnet on Earth?
3. What do electromagnets consist of?
4. What devices employ electromagnets?
5. What is the advantage of using superconducting magnets?

Exercise 4. Read the text "Magnetic Materials" again and decide whether the sentences are true or false.

1. A magnet is a material that exerts a force on other materials without contacting them.
2. Lodestone is a rare earth permanent magnet.
3. Neodymium magnets are the most powerful permanent magnets on Earth.
4. Samarium Cobolt magnets are able to operate at high temperatures.
5. Magnets strongly attract objects that contain gold, aluminium, silver.
6. Electromagnet is known as a common natural magnet.
7. Electromagnets can be turned on and turned off.
8. Permanent magnets are stronger than electromagnets.
9. Superconducting magnets find application in health care.

MAGNETIC MATERIALS

A magnet is a material that can exert a force on other materials over a distance. This force is known as magnetism and may either attract or repel. It is a basic force of nature, like electricity and gravity. However, magnetic forces are not related to gravity. The amount of gravity is based on an object's mass, while magnetic strength is based on the material that the object is made of.

There are many different types of magnetic materials. People have known for a long time that a certain type of rock, called **lodestone**, is a natural magnet. There are also **rare earth permanent** magnets like **neodymium** (Nd) and **samarium** (Sm) which are used to produce magnetic materials. These metals are rarely found in economically exploitable concentration. Neodymium magnets are the strongest on Earth and the

most expensive. These magnets are used in renewable energy devices from electric cars to wind turbines.

Samarium Cobalt magnets are made from an alloy of samarium and cobalt. These magnets are famous for their ability to operate at high temperatures up to 300 degrees Celsius. These magnets are, however, extremely brittle and crack very easily.

A permanent magnet is a device made from a **magnetized** material that creates a **persistent** magnetic field around an object. A good magnet produces high magnetic field and is stable against the influences which might demagnetize the material. Another important quality of the permanent magnet is that it can be magnetized and **retain** the **magnetization** for a long period of time even after the removal of the external field. Permanent magnet strength depends upon the material used in its creation. Magnets strongly attract objects that contain iron, nickel, cobalt and their alloys.

Other magnets are known as electromagnets. These are devices in which magnetism is produced by an electric current. Electromagnets are different because they have a ferromagnetic material (usually iron or steel) located inside the **coil** of wire. When electric current is passed through the coil, a soft iron **core enhances** the magnetic field produced by the coil. When the current is **turned off**, the magnetic force of an electromagnet **disappears**. This property makes an electromagnet more useful than a permanent magnet in many applications.

Electromagnets are used to lift large masses of magnetic materials, such as **scrap iron**. They are essential to the design of the electric motor and generator. They are also employed in doorbells, circuit breakers, loudspeakers, atomic **particle accelerators**, and electromagnetic brakes and **clutches**. Electromagnetic **propulsion** systems can provide motive power for spacecraft.

Electromagnets are also essential to magnetic **levitation** systems that are found in **maglev trains**. Such systems often use a special kind of electromagnet whose coil is made of a superconducting metal. Because the coils of a superconducting electromagnet offer no resistance to the flow of electricity, no energy is **wasted** by the development of heat, and the magnetic field produced by the magnet can be very strong. Superconducting magnets are also used in **magnetic-resonance imaging** (MRI) and for energy **storage**. The first practical electromagnet was invented early in the 19th century.

Exercise 5. Match the two halves of the sentences.

1. Permanent magnets can retain magnetic properties	a) only when electric current passes through them.
2. Electromagnets display magnetic properties	b) by the amount of electric current applied to it.
3. Permanent magnet strength	c) for a long time.
4. The strength of an electromagnet can be adjusted	d) every time an electric current is removed.
5. If a permanent magnet loses its magnetic properties	e) depends on the material used in its creation.
6. An electromagnet loses its magnetic power	f) they can be recovered by remagnetizing.

Exercise 6. Find words and word combinations in the text "Magnetic Materials" which mean the same as the following.

1. A technique that uses magnetism, radio waves and a computer to create a picture of areas inside the body.
2. Recyclable material left from old vehicles.
3. Metals that are rarely found in their concentrated form.
4. A machine that pushes particles to nearly the speed of light.
5. A naturally magnetic iron ore.
6. A device composed of a copper wire wound up in a spiral form.
7. The force that makes things fall to the ground.

Exercise 7. Complete the sentences with the words in the box.

attract, levitation, propulsion, permanent, enhance, repel, turn off, persistent

1. Don't forget to ____ the lights when you leave.
2. The decision to use electricity instead of horses for ____ was made in 1892.
3. – Can we ____ the conductivity of semiconductors? – Actually, certain impurities make semiconductors better transmit electricity.
4. One promising application of electromagnetic technology relates to Maglev, or magnetic ____, trains.

5. Two North poles will ____ each other.
6. Any problem can be solved if you are ____ and patient.
7. The North pole will ____ a South pole.
8. She is looking for a ____ job.

Exercise 8. Study the words and word combinations in bold from the text "Electromagnetism" and write them down into your personal vocabularies.

Exercise 9. Match the words having a similar meaning.

1. Circular	a. Speed
2. To create	b. Value
3. To deduce	c. Interaction
4. Movement	d. To establish
5. Rate	e. Round
6. To wrap	f. To cause
7. To induce	g. Motion
8. Relationship	h. To wind
9. Magnitude	i. To conclude

Exercise 10. Scan the text and complete the following sentences.

1. Electromagnetism establishes the relationship between ____.
2. Electromagnetic induction was discovered by ____.
3. The factors that influence the electromagnetic induction are ____.
4. To produce a much stronger magnetic field we need to use ____.

Exercise 11. Read the text again. Discuss it with your partners using the questions below.

1. Is / electromagnetism / when / produced?
2. Law / is / of electromagnetism / basic / what / the most?
3. Did / Faraday / what / perform / experiment?
4. The law / show / what / of electromagnetic / does / induction?
5. Electromagnets / why / instead of / are / permanent / used / magnets?
6. Does / an electromagnet / what / consist of?

7. How / turned off /electromagnet / can / be?
8. Electrical / functions / electromagnetic / equipment / on the principle of / what / induction?

ELECTROMAGNETISM

Magnetism and electricity are always connected. A magnetic field is **created** by a moving electric current and a magnetic field can **induce movement** of charges (electric current). Magnetism, along with electricity, belongs to a larger phenomenon, electromagnetism, or electromagnetic force generated by the passage of an electric current through **matter**. When electric current passes through a conductor, a **circular** electromagnetic field is created around it.

A very important **law** linking electricity with magnetism is Faraday's law of **electromagnetic induction**. Electromagnetic induction can be generated in two ways, namely when the electric conductor is kept in a moving magnetic field and when the electric conductor is constantly moving within a static magnetic field. The phenomenon of electromagnetic induction was first discovered by Michael Faraday in 1831 when he moved a permanent magnet through an electric coil. He noticed a change in voltage of the circuit.

According to Faraday's law, a voltage is induced in a circuit whenever **relative motion** exists between a conductor and a magnetic field and that the **magnitude** of this voltage is proportional to the **rate** of change of the **flux**. The law shows how a magnetic field **interacts** with an electric circuit. Electromagnetism helped in **establishing** the **relationship** between electricity and magnetism.

Michael Faraday later **deduced** the factors that could influence the electromagnetic induction as the number of coils, the strength of the magnet, the changing magnetic fields and the speed of relative motion between a coil and a magnet.

While permanent magnets produce a good and sometimes very strong static magnetic field, in some applications the strength of this magnetic field is still too **weak** or we need to be able to control the amount of magnetic flux that is present. So, in order to produce a much stronger and more controllable magnetic field we need to use electricity.

By using coils of wire **wrapped** or **wound** around a soft magnetic material such as an iron core we can produce very strong electromagnets

for use in many different types of electrical applications. The electromagnetism created can be turned on and off by cutting off the electric current flowing in the conductor.

Electromagnetism has been **extended** to quantum physics. It has helped in findings related to the nature of light and in the discovery of the electromagnetic spectrum. Electromagnetism is also used in devices such as solenoids, electric motors and generators, transformers, induction cookers, in musical instruments like electric guitar, electric violin, etc.

Exercise 12. Choose the correct word below.

1. The phenomenon of electromagnetic induction was first (***invented / discovered***) by Michael Faraday.
2. Electromagnetism is a branch of physical science that describes the (***relationship / application***) between electric current and magnetic field.
3. It is possible for electricity to give rise to (***gravity / magnetism***), and symmetrically for magnetism to give rise to (***speed / electricity***).
4. Magnetic (***flux / circuit***) is a measure of quantity of magnetism.
5. A strong field can be produced if an insulated wire is (***moved / wrapped***) around a soft iron core and current is passed through the wire.
6. If the strength of the magnetic field is too (***weak / strong***) we need to use electricity.
7. Our task is to determine the (***magnetism /magnitude***) of an angle.
8. Johannes Kepler studied the (***motion / induction***) of Mars trying to (***make / deduce***) from his observations how the planet moves.
9. The current in the primary winding is (***measured / induced***) by the rotating magnet.

