МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ЖИТОМИРСЬКИЙ АГРОТЕХНІЧНИЙ ФАХОВИЙ КОЛЕДЖ

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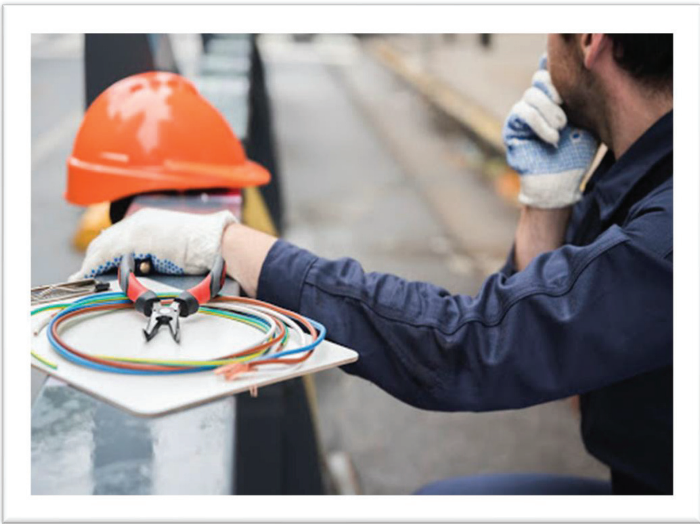
ENGLISH FOR ELECTRICAL ENGINEERING

НАВЧАЛЬНИЙ ПОСІБНИК З ДИСЦИПЛІНИ «ІНОЗЕМНА МОВА (АНГЛІЙСЬКА) ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ»



ЖИТОМИР
ПП «ЄВРО-ВОЛИНЬ»
2024

УДК [621.3:811.111](075.8)
К 64

Рекомендовано цикловою комісією іноземних мов Житомирського агротехнічного фахового коледжу (Протокол № 6 від 15.01.2024 р.)
Затверджено на засіданні кафедри «Електроенергетика, електротехніка та електромеханіка» Житомирського агротехнічного фахового коледжу (Протокол № 6 від 15.01.2024 р.)
Схвалено до друку методичною радою Житомирського агротехнічного фахового коледжу (Протокол №5 від 18.03.2024 р.)

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К 64 English for Electrical Engineering. Навчальний посібник з дисципліни «Іноземна мова за професійним спрямуванням». – Житомир: ПП "Євро-Волинь", 2024. – 152 с.

Навчальний посібник розроблений відповідно до навчальної програми дисципліни «Іноземна мова за професійним спрямуванням», яка відповідає стандартам освітньої програми 141 «Електроенергетика, електротехніка та електромеханіка», галузі знань 14 «Електрична інженерія», крім того, при створенні посібника автори врахували зміни, що відбулися в лінгвістичних та соціально-психологічних концепціях, які лежать в основі неспеціалізованої методики навчання іноземних мов.

Посібник містить ефективну систему засобів, зокрема вправ і завдань, які сприяють формуванню комунікативної компетентності як пріоритетної мети опанування здобувачами освіти іншомовним спілкуванням за професійним спрямуванням.

Посібник розрахований на фахівців в галузі електроенергетики, електротехніки та електромеханіки, наукових працівників, викладачів вищих навчальних закладів, технікумів і коледжів, здобувачів вищої та фахової передвищої освіти.

УДК [621.3:811.111](075.8)

ISBN 978-617-7992-71-3

ПЕРЕДМОВА

Оновлення змісту навчання іноземних мов у вищих навчальних закладах пов'язується з деякими змінами в стратегічних напрямах розвитку сучасної вищої освіти – спрямуванням навчальної діяльності на вироблення у здобувачів освіти необхідних життєвих компетентностей, що в майбутньому давали б можливість випускникам ВНЗ комфортно почуватися в сучасному світовому мультинаціональному просторі.

Запропонований посібник з англійської мови можна розглядати в якості носія змісту іншомовної освіти та засобу навчання іншомовного спілкування. Його метою є відображення певної моделі діяльності здобувачів освіти, яка забезпечується на дидактичному і методичному рівнях за допомогою доцільно підібраних засобів навчання, що узгоджуються з комунікативно-діяльнісним підходом і сприяють успішному виконанню цілей, визначених чинною програмою.

Цей посібник – поліфункціональний та вигідно вирізняється серед інших видань як способами подання фактичного і мовного матеріалу, так і запропонованою методикою роботи з ним.

У змісті навчального посібника передбачена ефективна система засобів, зокрема вправ і завдань, які сприяють формуванню комунікативної компетентності як пріоритетної мети опанування здобувачами освіти іншомовним спілкуванням за професійним спрямуванням.

Завдання, запропоновані в посібнику, збагачують лексику здобувачів освіти та націлюють їх на активне сприйняття тексту та цілеспрямований пошук інформації у ньому. Після текстові завдання дозволяють не лише перевірити розуміння та закріпити необхідні лексичні одиниці, але й дати майбутнім фахівцям можливість висловити свою точку зору стосовно проблеми, спираючись на власний досвід і знання інших дисциплін. Як результат – висловлювання здобувачів освіти набувають різнобічності і особистісної значущості.

Більшість текстових матеріалів у посібнику є автентичними, знайденими у друкованих джерелах виданих у Великій Британії та США, а також у відкритому доступі в Інтернет мережі. Окремі тексти є авторськими перекладами. Завдання і вправи розроблено авторами з урахуванням Загальноєвропейських рекомендацій з мовної освіти. Тестові завдання пропонуються у форматах, що відповідають міжнародним екзаменам (TOEFL, KET, PTE). Додатки до основної частини посібника у формі тестів та термінологічного словника допоможуть майбутнім фахівцям засвоїти професійну лексику та оперувати спеціальною термінологією у процесі ділового спілкування з представниками інших країн. Аналіз однієї з найпопулярніших систем оцінки знання англійської мови (CEFR) допоможе здобувачам освіти здійснити самооцінку свого рівня володіння англійською мовою, а запропоновані ресурси для вивчення мови сприятимуть подальшому розвитку мовленнєвої компетентності майбутніх фахівців.

Загалом, матеріали посібника стимулюють розвиток пізнавальних інтересів здобувачів освіти та сприяють мотивації до вивчення англійської мови.

Посібник розрахований на фахівців в галузі електроенергетики, електротехніки та електромеханіки, наукових працівників, викладачів вищих навчальних закладів, технікумів і коледжів, здобувачів вищої та фахової передвищої освіти.

ЗМІСТ

CONTENTS

CHAPTER 1. ELECTRICITY

ACTIVITY 1. Find the meaning of the words given in bold print in the dictionary. Read the following article and do the activities that follow it.

It is impossible to imagine our civilization without electricity: economic and social progress will be turned to the past and our daily lives completely **transformed**.

Electricity is the **flow** of tiny **particles** called electrons and protons. It can also mean the energy you get when electrons flow from place to place. Electricity can be seen in nature in **a bolt of lightning**. Lightning is nothing but a large number of electrons flowing through air all at once, **releasing** a huge **amount** of energy. Scientists have also learned how **to generate**, or create, electricity. This is useful because electricity that is generated can be controlled and sent through **wires**. Then it can power such things as **heaters**, light **bulbs**, and computers. Today, electricity provides most of the energy to run the modern world.

Arrange the sentences in logical order according to the text. Then use them as a plan to retell it.

A. Electricity can be seen in nature in a bolt of lightning.

B. Electricity provides most of the energy to run the modern world.

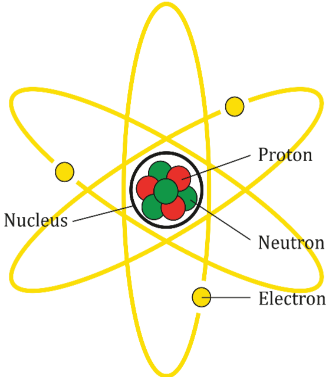
C. It can power such things as heaters, light bulbs, and computers.

D. Scientists have learned how to generate, or create, electricity.

E. It is impossible to imagine our civilization without electricity

1)	**2)**	**3)**	**4)**	**5)**

ACTIVITY 2. Fill in the gaps in these sentences with a suitable word. The first letter of each missing word is given. The words in the box bellow the text can help you.



Everything in the **u**_______ is made of tiny **o**_______ called atoms. Each atom has even tinier particles called **p**_______ and electrons. These tiny particles swirl around each other continuously. An electron has what is called a negative **c**_______. A proton has a positive charge. Positive and **n**_______ charges try to pull each other together. However, two positive charges, or two negative charges, will push each other away. Electricity results when **e**_______ are pushed and pulled from **a**______ to atom.

negative, **protons**, **atom**, **charge**, **universe**, **electrons**, **objects**

ACTIVITY 3. Read the text below. Match choices (A – F) to (1 – 4). There are two choices you do not need to use.

STATIC ELECTRICITY

Most objects have a balance of positive and negative charges, so they **1)**__________. This means that they do not push or pull on each other electrically. However, sometimes electrons can build up in an object. Two such objects **2)** __________ because they are no longer neutral. This push or pull from extra electrons is called static electricity. Static electricity can cause interesting effects, such **3)** __________, when it is released. Sometimes the extra electrons build up by rubbing one object against another. For example, when one rubs a balloon against one's hair, electrons move from the balloon to the hair. Because then the hair has extra electrons, which all have the same kind of charge, they try **4)** __________ and end up sticking into the air like spikes!

A – can push or pull on each other

B – swirl around each other continuously

C – are considered neutral

D – get when electrons flow from place to place

E – as sparks or lightning bolts

F – to fly away from each other

ACTIVITY 4. Put the words into correct order to make up sentences.

1. another \ power \ is \ for \ word \ energy.
2. nuclear \ uranium \ from \ people \ atoms \ get \ energy.
3. energy \ different \ humans \ many \ of \ sources \ use .
4. things \ makes \ energy \ move.
5. gas \ energy \ burn \ oil \ coal \ and \ natural \ for \ people .

ACTIVITY 5. Find the meaning of the words given in bold print in the dictionary. Read the following article and do the activities that follow it.

GENERATING ELECTRICITY

Many moving electrons are called an **electric current**. A city's **power plant** produces a **powerful** electric current and sends it through wires. The electricity used for lighting, **heating**, and running **appliances** is made by machines called generators. Generators cause a current to flow by moving **a magnet** past **a coil of wire**, which pushes electrons through the wires of the coil. Wires carrying the current travel to houses and other buildings. More wires connect to **the power outlets** in rooms. When a person **plugs in** an iron or another electric device, the current travels into the device. The current then makes the device work. **A chemical reaction** in a battery can also produce an electric current.

A) Match the words (1-6) and (a-f) to make phrases.

1. a running	**a.** outlet
2. a coil	**b.** current
3. a power	**c.** plant
4. an electric	**d.** reaction
5. a chemical	**e.** appliance
6. a power	**f.** of wire

B) Choose the correct items to complete the sentences. Translate the following sentences into Ukrainian.

1. When a person ___________ an iron or another electric device, the current travels into the device.
2. The electricity used for lighting, heating, and running appliances is made by machines called ___________.
3. A chemical ___________ in a battery can also produce an electric current.
4. Many moving ___________ are called an electric current.
5. A city's power plant produces a powerful _____ _____ and sends it through wires.

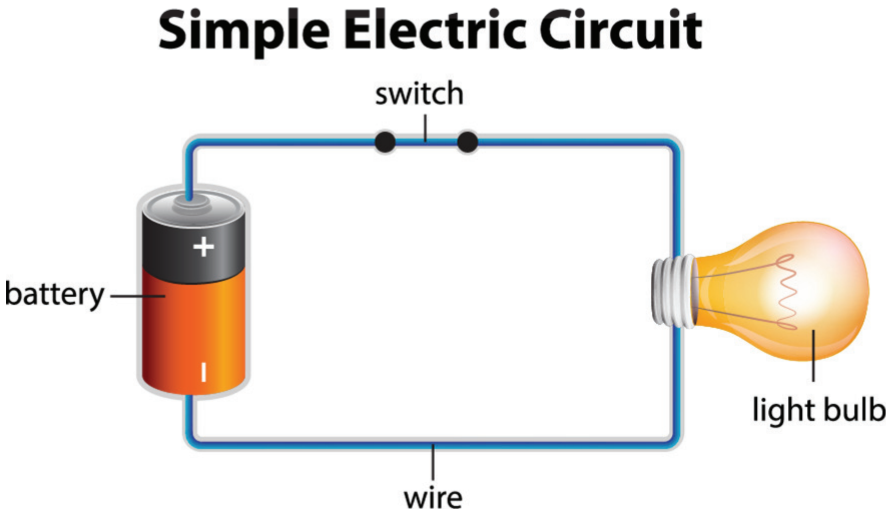
C) Answer the questions.

1. What makes any electric device work?
2. What is an electric current?
3. Where is electric current produced?
4. What do generators cause?
5. What do wires connect to in rooms?

ACTIVITY 6. Read and translate the text below.

An electric circuit is a closed path in which electrons move to produce electric currents. Indeed, all the simple modern marvels are a consequence of this scientific principle. Read on to understand more on the components, types, and other concepts related to electric circuits.

Electric circuits are important concepts that have practical applications in our daily lives. It is a very simple concept that incorporates three different components: a source of electrical energy, a device, and a closed loop of conducting material.



ACTIVITY 7. Read the following article and do the activities that follow it.

SOURCE OF ELECTRICAL ENERGY

The first component in an electric circuit is the source of electrical energy that allows electrons to move. This source could be a battery, a solar cell, or a hydroelectric plant - a place where there is a positive terminal and a negative terminal and from where charge could flow from one to the other. This push of electric charge is called voltage whose potential is measured in volts.

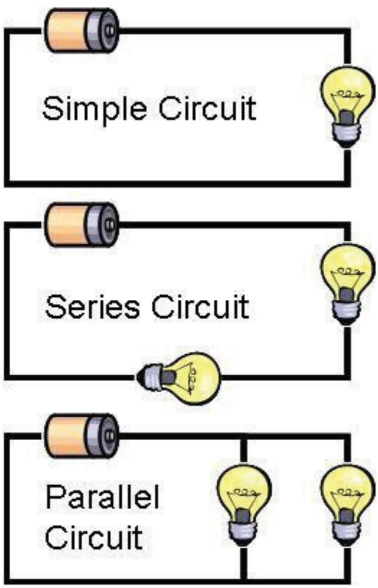
DEVICE IN THE ELECTRIC CIRCUIT

The second component is the device. It responds to the current passing through it. Today, a device is something that can be plugged into a wall socket and used with electricity. The loop is generally closed using a piece of conducting material. It is usually a wire but there are other kinds of materials that can close the loop too. For example, there are various strips of metal inside the television that have been deposited onto a plastic surface that may be the conducting material or even in some cases, the chassis of a device that becomes part of the closed circuit.

RESISTANCE OF THE ELECTRIC CIRCUIT

The third component is the resistance; every circuit has some resistance to the flow of electrons. Electrons collide with other electrons and atoms that make up the wire and they convert some of their energy to heat. It is simply not possible to transfer energy from one form to another without losing some of that energy as heat.

TYPES OF ELECTRIC CIRCUITS



There are two types of circuits found in homes and other common devices: series circuits and parallel circuits.

Series circuits consists of several devices, each of them linked up one after another after another in just a single large loop. However, different devices have different voltages across them, the same current flows through every device in the series circuit.

If any one of the devices in a series circuit is broken, the whole circuit fails. For instance, if there are three light bulbs connected in a series, in just one loop of wire connected to a battery. If one light bulb is unscrewed, the whole circuit fails.

In parallel circuits, different devices are arranged so that a single source supplies voltage to separate loops of wire. The voltage in every device across the circuit is the same, but in general, different devices are going to see different currents. In this case, each device is going to work even if the other ones fail.

For instance, if two light bulbs are linked up in parallel and one is unscrewed, the other one will work. Modern Christmas tree lights are done in parallel circuits so that even if a single light burns out, the whole strand does not have to be thrown out.

A) Match the words (1-6) and (a-f) to make phrases.

1. a light	**a.** terminal
2. a single	**b.** of the electric circuit
3. an electric	**c.** source
4. the resistance	**d.** bulb
5. a parallel	**e.** circuit
6. a negative	**f.** circuit

B) Answer the questions.

1. What could a source of electrical energy be?
2. What is an electrical device?
3. What is called voltage?
4. How many types of circuits can be found in homes? What are they?

ACTIVITY 8. Put the verbs in the brackets into the Present Simple Active or the Present Simple Passive. Translate the sentences into Ukrainian.

1. The flow or movement of electrons through the electrical circuit ________ (to call) the electrical current.
2. Current ________ (to measure) in amperes.
3. One ampere ________ (to correspond) to about 6 billion electrons passing a point in that circuit every second.
4. Another important term associated with electricity ________ (to be) power.
5. Power ________ (to define) as work divided by time.

6. In an electrical circuit power _______ (to equal) current voltage, measured in watts.

7. The higher the wattage, the faster the energy consumed by that object, be it a light bulb, an amplifier, or any electrical device.

ACTIVITY 9. Fill in the gaps with the words from the box. Use each word only once. Then translate the text into Ukrainian.

THE MAIN COMPONENTS OF ELECTRIC CIRCUITS

The main components of any ___**1**___ are devices that produce and utilize electric energy. They are power sources, utilizing ___**2**___, connecting conductors.

The most common power ___**3**___ are electric generators and primary cells. Electric generators convert chemical ___**4**___ into electric energy.

Loads include electric heaters, electric motors, incandescent ___**5**___, etc. Motors convert electric energy into mechanical, incandescent lamps and heaters convert electric energy into light and heat. Utilizing ___**6**___ or loads convert electric energy into thermal, mechanical or chemical energy.

Electric power is delivered from power sources to loads by electric ___**7**___. According to their material, wires can be aluminum, copper, steel, etc.