Exercise 13. Match the words on the left with words on the right to make word combinations.

circular electromagnetic, particle, scrap, ferromagnetic, magnetic levitation, magnetic-resonance, rare earth, electromagnetic, relative, quantum, soft iron, induction	induction, core, physics, accelerator, iron, imaging, field, magnet, cooker, motion, material, system

Exercise 14. Find eighteen words related to magnetic materials and electromagnetism in the puzzle. Read across, down, and diagonally.

F	E	R	R	O	M	A	G	N	E	T	I	C
L	O	D	E	S	T	O	N	E	Z	I	T	X
E	L	E	C	T	R	O	M	A	G	N	E	T
V	K	A	O	M	W	W	J	Y	E	D	Z	R
I	X	Y	I	C	O	R	E	N	U	U	S	A
T	Z	F	L	U	X	T	A	T	B	C	O	R
A	N	E	O	D	Y	M	I	U	M	T	L	E
T	J	G	Q	C	R	N	X	O	V	I	E	E
I	R	O	N	E	G	H	U	L	N	O	N	A
O	X	Q	P	A	N	O	R	T	H	N	O	R
N	S	A	M	A	R	I	U	M	P	P	I	T
A	C	C	E	L	E	R	A	T	O	R	D	H

GRAMMAR
REVISION OF TENSES

Exercise 1. Match the Tenses with their forms and time words.

Tense	Active Voice	Passive Voice	Time words
Present Progressive	drive / drives	is / are being trans-lated	usually, always, often, sometimes, rarely, seldom
Past Progressive	made, provided	is / are built	from 3 to / till 4 yesterday, the whole day yesterday, at 3 yesterday, while
Future Progressive	have / has lived	had been informed	now, at the moment, nowadays, today
Present Simple	am / is / are reading	was / were being fixed	tomorrow, next month, in a few days
Past Simple	will have come	will be performed	at this time tomorrow, from 3 to / till 5 tomorrow, the whole day tomorrow
Future Simple	had written	was / were checked	just, already, yet, never, ever, recently, lately, since, for

Present Perfect	was / were testing	will have been measured	by 2 yesterday, by the time we arrived, before, after + Past Simple
Past Perfect	will leave	–	since, for, all my life, how long
Future Perfect	have / has been trans-lating	–	by 2 tomorrow, by 2040, by the time we arrive, after, before + Present Simple
Present Perfect Continuous	will be doing	have / has been developed	yesterday, two days ago, last month, the day before yesterday, in 2001

Exercise 2. Complete the sentences using Present Simple or Present Progressive (Active Voice).

1. Today we (to participate) in the experimental physics conference.
2. Superconducting magnets (to operate) at a very low temperature of 1.9K (– 271.3°C).
3. Right now, Pavel (to dissolve) ordinary table salt in water to prove that a saltwater solution (to be) a good conductor.
4. The electricians (to have) a fire drill at the moment.
5. The Large Hadron Collider usually (to run) from May to mid-December, using the power to accelerate protons to nearly the speed of light.
6. – Where electricity (to come) from? – It (to come) from a power plant situated 35 km from the laboratory.
7. – Can I speak to Professor Tomson? – I'm afraid not, he (to take part) in the workshop on high-energy physics.
8. Power consumption (to fall) to about 80 megawatts during the winter months.

Exercise 3. Complete the sentences using Present Simple or Present Progressive (Passive Voice).

1. Electromotive force (to measure) in volts and generally (to call) voltage.
2. New research results (to present) by a young scientist now.
3. The components and subsystems often (to design), (to build) and (to test) separately before they (to join) together to work in harmony.

4. At the moment the students (to select) for working in experimental teams.

5. Currently, a new experiment at the particle accelerator (to run) by collaborations of scientists from all over Europe.

6. Usually students (to require) to prepare a short report on their work at the laboratory.

7. Scrap iron commonly (to lift) by electromagnets.

8. Smart meters show in real time how much electricity and gas (to use) by householders.

Exercise 4. Choose the right option of Past Simple or Past Progressive (Active or Passive).

1. The electric motor ***introduced / was being introduced / was introduced*** in elevator construction in 1880 by the German inventor Werner von Siemens.

2. The ancient Greeks ***were observed / observed / was observing*** that amber, when rubbed, ***attract / were attracting / attracted*** small, light objects.

3. At the laboratory practical the students ***were connected / were being connected / were connecting*** a light bulb to an electric battery by two copper wires.

4. While I ***solved / was solving / was being solved*** an equation my groupmates ***measured / were being measured / were measuring*** the potential difference.

5. The magnetic properties of solenoids ***was demonstrated / were demonstrated / was demonstrating*** by Andre Marie Ampere.

6. When the students ***were watching / was watched / was being watched*** a video about Maglev trains they ***became / were become / were becoming*** surprised at magnetic levitation technology.

7. The first practical radio signaling system ***produced / was produced / was being produced*** by Italian engineer Marconi in 1895.

8. The most important technological innovations ***were discussing / were discussed / were being discussed*** during the whole seminar yesterday.

Exercise 5. Complete the sentences using Present Perfect or Past Simple (Active or Passive).

1. They just (to take) the meter readings.
2. Most elevators of the 19th century (to power) by steam engines or some form of hydraulic drive.
3. English scientist Michael Faraday (to introduce) the concept of lines of force, a concept that (to prove) extremely useful in the study of electricity.
4. Since the introduction of electric motive power for elevators various improvements (to make) in motors and methods of control.
5. The main focus of research at CERN (European Council for Nuclear Research) (to move) in recent years towards the Large Hadron Collider.
6. The first successful escalator (to construct) by the Otis Elevator Company in 1890.
7. Vibration measurements just (to carry out) near the laboratory facilities in preparation for civil engineering work.
8. – You already (to attend) the lecture of Professor Jonson? – Not yet. As I know, he (to investigate) valuable properties of superconductors recently.

Exercise 6. Complete the sentences using Past Perfect or Past Simple (Active or Passive).

1. After we (to dissolve) sodium chloride in pure water it (to become) a conductor.
2. In 1791 Italian biologist Luigi Galvani (to publish) the results of experiments that he (to perform) on the muscles of dead frogs.
3. After the connection (to make) properly the bulb (to start) to glow.
4. In 1800 Italian scientist, Alessandro Volta, (to announce) that he (to create) the voltaic pile, a form of electric battery.
5. After a small amount of impurities (to add) to silicon it (to begin) to conduct electric current.
6. While maglev transportation first (to propose) more than a century ago, the first commercial maglev train (to make) by 2002 in Shanghai, China.

7. After electromagnets (to cool) to extremely low temperatures they (to demonstrate) an unusual behavior.

Exercise 7. Complete the sentences using Simple, Progressive, Perfect (Active or Passive) tense forms of the verbs in brackets.

1. Currently, the researchers (to work) on a way to use superconducting wires without losing energy needed to cool the wires.
2. A famous scientist (to invite) to present his idea of electromagnetic propulsion system at a Joint Propulsion conference last month.
3. When the switch is closed, current (to flow) and the bulb (to light).
4. For decades, rocket engines (to be) the only means of space travel.
5. Now aerospace engineers (to devise) innovative ways to take us to stars, including light propulsion, nuclear fusion propulsion and antimatter propulsion.
6. There are two basic ways in which the parts of a circuit (to arrange).
7. The invention of electric battery (make) the study of electric current much easier.
8. As a rule, when electric current (to flow) through the filament, the filament (to heat) up and the bulb (to light).
9. After James Maxwell (to sum up) almost all the laws of electricity and magnetism he (to produce) four mathematical equations which describe the interrelation of magnetic and electric fields.
10. This research institution continually (to work) on better superconducting magnets and very rapid, high-power solid-state switches.
11. A compass always (to point) north because the metal needle (to attract) to the pull of the North pole.
12. Various polymeric material samples (to test) on the International Space Station for a year to determine their resistance to the space environment.
13. An important experiment at the particle accelerator (to carry out) by a research team from 3 to 6 p.m. yesterday.
14. Since its launch in 1990, Hubble Space Telescope (to take) over a million of observations that (to change) our fundamental understanding of the cosmos.

Exercise 8. Translate the following sentences into English.