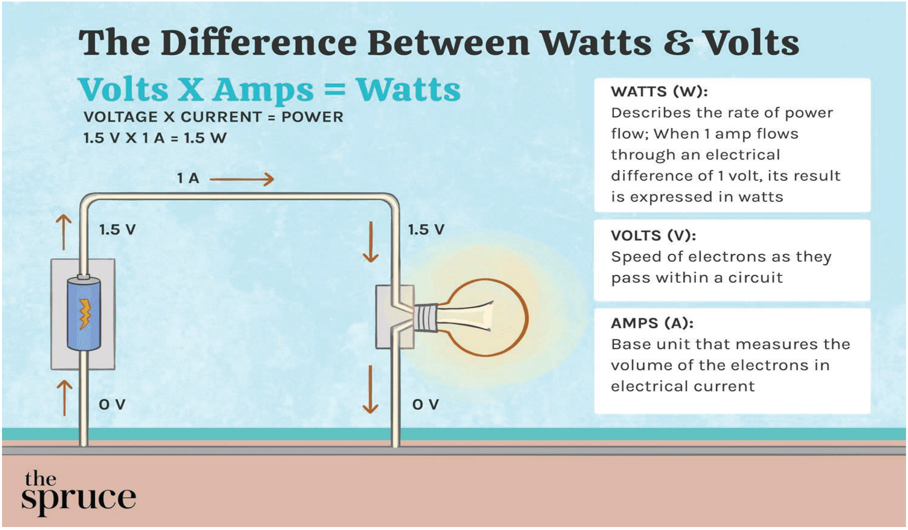
In addition to these three main ___**8**___, electric circuits use different types of switches, protection devices (relays and fuses), and meters (ammeters, voltmeters, wattmeters, etc.)

wires, energy, loads, sources, devices, components, lamps, circuit

ACTIVITY 10. Learn important electricity terms and main electrical circuit symbols.

Conductors and Insulators: Good conductors are materials that let electricity flow through them easily. Most metals are good conductors, which is why metal is used in electrical wiring all over the world. The opposites of conductors are insulators.

Insulators do not carry electricity well. We need insulators to protect people from flowing electricity. Rubber and plastics are examples of good insulators.



Voltage: Voltage is the force that makes electrons flow. It is a difference in potential energy between two different points in a circuit.

Current: Current is the rate of the flow of electrons. It is measured in amperes, which are also called amps.

Power (Watts): The power used in a circuit is measured in watts. Watts are calculated by multiplying the voltage by the current.

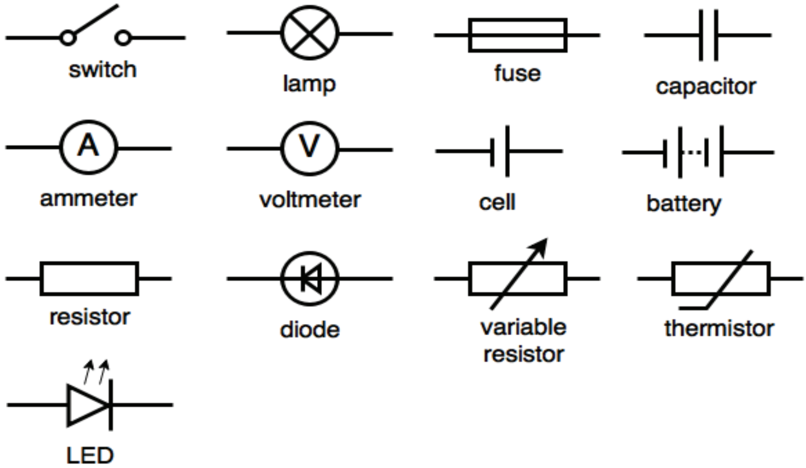
Resistance: This is the measure of how well something conducts electricity. If it has a low resistance, the object is a great conductor of electricity, and if it has a high resistance that means that it doesn't conduct electricity well.

Direct current (DC) is a constant flow of electrical charge in a single direction. The inner workings of most electronics use direct current.

Alternating current (AC) is a current in which the flow of the electrical charge constantly switches directions. Power lines in the United States transmit power using alternating currents.

Electrical circuit symbols are small drawings or pictograms used to represent various electrical devices in a diagram or plan of an electrical circuit.

These are some of them:



ACTIVITY 11. Find the meaning of the words given in bold print in the dictionary. Read and translate the article about conductors.

CONDUCTORS

According to their **conductivity**, all materials are divided into **conductors**, **insulators** and **semiconductors**.

Conductors are materials having a very high conductivity. The most common of them are metals (**copper, aluminum, steel** and others), **carbon** and **electrolytes**. Their **coefficient of resistance** is different. Copper, for example, has a positive coefficient while carbon has a negative coefficient of resistance.

According to their **resistivity**, conductors are divided into two groups. The first one includes materials with low resistivity: copper, aluminum and others. These metals are used to produce **wire conductors** due to their high **mechanical strength**. The second group includes materials with high resistivity; one of them is **nichrome**. Due to its good heat resistance, nichrome is used to produce **heaters**.

Carbon is commonly used to produce **electrodes** and brushes for electric machines.

Arrange the sentences in logical order according to the text. Then use them as a plan to retell it.

A. According to their resistivity, conductors are divided into two groups.

B. The second group includes materials with high resistivity.

C. Conductors are materials having a very high conductivity.

D. The first group includes materials with low resistivity

E. According to their conductivity, all materials are divided into conductors, insulators and semiconductors.

1)	**2)**	**3)**	**4)**	**5)**

ACTIVITY 12. Read and discuss the text below.

THE IMPORTANCE OF ELECTRICITY IN OUR DAILY LIFE

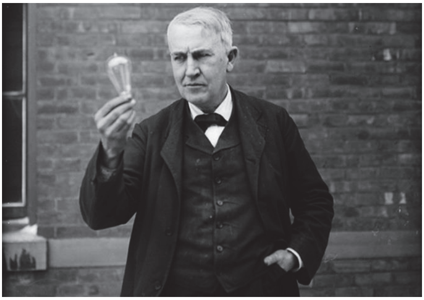
The electricity we use in our daily lives is an important source of energy.

The electricity is produced by converting natural energy sources such as coal, natural gas, nuclear energy, solar energy, and wind energy into electrical energy, which has become of great importance in facilitating human lives and achieving the renaissance in the nation's economy.

In the past, humans used candles and whale oil lamps to illuminate, cold iceboxes for food preservation, and wood-burning stoves for heating.

Today, with the discovery of electricity, human life has become easier by using electricity to perform many functions every day, such as lighting, heating, cooling of homes and operating various electrical appliances.

The discovery of electric energy led to the creation and the invention of devices that revolutionized its era and the inventions of scientists have contributed to the development and progress of the use of electricity.

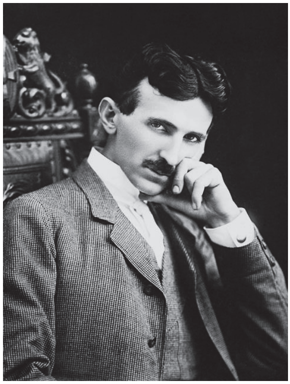


For example, Thomas Edison invented the light bulb, which is one of the most important inventions in human history.

In 1837, Samuel Morse invented the telegraph that was connected to electrical wires across Europe, America, and India.

In 1876 AD, the scientist Alexander Graham Bell invented the telephone devise that transmits sound over long distances by flowing electrical current in copper wires and converting sound to electrical current, and the headphones at the other end convert the electrical vibrations into sound signals.

Nikola Tesla also contributed in bringing electrical inventions to homes to operate interior lighting and factories to operate industrial machinery through the generation, transmission, and use of alternating electricity (AC), and to reduce the cost of transporting electricity over long distances.



Now, energy and electricity are affecting modern agricultural methods, whereby the process of conditioning and storing grains and grass on farms is carried out by modern electrical machinery, as well as milking and cooling milk in dairy farms. Electric-powered equipment has been developed to conserve and store agricultural crops to help cope with the harsh weather conditions that may occur at the time of the harvest. The electrical appliances also helped reduce labor by harvesting the grains within days instead of months and drying them with electric-powered fans. Until they are used for longer periods, agricultural crops are kept in stores with temperature-controlled electric refrigerators.

ACTIVITY 13. Read the text about the importance of electricity in our daily life again. Are these sentences true (T) or false (F) or is the information not mentioned (NM) in the text.

1. Alexander Graham Bell invented the light bulb.
2. Energy and electricity are affecting modern agricultural methods now.
3. The telephone is a devise that transmits sound over long distances by flowing sound in copper wires.
4. In 1896 the scientist Alexander Graham Bell invented the telephone.
5. Electric-powered equipment help to conserve and store agricultural crops.
6. The electrical appliances help reduce labor by harvesting the grains within days instead of months.
7. Electricity can be seen in nature.

8. Samuel Morse contributed in bringing electrical inventions to homes to operate interior lighting and factories to operate industrial machinery through the generation, transmission, and use of alternating electricity (AC), and to reduce the cost of transporting electricity over long distances.

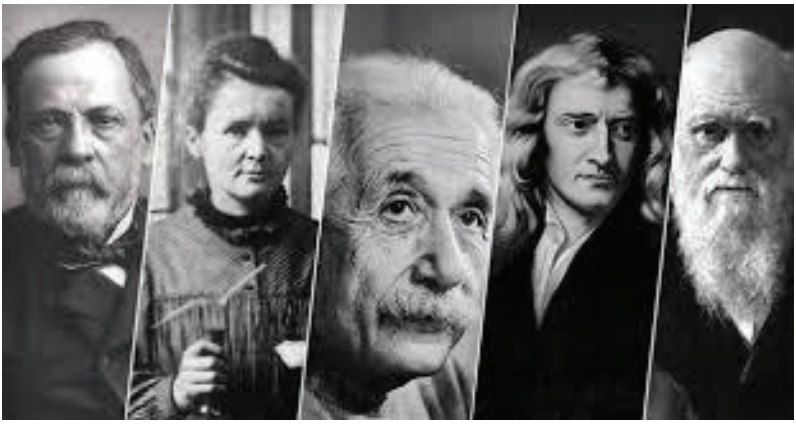
9. Nikola Tesla invented the telegraph that was connected to electrical wires across Europe, America, and India.

10. The electricity is produced by converting natural energy sources such as coal, natural gas, nuclear energy, solar energy, and wind energy into electrical energy.

ACTIVITY 14. Match the inventor to his invention.

1. Samuel Morse	**a.** the AC electric motor
2. Benjamin Franclin	**b.** the nuclear reactor
3. Nikola Tesla	**c.** the telephone
4. Thomas Edison	**d.** the telegraph
5. Alexander Graham Bell	**e.** the light bulb
6. Enrico Fermi	**f.** the lightning rod

ACTIVITY 15. Make ppt presentation about one of the famous scientists and inventors who have contributed to the development and progress of the use of electricity.



CHAPTER 2. POWER SYSTEM AND ELECTRIC POWER CONSUMERS

ACTIVITY 1. Find the meaning of the words given in bold print in the dictionary. Read the following article and do the activities that follow it.

ELECTRIC POWER CONSUMERS AND POWER SYSTEM

An electric **power consumer** is an enterprise utilizing electric power. Its operating characteristics vary during the hours of day, days and nights, days of week and seasons.

All electric power consumers are divided into groups with common **load characteristics**. The first group consists of municipal consumers with a predominant lighting load: dwelling houses, hospitals, theatres, street lighting systems, etc. The second group consists of **industrial consumers** with a predominant power load (electric motors): industrial plants, mines, etc. The third group consists of transport, for example, electrified railways. The fourth one consists of agricultural consumers, for example, electro tractors.

The **operating load conditions** of each group are determined by the **load graph**. The load graph shows the consumption of power during different periods of day, month, and year. On the load graph the time of the maximum loads and minimum loads is given.

Large industrial areas with cities are supplied from **electric networks** fed by **electric power plants**. These plants are interconnected for operation in parallel and located in different parts of the given area. They may include some large **thermal and hydroelectric power plants**.

The total sum of the electric power plants, the networks that interconnect them and the power utilizing devices of the consumers, is called a **power system**. All the components of a power system are interrelated by the common processes of protection, distribution, and consumption of both electric and heat power.

In a power system, all the parallelly operating plants take part in carrying the total load of all the consumers supplied by the given system.

The building up of a power system is of great importance for the national economy.

A) Match the words (1-7) and (a-g) to make phrases.

1. a power	**a.** economy
2. a load	**b.** network
3. a power	**c.** plant
4. an electric	**d.** graph
5. a national	**e.** consumer
6. a power	**f.** characteristic
7. a load	**g.** system

B) Choose the correct items to complete the sentences. Translate the following sentences into Ukrainian.

1. Large industrial areas with cities are supplied from_____________ fed by electric power plants.

2. All electric _____________ are divided into groups with common load characteristics.

3. The total sum of the electric power plants, the networks that interconnect them and _____________ of the consumers, is called a power system.

4. The load graph shows _____________of power during different periods of day, month, and year.

5. In a power system, all the parallelly operating plants take part in carrying ________ of all the consumers supplied by the given system.

C) Answer the questions.

1. What is an electric power consumer?
2. How many groups can electric power consumers be divided into?
3. What consumers does each group consist of?
4. What are the operating load conditions determined by?
5. What does a load graph show?
6. What is called a power system?
7. What processes are the components of a power system interrelated by?

ACTIVITY 2. Read the text below. Match choices (A – F) to (1 – 4). There are two choices you do not need to use.

ELECTRIC POWER PLANTS

Electric power is generated at electric power plants. The main unit of an electric power plant comprises a prime mover and **1) ______________________.** In order to actuate the prime mover energy is required. Many different sources of energy are in use nowadays. To these sources belong heat obtained by burning fuels, pressure due to the flow of air (wind), solar heat, etc.

According **2) ________________________**, power plants are divided into groups. Thermal, hydraulic (waterpower) and wind plants form these groups.

According to the kind of prime mover, electric power plants can be divided into the following types:

- **Steam turbine plants**, where steam turbines serve as prime movers. The main generating units at steam turbine plants are the turbo generators. Steam turbine plants belong to the modern, high-capacity class of power plants.

- **Steam engine plants**, in which the prime mover is a piston-type steam engine. Nowadays no large generating plants of industrial importance are constructed with such prime movers. They are used only **3) ______________________.**
- **Diesel engine plants** where diesel internal combustion engines are installed. These plants are of small capacity and they are used for local power supply.
- **Hydroelectric power plants** use **4) _____________________.** Therefore, they are called hydro turbine plants. Their main generating unit is the hydro generator.

Modern wind-electric power plants utilize various turbines; these plants as well as the small capacity hydroelectric power plants are widely used in agriculture.

A – water turbines as prime movers

B – the generator, which it rotates

C – the turbo generators

D – small capacity hydroelectric power plants

E – to the kind of energy used by the prime mover

F – for local power supply

ACTIVITY 3. Match the words (1-10) and (a-j) to make phrases then make your own sentences with them.

1. main generating	**a.** power plants
2. electric power consumers are	**b.** in agriculture
3. electric power	**c.** the consumption of power
4. take part	**d.** units
5. modern wind-electric	**e.** divided into groups
6. widely used	**f.** of power plants
7. load graph shows	**g.** a power system
8. high-capacity class	**h.** as prime movers
9. the components of	**i.** plants
10. steam turbines serve	**j.** in carrying

ACTIVITY 4. Read and translate the text below.

Hydroelectric power plants transform the hydraulic energy of a river, either natural or artificial, into renewable electrical energy.

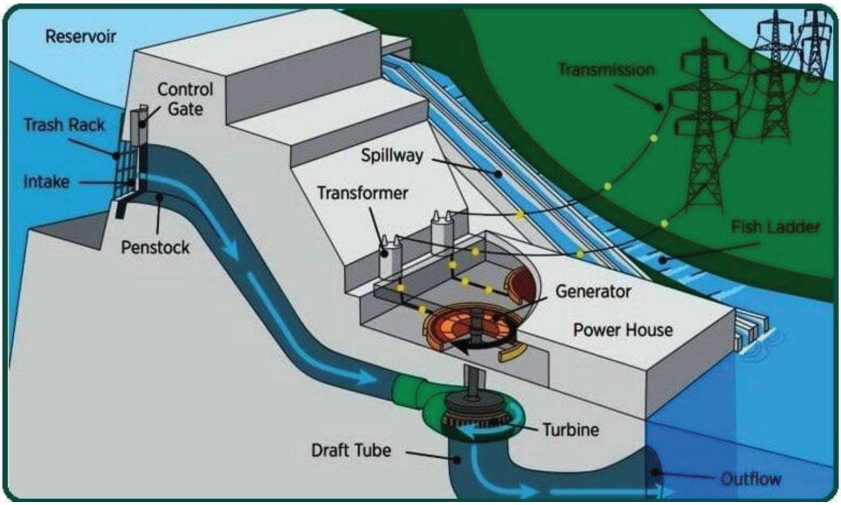
So just how do we get electricity from water? Actually, hydroelectric and coal-fired power plants produce electricity in a similar way. In both cases, a power source is used to turn a propeller-like piece called a turbine, which then turns a metal shaft in an electric generator, which is the motor that produces electricity. A coal-fired power plant uses steam to turn the turbine blades, whereas a hydroelectric plant uses falling water to turn the turbine. The results are the same.

In the energy sector of Ukraine, hydroelectric power plants occupy the third place after thermal (coal and natural gas) and atomic energy.

The Dnipro hydroelectric power station is a large hydroelectric power plant of the south of Ukraine, which is the oldest among the cascade of power stations on the Dnipro River and is rightfully considered a symbol of Zaporizhzhia and an entire era.

This is a large hydroelectric power station in the south of Ukraine, the fifth stage of a cascade of hydroelectric power stations, provides electricity to the Donetsk-Kryvyi Rih industrial area.

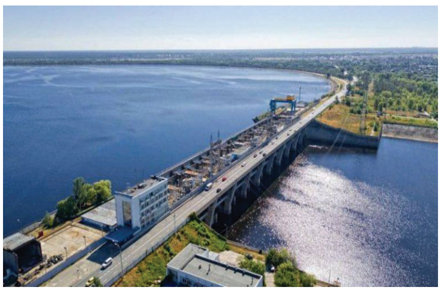
ACTIVITY 5. Match the words with their Ukrainian equivalents.



1. Draft Tube	a. відтік
2. Control Gate	b. передача
3. Trash Rack	c. тягова труба
4. Spillway	d. сміттєутримуючі решітки
5. Outflow	e. контрольні ворота
6. Fish Ladder	f. водозлив
7. Penstock	g. рибні сходи
8. Transmission	h. напірний трубопровід

ACTIVITY 6. Read the text about hydroelectric power plants again. Are these sentences true (T) or false (F) or is the information not mentioned (NM) in the text.

1. A hydroelectric plant uses falling water to turn the turbine.
2. Hydroelectric and coal-fired power plants produce electricity in different ways.
3. The experience shows that hydroelectric plants are always reliable and safe.
4. Hydroelectric power plants transform the hydraulic energy of a river, either natural or artificial, into renewable electrical energy.
5. Kyiv hydroelectric power plant is the oldest among the cascade of power stations on the Dnipro River.



ACTIVITY 7. Find the meaning of the words given in bold print in the dictionary. Read the following article and do the activities that follow it.

ATOMIC POWER STATIONS

An atomic power station is similar to **conventional power stations**, the only difference being the **furnace,** that is to say, instead of a coal-burning furnace it has a nuclear furnace. This means that heat is produced by **nuclear fission** in a reactor.

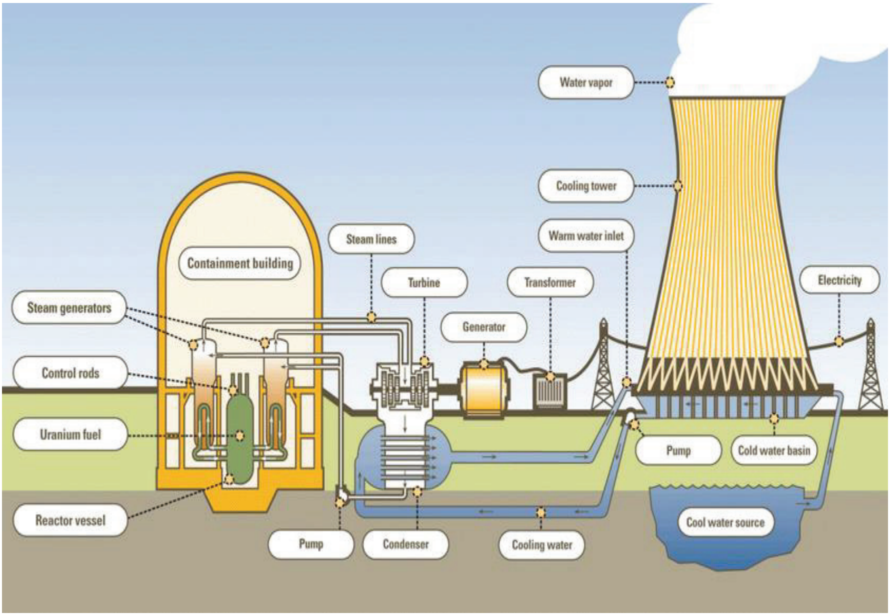
The experience that has been accumulated shows that atomic power stations are reliable and safe. At the same time, the best design for an atomic power station has to be found.

There is a large number of variants of projects for using **atomic fuel** for the output of electric power. The electricity generated by atomic power stations still costs much less than that obtained from **thermal power stations**, to say nothing of the electricity produced by hydropower stations.

In spite of this, there is great need for developing the best types of atomic power stations. Yet, scientists in different countries failed in developing the best type of atomic power stations.

In some areas of the world, there is a **shortage** of fuel and waterpower necessary for the development of electrification. To supply these areas fuel has to be transported over long distances. Fuel, even **high-grade fuel**, contains only an insignificant **quantity of power**. For example, a ton of oil if fully burnt yields **approximately** 12,000 kilowatt-hours of electricity, coal giving even less than that – only 8,000 kilowatt-hours. Yet, as little as half a gram of uranium can produce as much as 10,000 kilowatt-hours of electricity.

For that reason, atomic power stations are being built in industrially developed areas, with **poor power resources**. It is believed that atomic power station will be built in **permafrost** regions too. It is known that use is made of different reactors nowadays. Mention should be made that work has been started to utilize the energy of the atom not through the conversional steam turbine generator **scheme** but though the conversion of atomic power directly into electricity.



The scientists are studying reactors operating on fast moving neutrons, it is planned to install such reactors in future industrial atomic power stations. There is a great future in the **nuclear synthesis** of **light nuclei of thermonuclear reactions** that is a source of **inexhaustible energy**. There is no doubt that this problem will be successfully solved.

A) Translate the following special words and word combinations into Ukrainian:

Steam line \ steam generator \ warm water inlet \ cool water source \ control rods \ water vapor \ cooling tower \ containment building \ uranium fuel \ reactor vessel \ pump.

B) Arrange the sentences in logical order according to the text.

A. The experience that has been accumulated shows that atomic power stations are reliable and safe.

B. The scientists are studying reactors operating on fast moving neutrons.

C. An atomic power station is similar to conventional power stations.

D. The atomic power station will be built in permafrost regions.

E. The electricity generated by atomic power stations still costs much less than that obtained from thermal power stations.

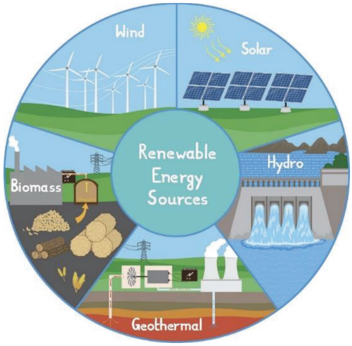
1)	**2)**	**3)**	**4)**	**5)**

C) Choose the correct items to complete the sentences. Translate the following sentences into Ukrainian.

1. Atomic power stations are being built in ___________ areas, with poor power resources.
2. The electricity generated by atomic power stations still costs ___________ than that obtained from thermal power stations.
3. The experience that has been accumulated shows that ___________ are reliable and safe.
4. The scientists are studying reactors operating on ___________ neutrons, it is planned to install such reactors in future industrial atomic power stations.
5. There is a large number of variants of projects for using ___________ for the output of electric power.

ACTIVITY 8. Read and discuss the text below.

THE FUTURE OF ELECTRICITY: RENEWABLE ENERGY



Renewable energy is energy produced from sources like the sun and wind that are naturally replenished and do not run out. Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation.

Renewable energy sources, such as biomass, geothermal resources, sunlight, water, and wind, are natural resources that can be converted into these types of clean, usable energy.

SOLAR ENERGY

The amount of sunlight that strikes the earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year. Solar technologies convert sunlight into electrical energy either through photovoltaic (PV) panels or through mirrors that concentrate solar radiation. This energy can be used to generate electricity or be stored in batteries or thermal storage.

WIND ENERGY

Once called windmills, the technology used to harness the power of wind has advanced significantly over the past ten years, with the United States increasing its wind power capacity 30% year over year. Wind turbines, as they are now called, collect and convert the kinetic energy that wind produces into electricity to help power the grid.

BIOENERGY

Bioenergy is one of many diverse resources available to help meet our demand for energy. It is a form of renewable energy that is derived from recently living organic materials known as biomass, which can be used to produce transportation fuels, heat, electricity, and products. Biomass power plants typically directly burn feedstock such as wood chips, agricultural waste, some types of garbage or animal manure to produce electricity. Or they can convert the materials into combustible gases, then burn those to generate power.

GEOTHERMAL ENERGY

Geothermal energy is heat energy from the Earth [Geo (earth) + thermal (heat)]. Geothermal resources are reservoirs of hot water that exist or are human made at varying temperatures and depths below the Earth's surface. Wells, ranging from a few feet to several miles deep, can be drilled into underground reservoirs to tap steam and very hot water that can be brought to the surface for use in a variety of applications, including electricity generation, direct use, and heating and cooling. Humans have been harnessing the power of super-hot steams underneath the Earth’s surface for more than 10,000 years, but the first geothermal power generator was built in Italy in1904.

FUEL CELLS

Fuel cells produce energy through chemical reactions that combine hydrogen with oxygen. When a hydrogen-rich fuel such as natural gas or biogas flows through a fuel cell and reacts with oxygen, it produces electricity, heat and water. Fuel cells, which emit about half of the emission of a fossil fuel power plant, aren't cheap enough to become a primary power source, but they are being used by a growing number of companies to provide backup power as well as reduce their carbon footprints. Fuel cells also are making their way into the automotive world to create zero-emissions cars.

MARINE ENERGY

The rhythmic and powerful movements of the ocean current and waves can drive electric generators to produce a steady stream and vast amount of power, which would then be transported to land via cables. But developing equipment that will effectively capture that mechanical energy and withstand the corrosive salt water and other natural elements out in the ocean has proven extremely challenging.

ACTIVITY 9. Write the questions to the sentences using the question words in brackets.

1. Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation. (What…for?)

2. Solar energy can be used to generate electricity or be stored in batteries or thermal storage. (What…to?)

3. Wind turbines collect and convert the kinetic energy that wind produces into electricity to help power the grid. (What?)

4. Biomass power plants can convert the materials into combustible gases. (What…into?)

5. Geothermal energy is heat energy from the Earth. (Where…from?)

6. Fuel cells produce energy through chemical reactions that combine hydrogen with oxygen. (What…through?)

7. The rhythmic and powerful movements of the ocean current and waves can drive electric generators to produce a steady stream and vast amount of power. (What?)

8. Fuel cells are making their way into the automotive world to create zero-emissions cars. (What…into?)

ACTIVITY 10. Choose the correct items to complete the sentences. Translate the following sentences into Ukrainian.

1. Bioenergy is one of many __________ available to help meet our demand for energy.

2. The amount of sunlight that strikes__________ in an hour and a half is enough to handle the entire world's energy consumption for a full year.

3. Fuel cells are making their way into ________ to create zero-emissions cars.

4. Once called windmills, the technology used to harness __________ has advanced significantly over the past ten years, with the United States increasing its wind power capacity 30% year over year.

5. Renewable __________, such as biomass, geothermal resources, sunlight, water, and wind, are natural resources that can be converted into these types of clean, usable energy.

ACTIVITY 11. Read the following article and answer the questions after it.

POWER TRANSMISSION LINES

A power system is an interconnection of electric power stations and electric power consumers by high voltage power transmission lines. Nowadays the electricity is transmitted over long distances and the length of transmitting power lines varies from area to area.

A wire system is called a power line in case it has no parallel branches and a power network in case it has parallel branches.

According to their functions, power lines and networks are subdivided into transmission and distribution lines. Transmission lines serve to deliver power from a station to distribution centers. Distribution lines deliver power from distribution centers to the loads.

Lines are also divided into overhead, indoor and cable (underground).

Overhead lines comprise line conductors, insulators, and supports. The conductors are attached to the insulators, and these are attached to the supports. The greater the offered resistance, the higher are the heating losses in the conducting wires. The losses can be reduced simply by using a step down transformer.

Indoor lines include conductors, cords, and buses. A conductor may comprise one wire or a combination of bare wires not insulated from one another. They deliver electric current to the consumer.

As to underground lines, they are suitable for urban areas. Accordingly, they are used in cities and in the areas of industrial enterprises.

Answer the questions:

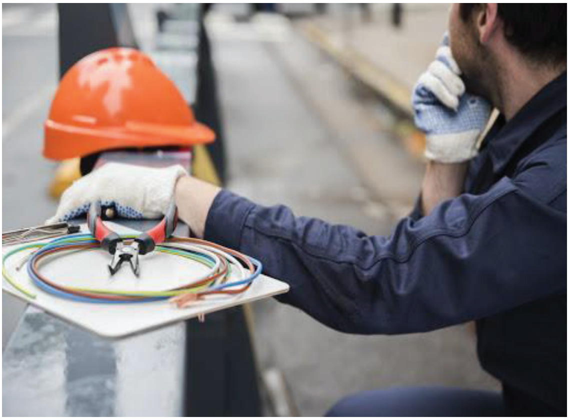
1. What is the difference between a power line and a power network?
2. How can we divide power transmission lines according to their functions?
3. What do overhead lines comprise?
4. How can heating losses be reduced?
5. What do indoor lines include?
6. Where are underground lines used?

ACTIVITY 12. Make ppt presentation about renewable energy sources and providing renewable electricity.

CHAPTER 3. ELECTRICAL ENGINEERING

ACTIVITY 1. Read the following article and answer the questions after it.

WHAT IS ELECTRICAL ENGINEERING?



Electrical engineering covers the study, design, and application of equipment and systems that use electricity. Electricity is central to our lives and its role will continue to grow in the coming decades as green transportation and renewable energy rely more and more on smart electric energy.

Electrical engineers use their knowledge of electricity, electromagnetism and electronics to build everything from electric cars to control systems. Because electrical currents are invisible to the human eye, electrical engineers rely on mathematics to create models that help them understand their mechanics.

Electrical engineers design, develop, test, and supervise the manufacture of electrical equipment, such as electric motors, radar and navigation systems, communications networks, or power generation equipment. They invent advanced electronic and photonic devices, integrated circuits, or information processing systems. Electrical engineers also design the electrical systems of automobiles and aircraft, wireless systems, autonomous systems, computing systems, and signal and information processing systems.

Answer the questions:

1. What is electrical engineering?
2. What knowledge do electrical engineers use in their work?
3. What can electrical engineers do?

ACTIVITY 2. Put the words into correct order to make up sentences.

1. devices \ electrical engineers \ advanced \ invent \ electronic and photonic.
2. knowledge of electricity \ electrical engineers \ their \ to build \ use \ electromagnetism \ and \ electronics \ everything .
3. invisible \ electrical \ are \ to \ currents \ the human eye.
4. aircraft \ electrical \ also \ automobiles \ design \ the electrical systems \ of \ and \ engineers.
5. electrical engineering \ use electricity \ the study \ and \ application of equipment \ and \ design \ systems \ covers \ that.

ACTIVITY 3. Read and discuss the text below.

WHAT IS A POWER ENGINEER?

A power engineer is responsible for designing, maintaining, and operating various types of power systems. These power systems can include electrical power grids, renewable energy systems, and traditional fossil fuel-based power plants. Power engineers must have a strong understanding of electrical and mechanical engineering, as well as an understanding of the various technologies used in power generation, distribution, and transmission.

Power engineers may work in a variety of industries, including utilities, manufacturing, and government. Their responsibilities can range from designing new power systems to ensuring that existing systems are operating efficiently and safely. They may also be responsible for troubleshooting issues and developing solutions to improve power system performance. In addition to technical knowledge, power engineers must also have strong problem-solving, communication, and project management skills to be successful in their role.

The importance of power engineers cannot be overstated in our modern society, which relies heavily on energy and power to operate. Power engineers play a crucial role in designing and maintaining the infrastructure that supplies electricity to homes, businesses, and industries. Without their expertise, we would not be able to access the reliable and affordable power that we rely on for daily life.

Additionally, power engineers are key players in the transition to more sustainable and environmentally friendly forms of energy, such as solar and wind power. As the demand for energy continues to grow, the work of power engineers will be increasingly important to ensure that our energy systems are safe, efficient, and sustainable for generations to come.

ACTIVITY 4. Put the words into correct order to make up sentences.

1. Power engineers / of electrical and mechanical / a strong understanding / must have / engineering.
2. Power engineers / that / the infrastructure / in designing and maintaining / play a crucial role / supplies electricity.
3. Power engineers / in a variety / may work / of industries.
4. Power engineers / with new technologies / must stay current / and industry developments.
5. Power engineers / designing / are responsible for / new power systems.
6. Power engineers / are responsible for / various types / designing, maintaining, and operating / of power systems.

ACTIVITY 5. Choose the correct items to complete the sentences. Translate the following sentences into Ukrainian.

1. Power engineers must have a strong understanding __________.
2. Power engineers are key players in the transition to environmentally friendly __________, such as solar and wind power.
3. The responsibilities of power engineers can range from designing new power systems to __________ are operating efficiently and safely.
4. Power engineers are responsible for designing, __________, and __________ various types of power systems.
5. Power engineers play a crucial role in designing and maintaining the infrastructure that supplies electricity to __________, __________, and industries.

ACTIVITY 6. Find the meaning of the words given in bold print in the dictionary. Read and translate the following articles.

TYPES OF POWER ENGINEERS

There are several types of power engineers, each with their own specialization and responsibilities. Some common types of power engineers include:

Electrical power engineers: Electrical power engineers design, maintain, and operate electrical power systems, including the generation, transmission, and distribution of electricity.

Control systems engineers: Control systems engineers design and maintain the automated control systems used in power generation and distribution. This can include systems that regulate the flow of electricity, monitor equipment performance, and manage power grid stability.

Renewable energy engineers: Renewable energy engineers design and maintain renewable energy systems, such as solar and wind power systems. They may also be involved in developing new renewable energy technologies.

Substation engineers: Substation engineers design and maintain the equipment used to transform high voltage electricity from power plants into lower voltage electricity that can be used by homes and businesses.

Power systems engineers: Power systems engineers design and manage the overall power system infrastructure, including the equipment, software, and processes used to generate, transmit, and distribute power.

Transmission and distribution engineers: Transmission and distribution engineers design and maintain the infrastructure used to transmit and distribute electricity, including power lines, transformers, and switchgear.

ACTIVITY 7. Write the questions to the sentences using the question words in brackets.

1. There are several types of power engineers, each with their own specialization and responsibilities. (What?)
2. Electrical power engineers design, maintain, and operate electrical power systems, including the generation, transmission, and distribution of electricity. (Who?)
3. Renewable energy engineers may also be involved in developing new renewable energy technologies. (Where?)
4. Substation engineers design and maintain the equipment used to transform high voltage electricity from power plants into lower voltage electricity that can be used by homes and businesses. (Who?)

ACTIVITY 8. Read the text below. Match choices (A – G) to (1 – 5). There are two choices you do not need to use.

THE WORKPLACE OF A POWER ENGINEER

Power engineers work **1) __________** , including power plants, electrical utilities, manufacturing facilities, and government agencies. Depending on their specific job duties, power engineers may **2) __________** or control room, or they may spend significant amounts of time in the field, working on equipment or overseeing construction projects.

In power plants and utilities, power engineers are responsible for ensuring that the electrical grid is operating safely and efficiently. They monitor the flow of electricity and make adjustments as necessary to maintain a steady supply of power. They also troubleshoot problems that arise, such as power outages or equipment failures, and work to quickly restore power to customers.