1. – От чего зависит сила магнитного поля, производимого электромагнитом? – Она зависит от количества катушек с проволокой, от величины тока и от материала сердечника.
2. Сверхпроводящие магниты используются в магнитно-резонансной томографии для медицинской диагностики.
3. Из своего эксперимента Майкл Фарадей сделал вывод, что любое изменение магнитного потока в катушке с проволокой вызывает напряжение во всей катушке.
4. Только что были продемонстрированы свойства магнитов притягиваться и отталкиваться.
5. В настоящее время Япония и Китай разрабатывают технологию поезда на магнитном подвесе. Прототипы таких поездов уже тестируются, чтобы проверить их безопасность и эффективность.
6. – Каким образом поезд на магнитной подушке достигает скорости свыше 500 км/ч? – Поезд удерживается над поверхностью полотна с помощью силы сверхпроводящих электромагнитов, которые также не оказывают сопротивления электрическому току во время движения поезда.
7. Английские ученые Майкл Фарадей и Джеймс Максвелл сделали огромные открытия в области электромагнетизма.
8. – Какие редкоземельные металлы используются для изготовления постоянных магнитов? – К ним относятся неодим и самарий, которые применяются для производства очень мощных постоянных магнитных сплавов.
9. После того, как источник питания был выключен, электромагнит перестал создавать магнитное поле.
10. В данный момент оператор крана перемещает металлолом весом около тонны с помощью подъемного электромагнита.
11. – Какие предметы притягивают магниты? – Насколько я знаю, магниты притягивают только предметы, которые содержат железо, никель, кобальт и их сплавы.
12. – Увеличивалась ли область катушки электромагнита с начала эксперимента? – Да, после того как мы добавили больше витков, сила магнитного поля возросла до нужных значений.

SPEAKING

Exercise 1. Discuss the following questions with your partner.

1. – A magnet / what / is? – As I know, …
2. – Neodymium and samarium / are / why / rare / called / earth / magnets? – I suppose, …
3. – The ends / are / called / what / of a magnet? – No doubt, …
4. – The north pole / does / of one magnet / the north pole / attract / of another magnet? – If I remember right, …
5. – Like / repel / do / poles / or / each other / attract? – Actually, …
6. – Aluminium / a magnetic / is / material? – It seems to me, …
7. – Which / attracted / to a magnet / are / metals? – I think, …
8. – The area / is / a magnet / surrounding / called / what? – As far as I know, …
9. – an electromagnet / what / is? – In fact, …
10. – The metal center / is / of an electromagnet / what / called? – I think, …
11. – An iron core / increase / why / the magnetic field / does / of a coil of wire? – As I know, …
12. – Do / electromagnets / why / work? – I suppose, …
13. – advantages / an electromagnet / what / over / magnet / have / does / a permanent? – It seems to me, …
14. – How / you / the electromagnet / make / do / stronger? – You know, …
15. – What / and magnetic field strength / between / the relationship / electric current / is / in an electromagnet? – If I remember right, …
16. – Where / electromagnets / are / used? – As I know, …

UNIT 6
ELECTRICAL MACHINES

SWITCH ON

Exercise 1. Cross out an odd word.

1. Generator, transformer, motor, conductor.
2. Force, power, automation, voltage.
3. Stator, motor, conversion, rotor.
4. To cause, to force, to rotate, to induce.
5. Mechanical, different, electrical, kinetic.
6. Machine, device, rate, appliance.
7. Application, principle, use, employment.

Exercise 2. Match the words in the box to their definitions.

electrical machine, generator, motor, stator, rotor, transformer

1. A piece of electrical equipment which changes the voltage level of alternating current.
2. An electrical device that changes energy from one form into another.
3. A machine that converts mechanical energy into electrical one.
4. A moving component of a motor or a generator.
5. A machine that converts electrical energy into mechanical.
6. A stationary part of a motor or a generator.

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Electrical Machines" and write them down into your personal vocabularies.

Exercise 2. Match the words and word combinations having an opposite meaning.

1. To increase	a. External
2. Tiny	b. To decrease
3. Moving	c. Slow
4. To induce	d. Stationary

5.	Rapid	e.	Huge
6.	Efficiency	f.	To prevent
7.	Internal	g.	Inefficiency

Exercise 3. Read the text "Electrical Machines" and decide whether the sentences are true or false.

1. The demand for electrical machines is growing rapidly in many sectors of industry nowadays.
2. All electrical machines have two basic parts called stator and rotor.
3. A steam turbine is used as a prime mover for a generator.
4. Electromechanical conversion process is irreversible.
5. An electric motor converts mechanical energy into electrical energy.
6. Electric motors are rather inefficient.
7. A transformer is a static machine.
8. A transformer is a DC device.
9. Transformers convert electrical energy into mechanical energy.

ELECTRICAL MACHINES

Electrical machines are devices which **convert** mechanical energy into electrical energy or vice versa. They can be found practically everywhere in the modern world. **Applications** range from **tiny** motors for computer hard drives to **large-scale** industrial motors and machines for power generation. The application of electrical machines continues to grow at a **rapid** rate in such sectors as hybrid and all-electric **vehicles**, aerospace, **renewables** and **advanced** industrial automation.

An electrical machine which converts mechanical form of energy into electrical form is called **a generator**. Generators work on the principle that whenever a conductor moves in a magnetic field, an e.m.f. **is induced** in the conductor. Generators have two basic parts named **stator** and **rotor.** Mechanical energy is provided to the rotor of a generator by means of a **prime mover** like a steam turbine, water turbine or wind turbine. Mechanical energy can also be provided by **internal combustion engines** or similar sources.

Most of the generated electrical energy is used to drive various industrial machines in which it is converted back to mechanical form. Thus, it is possible to obtain a mechanical form of energy from an electrical form as the electromechanical conversion process is **reversible**. An electrical

machine which converts electrical energy into mechanical energy is called **a motor**. When a current carrying conductor is placed in a magnetic field, the conductor **experiences** a mechanical force and this is the principle behind motoring action.

Just like generators, motors also consist of two basic parts, stator and rotor. In a motor, we give **electric supply** to both the stator and rotor **windings** which **causes** a mechanical force between the stator and rotor. This force causes the rotor **to rotate**. The generated mechanical energy is used to drive a mechanical **load**. There are certain losses in such a conversion but similar to generators, practically all motors have **efficiency** above 90%. Electric motors and generators are called rotating electrical machines because mechanical energy usually appears in the form of a rotational movement.

Different from rotating machines power transformers are electrical machines which have no moving parts. Transformers do not actually make conversion between mechanical and electrical form, but they transfer electric power from one AC level to another. A transformer is certainly an AC device. They can **decrease** or **increase** the voltage while transferring the power without changing the frequency, but with the corresponding increase or decrease in the current. A transformer has two separate **coils,** wound on a magnetic **core**. One of the windings **is excited** by AC voltage of certain level, then due to the induction principle, the voltage gets induced in the second coil which is at different level.

Exercise 4. Read the text again and say

1. Where electrical machines are used.
2. What principle the work of generators is based on.
3. What a motor is.
4. What basic parts generators and motors consist of.
5. Why generators and motors are called rotating electrical machines.
6. What a transformer is used for.
7. How a transformer works.

Exercise 5. Complete the sentences with the words in the box. You may have to change some words slightly.

applications, reversible, core, vehicles, to be excited, coil, renewables, advanced, to increase, efficiency

1. The rotor winding ____ by the DC supply.
2. ____ automation technologies will create demands for entirely new careers in autonomous systems and artificial intelligence.
3. The reason we use a magnetic ____ in a transformer is to provide the magnetic field for the ____ to decrease or ____ the voltage.
4. Electromechanical energy conversion is a ____ process i.e. the energy can be transferred back and forth between the electrical and the mechanical systems.
5. The ____ of a motor depends on its design, materials, load and operating conditions.
6. Electric ____ are becoming an increasingly popular alternative to gasoline-powered cars nowadays.
7. Today, ____ are the world's fastest growing, most affordable source of electricity.
8. Electric machines have been developed for a very wide range of ____.

Exercise 6. Read the groups of derivatives and translate them into Russian.

1) to excite, excited, exciting, excitement;
2) to reverse, reversible, reversion;
3) efficiency, efficient, efficiently;
4) to renew, renewed, renewable, renewal;
5) to advance, advanced, advancement;
6) to rotate, rotational, rotation, rotating;
7) to move, movement, moving, mover.

Exercise 7. Complete the sentences replacing the words in italics with appropriate word from exercise 6. You have to change some words slightly.

1. The engines were stopped and ***changed to opposite direction***.
2. This is the most ***high-level*** type of engine available.
3. He developed a ***well-organized*** system for ***transportation*** of raw materials to the factory.
4. Cells are being constantly ***replaced***.
5. ***Turn*** the handle by 180º to open the door.

6. In solar panels the energy from the sun ***stimulates*** electrons in a semiconducting material, creating the current flow.

7. Why not have a look at the real solutions such as ***inexhaustible*** power sources and better energy ***regulation***?

8. This new method is a great ***improvement*** over past techniques.

Exercise 8. Study the words and word combinations in bold from the text "Types and General Construction of Rotating Machines" and write them down into your personal vocabularies.

Exercise 9. Skim the text and name these things.