In manufacturing facilities, power engineers are responsible **3) __________** that power the equipment used in production. They also oversee the installation of new equipment and work to optimize the efficiency of existing systems.

In government agencies, power engineers may work on projects related to energy policy or renewable energy sources. They may also be involved in **4) __________** improve the efficiency and sustainability of the electrical grid.

Regardless of the specific setting, power engineers often work long hours and may be on call for emergencies outside of regular business hours. They must be able **5)** __________ decisions under pressure, and they must have a strong understanding of electrical systems and the principles of engineering. While the work can be challenging, power engineers also have the satisfaction of knowing that they are helping to keep the lights on and power the modern world.

A – for designing and maintaining the electrical systems
B – have the satisfaction of knowing
C – research and development of new technologies to
D – in a variety of settings
E – power engineers may work on projects
F – spend most of their time in an office
G – to think quickly and make

ACTIVITY 9. Read the following article and answer the questions after it.

DUTIES AND RESPONSIBILITIES

The specific duties and responsibilities of a power engineer can vary depending on their job title and industry. However, some common tasks and responsibilities of power engineers include:

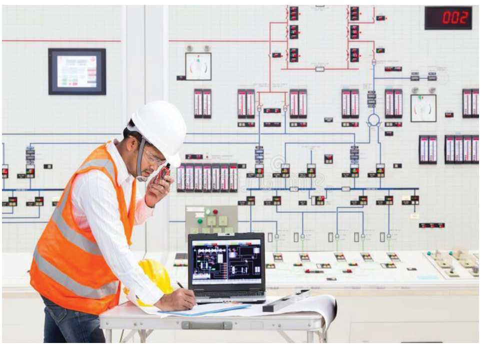
Designing power systems: Power engineers are responsible for designing new power systems, which involves determining the electrical load requirements and selecting the appropriate equipment and technology to meet those needs.

Installing and maintaining equipment: Power engineers are responsible for installing and maintaining the various components of power systems, such as generators, transformers, and distribution networks.

Troubleshooting: When power systems experience problems, power engineers are responsible for identifying and resolving the issues. This may involve conducting diagnostic tests, repairing or replacing faulty equipment, or making changes to the system configuration.

Ensuring safety and compliance: Power engineers must ensure that power systems are operating safely and in compliance with relevant regulations and standards. This includes conducting safety inspections and making necessary repairs or modifications to equipment and systems.

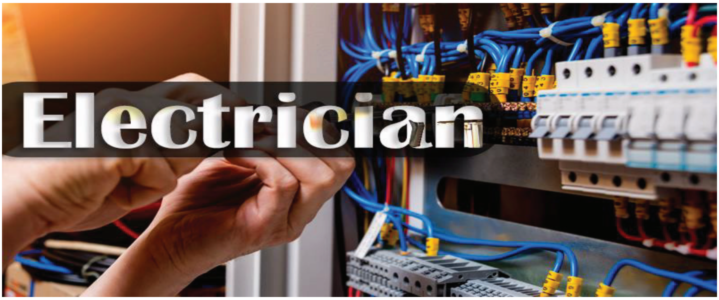
Managing projects: Power engineers may be responsible for managing projects related to power system design, installation, or maintenance. This may involve coordinating with other engineers and stakeholders, managing budgets and timelines, and overseeing the work of technicians and other staff.



Staying up-to-date with technology and industry developments: Power engineers must stay current with new technologies and industry developments in order to design and maintain cutting-edge power systems. This may involve attending industry conferences and training sessions, reading industry publications, and participating in professional organizations.

Answer the questions:

1. What are power engineers responsible for?
2. When are power engineers responsible for identifying and resolving the issues?
3. What may resolving the issues involve when power systems experience problems?
4. What does ensuring safety of power systems include?
5. Why should power engineers stay current with new technologies and industry developments?



ACTIVITY 10. Fill in the gaps in these sentences with a suitable word. The first letter of each missing word is given. The words in the box bellow the text can help you.

Electricians install, **m**__________ and repair electrical systems in industrial, commercial and domestic **e**___________. Electricians might work in both **i**___________ and **o**__________ settings. Electrical **e**___________ and systems may include **s**__________, motors, **c**___________, fuses, thermal **r**__________, fault current protection switches, relays, **l**___________, air **c**__________ and metering equipment as well as crime and fire **a**__________ systems and renewable **e**__________ technologies. They are able to work on their own proficiently and work without immediate supervision in the most efficient and economical manner.

cables, alarm, equipment, conditioning, indoor, lighting, switchboards, energy, maintain, environments, relays, outdoor

ACTIVITY 11. Use the following ideas to talk about the profession of an electrician.

10 LINES ON ELECTRICIAN

1. Electrician is a person who manufactures and repairs things that run on electricity.
2. Electrician does electrical wiring and repairs in our homes.
3. Installation of things used in homes like TV, fridge, washing machine, cooler, fan, etc. is done by an electrician only.

4. Wherever we have to make electrical connections in our homes, this work is also done by the electrician.
5. Electrician is a very useful community in our society.
6. Without an electrician our life would not have been so smooth.
7. Electrical work is a dangerous job, for this, electricians first take training for it, then they become a skilled electrician.

8. How to use electricity, how to maintain it, how to reduce short circuit conditions, etc., are all taught during training.
9. They have special types of tools to do electrical work.

10. The most commonly used tools by an electrician are a screwdriver, tester, multimeter, hammer, tape, wire cutter, etc.

ACTIVITY 12. Read and discuss the text below.

ANALYSIS OF THE IMPACT THAT ELECTRICIANS HAVE ON SOCIETY AND THE ECONOMY

Electricians have a significant impact on society and the economy. They are responsible for ensuring that our homes and buildings have safe and reliable electrical systems. Without them, we would not have access to electricity and our daily lives would be greatly impacted. They also play an important role in the economy, as the demand for electricians is always high and their skills are in high demand.

In terms of society, electricians are responsible for maintaining and upgrading the electrical infrastructure that powers our homes, businesses, and communities. They ensure that our lights turn on, our appliances work, and our buildings are safe.

They also play a crucial role in the development and implementation of alternative energy sources, such as solar and wind power, which are becoming increasingly important as society looks for ways to reduce its dependence on fossil fuels.

ACTIVITY 13. Answer the questions.

1. Why have you decided to become an electrician?
2. What is electrical engineering?
3. What knowledge do electrical engineers use in their work?
4. What specific duties and responsibilities does a power engineer have?
5. Where do you take training to become a skilled electrician?

ACTIVITY 14. Find the meaning of the words given in bold print in the dictionary. Read and translate the following articles.

WHAT WILL ELECTRICIANS BE DOING IN THE FUTURE?

The electrical field is **vast and diverse**, whether related to any **skill or simple** electrical engineering.

Moreover, as the world is progressing, **manual work** is reduced, and technology is taking over with new gadgets and appliances; hence, the electricians play a significant part in **the ultimate progress** of the world towards technology and **saving time** with the energy of people. However, the future holds many new and **adventurous things** for this field.

Currently, the electrician will have roles limited to **skilled working**; however, they can be employed for contracts related to **lighting system upgrades** in the future.

It is essential to preserve **the non-renewable energy resources** and switch to renewable ones to sustain energy for future generations. The demand for energy, especially **green energy**, will increase significantly. In the future, the need for these workers can grow more than 50 percent, including jobs such as **installing solar panels**, developing and inventing new energy solutions, and working on new **automated tracking systems**.

The workers themselves are enthusiastic in current projects towards sustainable energy; three in four workers working on **sustainable energy** noted that they enjoyed the process of learning something new and implementing it.

Nowadays, power is being generated through coal and water worldwide; however, newer **vehicles generates power** through wind and thermal energy. Therefore, there is a high chance of increasing job opportunities and onsite work for electrically skilled workers in the power generation field through wind and thermal energy for **plant installation and repairing**.

These are just a few ways that the field is changing but it is exciting to see how different professions are gearing toward sustainability initiatives.

ACTIVITY 14. Make ppt presentation about benefits of being an electrician.

CHAPTER 4. ADDITIONAL READING

TEXT 1. ENGINEERING

Task 1. Read and translate the article.

Engineering is largely a practical activity. It is about putting ideas into action. Civil engineering is concerned with making bridges, roads, airports, etc. Mechanical engineering deals with the design and manufacture of tools and machines.

Electrical engineering is about the generation and distribution of electricity and its many applications. Electronic engineering is concerned with developing components and equipment for communications, computing, and so on.

Mechanical engineering includes marine, automobile, aeronautical, heating and ventilating, and others. Electrical engineering includes electricity generating, electrical installation, lighting, etc. Mining and medical engineering belong partly to mechanical and to electrical.

Transport: Cars, trains, ships, and planes are all products of mechanical engineering. Mechanical engineers are also involved in support services such as roads, rail track, harbors, and bridges.

Food processing: Mechanical engineers design, develop, and make the machines and the processing equipment for harvesting, preparing and preserving the foods and drinks that fill the supermarkets.

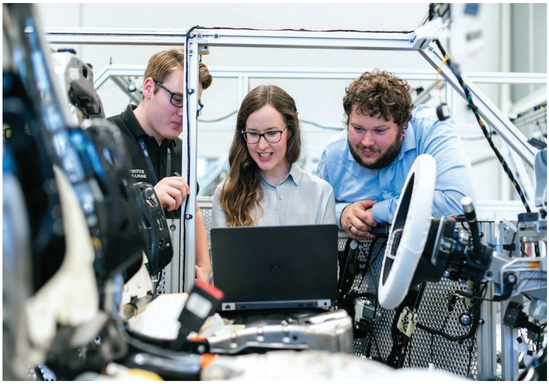
Medical engineering: Body scanners, x-ray machines, life-support systems, and other high-tech equipment result from mechanical and electrical engineers combining with medical experts to convert ideas into life-saving and preserving products.

Building services: Electrical engineers provide all the services we need in our homes and places of work, including lighting, heating, ventilation, air-conditioning, refrigeration, and lifts.

Energy and power: Electrical engineers are concerned with the production and distribution of electricity to homes, offices, industry, hospitals, colleges and schools, and the installation and maintenance of the equipment involved in these processes.

Task 2. Translate the following word combinations into Ukrainian.

- mechanical engineering
- electrical engineering
- distribution of electricity
- electronic engineering
- developing components
- electrical installation
- preserving the foods
- medical engineering



Task 3. Answer the questions.

1. What is engineering?
2. What is civil engineering?
3. What does mechanical engineering deal with?
4. What is electrical engineering?
5. What is electronic engineering concerned with?
6. What does mechanical engineering include?
7. What do mining and medical engineering belong to?
8. What are products of mechanical engineering?
9. What do electrical engineers provide us?
10. What are electrical engineers concerned with?

TEXT 2. PORTABLE GENERATOR

Task 1. Read and translate the article.

Although most electricity comes from power stations, power can also be generated by far smaller means. Nowadays, electricity generators can be small enough to hold in the hand.

Portable generators are made up of two main parts: an engine, which powers the equipment, and an alternator, which converts motion into electricity.

In a typical four-stroke engine, when the piston descends, the air inlet valve opens and a mixture of air and petrol is sucked in through a carburetor.

The valve closes, the piston rises on the compression stroke and a spark within the upper chamber ignites the mixture. This mini-explosion pushes the piston back down, and as it rises again the fumes formed by the ignition are forced out through the exhaust valve.

This cycle is repeated many times per second. The moving piston makes the crankshaft rotate at great speed.

The crankshaft extends directly to an alternator, which consists of two main sets of winding – coils of insulated copper wire wound closely around an iron core. One set, called stator windings, is in a fixed position and shaped like a broad ring. The other set, the armature windings, is wound on the rotor, which is fixed to the rotating crankshaft. The rotor makes about 3,000 revolutions per minute.

The rotor is magnetized and as it spins round, electricity is generated in the stator windings through the process of electromagnetic induction. The electric current is fed to the output terminals or sockets.

This type of generator can produce a 700-watt output, enough to operate lights, television, and some domestic appliances. Larger versions provide emergency power to hospitals and factories.

In the four-stroke cycle, the piston descends on the intake stroke, during which the inlet valve is open. The piston ascends on the compression stroke with both valves closed and ignition takes place at the top of the stroke. The power or expansion stroke follows. The gas generated by the burning fuel expands rapidly, driving the piston down, both valves remaining closed. The cycle is completed by the exhaust stroke, as the piston ascends once more, forcing the products of combustion out through the exhaust valve. The cycle then repeats itself.

Task 2. Translate the following word combinations into Ukrainian.

- power station
- electricity generator
- portable generator
- coils of insulated copper wire
- an iron core
- armature windings
- rotating crankshaft
- electromagnetic induction
- the electric current
- the output terminals
- domestic appliances
- emergency power

Task 3. Answer the questions.

1. What are portable generators made up?
2. What does the valve and the piston do on the compression stroke?
3. Does the crankshaft extend directly to an alternator?
4. How many sets of windings does the crankshaft consist of?

5. How much revolutions does the rotor make per minute?

6. What is generated in the stator windings through the process of electromagnetic induction?

TEXT 3. THE SOURCES OF ENERGY

Task 1. Read and translate the article.

All the sources of energy put together is the energy locked up in the nuclei of atoms of matter itself. It has been known for at least a century. It is called nuclear energy.

The amount of energy which might be released when the nucleus of one atom is split is very small. But scientists have succeeded in breaking apart the nuclei of billions of atoms and in harnessing their energy. A pound of U235 (Uranium-235) can supply as much energy as the burning up of 3, 000, 000 pounds of coal. Nuclear energy can be used for good and evil. Mankind is interested in atomic energy being used only for peaceful purposes.

Many atomic power plants for producing electric energy were built in many countries of the world. There are great possibilities of using nuclear energy for transport purposes. A number of countries are working at the development and construction of various kinds of locomotives, airplanes and other means of transport. Many atomic powered ships have been already built. Nuclear energy is and will be used in medicine and in many spheres of life where the atom may find useful application.

There are different forms or types of energy. Fuels such as coal, oil (petroleum), and wood contain chemical energy. When these fuels are burnt, the chemical energy changes to heat and light energy.

Electricity is the most important form of energy in the industrialized world, because it can be transported over long distances via cables and transmission lines. It is also a very convenient form of energy, since it can power a wide variety of household appliances and industrialized machinery. It is produced by converting the chemical energy from coal, oil, or natural gas in power stations.

Task 2. Translate the following word combinations into Ukrainian.

- nuclei of atoms
- nuclear energy
- atomic power plants
- chemical energy
- household appliances
- industrialized machinery

Task 3. Answer the questions.

1. How much the sources of energy is locked up in the nuclei of atoms?
2. What have the scientists succeeded in?
3. How much energy can uranium-235 supply?
4. How and where can nuclear energy be used?
5. Are there great possibilities of using nuclear energy for mankind?
6. Is nuclear energy used in many spheres of life?

TEXT 4. ELECTRICITY AND MAGNETISM

Task 1. Read and translate the article.

An electric current is a flow of electricity. There are two kinds of electricity, positive and negative. Glass rubbed with silk is positively charged, ebonite rubbed with fur is negatively charged.

Like charges repel, unlike charges attract. The leaf electroscope is used to detect, distinguish and measure charges.

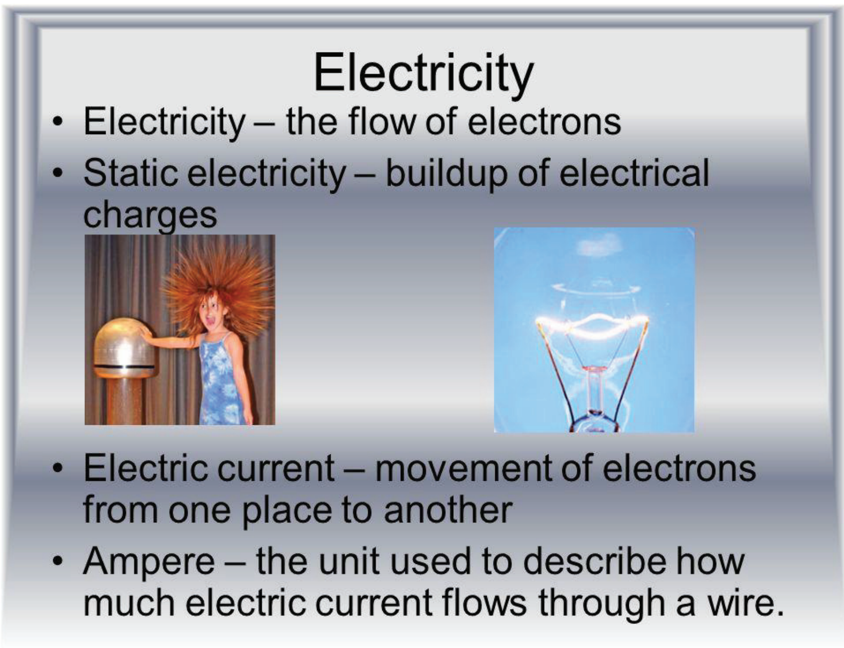
The ultimate particle of negative electricity is called the electron; that of positive electricity is called the proton.

It has been known for centuries that certain black, heavy stones have the property of attracting iron, this property being called magnetism. A body that exhibits magnetism is called a magnet. The two parts of a magnet that show the strongest magnetism are called the North Pole and the South Pole.

Magnets not only affect ordinary iron, but they affect one another. When a pole of one magnet is brought toward a pole of the second magnet, they will repel if both are north poles or both are south poles, but they will attract if one is a north pole and the other a south pole.

The region in which magnetic forces act is called a magnetic field. When placed in a strong magnetic field, iron becomes magnetized. Electricity and magnetism are closely connected.

Almost all metals are good conductors of electricity, with copper being one of the best conductors of all. Glass, paper, rubber are the most common non-conductors or insulators.



Many practical applications have resulted from the utilization of the magnetic effect of an electric current. These effects are used in motors, in most electric meters (ammeters, voltmeters and galvanometers), in electromagnets and in practically all electromechanical apparatus.

Task 2. Translate the following word combinations into Ukrainian.