1. A machine associated with DC supply.
2. A machine associated with AC supply.
3. The DC machine using DC supply to produce mechanical energy.
4. AC machines which use AC supply and run at a constant speed.
5. AC machines using an AC supply but running at a subsynchronous speed.
6. An arrangement of conductors where e.m.f. is induced.
7. The current in the field winding.

Exercise 10. Read the text again and answer the questions below.

1. The electrical machines are classified according to the type of power supply, aren't they?
2. What types of the AC machines are there?
3. What parts does a rotating machine consist of?
4. Where are armature and field windings placed in most machines?
5. What are stators and rotors made of?
6. Why is the construction used for stators and rotors laminated?
7. What are the radial or axial ventilating air ducts used for?

TYPES AND GENERAL CONSTRUCTION OF ROTATING MACHINES

Basically, the electrical machines are classified according to the type of power supply. A machine associated with DC supply is called a DC machine. The DC machine can be a generator producing DC e.m.f. or a DC motor using DC supply to produce mechanical energy.

A machine associated with AC power supply is called an AC machine. The AC machines are further classified as **synchronous machines** and **asynchronous machines**. The synchronous machines are further divided as synchronous generators which produce AC e.m.f. while the AC machines using AC supply and run at a constant **speed** are called synchronous motors.

AC machines using an AC supply but running at a subsynchronous speed which is slightly less than the synchronous speed, are called **induction machines**. Depending upon whether machines use single phase or three phase AC supply, they are further classified as single phase AC machines and three phase AC machines.

Every rotating machine must possess the following parts:

- a **stationary** part called **stator**
- a **rotating** part called **rotor**
- a shaft
- a **slip ring**, **brush assembly**
- **bearings**

In addition to these a machine has a **field winding** and an **armature winding**. **The former** is used as a primary source of flux when current is passed through it and **the latter** is an arrangement of conductors where e.m.f. is induced. The current in the field winding is always a DC current. There is an appropriate **air gap** between a stator and a rotor of the machine. In most machines armature winding is placed on the stator while the field winding is placed on the rotor.

Both stator and rotor are made of high grade magnetic material such as **silicon steel**. It provides low **reluctance** path to the **flux**. The construction used for stators and rotors is **laminated** so as to keep **eddy current** losses as low as possible. In practice, it is required to **feed** into or take out power from the rotor. This is achieved by using a slip ring and brush assembly. The slip rings are connected to the rotor winding and rotate along with the rotor. Thus, slip rings behave as rotating winding **terminals** while brushes behave as **stationary** terminals of rotating winding. The power can be fed into or taken out from the brushes.

The **radial** or **axial** ventilating **air ducts** are also provided in the machines for cooling purposes. For large machines instead of air, hydrogen is used as a ventilating medium.

Exercise 11. Choose the correct word in the sentences below.

1. DC ***(motors / generators)*** produce mechanical energy.
2. Synchronous motors use ***(DC supply / AC supply)***.
3. Induction machines run at ***(synchronous / subsynchronous)*** speed.
4. The current in the field winding is always a ***(direct / alternating)*** current.
5. In electrical machines the armature winding is usually placed on ***(the stator / the rotor)***.
6. Brushes behave as ***(stationary / rotating)*** terminals of rotating windings.
7. E.m.f. is induced in a ***(field / armature)*** winding.
8. Ventilating air ducts are used for ***(cooling / heating)*** purposes.

Exercise 12. Unjumble the letters to make the words in bold from the text.

1. Barneig	2. Aatumrer
3. Airdal	4. Indwnig
5. Tcundiino	6. Elurtacnce
7. Rbsuh	8. Elmmnaiat
9. Lxfu	10. Epsed

Exercise 13. Match the words that go together in the text "Types and General Construction of Rotating Machines" and translate the word combinations into your language.

1. Silicon	a. Winding
2. Induction	b. Ring
3. Air	c. Machine
4. Low	d. Assembly
5. Single	e. Medium
6. Field	f. Losses
7. Ventilating	g. Steel
8. Slip	h. Gap
9. Brush	i. Phase
10. Current	j. Reluctance

GRAMMAR
MODAL VERBS

Exercise 1. Complete each sentence with the modal verb *can* or *can't*.

1. Electrical machines ____ convert mechanical energy into electrical energy and vice versa.
2. A transformer ____ increase or decrease the voltage without changing the frequency.
3. You ____ use this device, it's out of order.
4. One ____ find electrical machines practically everywhere in the modern world.
5. Engineers ____ use rubber for electrical conductors.
6. – I ____ solve this problem. – ____ you help me?
7. Many elements ____ form compounds with carbon.
8. Some materials ____ change shape significantly, but ____ return to their original shape.
9. A computer ____ store a great amount of information.
10. He ____ say anything about the classification of electrical machines.

Exercise 2. Use could / couldn't, was / were able to, will / won't be able to, to describe past or future ability or lack of it.

Example: *The operator can control the robot remotely now.*
The operator could / was able to control the robot remotely a few days ago.
The operator will be able to control the robot remotely in a week.

1. Now he can continue his studies.
2. I can explain the difference between DC and AC easily.
3. We can't use this old technology in production.
4. The engineers can extract copper in a few ways.
5. Can you change gas volume without changing its temperature?
6. Only our company can produce this type of machines.

Exercise 3. Choose the right option in the sentences below to express permission and possibility.

1. He ***will be allowed / was allowed*** to continue his research in a month.
2. He ***might have taken / may*** take his exam a week ago.
3. The teacher said we ***may / might*** use the dictionary during the exam.
4. The students ***were allowed / will be allowed*** to use new lab facilities during the previous experiment.
5. I hope next time we ***may / will be allowed*** to work with the new installed equipment.
6. The engineers were sure they ***might have made / will be allowed to make*** any changes to the system.
7. I thought I ***was allowed / will be allowed*** to drive my father's car.
8. Maybe this time we ***will be allowed to / might*** watch the process of doping.

Exercise 4. Say what people *must* or *mustn't* do in different situations.

1. You ____ smoke in a petrol station.
2. One ____ overload the circuit.
3. Engineers ____ prevent the conducting wires from overheating.
4. Students ____ be late for the classes. They ____ come on time.
5. The engineers ____ break the safety rules, they ____ follow all the instructions.
6. You ____ work with faulty electrical devices.
7. You ____ contact the source of electricity.
8. Students ____ include the objective of the laboratory experiment in the report.
9. You ____ switch on the current without teacher's permission.

Exercise 5. Use *have (has) to / (don't / doesn't) have to* instead of *must (mustn't)* to express obligation.

1. You mustn't do all the exercises on page 23.
2. He must use waterproof insulation.
3. Must he describe the whole procedure in detail?
4. You must work hard to pass your exam in English.

5. She mustn't use the computer to solve the problem.
6. Must the students study all the properties of conductors for the seminar?
7. Engineers must cope with the changing demands of industries.
8. They mustn't use these materials as electric conductors.

Exercise 6. Rephrase the sentences below. Express your advice or recommendation using the modal verb *should (shouldn't).*

Example: *It's better for you to learn this rule by heart.*
You should learn this rule by heart.

1. It's important for you to think about all the information given.
2. I advise you to identify all the necessary steps to solve the equation.
3. I recommend you to be as accurate as you can.
4. It isn't a good thing for you to ignore the safety rules.
5. It is the best thing to present the results of your research at the conference.
6. I advise you not to make the same mistake again.
7. I don't think it's a good idea to discuss the problem right now.
8. I think it is the best thing to check your computer for viruses straightaway.

Exercise 7. Choose the right option in the sentences below.

1. Electric current ____ be produced by battery cells.
2. He tried hard but ____ complete the work without teacher's help.
3. You ____ throw things in the science lab. It's dangerous.
4. Electromagnets ____ only produce magnetism when electric current passes through them.
5. Transformers don't ____ be made with just two sets of windings.
6. You ____ look at another student's work. You must work independently.
7. He ____ take a taxi to be in time for the appointment.
8. A robot ____ obey the orders given by human beings.
9. I ____ wait any longer. My English class starts in 10 minutes.
10. The fire spread quickly but everyone ____ escape.
11. You ____ keep the electric drill till Friday. I don't need it.

1.	a)	can	b)	is allowed to	c) had to
2.	a)	must	b)	wasn't able to	c) has to
3.	a)	should	b)	can	c) mustn't
4.	a)	have to	b)	were allowed to	c) can
5.	a)	have to	b)	be able to	c) must
6.	a)	must	b)	mustn't	c) have to
7.	a)	mustn't	b)	had to	c) have to
8.	a)	shouldn't	b)	is not allowed	c) mustn't
9.	a)	can't	b)	have to	c) may
10.	a)	may not	b)	can	c) was able to
11.	a)	must	b)	was able to	c) may

Exercise 8. Correct the mistakes in the sentences below.

1. We were to allowed use cell phones during the classes.
2. May I to switch on the electric drive?
3. He don't have to explain the rule once again.
4. Do forces can exist without motion?
5. I will able to repair this faulty device in an hour.
6. He really wants be able to use a computer properly.
7. They had answer all the questions correctly to pass the exam.
8. Transistors can to vary in size tremendously.
9. Did he can rely on the readings of this meter?
10. You should to think over this offer one more time before rejecting it.

Exercise 10. Make a list of things

a) you can (can't do) well;
b) you should do if you want to be an expert in your field;
c) you mustn't do at the science lab;
d) you are allowed to do / may do at the coworking center.

Exercise 11. Translate the following sentences into English.

1. Электрические машины – это электромеханические устройства, которые способны преобразовывать электрическую энергию в механическую и наоборот.

2. Студенты должны знать принцип работы и основные части электрических машин.

3. Какие машины можно отнести к электрическим? – Насколько я знаю, это все виды электродвигателей, электрогенераторов и трансформаторов.

4. Механическая энергия в генераторах и большей части двигателей имеет форму вращательного движения, поэтому их называют вращающимися электрическими машинами.

5. Трансформаторы могут уменьшать или увеличивать напряжение при передаче энергии без изменения частоты, но с соответствующим увеличением или уменьшением тока.

6. Тебе следует подготовить доклад об индукционных машинах к семинару. В прошлый раз ты не смог ответить ни на один вопрос.

7. Любой электрический генератор должен иметь 2 основные части: вращающуюся, называемую ротором, и неподвижную, называемую статором.

8. И статор, и ротор изготавливаются из высококачественного магнитного материала, такого как кремниевая сталь.

9. Я должен был завершить курсовую работу по машинам переменного тока вчера, но не смог этого сделать. Теперь мне придётся работать весь день, чтобы сдать ее завтра.

10. Павел возможно сдаст свои экзамены, если будет повторять каждый день.

11. Мне разрешили работать с электрическим оборудованием высокого напряжения после инструктажа по технике безопасности.

12. – Двигатель внутреннего сгорания может предоставить механическую энергию для генератора? – Безусловно, кроме того, паровая и ветряная турбины могут использоваться как первичные двигатели.

13. Вам следует выключить эту машину перед обслуживанием.

14. Конструкция статора и ротора должна быть спроектирована таким образом, чтобы снизить потери от вихревых токов.

SPEAKING

Exercise 1. Interview your partner about electrical machines. Put the words in questions in the correct order.

Dialogue 1.

– Where / machines / can / applied / electrical / be?

– You know, they…

– I see. And / machines / what / can / referred to / be / as / electrical / machines?

– So, all types of … are called electrical machines.

– Well, what / is / between / the difference / generators / and / motors?

– If I'm not mistaken, generators …, while motors …

Dialogue 2.

– What / does / parts / every / machine / rotating / consist of?

– If I remember right it must possess …

– Well, and what / are / materials / stators / rotors / usually / made of / and?

– Both stators and rotors are made of … because …

– By the way, what / are / rings / and / brushes / slip / for / used?

– In practice, it is required to … So, …

Dialogue 3.

– What / do / know / of / machines / rotating / you / types?

– So, according to … there are …

– And as far as I know the AC machines are further classified as …, aren't they?

– Yes, you are quite right. And can / tell / me / you / what / induction / called / machines / are / machines?

– They are AC machines which …

UNIT 7
TRANSFORMERS

SWITCH ON

Exercise 1. Transformers work on the principle of Faraday's law of electromagnetic induction. What does this law show? Choose the right option.

According to Faraday's law the induced voltage is proportional to
1. The rate of change of the magnetic field strength.
2. The rate of change of the magnetic force.
3. The rate of change of the magnetic flux.
4. The rate of change of the loop area.

Exercise 2. Test your knowledge of transformers with a simple quiz.

1. A transformer is a device which
a) can step up and step down the level of voltage;
b) works without changing the power;
c) works through electromagnetic induction;
d) all above.
2. A transformer
a) steps up and down DC voltages;
b) changes AC to DC;
d) changes DC to AC;
c) steps up or down AC voltages.
3. Why is a transformer core made of iron?
a) iron is very dense;
b) iron is easily magnetized;
c) iron is cheap;
d) iron rusts
4. Which of the following best describes a transformer that increases the voltage on the primary from 120V to 1200 V on the secondary?
a) a step-out transformer;
b) a step-down transformer;
c) a step-up transformer;
d) a step-in transformer.

5. What is meant by a step-down transformer?

a) one where the output voltage is larger than the input voltage;

b) one where the output voltage is the same as the input voltage;

c) one where the output voltage is smaller than the input voltage.

6. Why do National Grid overhead transmission cables use very high voltages?

a) higher voltages mean higher currents which wastes less energy;

b) higher voltages mean lower currents which wastes more energy;

c) higher voltages mean lower currents which wastes less energy.

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Transformers" and write them down into your personal vocabularies.

Exercise 2. Match the words and word combinations having a similar meaning.

1. To step up	a. To wrap
2. Coil	b. Proportion
3. To wind	c. Isolated
4. To step down	d. To raise
5. Ratio	e. Value
6. Fluctuating	f. Winding
7. Magnitude	g. To reduce
8. Separate	h. Varying

Exercise 3. Match the definitions.

1. A laminated iron core	a) is considered as an output winding
2. A primary winding	b) an electric current induced in the core of a transformer by a magnetic field
3. Eddy current	c) is used as an input winding
4. A secondary winding	d) a core composed of thin layers of iron bonded together

Exercise 4. Read the text "Transformers" and discuss it with your partner using the questions below. First, make the right order of the questions.

1. A transformer / step up / does / or / the voltage / step down?
2. Consist of / what / a transformer / does?
3. Why / a core / a laminated / does / construction / have?
4. Made of / a transformer core / iron / is / why?
5. Do / work on / what / transformers / principle?
6. Induces / the secondary / what / voltage / in / coil?
7. Does / the voltage / depend on / what / between / the primary and secondary?
8. Type / has / in the primary / has / than in the secondary / what / more turns / of a transformer?
9. Which / the highest / has / coil / current?
10. Transformers / the voltage / do / from / raise / electric / or reduce / generators?

TRANSFORMERS

A transformer is a static electrical device used to convert AC voltage from one **magnitude** to another without changing the **frequency**. The voltage is either stepped up or stepped down. The simplest type of a transformer consists of two coils of wire, which are also known as **windings**.

The **primary coil** is connected to the AC voltage source while the **secondary** leads to the AC output. The coils are not electrically connected. Instead, they are **wound around** a **laminated iron core** to make electrical energy pass more efficiently from one coil to the other. A laminated construction of the core is used to **reduce** heating from **eddy currents** in the coils.

Transformers work on the principle of Faraday's law of electromagnetic induction. When voltage is introduced to the primary coil, it produces a magnetic field. The iron core is easily magnetized and increases the strength of the magnetic field. The **fluctuating** magnetic field in the core induces the voltage in the secondary coil. The change of voltage between the primary and secondary depends on the **turns ratio** of the two coils. The amount of electricity being produced depends on the

number of times the coil is wound around the core. The more times it's wound around, the higher the voltage.

If the first coil has more turns that the second coil, the secondary voltage is smaller than the primary voltage. This is called a **step-down transformer**. In a **step-up transformer**, we use more turns in the secondary than in the primary to get a bigger secondary voltage and a smaller secondary current. Considering both step-down and step-up transformers, you can see it's a general rule that the coil with the most turns has the highest voltage, while the coil with the fewest turns has the highest current.

Transformers are employed for various purposes. For example, they reduce the voltage of conventional power circuits to operate low-voltage devices, such as doorbells. Transformers also **raise** the voltage from electric generators so that electric power can be transmitted over long distances with minimal **loss**.

Exercise 5. Agree or disagree with the following statements.

1. A transformer has no moving parts.
2. Transformers generate electrical power.
3. Transformers can only work with direct current.
4. Electricity is passed from the primary coil to the secondary without the wires actually touching.
5. A core is a construction of many thin laminated steel sheets or layers.
6. When the AC supply is given to the primary winding a magnetic flux is produced in the coil.
7. In a step-up transformer the potential difference created in the secondary coil is less than the potential difference in the primary coil.
8. In a step-down transformer the potential difference created in the secondary coil is equal to the potential difference in the primary coil.
9. The number of turns in the primary coil to the number of turns in the secondary coil determines the magnitude of the voltage.
10. The more times the coil is wound around the iron core, the lower the voltage.
11. Transformers increase the voltage inside electrical appliances.

Exercise 6. Match the words that go together in the text "Transformers". Check that you know the meaning of the phrases. Then complete the sentences below.