- flow of electricity
- the ultimate particle of negative electricity
- conductors of electricity
- the property of attracting iron
- magnetic forces
- a strong magnetic field
- electromechanical apparatus
- magnetic effect
- the ultimate particle of negative electricity
- practical applications
- positively charged

Task 3. Answer the questions.

1. What is an electric current?
2. How many kinds of electricity are there?
3. What is the leaf electroscope used for ?
4. What is called magnetism ?
5. What is called the North (South) pole?
6. When do poles repel each other?
7. When do poles attract each other?
8. What is called a magnetic field?

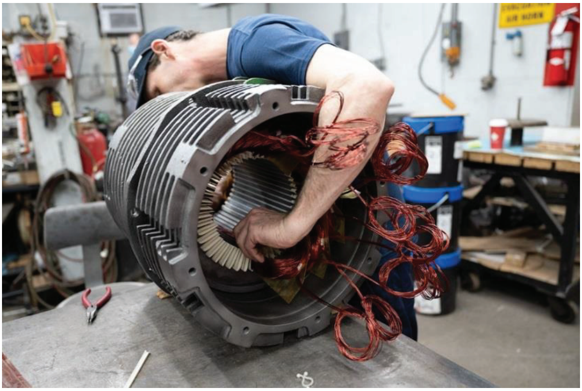
9. What metals are the best conductors?

10. What is called an electric current?

11. Where are the magnetic effects of an electric current used?

TEXT 5. ELECTRIC MOTOR

Task 1. Read and translate the article.



In an electric motor an electric current and magnetic field produce a turning movement. This can drive all sorts of machines, from wristwatches to trains. An electric current running through a wire produces a magnetic field around the wire. If an electric current flows around a loop of wire with a bar of iron through it, the iron becomes magnetized.

It is called an electromagnet; one end becomes a north pole and the other a south pole, depending on which way the current is flowing around the loop.

If you put two magnets close together, like poles – for example, two north poles – repel each other, and unlike poles attract each other.

In a simple electric motor, a piece of iron with loops of wire round it, called an armature, is placed between the north and south poles of a stationary magnet, known as the field magnet. When electricity flows around the armature wire, the iron becomes an electromagnet.

The attraction and repulsion between the poles of this armature magnet and the poles of the field magnet make the armature turn. As a result, its north pole is close to the south pole of the field magnet. Then the current is reversed so the north pole of the armature magnet becomes the south pole. Once again, the attraction and repulsion between it and the field magnet make it turn. The armature continues turning as long as the direction of the current, and therefore its magnetic poles, keeps being reversed.

To reverse the direction of the current, the ends of the armature wire are connected to different halves of a split ring called a commutator. Current flows to and from the commutator through small carbon blocks called brushes. As the armature turns, first one half of the commutator comes into contact with the brush delivering the current, and then the other, so the direction of the current keeps being reversed.

Task 2. Translate the following word combinations into Ukrainian.

- electric motor
- electric current
- magnetic field
- a loop of wire
- stationary magnet
- carbon blocks

Task 3. Answer the questions.

1. What does an electric current do in an electric motor?
2. What is called an electromagnet?
3. What is called an armature?
4. When do the iron become an electromagnet?
5. What makes the armature turn?

TEXT 6. THE PURPOSES OF ELECTRIC NETWORKS

Task 1. Read and translate the article.

An electric network is a combination of electric devices for transfer and distribution of electric energy, consisting of substations, switchboards, conduction, air transmission lines and cable transmission lines operating on a certain territory.

The main purpose of electric networks is supply of electricity to consumers. Electric networks are used for connection of electricity receivers and consumers in aggregate to power sources. This problem is rather complicated because of a large number of electricity receivers and large areas, on which they are located.

The second purpose of electric networks is transfer of electric energy from the place of its generation to the place of its consumption. In most cases, power sources (coal, oil, gas, and water resources) are located at a significant distance from the centers of consumption – factories, inhabited areas, etc. In many cases, transportation of fuel, coal, for example, can be unprofitable; construction of power stations close to fuel pool and transfer of electric energy via electric networks is more preferable. If distances are large, and volumes of transmitted electric energy are significant, a construction of high-capacity transmission lines for a very high voltage is necessary.

Electric networks are also used for creation of energy systems. An energy system is a combination of power plants and constructions, where their generating part is connected through power links for parallel operation, it has a uniform dispatching management and uniform reserve of capacity, and this reserve can be used in any part of the system. Thus, three main features define an energy system: parallel operation of centers of energy production, a uniform management and a uniform common system reserve.

Task 2. Translate the following word combinations into Ukrainian.

- electric networks
- electric devices
- supply electricity to consumers
- transfer of electric energy
- power sources
- transportation of fuel
- transfer of electric energy
- an energy system

Task 3. Answer the questions.

1. What is an electric network?
2. What does an electric network consist of?
3. What is the main purpose of electric network?
4. What are electric networks used for?
5. What is the second purpose of electric network?
6. Where are power sources located?
7. What is an energy system?
8. How many features does an energy system define?

TEXT 7. ENERGY

Task 1. Read and translate the article.

In the language of science, energy is the ability to do work. There are various forms of energy, such as heat, mechanical, electrical, chemical, atomic and so on. One might also mention the two kinds of mechanical energy – potential and kinetic, potential energy being the energy of position while kinetic energy is the energy of motion.

It is well known that one form of energy can be changed into another. A waterfall may serve as an example. Water falling from its raised position, energy changes from potential to kinetic energy. The energy of falling water is generally used to turn the turbines of hydroelectric stations. The turbines in their turn drive the electric generators, the latter producing electric energy. Thus, the mechanical energy of falling water is turned into electric energy. The electric energy, in its turn, may be transformed into any other necessary form.

When an object loses its potential energy, that energy is turned into kinetic energy. Thus, in the above-mentioned example when water is falling from its raised position, it certainly loses its potential energy, that energy changing into kinetic energy.

We have already seen that energy of some kind must be employed to generate the electric current. Generally speaking, the sources of energy usually employed to produce current are either chemical, as in the battery, or mechanical, as in the electromagnetic generator. Chemical sources of current having a limited application, the great quantities of electric energy generated today come from various forms of mechanical energy.

Every year we need more and more energy. We need it to do a lot of useful things that are done by electricity. However, the energy sources of the world are decreasing while the energy needs of the world are increasing. These needs will continue to grow as more motors and melted metals are used in industry and more electric current is employed in everyday life.

Task 2. Translate the following word combinations into Ukrainian.

- chemical sources of current
- industrial application
- semiconductor devices
- potential energy
- solar furnace
- source of direct current
- to change electric energy
- electric device

Task 3. Answer the questions.

1. Can one form of energy be changed into another form?
2. Does a generator produce mechanical energy?
3. Is the sun an unlimited source of energy?
4. Can we employ solar energy directly?
5. Have scientists transformed solar energy into electric energy?
6. Is potential energy the energy of motion?
7. Do we need more and more electric energy every year?
8. Are there various forms of energy?
9. Do you use electric energy every day?

TEXT 8. LASERS AND MASERS

Task 1. Read and translate the article.

A laser is a machine for making and concentrating light waves into a very intense beam. The letters LASER stand for Light Amplification by Stimulated Emission of Radiation. The light made by a laser is much more intense than ordinary light. With ordinary light, all the light waves are different lengths. With lasers, all the light waves have the same length, and this increases the intensity.

Atoms are made up of neutrons, electrons and protons. The electrons circle round the protons and neutrons. In a laser, the electrons are "excited" to a high energy level. As the electrons fall back from their "excited" state to their normal state, they give off energy. This energy is given off as light which can be seen. A number of materials have this property including some gases, liquids, solids and semiconductors. Thus a number of different types of lasers have been developed.

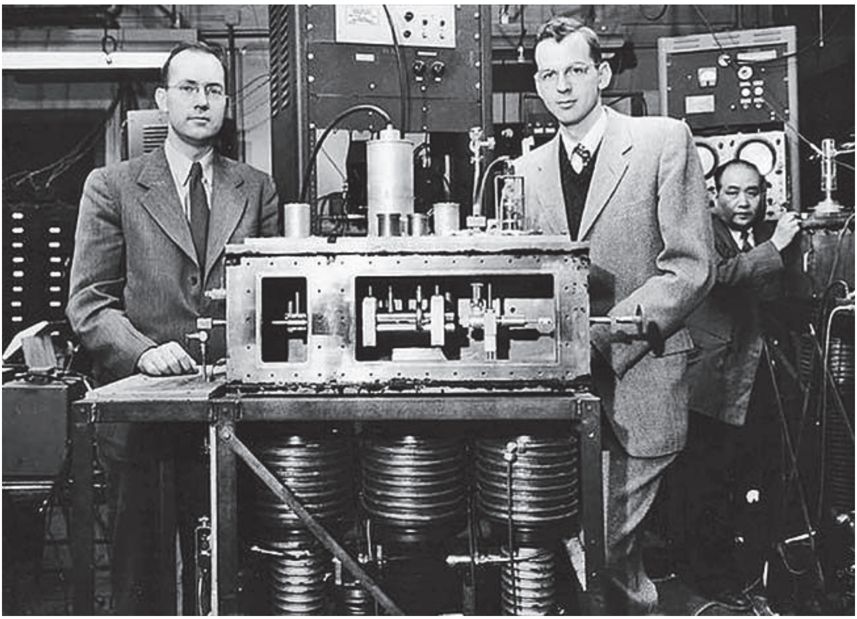
Lasers are now used for many scientific, medical, and industrial purposes. The thin beam of light gives a lot of heat and it is used to join metal when a very small joint is needed. The beam can also be used as a drill, to make holes in steel, or even in diamonds. Because the beam is so small, it's very important in delicate surgery and is used in eye operations.

Lasers are also used in holography. A hologram is a three- dimensional image, a bit like a photograph. It’s different from a photograph because it looks solid.

The word MASER is also an acronym – for Microwave Amplification by Stimulated Emission of Radiation. The maser is operated on the same principle as the laser except that the wavelengths generated are much longer and therefore the energy jumps involved are smaller. The excited bodies in a maser are molecules rather than atomic electrons and the beam generated is a coherent beam of microwaves which is not visible to the eye.

Masers have made revolutionary advance possible in a number of different fields. They are up to 1.000 times more sensitive than any other type of amplifiers. Maser amplifiers mounted on radio telescopes can increase even their great range by a factor of 10, allowing us to reach out to the bounds of the known universe. Because of the very constant frequency with which masers can be made to oscillate they can be used as master controls for atomic clocks of unbelievable accuracy:

An error not exceeding 1 second in 10.000 years has already been achieved.



*Charles Hard Townes (**left**) is pictured in 1954 with the maser he developed with then-graduate student James P. Gordon (**right**) and then-postdoctoral researcher H.J. Zeiger (**not shown**). The device radiated at a wavelength of a little more than 1 cm and generated approximately 10 nW of power. Courtesy of Smithsonian Institution.*

Task 2. Translate the following word combinations into Ukrainian.

- sword of heat
- light amplification
- stimulated emission
- technological tool
- the thin beam of light
- thermonuclear fuel
- required temperature

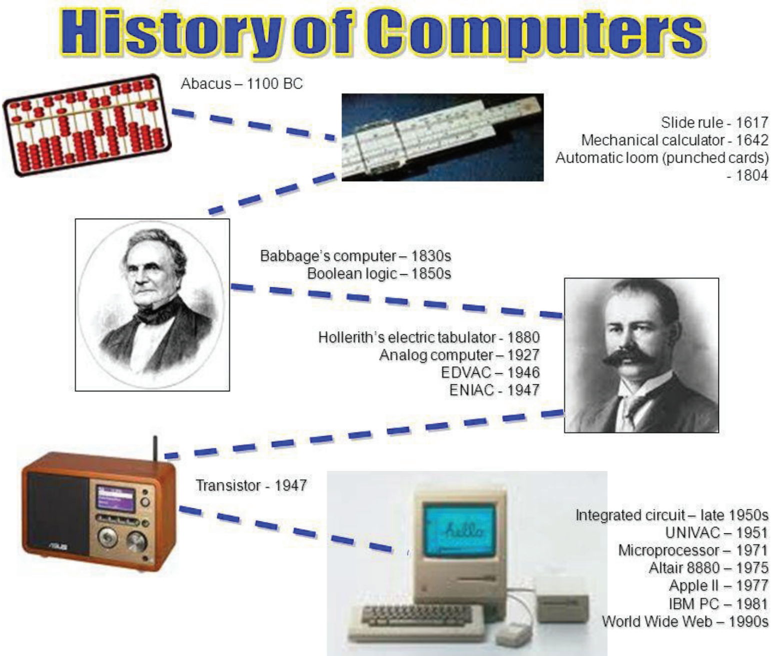
Task 3. Answer the questions.

1. What are atoms made up of?
2. To what level are the electrons excited in a laser?
3. When do they give off energy?
4. In what form is this energy given off?
5. Are lasers used in holography?
6. What is the maser?
7. Have masers made revolutionary advance possible in a number of different fields?
8. What are up to 1.000 times more sensitive than any other type of amplifiers?

TEXT 9. THE DEVELOPMENT OF THE COMPUTER

Task 1. Read and translate the article.

The inventions and ideas of many mathematicians and scientists led to the development of the computer. The first mechanical calculating machines were invented during the 1600's. One of the more notable of these devices was built in 1642 by the French mathematician and scientist Blaise Pascal.



During the 1830's, an English mathematician named Charles Babbage developed the idea of a mechanical digital computer. He tried to construct a machine called an analytical engine. The machine contained the basic elements of an automatic computer and was designed to perform complicated calculations according to a sequence of instructions. However, the technology of Babbage's time was not advanced enough to provide the precision parts needed to complete the machine.

Another important contribution to the development of the computer was made in the mid-1800's by George Boole, an English logician and mathematician. Boole devised a system of formulating logical statements symbolically so that they could be written and proved in a way similar to that of ordinary algebra.

In 1930 the first reliable analogue computer was built . This machine called a different analyser, solved differential equations.

During the 1940's John Von Neumann, an American mathematician, introduced an idea that improved computer design. He proposed that programs could be coded as numbers and stored with data in a computer's memory.

The invention of the transistor in 1947 of related solid-state devices during the 1950's and 1960' resulted in the production of faster and more reliable electronic computers. The new machines also were smaller and less expensive than earlier models.

The continued miniaturization of electronic equipment during the late 1960's and 1970's led to further advances in computer technology. The development of the integrated circuit enabled engineers to design both minicomputers and high-speed mainframes with tremendous memory capacities.

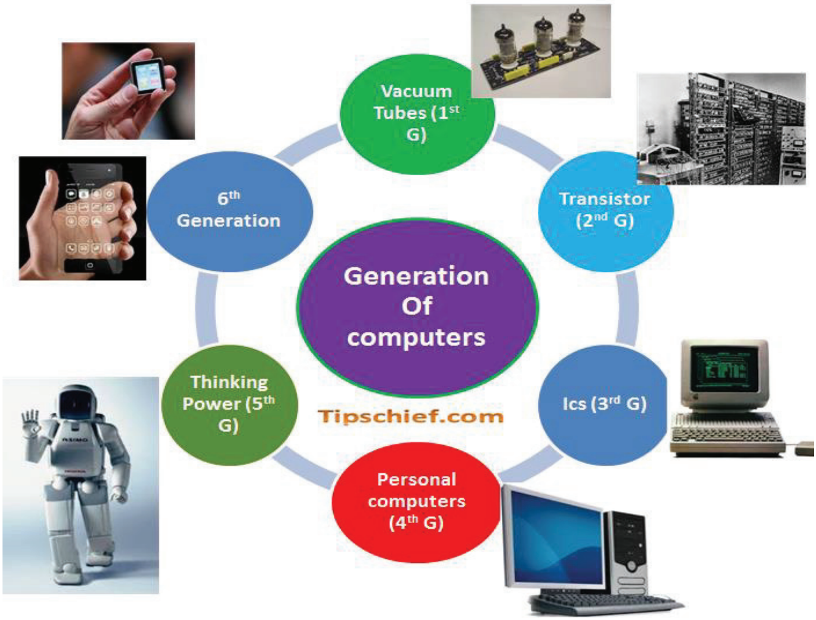
Researches are seeking ways improve memories and auxiliary storage equipment. They expect to produce an efficient magnetic bubble unit, which is faster and cheaper to operate than mechanical tape or disk units. A magnetic bubble unit is a semiconductor chip that stores data in tiny, cylindrically shaped areas called bubbles.

Task 2. Translate the following word combinations into Ukrainian.

- mechanical calculating machine
- digital computer
- analogue computer
- analytical engine
- sequence of instructions
- logical statement
- solid-state device
- integrated circuit
- high-speed mainframe
- auxiliary storage equipment
- magnetic bubble unit
- semiconductor like chip

- a very large-scale integrated circuit(VLSI)
- to devise hardware and software

Task 3. Answer the questions.



1. What did the inventions and ideas of many mathematicians and scientists lead to?

2. When were the first mechanical calculating machines invented?

3. Who developed the idea of a mechanical digital computer?

4. The technology of Babbage's time was not advanced enough, was it?

5. What was built in 1930?

6. What did John Von Neumann introduce during 1940's?

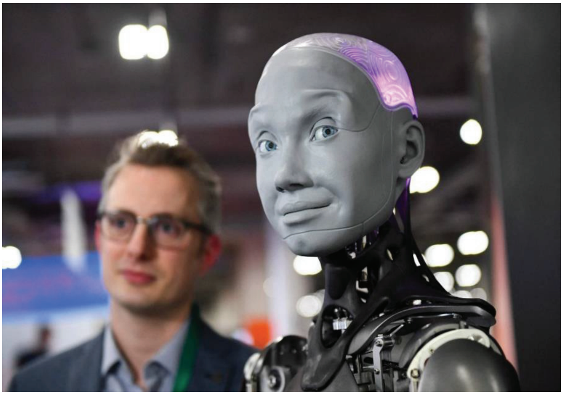
7. What is a magnetic bubble unit?

8. Is the development of the integrated circuit enabled engineers to design both minicomputers and high-speed mainframes with tremendous memory capacities?

9. Who devised a system of formulating logical statements symbolically?

TEXT 10. COMPUTERS AND CYBERNETICS

Task 1. Read and translate the article.