1) primary	a) ratio
2) step-down	b) induction
3) eddy	c) coil
4) wound	d) loss
5) laminated	e) transformer
6) electromagnetic	f) devices
7) minimal	g) around the core
8) turns	h) currents
9) fluctuating	i) iron core
10) low-voltage	j) magnetic field

1. Transformers use ____ to change the voltage of alternating current.
2. In a ____ we have less turns in the secondary than in the ____.
3. The ____ induces the potential difference in the secondary coil.
4. The voltage produced in the secondary coil mainly depends on the ____ of the transformer.
5. To reduce ____ metal cores of transformers are often arranged in small laminations with an insulation between them.
6. The construction of a transformer consists of two separate coils ____.
7. Controllers, sensors, cameras and other equipment in building systems work as ____.
8. Electricity is transmitted over long distances at high voltage and low current to produce ____.
9. A transformer is usually equipped with two windings wrapped around a ____.

GRAMMAR
THE INFINITIVE

Exercise 1. Insert *to* where necessary.

1. A bulb filament may ____ burn out if too much current flows through it.
2. The Italian scientist Alessandro Volta was the first ____ create an electric battery.

3. If you let me ____ borrow your laptop, I promise ____ give it back this evening.

4. I had originally decided ____ work abroad, but your advice made me ____ change my mind.

5. Silicon and germanium can ____ conduct electric current when small amounts of certain impurities are added to them.

6. The voltage is high enough ____ to be transmitted over long distances.

7. You'd better ____ check the battery charge.

8. Please remind me ____ phone the chief engineer in half an hour.

9. Transformers are efficient enough ____ produce minimal power losses.

Exercise 2. Compare two pairs of sentences. Identify the functions of the Infinitive. Translate the sentences into Russian.

1. a. It is necessary to use a laminated transformer core.
   b. A transformer core is laminated to reduce eddy current losses.
2. a. A transformer core is usually made of ferromagnetic material in order to increase the strength of the magnetic field.
   b. To use an iron core is essential to increase the strength of the magnetic field.
3. a. To produce a magnetic flux the primary winding must be connected to the AC supply.
   b. It is important for the primary winding to be connected to the AC supply to produce a magnetic flux.
4. a. A step-down transformer is used to decrease the voltage.
   b. To distribute power to our homes safely is highly important.
5. a. Power plants transmit electricity at extremely high voltages to save energy.
   b. It is necessary to transmit electricity at high voltages to save energy.

Exercise 3. Answer the following questions using the Infinitive.

Example: *Why do we use step-up transformers? We use step-up transformers* ***(in order) to increase*** *the voltage.*

1. Why are step-down transformers used?
2. Why is a transformer core laminated?

3. Why is the core made of iron?
4. Why are the coils wound around a soft iron core?
5. Why do we use more turns in the secondary coil than in the primary one?

Exercise 4. Put the verbs in brackets into the correct Passive or Active Infinitive.

Example: *I don't remember* ***to be told*** *(tell) the news before.*

1. Power plants want electric power ____ (transmit) over long distances with minimal loss.
2. James Maxwell was the first ____ (discover) that magnets have poles.
3. Particle accelerators are machines that propel charged particles at incredibly high speeds in order ____ (observe) what happens when they collide.
4. Since its launch in 1990, Hubble Space Telescope has provided data ____ (use) to write thousands of publications.
5. We are waiting for his research results ____ (present) at the conference.
6. An electromagnet is powerful enough ____ (move) scrap steel from one place to another.
7. In order for an electromagnet ____ (form), an electric current must pass through a coil of wire wrapped around an iron core.

Exercise 5. Rephrase the following sentences using Complex Object with the Infinitive, as in the example.

Example: *Why don't you come to the Museum of Technology with us? (I would like) I would like you to come to the Museum of Technology with us.*

1. Electromagnets can be switched on and off. (Electric current allows).
2. He had to pay for the damage. (They made).
3. A step-up transformer increases the voltage. (A step-up transformer lets).
4. Pavel said I could use his electric drill. (Pavel allowed).

5. They must fix the electric wiring right now. (I want).
6. Eddy currents heat up the core. (Eddy currents cause).
7. The core is laminated to reduce eddy currents to a minimum. (Lamination lets).
8. Transformers improve safety and efficiency of power systems. (Transformers allow).
9. I was told that I should carry out the necessary measurements to ensure the system is safe. (The specialist advised).
10. Don't switch off the current. (I don't recommend).

Exercise 6. Put the words in the sentences in the correct order. Translate the sentences and analyze the use of the Infinitive.

1. Function / is / of a transformer / the basic / the value / to change / of voltage.
2. You / I would like / the latest innovations / to use / in your field.
3. The greater / in the secondary coil / number of turns / to be increased / the voltage / enables.
4. Lets / in the secondary coil / the fluctuating / the voltage / magnetic field / to be induced.
5. Them / Pavel / to check / wants / again / the circuit.
6. Expect / the technician / we / faulty / as soon as possible / to fix / electrical devices.
7. To obtain / the observations / us / new data / enabled.

Exercise 7. Put the verbs into the correct Complex Subject with the Infinitive form.

1. Rubber and plastic ____ (to know) to be good insulators.
2. An electromagnet ____ (to be unlikely) to work when current is turned off.
3. Semiconductors ____ (to seem) to conduct electricity under certain circumstances.
4. Transformers ____ (to consider) to work on the principle of electromagnetic induction.
5. The voltage ____ (to expect) to be induced by the fluctuating magnetic field.

6. A step-up transformer ____ (to appear) to have more turns in the secondary winding than in the primary one.
7. A transformer ____ (to suppose) to be step-down if the output voltage is smaller than the input voltage.
8. A conductor ____ (to be sure) to have low resistance.

Exercise 8. Correct the mistakes.

1. The job of the protection system is monitor the superconducting magnets for tiny changes in voltage.
2. The first scientist to be recognized the magnetic properties of Earth was the English physicist William Gilbert.
3. Escalators let a lot of people to move a short distance at a good speed.
4. A conductor allows an electric current flow through it but it does not permit the current flow with perfect freedom.
5. Voltage drop can to be calculated from this equation.
6. It is necessary improve current approaches to magnetic levitation.
7. The electrician warned us not touch the cables.
8. A varying magnetic flux makes the voltage to induce in the coil.
9. Power stations is known to transmit electric power at a very high voltage over long distances.
10. A laminated core is appeared to be very efficient.

Exercise 9. Translate the following sentences into English.

1. Функция батареи – поддерживать разницу потенциалов.
2. Трансформатор используется, чтобы преобразовывать напряжение переменного тока.
3. Необходимо увеличить сопротивление материала сердечника, чтобы уменьшить потери в трансформаторе.
4. Чтобы уменьшить вихревые токи, сердечники трансформаторов делают из изолированных стальных пластин.
5. Чтобы вызвать магнитный поток в сердечнике, важно подключить первичную обмотку к источнику переменного тока.
6. Основная задача сердечника – создать замкнутый путь для магнитного потока с наименьшим сопротивлением.

7. Электротехническая сталь достаточно магнитная, чтобы использовать ее для изготовления сердечников трансформаторов.

8. Мы бы хотели, чтобы вы объяснили нам рабочий принцип трансформатора.

9. Ученые ожидают, что инженеры построят и протестируют машины, на которые можно будет полагаться.

10. Вихревые токи заставляют сердечник нагреваться, что ведет к потере энергии в трансформаторе.

11. Пластинчатый сердечник позволяет снизить потери от вихревых токов.

12. Александра попросили сделать доклад о своем исследовании на конференции.

13. Постоянная экспериментальная работа позволила нам прийти к этому выводу.

14. Известно, что силовые трансформаторы состоят из сердечника и нескольких катушек с проволокой, называемых обмотками.

15. Говорят, что космический телескоп Hubble сделал более миллиона наблюдений вселенной.

16. Трансформатор считается статической машиной, поскольку у него нет движущихся частей.

17. Ожидается, что этот исследователь представит свою идею системы электромагнитного импульса на предстоящей конференции.

18. Определенно, новые сверхпроводящие материалы появятся в ближайшем будущем.

19. Маловероятно, что этот трансформатор вышел из строя.

SPEAKING

Exercise 1. Work in pairs. Read the text about the use of transformers. Discuss it with your partner using the questions below.

A transformer is an electrical device that changes the voltage of an AC supply, such as the mains electrical supply. A transformer changes a high-voltage supply into a low-voltage one, or vice versa. A transformer that increases the voltage is called a step-up transformer. A transformer that decreases the voltage is called a step-down transformer.

Electricity is transferred from power stations to consumers through the wires and cables of the National Grid. When current flows through a

wire some energy is lost as heat. The higher the current, the more heat is lost. To reduce these losses, the National Grid transmits electricity at a low current. This needs a high voltage.

Power stations produce electricity at 25,000V. Electricity is sent through the National Grid cables at 400,000V, 275,000V and 132,000V.

Step-up transformers are used at power stations to produce the very high voltages needed to transmit electricity through the National Grid power lines. These high voltages are too dangerous to use in the home, so step-down transformers are used locally to reduce the voltage to safe levels. The voltage of household electricity is about 230V.

1. – What / of / the basic / a transformer / is / function?
2. – Does / what kind / a transformer / of voltage supply / change?
3. – Is / a step-up / what / transformer /?
4. – Called / step-down / is /what transformer?
5. – Is / to consumers / how / transferred / electricity?
6. – Why / lost / energy / is / when current / through / flows / wires?
7. – The National Grid / what / do / the losses / does / to reduce?
8. – What voltage / power / do / plants / electricity / at / produce?
9. – Sent / electricity / is / at 400,000V / through / or at 230V / the National Grid cables?
10. – Are / what kind / stations /of transformers / at power / used?
11. – Step-up / do / transformers / high / produce / voltage /or / low?
12. – Voltages / used / high / in the home / are?
13. – Of transformers / used / what kind / locally / are?
14. – Why / step-up / used / are / transformers?
15. – Does / electricity / what amount / household / require / of voltage?

UNIT 8
ELECTRIC DRIVE SYSTEMS

SWITCH ON

Exercise 1. Study the diagram of an electric drive system (Fig. 1). With its help, match these definitions to the correct item on the diagram.

1. It converts electrical energy into mechanical energy.
2. It provides the required energy to the electric drive system.
3. It monitors the operation of the entire system and ensures the overall system performance and stability.
4. It provides the motor with adjustable voltage, current and frequency.
5. It measures signals coming from the motor.
6. It is determined by the nature of the industrial operation.

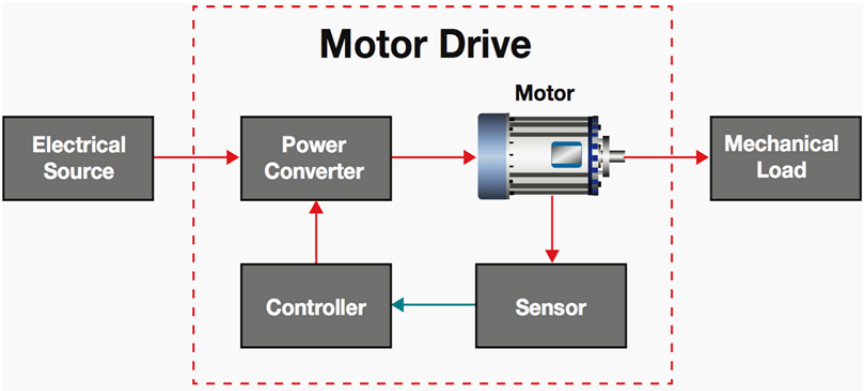

Fig. 1. Electric drive

Exercise 2. Test your knowledge of electric drives with a simple quiz.

1. Electric drives are becoming more and more popular because
a) they are simple and reliable;
b) they are cheap in cost;

c) they provide smooth and easy control;
d) all above.

2. The major applications of electric drives are
a) electric trains and buses;
b) fans and compressor pumps;
c) robots;
d) all above.

3. An electric drive uses ____ as a prime mover.
a) a diesel engine;
b) a gas turbine;
c) an electric motor.

4. A controller provides control over
a) a power source and load;
b) a motor and power converter;
c) cost and weight of a motor.

5. The main disadvantage of an electric drive is that
a) it can be controlled remotely;
b) being compact, it requires less space;
c) it stops as soon as there is a failure of power supply;
d) it is pollution free.

6. The type of control in a compressor motor of a fridge is
a) manual;
b) semi-automatic;
c) automatic.

VOCABULARY & READING

Exercise 1. Study the words and word combinations in bold from the text "Electric Drive System" and write them down into your personal vocabularies.

Exercise 2. Complete the sentences replacing the words in italics with appropriate word from your active vocabulary. You have to change some words slightly.

1. The computer makes adjustments based on ***response*** from the sensors.
2. Most of the functions of the device are ***modifiable*** through software.

3. An automotive expert determined the amount of ***turning force*** needed to ensure that the car would travel at its maximum speed.

4. This technology offers improved ***capacity*** as well as speed and automation in one system.

5. When a dual-arm manipulator carries the object from one place to another, the two arms and the gripped object constitute a ***closed-cycle system***.

6. Newton concluded that these forms of light vibrate at different ***rates per second.***

7. After the wiring is done we add appliances and other electrical ***devices that consume electrical energy.***

8. All cranes will be equipped with a functional weight indicator on the main ***lift***, visible by the operator.

9. Cars of the future will likely ***include*** more than one type of fuel system.

Exercise 3. Match the devices to their definitions.

1. Rectifier	a) converts constant AC voltage and frequency into another AC voltage and frequency
2. Cycloconverter	b) converts DC to AC
3. Inverter	c) converts fixed DC voltage into variable DC voltage
4. Chopper	d) converts AC to DC

Exercise 4. Read the text "Electric Drive System" and decide whether the sentences are true or false.

1. A drive is a combination of various systems for the purpose of motion control.

2. Applications of electric drives include diesel generators, electrical appliances like smartphones, TV-sets, electric kettles.

3. An electric drive is an open-loop system.

4. An electric drive incorporates a power source, a power modulator and a controller.

5. Converters are used to regulate the available sources to suit the load.

6. Diode rectifiers are used to convert DC to AC.

7. Cycloconverters are used to convert the fixed DC frequency and voltage into variable DC frequency and voltage.

8. A sensing unit identifies certain drive parameters like motor current and speed.

9. An electric motor converts mechanical energy into electrical energy.

10. Both AC and DC motors are used for electric drives.

ELECTRIC DRIVE SYSTEM

More than half of the electrical energy generated worldwide is converted into mechanical motion, and the importance of **electric drives** for transport and movement is growing steadily.

An electric drive is a form of machine equipment designed to convert electrical energy into mechanical energy under the necessary control. Electric drive systems control the motion and processes of different electrical machines and mechanisms. Typical applications of electric drives include fans, compressor pumps, **hoists**, cranes, escalators, conveyors, electric locomotives and cars.

An electric drive is a **self-adjusted closed-loop system** with five main functional blocks namely a power source, a power converter, an electric motor, a mechanical **load** and a **controller** which **incorporates** a sensing unit and a control unit. In a closed loop system, the output of the system is a feedback to the input.

A power source provides the required energy to the electric drive system. The basic power sources are AC (**the mains**), DC (a battery) or renewable sources like solar or wind. A power **converter** provides the motor with **adjustable** voltage, current and **frequency**. Converters are used to convert or regulate the available sources to suit the load.

The main types of conversion are AC to DC, DC to AC, DC to DC, AC to AC. Diode **rectifiers** are used to convert AC to DC. **Inverters** are employed to get AC from DC. **Choppers** or DC to DC converters are used to convert fixed DC voltage to a variable DC voltage. It is a high speed switch which connects and disconnects the load from power source to get variable voltage at the output. Cycloconverters are used to convert the fixed AC frequency and voltage into variable AC frequency and voltage.

A controller is an electronic device that takes signals from sensors, processes them and generates a reference signal. A controller regulates energy through the **feedback** coming from the sensor unit. This output signal tells the drive how much power to generate in order to control motor **torque** or motor **shaft rotation**. Nowadays, this control can be done easily with the help of software. So, the controlling is becoming more and more accurate.

An electric motor converts electrical energy into mechanical energy. It also can be viewed as a device that transfers energy from the electrical source to the mechanical load. Both AC and DC motors are used for electric drives. The basic criterion in selecting an electric motor for an electric drive system is that it should meet the power level and **performance** required by the load.

Electric drives are getting more and more popular and are used in a wide range of applications because:

- they do not pollute the environment;
- they are available with wide range of torque, speed and power;
- electric braking can be employed therefore they have flexible control characteristics;
- being compact, they require less space;
- they have comparatively long lifetime.

Exercise 5. Explain why:

1) electric drives are used in pumps, escalators, robots and electric cars;
2) an electric drive is a self-adjusted system;
3) power sources are used;
4) converters are used;
5) a controller includes a sensing unit and a control unit;
6) electric drives are getting more popular.

Exercise 6. Complete the sentences with the words in the box.

the mains, drive, feedback, shaft, performance, hoist, load, frequencies, incorporate, torque

1. The lifting capacity of this chain ____ is five tons.
2. We know that electrons at any molecule can only absorb radiation at certain ____.
3. Motors convert electrical energy into mechanical energy in order to turn a ____.
4. The electrical system failed because it couldn't handle the ____.
5. Braking of a DC motor develops a negative ____ while the motor works as a generator and as a result the motion is opposed.
6. The ____ can easily be started and it does not require any refueling.
7. We tested to see if the increased ____ met the theoretical speed boost.
8. The smoke detector should be connected to ____ electricity and fitted with back-up batteries which will operate if the electricity supply should fail.
9. In order to provide a complete report, the engineers ____ the graphs and charts into the written text. In a closed loop system, the output of the system is a ____ to the input.