The computers or high-speed electronic machines of today have created entirely new technical possibilities in automatic control of industrial processes. First designed for solving mathematical problems, they soon paved the way for a new field of science – cybernetics – that studies general principles of control in both life and non-live systems. The importance of cybernetics is great in the sphere of engineering sciences. A newly developed field of knowledge is technical cybernetics. Its objectives are to control automatic industrial processes, to study problems of transmission of information and to develop new principles of automatic control.

One of the main problems of technical is the development of control algorithms to be used in processing and control of information flows. The algorithms worked out for employment in control machines are called programs. These are based on subdivision of the computation process into simple arithmetical operations and on determination of the logical operations to be performed with a view to fulfil the program which gives the sequence of the machine's operations, and must be coded or expressed in the adopted code system.

Two systems of computers are now created for control computer design.

One of these is the development of general-purpose control machines which may have much wider application but require more complicated logical circuitry and a greater number of instructions and commands employed in the computer. This approach permits control of a great variety of industrial units with the aid of one and the same computer.

The second system utilizes modern microcomputer techniques to develop special-purpose machines designed to control a particular process. This leads to the creation of more easily operated and low-cost control computers. Tests of some control computers manufactured for specific industrial units have shown their efficiency and quite sufficient reliability.

In our country both systems of control are applied. Electronic digital computers perform both arithmetical and logical operations, making it possible to govern processes under rather complicated conditions.

Task 2. Translate the following word combinations into Ukrainian.

- high-speed electronic machine
- non-live systems
- technical cybernetics
- automatic industrial processes
- problems of transmission
- general-purpose control machines
- complicated logical circuitry
- industrial units
- modern microcomputer techniques
- special-purpose machines
- sufficient reliability
- electronic digital computers
- rather complicated conditions

Task 3. Answer the questions.

1. What have the computers of high-speed electronic machines created?
2. What does cybernetics study?
3. Is the importance of cybernetics especially great in the sphere of engineering sciences?

4. What is the field of acting of technical cybernetics?

5. What is one of the main problems of technical cybernetics?

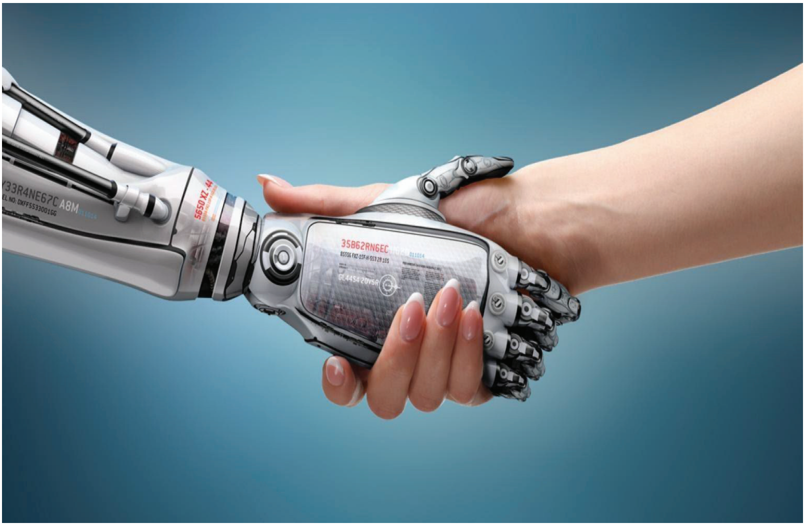
6. Where are the algorithms used? For what purpose are they used?

7. How many systems of computer are now created for control computer design?

8. What is the first system? What is its application?

9. What is the second system? What is its application?

10. What computers are low-cost, the computers of the first system or the computers of the second one?



TEXT 11. THE IMPORTANCE OF ELECTRICITY

Having access to electrical power will make it easier for people to do their work and take care of various essential tasks. It can also be used in many different ways which makes it convenient for people who are working throughout the house.

A lack of access to electrical power will make it much more difficult for people to carry out their work. It can also create safety issues because you will not be able to use electrical equipment if there is no power supply available. This will be even more problematic if you are living in a rural area that does not have access to the power grid. Electricity is important for many different reasons, including entertainment, comfort, heating, and cooling.

- **Electricity helps in maintaining a high quality of life**

Electrical appliances and equipment can make life much easier to deal with. Your standard of living would not be as high if electricity was taken away from your home.

You can cook meals, clean your house and enjoy a comfortable life because of all the useful electrical equipment you have access to.

Making use of modern power systems helps you maintain a decent quality of life and this all is possible only because of electricity. Without electricity, you would have to live in darkness every day, and it would have make things difficult.

- **Electricity is portable and can be transported easily**

There are many countries in the world where electrical power grids do not exist, which means residents must generate their own power. This usually requires the use of fuel like coal or diesel which can be expensive. Electrical energy is much more practical in this regard, because it is very easy to produce in one location and transport to other regions in the case of a power outage.

- **Electricity provide safety and security**

You will feel safe and secure if you have a backup generator in case of emergencies. If there was a blackout, this would be useful for powering your home and providing safety and security. Many people use solar panels to keep their electrical systems running. If you live in a rural area, there is no guarantee that the power will always be working properly.

- **Electricity is a clean source of energy**

Electricity is a clean source of energy that does not require any additional fuel to other sources are also available but they pollute. Electricity is reliable because it requires no fuel whatsoever to be generated, which makes it much cleaner than other options.

- **Electricity helps you to stay informed and connected**

Electrical devices allow you to stay informed and connected with those who matter most in your life. This type of equipment provides lots of useful functions to the owner.

Many people use mobile phones, tablets and other electronics to stay in touch with friends and family members. Outages can make it difficult for you to communicate with others, that is why a backup power source will be useful in this situation.

- **Electricity helps to improve productivity**

Electrical equipment can help a person be more productive and it is a very useful tool for professionals. For instance, people who work in offices will find that computers and photocopiers are fantastic tools to have access to.

Without electricity, these machines would not be able to function properly which means your productivity levels could drop significantly. Harsh weather conditions could also impact your productivity by disrupting the power supply.

- **Electricity helps people to complete their tasks on time**

If you are working in an industry where power is required for certain tasks, it will be necessary to have access to electricity at all times. For instance, people who work in construction or manufacturing would not be able to complete their duties without a stable power supply. It is also important for people to have access to electrical equipment in the medical field because this helps them to stay safe and healthy while they are at work. During natural disasters, rescue workers will be able to provide life-saving support if they have electricity available.

- **Electricity plays an important role in agriculture**

Most farms and ranches now use electrical systems to provide power for their machinery. This makes it much easier for the owners to take care of their business and manage all of their farm equipment.

Electrical systems also allow people to keep track of livestock and monitor the amount of water that is available for them. This means that farmers will be able to provide higher levels of care for their animals and make sure they are all safe.

- **Electricity helps improve the economy**

Electrical systems can improve the economy because it helps people to make more money. For example, power tools are often used by workers who use them in construction jobs. This makes it possible for them to complete their tasks more quickly and they are also able to work with greater safety.

The use of electrical power improves the overall productivity of people who are working in manufacturing jobs. Having access to this type of equipment will give you a competitive advantage because your business can be more productive which means higher sales levels.

- **Electricity is important for the entertainment industry**

Many people who work in the entertainment industry at events will find that electrical power is essential. This can be used to set up lights and sound systems which are important for any type of special event.

To create a more memorable experience, you may want to add lasers and other lighting effects when hosting an event. It is also important to have a backup power source in case the electricity goes out unexpectedly during your performance or presentation.

- **Electricity is very versatile and can be used in many different ways**

Not only electrical power be used for heating and cooling, but it can also provide lighting and other important comforts. Electricity provides comfort and peace of mind, which makes life easier to deal with.

Having access to the power grid is like having access to your own personal army. If you wanted, for instance, you could hire someone to string up all of the electrical wires in your home.

The power grid provides electricity that can be used in many different ways and makes life much easier.

APPENDIXES


work
analisis
marketing
team
idea
stategy
innovation
competitors
plan
activities
success

APPENDIX 1. SELF-ASSESSMENT TEST

COMPLETE THE SENTENCE USING A RIGHT VARIANT:

1. We use 4 things to make electricity: oil, coal, … or nuclear power.

a) gas
b) water
c) iron
d) steel

2. The center of the Earth is very…

a) warm
b) hot
c) cold
d) wet

3. Today there's a new job for windmills to produce …

a) oil
b) gas
c) water
d) electricity

4. Nowadays the electricity transmitted over long …

a) road
b) way
c) distances
d) system

5. A power system is an … of electric power.

a) insulators
b) interconnection
c) transmission
d) conductors

6. Electric power is generated at …

a) electric power plants
b) energy
c) wind
d) fuels

7. A new … creates a new lake in the mountain.

a) dam
b) steam
c) oil
d) coal

8. Nuclear … leaves dangerous radioactive waste.

a) power
b) force
c) affairs
d) coal

9. Steam … plants, in which is prime mover is a piston the steam engine.

a) engine
b) battery
c) electric
d) plants

10. Hydroelectric … plants employ water turbines or prime movers.

a) steam
b) water
c) power
d) dam

CHOOSE THE RIGHT UKRAINIAN TRANSLATION TO ENGLISH WORDS:

11. Power of sun, electric generator, voltaic

a) джерело, гальванічний, вугілля;

b) енергія сонця, електричний генератор, гальванічний;

c) гальванічний, вугілля, енергія сонця;

d) сонячна енергія, гідроенергетичний, тепло.

12. Solar power, steam, reliance

a) палити, пара, сила;

b) справи, ядерна енергія, джерело;

c) забруднення, гребля, вказувати;

d) сонячна енергія, пара, джерело.

13. Windmills, nuclear power, coal

a) вітряні млини, ядерна енергія, вугілля;

b) вітряні млини, гребля, нафта;

c) викачувати, ядерна енергія, сила;

d) прийняти, справи, вугілля.

14. Substance, matter, a flow

a) речовина, ізолятор, янтар;

b) речовина, матерія, потік;

c) обертатися, речовина, провідник;

d) ядро, речовина, потік.

15. Alternating current, to revolve, amber

a) змінний струм, обертатися, янтар;

b) електричне коло, провідник, речовина;

c) потік, пар, вітряна енергія;

d) радіоактивні відходи, обертатися, електричне коло.

16. Conductor, electric current, positively charged

a) ядро, електричний струм, матерія;

b) ізолятор, ядерна енергія, позитивно заряджений;

c) потік, електричний струм, негативно заряджений,

d) провідник, електричне коло, позитивно заряджений.

17. An electric circuit, negatively charged, steam

a) електричне коло, пар, палити;

b) електричне коло, негативно заряджений, пар;

c) змінний струм, ядерна енергія, струм;

d) електричний струм, негативно заряджений, матерія.

18. Greenhouse effect, transformer, voltage

a) паливні елементи, трансформатор, струм;

b) сонячна енергія, трансформатор, джерело;

c) парниковий ефект, трансформатор, напруга;

d) парниковий ефект, забруднення, струм.

19. Pump, dam, solar panels

a) викачувати, гребля, сонячні батареї;

b) електричний генератор, речовина, янтар;

c) ядро, сонячні батареї, електричний струм;

d) пар, вугілля, кислотні дощі.

20. Dangerous radioactive waste, acid rain, hydro-electric power

a) геотермічна енергія, гребля, електричний струм;

b) викачувати, кислотні дощі, струм;

c) ядерна енергія, пар, гідроелектрична енергія;

d) небезпечні радіоактивні відходи, кислотні дощі, гідроелектрична енергія.

CHOOSE THE RIGHT ANSWER ON THE QUESTION:

21. What can we use to make electricity?

a) plants

b) animals

c) water

d) gas

22. Where did the first geothermal power station in the world open?

a) Canada

b) Germany

c) Italy

d) Monaco

23. **What does a new dam create?**

a) lake
b) sea
c) river
d) ocean

24. **Where were the windmills first used?**

a) Italy
b) Iran
c) England
d) Scotland

25. **What is used to produce electricity with the power of sun?**

a) warm
b) plants
c) mirror
d) animals

26. **What can the windmills produce?**

a) gas
b) electricity
c) water
d) oil

27. **What is electric power generated?**

a) wind plants
b) electric power plants
c) diesel-engine plants
d) steam

28. **What groups are power plants divided according to the kind of energy used by the prime mover?**

a) gas, energy, hydraulic
b) oil, wind, water
c) wind, thermal, gas
d) thermal, hydraulic, wind

29. **How are transmission lines classed?**

a) outdoor, overhead, cable
b) overhead, indoor, cable
c) wind, water, cable
d) overhead, water, cable

30. **What is an electric power consumer?**

a) it is interconnection of electric power
b) it is power lines
c) it is an enterprise utilizing electric power electricity
d) it is a wire system

KEY ANSWERS

Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answers	a	b	d	c	b	a	a	a	a	c	b	d	a	b	a

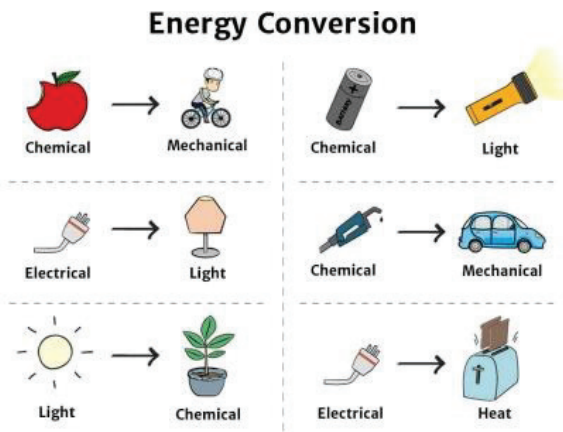
Tasks	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Answers	d	b	c	a	d	d	c	a	b	c	b	b	d	b	c

APPENDIX 2. EXTENSIVE READING

1. ENERGY

What is energy? A scientist would say that energy is the ability to do work. You use energy when you walk. You carry your books with you to the Institute. It takes energy to carry books. You can do nothing without using energy. You wash with water warmed by energy. You put on clothes washed and ironed with energy.

There are many forms of energy. Each of these is useful to us. For example, we use heat energy to do a lot of useful things, namely, to heat our homes, to transport us from one place to another, and so on.



Automobiles, trams, trains and airplanes are moved by changing heat energy to other forms of energy.

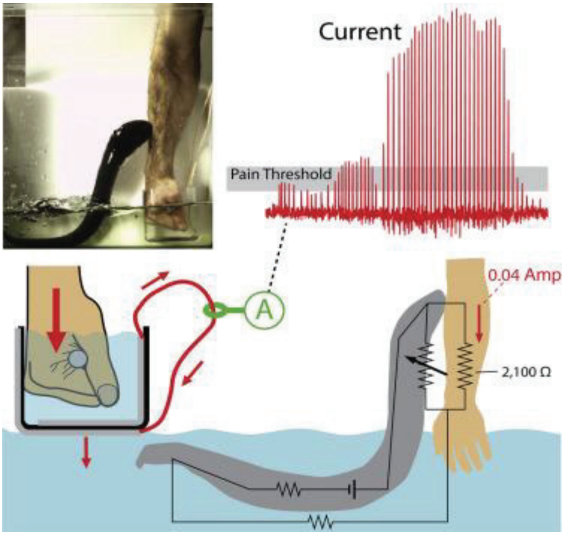
Electrical energy does many things for us. It is changed to other forms, such as: light, mechanical, heat, chemical, and others. When you watch television, you hear the sound and see the picture. The television (TV) set gets warm. Thus, electrical energy changes to heat, light and sound.

Many machines use electrical energy. They change energy from one form to another. Devices that are operated with electrical energy help us to work. Indeed, electricity plays an important part in modern life.

2. ELECTRIC FISH

The electric fish is mentioned in the oldest writings of man.

History tells us that the Greeks and the Romans knew about it. They knew, for example, that any man coming into contact with the electric fish could obtain an electric shock. In later years, experiments were made to find out the nature and amount of the shock given by one of them called the electric eel. The so-called electric eel is found in the tropical waters of South America. Small electric eels, only one inch long, can give a small shock. However, by the time they are 6 inches long their internal battery gives as much as 200 volts. When it is quite grown a good electric eel can generate 600 volts. When it is short circuited, a current of 1 ampere can be obtained. A two-meter long eel could light a dozen 50 watt lamps.



The electricity in the electric eel seems to be produced at will.

Besides, the discharges take place at speeds from 10 to 100 per second. It is interesting to mention here that the eel's head end is positively charged and the opposite end is negatively charged. By the way, the electric eel has some ability for finding polarity. Thus, if two charged electrodes are placed in water, even in the dark, the electric fish which is somewhere near the electrodes, will move towards the positive electrode, possibly thinking that it is the head of a friend.

3. APPLICATIONS OF THE ELECTROMAGNET

Electromagnets always find an application when it is desirable to convert electrical energy into mechanical energy.

Telegraph systems and telephones, relays, motors and generators, radio sets and television sets, electrical measuring instruments as well as thousands of other valuable and necessary devices are known to contain electromagnets. They may be used, as well, to protect electrical circuits against overloads and underloads.

One of the first applications of the electromagnet was in telegraphy. Shilling was the first to construct the electromagnetic telegraph. He demonstrated his invention as far back as 1832.

As mentioned above, the telephone also uses electromagnets, uses many of them, in fact. As soon as men learned to send words over the long wires of the telegraph circuit, the next problem to be solved was the telephone. Was it not possible to send the spoken word over similar wires? As a matter of fact, the first practical telephone was invented by the American scientist Bell in 1876 and was further improved by Edison.

4. SURFACE TENSION

If due measures are taken steel needles and safety-razor blades may float on the water surface. This is easier when they are slightly oiled.

Flies, mosquitoes, and other insects can. walk on the surface of water without even getting their feet wet.

The reason for such strange phenomena is surface tension, that is, the tendency of a liquid surface to act like a stretched elastic membrane. When water comes in contact with air, the molecules at the surface are attracted more strongly to the water beneath than to the air above. The result is that the surface molecules become more tightly joined together than those in the interior of the liquid. If an object (such as a fly's foot, a steel needle, or a safety-razor blade) is not too heavy and is not easily wet by water, it merely dents this surface layer without breaking through. (The student is unlikely to know that the verb "to dent" means to make a minute slightly hollow).

Some liquids have greater surface tension than others. Alcohol, for instance, has a considerably lower tension than water. Temperature also affects surface tension. As the thermometer goes up, molecules jump about more freely and surface tension weakens. That's why hot water leaks more readily through a tiny hole than does cold water.

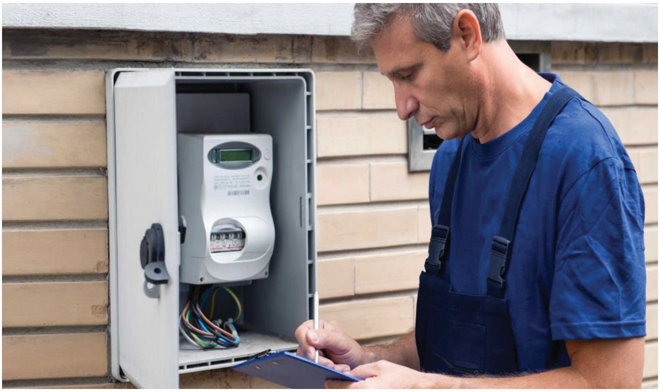
Certain substances, such as soap can lower the surface tension of water considerably.

To prove the last statement convincingly, dip the corner of a bar of soap into the water on which your blade is floating. The surface tension of soap water is weakened and almost instantly the blade breaks through the surface layer and falls to the bottom of the container.

5. ELECTRIC METER

How would you measure electricity? You can weigh coal. You can count apples. You can measure milk. But it is quite different with electricity because you cannot even see it. Electricity does not weigh anything. How do you measure electricity?

Well, that was not an easy question to answer, even for the scientists who tried all kinds of ways to find a suitable arrangement.



But the problem was finally solved and if you want to see how, look at your electric meter.

It does more than just measure current. It multiplies current times voltage which is not an easy thing to do when you remember that the voltage is changing from 127 volts positive to 127 volts negative and back again 50 times a second. The current is also changing all the time with the demands of your electric appliances. The multiplication of current times voltage gives watts, which is a measure of the electric power.

Having the watts all figured out at any instant, the meter multiplies those by the length of time they are being used. This gives an answer in watt-hours, which is a measure of electric energy. Then, as if that were not enough, the meter is divided by 1000 and shows the final result of the calculation on a set of dials at any and every instant in terms of kilowatt-hours, the units in which you get electric energy.

Knowing what it has to do, one might expect a meter to be as big as a piano. But as everybody knows, it is not. On the contrary it is a little box, starting its arithmetic lesson when you turn on the light, stopping when you turn it off.

6. GALVANOMETER

The most important measuring instrument is the galvanometer. It is used to detect and measure small electric currents. For the sake of simplicity it may be thought of as a D.C. motor which can rotate only part of a turn because it has no commutator. It has a very low resistance.

The current to be measured passes through a coil which is wound around a soft-iron armature turned between the poles of a permanent magnet. A pointer attached to the coil measures the rotation of the coil. A.C. cannot be used because the armature would no sooner start to rotate in one direction than the reversal of the current would start it rotating in the opposite direction. Hence, it would remain stationary.

In all of the experiments in which we use an ammeter, its connection in the circuit is always in series. This is necessary because all the current to be measured has to pass through the ammeter. If we attempted to use a galvanometer instead of an ammeter in order to measure current, the galvanometer would be probably damaged.

There are two reasons why we cannot use the galvanometer directly in series. First, it is a sensitive instrument and is so constructed that a very low current is sufficient to move the pointer to the end of the scale. Let us assume that 0.01 ampere can move the galvanometer pointer to the full scale, that is, to the end of the dial. If the current we are measuring is more than this amount, as it usually is, it is too great for the galvanometer to withstand and the instrument, of course, is damaged.

Second, the galvanometer has a resistance of its own. Hence when we connect a galvanometer into a circuit its resistance reduces the very current it has to measure. As a result, our measurements will be incorrect.

7. REFRIGERATOR

As you know, whenever a gas turns into a liquid, heat is invariably developed. Similarly, heat is required to turn a liquid into a gas. Whenever a liquid is vaporized, heat is taken from the immediate surroundings. When ether evaporates on your finger, it turns from a liquid to a gas and takes heat from your finger in this process. If there were enough ether on your finger and a constant supply of heat could be kept the rapid evaporation would cool your finger so much that it would become frozen. This is the principle the modern refrigerator is based upon.

Some gasses are easily liquefied and when liquid, they are easily turned back into the gaseous state. Sulfur dioxide is pumped under pressure until it liquefies. The liquid sulfur dioxide is pumped into a coil of small pipes, which surrounds a number of trays filled with water. As soon as the liquid enters this coil, it passes through a nozzle which creates a very fine spray, causing it to expand. In expanding this liquid becomes a gas again and when expanding, it takes up a considerable amount of heat from the immediate surroundings. The water in the trays has to supply this heat, and finally it loses enough heat to freeze to ice. The gas thus formed is led back to the compressor where it is compressed again and sent out in a liquid form.

The same cycle takes place all over again and again. This continuous changing from a liquid to a gas and from a gas back to a liquid is going on as long as the compressor runs. The compressor thus really supplies the energy required for making the ice in the trays and producing the cold air that circulates throughout the refrigerator.

This energy, however, undergoes several interesting transformations in the process of refrigeration as we have just seen.

8. BOILING

If we heat some water in an open glass container, we can see that evaporation goes on from the top surface. This evaporation is indicated by the clouds forming where the vapor mixes with the colder air and condenses. We find that the temperature of water gradually rises until the thermometer registers 100°C. A little before this point is reached, bubbles appear on the sides of the container.

They consist partly of gasses driven from liquid and partly of water-vapor, for evaporation is directed into the bubbles. Water is said to boil when vapor is formed both at the bottom of the container and at the top of it. The motion of the boiling water is caused by the bubbles of vapor rising through the water. The temperature of the boiling water is constant. This temperature is known as the boiling point of the liquid.

The boiling point of a liquid is the temperature at which it boils under some given pressure. When this point has been reached, further heating does not increase the temperature of the liquid but only changes it into steam.

When water boils in a container, we say that we see steam coming out of it. In fact, what we see is not steam at all but fine water particles. Steam itself is invisible. It is the condensed steam in the form of fine particles of water that we see.

As liquids always Increase in volume when passing into the vapor state, an increase in pressure always produces an increase in the boiling point.

Just as solids may under certain conditions be cooled below their melting points without freezing, liquids may be heated above their boiling points without boiling.

The principal laws of boiling are as follows:

1. When a liquid is heated, it begins to boil at a definite temperature, known as the boiling point, and on further heating the temperature remains constant at this value until the whole of the liquid is converted into vapor.
2. This temperature is constant for a given liquid if the pressure is constant.
3. The boiling point of a liquid increases if the pressure upon it is increased.
4. A definite quantity of heat is required to convert the unit mass of the liquid into vapor at the same temperature. This is known as the latent heat of evaporation.

9. STRUCTURE OF THE ATOM

The atom is the basic particle of all matter. All solids, gasses, and liquids are composed of atoms.

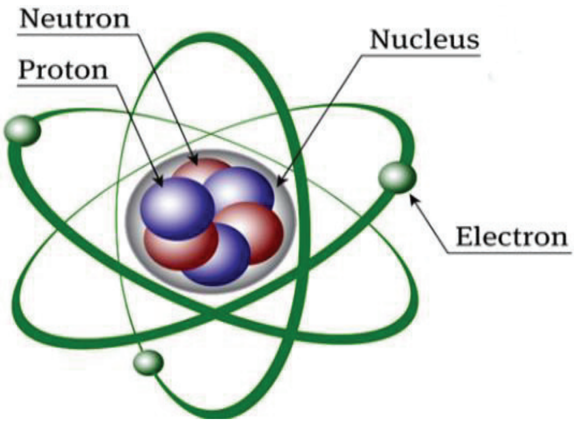
For a time the atom was considered to be indivisible but then it has been found that the atom in its turn can be divided into many different components.

In dividing the atom, man releases forces of great magnitude.

These are forces that bind the central core of the atom. This central core - the nucleus - is extremely small in diameter.

The nucleus of the atom is of a highly complex structure. It is the three main components of the atom that we shall deal with below.

These are called protons, neutrons and electrons.



The proton carries a positive charge of electricity, the number of protons in the nucleus determining the element that the atom forms.

For example, if the nucleus has a single proton, then it will form the gas hydrogen. If 92 protons are present, the element will be uranium and so on. In short, if the number of protons in the nucleus is known, the element can be found out at once.

As mentioned above, the proton carries a charge of positive electricity. We know the bodies charged with the same kind of electricity to repel one another. When two protons are brought close together they repel one another with great force.

The second of these basic components of the nucleus is the neutron. The neutron does not carry a definite electric charge. The sub-particles that form the neutron do carry charges but the charge of one balances that of another, leaving the neutron neutral. It is from this state that it gets its name.

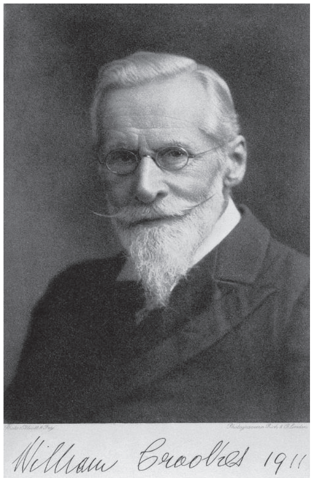
The third component of the atom is the electron. The electrons revolve around the nucleus. Each electron carries a negative charge of electricity that is equal to the positive charge of a proton in the nucleus.

As the charge of the electron is negative and that of the proton positive, it might be thought that the proton would attract the lighter electron and draw it into the nucleus. This would happen if the electron were not revolving around the nucleus.

The speed of the electron establishes sufficient centrifugal force so that it counteracts the neutral attraction. Thus the higher the speed of the revolving electron, i.e. the greater its energy, the farther from the nucleus it will revolve.

10. ELECTRON THEORY

The foundations of the modern theory of electricity were laid in the study of the electric discharge through gasses and in particular the so-called cathode rays.



The nature of these cathode rays was first described by Crookes (1879) when he considered them as negatively electrified particles which were emitted from a metal under the influence of a strong electric field.

Further experiments made on these particles confirmed that they carried a negative charge and the name "electron" was given to them.

It is the movement of the electrons, whether in a conductor or a gas which gives rise to the phenomenon known as the electric current.

The student should remember that an electron, being negatively charged, will move towards that end of the circuit or that part which is termed "positive. The old conception of the electric current flowing from the positive pole or end of the circuit to the negative was accepted long before the existence of the electron theory. It is in direct opposition to the real direction of electron flow. This conception is however too firmly established and the current is still assumed to flow from positive to negative.

The number of the electrons comprising the unit of current has been computed. At present, we know one microampere to be equal to the passage of 6 milliard electrons per second. To keep a 100-watt lamp burning requires a flow of six milliard milliard electrons not in a day, nor an hour, but every second. Six milliard milliard means the figure six with eighteen zeroes after it.

We know electrical energy changes into light energy in the electric lamp. Can light energy be changed back to electrical energy?

The emission of electrons under the impact of light energy is called photoelectric emission. The more intense the light, the more electrons are emitted by the metal exposed to light. Although most metals will emit electrons when their surfaces are exposed to ultraviolet light, some metals, such as sodium, potassium, and certain others will emit electrons when exposed to ordinary visible light rays and infrared rays as well.

The first discovery came in 1887 when Heinrich Hertz, the prominent German scientist, found out that for a given electromotive force an electric spark will jump across a larger gap if this gap is illuminated by ultraviolet light than if the gap is left in the dark.

The second discovery came about a year later when it was found that ultraviolet light falling upon a negatively charged metal plate caused it to lose its charge. As the plate was charged positively, there was no apparent change. The final discovery came about ten years later when Joseph Thomson, the famous English scientist, discovered that ultraviolet light falling upon a metallic surface caused it to emit electrons.

11. THERMOCOUPLE AND PHOTOCELL

There are two means of producing small electric currents for special purposes. One of these is the thermocouple or a thermopile.

The other is the photocell, sometimes called the electric eye.

The "iron-copper" thermocouple represents an iron wire and a copper wire, both being carefully cleaned at the end and making close contact with each other. At the point of contact unlike metals, a current tends to flow from one metal to the other because the outer electrons in the atoms of one metal have more potential energy than those in the other metal. The measure of this potential energy difference is called potential difference. This potential difference depends both upon the nature of the metals and upon the temperature at the point of contact.

A number of thermocouples are sometimes connected in series.

Such a combination called a thermopile is more sensitive than a single thermocouple.

The photocell generates a small electric current in response to the action of light. In one type, the light ejects electrons from a photosensitive surface upon which it falls. A photo sensitive electrode usually consists of a thin layer of caesium or a caesium compound on a surface of silver. This is the photocell cathode. The anode is a metal rod or a loop that, when the cell is in use, is connected to the positive terminal of a battery. It is the collector of electrons. The anode and the cathode are connected to short, light metal rods which extend through the base of the tube to form the support,

Electrons moving from the cathode to the anode constitute a small electric current whose magnitude is directly proportional to the amount of light falling upon the cathode.

Photocells perform a great number of very important services.

Perhaps, the best known use is in connection with motion pictures, where they are used in the reproduction of sound. They are also employed in television where they function in the signal transmission.

"Electric eyes" are also used in factories to give automatic control of illumination, by turning lamps on or off as required. Traffic signals, the devices for testing and recording the daily output of factories and many other types of safety devices are operated by photocurrents.

12. ELECTRIC LAMP

An incandescent electric lamp does not seem to have much resemblance to a heater but the two devices are similar in many respects. A lamp is a white-hot wire inside a glass bulb and a heater is a wire that is only red-hot.

The lamp's filament is heated by the passage of electric current. It glows because it is so hot.

Lamps using glowing wares were made as early as 1845 but they did not work well because all known wires burned or melted before they got white-hot. Edison wanted to find a wire that would not burn or melt at high temperatures. It was easy enough to avoid burning. He simply surrounded the wire by a glass bulb from which the air had been pumped out. Now the wire could not burn because there was no oxygen in the bulb.

But the problem of melting was harder to solve. The carbon-filament lamp which he produced as a result of thousands of experiments with different kinds of filaments could operate at a temperature of about 1900°C. Today instead of carbon filaments we use tungsten wires which usually operate at 2800°C. Tungsten is a metal with one of the highest melting points known. Because of their higher operating temperature tungsten-filament bulbs give almost 6 times as much light as carbon-filament bulbs for the same amount of electrical energy.

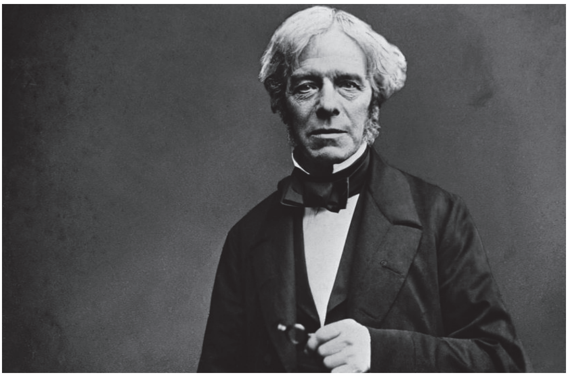
Lodygin was the first to discover the advantages of the metal wire filaments in comparison with other filaments. It is he who introduced tungsten filaments in a vacuum. He produced the first incandescent lamp and demonstrated his invention in

1873, lighting several Petersburg streets with his lamps. It was the world's first practical application of the incandescent lamp for lighting purposes.

Another inventor, Yablochkov, invented the arc lamp in 1876. He was working in Paris at that time. His electric candle, as he called it, consisted of two carbon rods placed in parallel and separated by an insulating material. The first alternating current generator was designed and used with the Yablochkov candle. The electric candle appeared in Paris streets in 1878. Compared with the existing gas lamps they were so brilliant that the system was used by many European cities. Yablochkov's invention together with the alternating current generator was a new and simple means of arc lighting.

13. FARADAY'S DISCOVERY

Although for certain purposes we still employ batteries to a limited extent to generate electric current, the usual procedure today is by electromagnetic induction. Great generators in our power stations, driven by powerful turbines, operate through the relative movement of conductors and magnets on a principle discovered by that remarkable man, Michael Faraday in 1831.



A bookbinder's apprentice in London, Faraday was a clever boy. In the early part of 1812 he was given tickets to hear a course of lectures by Humphry Davy at the Royal Institution. At the end of the course he bound his notes on the lectures and posted them to the lecturer with a request that he should be appointed to the post of assistant. A few months later, at the age of twenty-two Michael Faraday was appointed to a post at the Royal Institution at 25 shillings a week. Thus, he started on that remarkable career which lasted for nearly half a century, during which he laid the foundation for the electrical age. He became a skilful experimenter and an enthusiastic lecturer.

During the ten years or so before his great discovery, many investigators took a great interest in the connection between electricity and magnetism. It had been definitely established by Oersted's experiment that magnetism could be produced from the electric current. Why, then, could not the process be reversed and the electric current produced from magnetism?

The fulfillment of Faraday's hopes came in the year 1831 as a result of his experiments in the laboratory at the Royal Institution. We can read in his "Laboratory Notes" how, day by day, he carried on different experiments with wire and coils, permanent bar magnets and magnetic needles with varying results.

On October 17, 1831, he discovered that if he connected a coil of wire to a galvanometer and inserted a magnet into the coil, he obtained a deflection on the galvanometer. The coil consisted of eight windings of copper wire each 27 feet long, the windings being connected in parallel. When he was inserting one end of the magnet into the coil, he noticed that the deflection of the galvanometer continued only for a short time and stopped as soon as the magnet was completely inserted. No current was generated while the magnet remained stationary. When it was taken away, there was a second galvanometer deflection but this time in the reverse direction. In both cases, however, there was a current only during the time when the magnet was moving.

14. MAN AND HIS MACHINES

In all his activities man now makes use of a lot of machines. Although most of these are of quite recent origin, a few simple ones have come down from ancient times.