GRAMMAR
PARTICIPLE & GERUND

Exercise 1. Study the following word combinations with the Participle I Simple and Participle II. Translate them into Russian.

a) Participle I Simple

The system controlling the motion, the water containing impurity, the laminated core reducing eddy currents, the transformer improving safety and efficiency, the drive system providing flexible control, the force being measured now, the transformer working on the principle of electromagnetic induction, the amount of energy being produced by the motor right now.

b) Participle II

The voltage produced in the secondary coil, the container filled with gas, electromagnetic induction discovered by Michael Faraday, the data received from sensors, certain tasks done by people, the method of production known as Detroit automation, the current induced in the conductor, the resistance reduced automatically, the results presented at the conference, fossil fuels formed more than 65 million years ago.

Exercise 2. Complete the sentences using the proper form of the Participle I Simple and Participle II.

1. Signals ____ (to measure) by sensors are then sent to the controller.
2. In a simple circuit ____ (to consist) of a bulb, a battery, and two pieces of wire, the electric current flows from the negative terminal to the positive one.
3. The equipment ____ (to adjust) by a skillful operator now is very reliable.
4. The load includes all appliances ____ (to place) in the circuit, such as lights, switches, fuses and other devices.
5. Solenoid is a coil of wire in the form of a cylinder ____ (to have) a length much greater than its diameter.
6. Railways are controlled by automatic signaling devices, which have sensors that detect carriages ____ (to pass) a particular point.
7. In order for an electromagnet to be formed, an electric current must pass through a coil of wire ____ (to wrap) around an iron core.
8. The escalator ____ (to install) now in the underground station will move a lot of people upward and downward at a good speed.

Exercise 3. Choose the correct form of the Participle in bold.

1. Today almost all magnets are manufactured ***used / using*** various natural magnets from around the world.
2. ***Having analyzed / having been analyzed*** the tests results we calculated the required load.
3. When the connections are properly made, current flows through the wires ***being caused / causing*** the bulb to glow.
4. When ***cooling / cooled*** to extremely low temperatures, electromagnets demonstrate an unusual behavior.
5. ***Studying / studied*** the cosmos for over a quarter century, the Hubble Telescope has made more than a million observations.
6. ***Constructing / having constructed*** the first successful escalator in 1900 the Otis Elevator Company exhibited it at the exhibition in Paris.
7. Under load the armature turns more slowly, ***reducing / having reduced*** and ***permitting / having permitted*** a larger current to flow in the armature.

8. ***Having introduced / having been introduced*** by Michael Faraday the concept of lines of force proved extremely useful in the study of electricity.

Exercise 4. Complete the sentences using the correct form of the Participle.

1. The drive system ____ (to discuss) by the engineers right now has a number of advantages.
2. Materials ____ (to contain) iron, cobalt and nickel are attracted to a magnet.
3. Hoists and primitive elevators ____ (to operate) by human and animal power or by water wheels were in use as early as the 3rd century BC.
4. ____ (to introduce) in elevator construction in 1880 by the German inventor Werner von Siemens an electric motor increased the efficiency and speed of power elevators.
5. Electricity consists of charges ____ (to carry) by electrons, protons, and other particles.
6. At the top and bottom of the escalator, the steps collapse on each other, ____ (to create) a flat platform.
7. When ____ (to turn off) an electromagnet loses its magnetic force.
8. ____ (to invent) by the Chinese in the 1st BC the magnetic compass proved so important that it is ranked as one of the China's gifts to the West.

Exercise 5. Rephrase each sentence so that it begins with the Gerund as a subject.

Example: *It isn't a good idea <u>to do</u> an exam without revising.*
<u>Doing</u> an exam without revising isn't a good idea.

1. It's possible to charge many substances by rubbing.
2. It took a long time to write a report.
3. It's unsafe to touch the wires without rubber gloves.
4. It's important to follow the instructions properly.
5. It took lots of experiments to confirm this hypothesis.
6. It's easy to control an electric drive.
7. The current approach is to teach robots.
8. It's important to keep the electric drive system working.

Exercise 6. Complete the sentences using prepositions + Gerund. Use one of the following verbs in the box.

to lose, to control, to say, to increase, to use, to flow, to decrease, to reenter, to do, to move, to modify

1. **After** through the separate branches, the current merges again **before** ____ the current source.
2. Scientists describe the relationship between resistance, length and area **by** ____ that resistance is proportional to length and inversely proportional to cross-sectional area.
3. A superconducting coil allows the high currents to flow **without** ____ any energy to electrical resistance.
4. **By** the current, you can turn the electromagnet on and off.
5. Transformers are capable **of** either ____ or ____ the voltage and current levels of their supply **without** ____ its frequency.
6. **Instead of** ____ a flat surface, as in a conveyer belt, the escalators move a series of steps.
7. What are the advantages **of** ____ electric drives?
8. **After** ____ the same job for ten years, I felt I needed a change.

Exercise 7. Link these sentences using prepositions (by, instead of, without, before) + Gerund.

1. In Japan, engineers have taught a robot to dance. They demonstrate the movements themselves.
2. We were able to translate the article into English. We didn't use a dictionary.
3. Before you select an electric motor check the load requirements.
4. People don't perform certain hard and dangerous manufacturing tasks themselves. They use robots instead.
5. Some robots can learn. They mimic human actions.
6. An electric drive can be started immediately. It doesn't have to be preheated.
7. It's possible to achieve drive efficiency level up to 90 %. The objective is to optimally adjust the converter and motor to one another.

Exercise 8. Translate the following sentences into English.

1. Современный электропривод – это сложное устройство, состоящее из преобразователя электроэнергии, устройства управления и электродвигателя.
2. – Какие основные особенности современного электропривода? – Во-первых, используя полупроводниковые преобразователи энергии, можно контролировать скорость электропривода, во-вторых, применяя микропроцессорные контроллеры, возможно решать задачи управления электроприводом.
3. Преобразователь электрической энергии используется для управления электроэнергией, поступающей от сети к двигателю.
4. Управляя электрической энергией, преобразователь позволяет управлять скоростью двигателя. Наиболее распространенными разновидностями преобразователей энергии являются преобразователи частоты и выпрямители.
5. Система автоматического управления представляет собой микропроцессорную систему, запрограммированную специальными законами стабилизации скорости двигателя.
6. Исполнительный механизм или нагрузка – это механизм, который непосредственно выполняет полезную работу (подъем груза, движение транспорта, вращение вентилятора и т. д.).
7. Посредством использования катушек с проволокой, намотанных вокруг магнитного материала, такого как железный сердечник, мы можем создать очень мощный электромагнит.
8. Умножение ампер на вольты дает определенное количество ватт.
9. Необходимость уменьшения скорости двигателя или его полная остановка может возникнуть в любой момент, следовательно, торможение – это очень важная операция для привода с двигателем постоянного тока.
10. Автоматизированное производство невозможно без использования электроприводов.
11. Управление нагрузкой происходит путем расчета задания на текущую скорость. Задание на скорость подается на систему управления преобразователя электрической энергии.
12. Электроприводы, в состав которых, кроме двигателя, входят управляемые преобразователи энергии и системы автоматического

управления, способны выполнять производственную задачу с минимальным участием человека. Они получили название автоматизированных электроприводов.

SPEAKING

Exercise 1. Complete the text about electric and diesel-electric locomotives using the words from the box. Ask five questions to your partner about the text.

power	gain	efficiency	kinetic
powerful	work	efficient	thermal
powered	form	useful	stored
source	chemical	electrical	convert

An electric locomotive is one that is ____[1] by an external energy ____[2], most often via overhead electric lines. This differs from electric-diesel locomotive, which has an onboard fuel tank and a diesel-powered generator to provide electricity to its motors.

An electric locomotive needs to carry neither a generator nor fuel, its mass is therefore lower than a diesel-electric equivalent. This results in significant efficiency ____[3], as the electric locomotive's smaller mass means less ____[4] is done. Its motors are required to provide less ____[5]. This means less ____[6] and smaller motors can be used, thus further reducing weight and improving ____[7]. In addition, electric locomotives use only ____[8]energy. This means there is no need to ____[9] energy from one ____[10] to another on board the train.

In a diesel-electric unit, the energy conversion starts with ____[11] energy which is ____[12] within the hydro-carbon compounds of diesel. This fuel is used to produce ____[13] energy, and the heat is then converted by the engine into ____[14] energy, which provides the movement of the train. This process is a very long way from being 100 % ____[15] – only a small percentage of the initial chemical energy is converted to the ____[16] energy that is actually used to drive the train.

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CONTENTS

Учебное издание

ВАНИК Ирина Юрьевна
ЛАПКО Олеся Александровна

ENGLISH FOR AUTOMATED ELECTRIC DRIVES

АНГЛИЙСКИИЙ ЯЗЫК. АВТОМАТИЗИРОВАННЫЕ ЭЛЕКТРОПРИВОДЫ

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