The arrow, for example, has been well known to man since prehistoric times, since it was only by hunting that he could get his food. The wheel, one of the greatest inventions ever made by man, is also of prehistoric origin. A two-wheeled carriage is represented widely in his art and literature. The lever is probably of equally ancient origin. It is mentioned by the Greek philosopher Aristotle as a means of lifting a great weight by using a very small force.

After Aristotle there was little change in the number and kind of machines in use for nearly twenty centuries. Since then one new device after another has come to displace others that were less efficient only to be displaced in turn by other devices still faster or better. Let us have a look at a few of these changes.

In going from his home in Mount Vernon to New York to be inaugurated as the first President of America, Washington traveled in a horse-drawn carriage. The roads were extremely difficult to travel. The travel of a little over two hundred miles required seven hard days. That is a speed of about 35 miles a day. Men could travel by land in only two other ways - on foot and on horseback. Within half a century of that time a few short railways had been built in three different parts of the country.

At first the trains were drawn by horses; in 1831 the first steam locomotive in America was put into use. The "iron horse" soon proved its efficiency. New lines were designed and old ones extended. The speed of 35 miles a day had given way to regular schedules exceeding 35 miles an hour.

In the first decade of the twentieth century, it was thought that the limit of desirable speed had been reached. However, the substitution of diesel and electric engines for steam engines and numerous other improvements have shown that much higher speeds may be easily achieved. Modern transportation uses electricity in many ways. Without it transportation, as is known today, could not exist.

On the other hand, life today would be unthinkable without modern means of transportation. To reach any part of the world is a matter of hours or days, while a century or two ago it took weeks, sometimes even months or years.

15. UNITS OF MEASUREMENT

In measuring the rate at which electrons are moving through a conductor, an electrician could say that the electric current is flowing at the rate of one coulomb per second. However, electricians have a unit that measures it directly and, therefore, instead of using the above-mentioned expression, an electrician would simply say: the current is one ampere. The ampere is the electrical unit that measures directly the quantity of electricity flowing in the conductor.

The kiloampere, the largest unit of current, is equal to one thousand amperes. Where the ampere is too large a unit to be used, we may employ the milliampere or the microampere, the prefix "milli" meaning a thousandth and "micro" standing for a millionth.

Keep in mind exactly what a volt is because the term is constantly used in all branches of electrical work. It is the practical unit used to measure the pressure that causes the electric current to flow through the circuit.

However, it is necessary to have both larger and smaller units. Thus, we have a megavolt (million volts), a millivolt (a thousandth of a volt), and a microvolt, that is a millionth of a volt. In electrical circuits, we are also interested in the magnitude of the resistance in each conductor. Resistance plays a very important part in the operation of every electrical circuit.

For that reason, it became necessary that some special practical unit be developed. It would indicate definitely how much resistance was present in any given conductor or circuit. That unit is called the ohm, a megohm equaling one million ohms and a micro-ohm being one-millionth of an ohm.

The ohm was named after an experimenter who investigated the resistance taking place in electrical circuits. His name was George Simon Ohm. He carried on numerous experiments which demonstrated that there is a very close relationship between voltage, current, and resistance in any given circuit. He showed that the amount of current which flowed in a circuit depends both upon the amount of resistance in the circuit and the amount of voltage which caused the current to flow.

Having considered the measurement of electrical quantities, we shall now define two units of heat. These are the calories and the British thermal unit.

The first is a metric unit and may be defined as the average amount of heat required to raise the temperature of one gram of water one degree Centigrade. In the same way the British thermal unit, or BTU, is the average amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.

Since the calorie is a rather small quantity of heat, a large unit called the kilogram calorie, or large calorie, is often used. It is not difficult to understand that the kilogram calorie is 1,000 times as large as the calorie that was defined above.

16. PLASMA GENERATOR

As it is well known, electric current can be generated if a metal conductor continually crosses the lines of force of a magnetic field.

This is the principal feature of all designs of modern electric generators and electrical engines.

However, a generator can be constructed with nothing moving inside, thus eliminating the need for a steam turbine. A copper wire acts as a conductor in ordinary dynamos. However, the metal could be successfully replaced by a jet of gas heated to a plasma state.

Plasma is a rather new term in science and engineering. This term denoted another state of matter - the fourth state besides the solid, liquid and gaseous. It is caused by heating the matter to a temperature of 4000-5000°C and higher. In this case, the so-called ionized gas is produced with a tremendous mass of free electrons forced away from the atoms. In this state a substance becomes an excellent conductor of current.

If a jet of plasma is directed between the poles of a powerful magnet, an electric current would result which could be carried elsewhere by special electrodes. Thus, the rotor with the conductors, unlike the dynamo, is replaced here by a gaseous conductor continually crossing the magnetic field.

Though there are many difficulties in developing a plasma generator or, in other words, magneto hydrodynamic generator, scientists and engineers believe that it is a practical task. To fulfill this task it is necessary to study the physical properties of the plasma and to find the means of increasing its density and temperature.

Scientists and engineers are concentrating their attention on developing a power-generating installation based on the magneto hydrodynamic principle.

17. LASER

Some decades ago a new principle of electromagnetic wave generation was discovered. Light and radio waves are known to be electromagnetic oscillations. A new principle was applied to generate visible radio waves, i.e. light. The device used is called laser, or optical maser.

Under ordinary conditions all bodies absorb electromagnetic oscillation, either radio or light waves. Now scientists have developed a method of electromagnetic waves passing through substances, so that the waves are not absorbed but amplified many times. A laser beam is generated neither by an incandescent filament nor by an electric arc. It is produced in a ruby crystal. A laser beam is a thousand million times brighter than sunlight.

Laser beams possess some remarkable qualities. One of them is negligible divergence, unlike that of a searchlight beam. When a laser was directed towards the moon, it lit up an area only a few miles in diameter.

A second quality is that the waves of a laser beam have a highly uniform frequency and their stability is much greater than the oscillations emitted by an ordinary radio transmitter. Finally, a system of lenses enables a laser beam to be focused to a point at which all its energy is concentrated.

Laser beams can be used for precision machining of the hardest materials such as diamonds, hard alloys, etc.

It has recently been theoretically proved that a laser beam can be turned into electricity with high efficiency.

Scientists have developed different types of lasers and among the latest are lasers with semiconductor sources of light. Perhaps the most interesting thing about semiconductor lasers is that they can transform electrical energy directly into light wave energy. They perform it with an efficiency of one hundred per cent as compared with a maximum of about one percent of other lasers.

Theoretical calculations have shown that devices similar to semiconductor lasers can also transform the energy of light radio waves into electrical energy with an efficiency of up to 100 per cent.

This means that electric power may be transmitted over considerable distances with negligible loss without any use of transmission lines.

Today laser beams are used to machine diamonds cut and weld the hardest alloys and cure people. They find application in scientific research, computer techniques, communications and in monitoring cosmic bodies.

Laser design is still far from being perfect but remarkable results have already been obtained both in this country and abroad.

In time lasers will have the most different applications. They can be used to control chemical reactions, to produce high temperature plasma, to raise the sensitivity of radio telescopes, thus enabling them to be used to study galaxies inaccessible to modern instruments; to treat diseases and accelerate elementary particles.

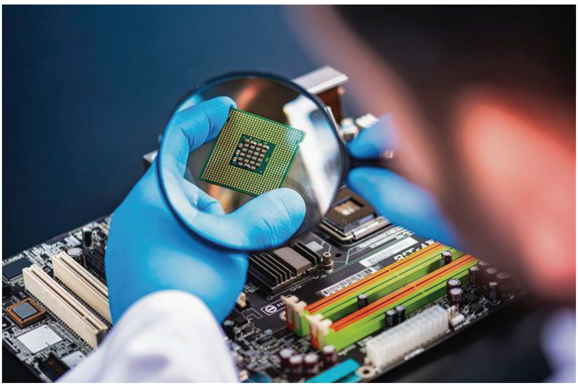
18. SEMICONDUCTORS

The periodic law of elements discovered by Mendeleyev had a number of important scientific and industrial results, one of them being the discovery of germanium. Germanium is the semiconductor used in most transistors available at present.

However, what are semiconductors? They include almost all minerals, many chemical elements, a great variety of chemical compounds, alloys of metals, and a number of organic compounds. Like metals, they conduct electricity but they do it less effectively. In metals all electrons are free and in insulators they are fixed. In semiconductors electrons are fixed, too, but the connection is so weak that the heat motion of the atoms of a body easily pulls them away and sets them free.

It is not difficult to understand that the term "semiconductor" has been used because the material in question really occupies a place between the conductors of the electric current and the non-conductors that is insulators. The term shows that they conduct electricity less readily than conductors do but much better than insulators.

Minerals and crystals appear to possess some unexpected properties. For instance, it is well known that their conductivity increases with heating and falls with cooling. As a semiconductor is heated, free electrons in it increase in number, hence, its conductivity increases as well.



However, heat is by no means the only phenomenon influencing semiconductors. They are sensitive to light, too. Take germanium as an example. Its electrical properties may greatly change when it is exposed to light. With the help of a ray of light directed at a semiconductor, we can start or stop various machines, affect remote control, and perform lots of other useful things. Just as they are influenced by falling light, semiconductors are also influenced by all radiation. Generally speaking, they are so sensitive that a heated object can be detected by its radiation.

As previously mentioned, such dependence of conductivity on heat and light has opened up great possibilities for various uses of semiconductors. The semiconductor devices are applied for transmission of signals, for automatic control of a variety of processes, for switching on engines, for the reproduction of sound, protection of high-voltage transmission lines, speeding up of some chemical reactions, and so on.

On the one hand, they may be used to transform light and heat energy directly into electric energy without any complex mechanism with moving parts, and on the other hand, they are capable of generating heat or cold from electricity.

Engineers and scientists turned their attention to semiconductors very many years ago. They saw in them a means of solving an old engineering problem, namely, that of direct conversion of heat into electricity without boilers or machines.

19. STEAM POWER STATION

A modern steam power station is known to consist of four principal components, namely, coal handling and storage, boiler house, turbine house, switchgear.

If you have not seen a power station boiler, it will be difficult for you to imagine its enormous size.

Besides the principal components mentioned above there are many additional parts of the plant. The most important of them is the turbo generator in which the current is actually generated.

A steam turbine requires boilers to provide steam. Boilers need a coal-handling plant on the one hand and an ash-disposal plant on the other. Large fans are quite necessary to provide air for the furnaces.

Water for the boilers requires feed pumps. Steam must be condensed after it has passed through the turbines, and this requires large quantities of cooling water. The flue gasses carry dust that must be removed by cleaning the gasses before they go into the open air.

A modern steam power station is equipped with one or more turbine generator units which convert heat energy into electric energy.

The steam to drive the turbine which, in its turn, turns the rotor or revolving part of the generator is generated in boilers heated by furnaces in which one of three fuels may be used: coal, oil and natural gas. Coal continues to be the most important and the most economical of these fuels.

20. HYDROELECTRIC POWER STATION

Modern hydroelectric power stations use waterpower to turn the machines that generate electricity.

In many countries, such as Norway, Sweden, and Switzerland, more electric energy is produced from water power than from steam. They have been developing large hydroelectric power stations for the past forty years, or so, because they lack a sufficient fuel supply. The tendency, nowadays, even for countries that have large coal resources is to utilize their waterpower in order to conserve their resources of coal. In fact, almost one half of the total electric supply of the world comes from water power.

The locality of a hydroelectric power plant depends on natural conditions. The hydroelectric power plant may be located either at the dam or at a considerable distance below. That depends on the desirability of using the head supply at the dam itself or the desirability of getting a greater head.

In the latter case, water is conducted through pipes or open channels to a point farther downstream where the natural conditions make a greater head possible.

The design of machines for using waterpower greatly depends on the nature of the available water supply. In some cases, great quantities of water can be taken from a large river with only a few feet head. In other cases, instead of a few feet, we may have a head of several thousands of feet. In general, power may be developed from water by action of its pressure, of its velocity, or by a combination of both.

A hydraulic turbine and a generator are the main equipment in a hydroelectric power station. Hydraulic turbines are the key machines converting the energy of flowing water into mechanical energy. Such turbines have the following principal parts: a runner composed of radial blades mounted on a rotating shaft and a steel casing that houses the runner.

21. CURRENT FLOW

ELECTRIC CURRENT IN SOLIDS

If electrons are added to one end of a solid conductor, such as a piece of copper wire, while some of them are removed from the other end of that conductor, an electric field is set up between the two ends of the wire. This field tends to cause free electrons in the wire to move from the negative end to the positive one. As previously stated, this movement of electrons constitutes an electric current.

The free electron moves comparatively slowly through the wire and travels a short distance before it collides with an atom. This collision generally knocks an electron free from the atom. This new free electron travels a short distance toward the positive end of the wire before its collision with another atom. Thus, there is a flow of electrons from the negative to the positive end of the wire.

Although the flow of electrons seems to be comparatively slow, the disturbance that causes this flow travels through the wire at a speed that approaches the speed of light (approximately 186,000 miles per second. The above action may be understood by visualizing a long hollow tube completely filled with balls. If a ball is added to one end of the tube, a ball at the other end is thrown out immediately. Thus, although each ball moves slowly and for only a short distance, the disturbance is transmitted almost instantaneously through the whole tube.

The device that supplies the electromotive force is considered to be a sort of pump. This pump removes electrons from one end of the conductor, thus creating a deficiency of electrons or a positive charge at that end and crowds them up at the other end, creating an excess of electrons or a negative charge.

ELECTRIC CURRENT IN LIQUIDS

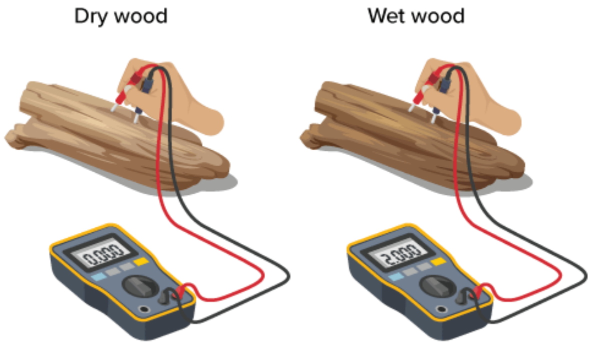
We know a molecule of ordinary table salt to consist of an atom of sodium and an atom of chlorine. When these two atoms combine to form a molecule of salt, the process is such that the sodium atom loses an electron and, hence, obtains a positive charge while the chlorine atom gains an electron, hence obtains a negative charge.

A charged particle is called an ion. The molecule of salt contains a positive sodium ion and a negative chlorine ion. Since unlike charges attract, the two oppositely charged ions are held close together. However, the molecule of salt dissolving in water, the ions separate, or dissociate.

If two metal plates (called electrodes) are set at opposite ends of the solution and a source of electromotive force is connected to these plates so that one becomes a positive (elec- tron-deficient) electrode and the other a negative (electron- excess) electrode, an electric field is created between these two electrodes.

Opposite charges attract each other, the negative chlorine ion is attracted to the positive electrode and the sodium ion is attracted to the negative electrode. Upon reaching the positive electrode, the chlorine ion surrenders its extra electron to the electrode and becomes a neutral chlorine atom. As the sodium ion reaches the negative electrode, it obtains an electron from the electrode and becomes a neutral sodium atom.

The effect of the electromotive force, then, is to cause a movement of ions through the solution. This movement constitutes an electric current and in this way, the electric current flows through a liquid.



ELECTRIC CURRENT IN GASSES

The molecules of a gas are known to be in a state of continuous motion, constantly colliding with one another. These collisions knock off electrons, producing free electrons and converting the atoms that have lost electrons into positive ions. Since a charged particle is called an ion, we may consider the free electrons as negative ions.

Thus, the gas contains positive and negative ions, just as an electrolyte does. If positive and negative electrodes are placed in the gas, the free electrons tend to travel to the positive electrode, and the positive ions to the negative electrode, thus producing an electric current.

Normally, a-positive or a negative ion cannot travel very far in a gas before meeting an ion of opposite charge. This meeting would tend to produce neutralization and would result in neutral molecules.

Since neutral molecules are not affected by the electric field between the two electrodes, the current would tend to stop flowing.

However, if the gas is placed in a sealed container (such as a glass tube or a bulb with the two electrodes sealed in and if most of the gas is pumped out, then the ions can travel considerable distances without being impeded. The effect of the electric field is to speed up the motion of the ions, so the farther they travel, the more velocity they obtain. If a fast- moving ion collides with a neutral molecule, the ion tends to knock electrons off the neutral molecule, thus creating more ions.

This process is cumulative and tends to keep a constant stream of ions moving towards the electrodes. In this manner, an electric current flows through a gas.

ELECTRIC CURRENT IN A VACUUM

If a free electron were in a vacuum within the electric field set up between positive and negative electrodes, the negatively charged electron would be attracted to the positive electrode. The movement of the electron would constitute a flow of electric current. It is upon this principle that the electron tubes used in radio and television receivers operate.

We can construct an electron tube by sealing a pair of metal electrodes into opposite ends of a glass bulb and by evacuating the air from within the bulb, leaving a vacuum. Connecting the electrodes to a source of electromotive force makes them positive and negative, respectively. A question now arises: how can we get the free electron into the tube?

As previously described, there is always a disorderly movement of free electrons within all substances, especially metals. If the difference of potential between the two sealed- in electrodes is made great enough, some of the free electrons of the negative electrode will be attracted so strongly to the positive electrode that they will let the former fly through the vacuum to the latter.

If a substance is heated, the movement of free electrons within that substance is increased. If the temperature is raised high enough, the movement of free electrons is increased to the point where some of the electrons actually fly off from the substance.

We call this process thermionic electron emission.

In most electron tubes, the negative electrode is heated to the point where it emits electrons. These electrons are attracted to the positive electrode and constitute a one-way flow of electric current through a vacuum from the negative to the positive electrode.

22. GASSES, SOLIDS, LIQUIDS AND PLASMA

According to molecular theory, a gas consists of a large number of molecules which are far apart in comparison to their diameter. Each molecule moves freely and rapidly in the straight line except when it meets another molecule or collides with the walls of its container. As a result of numerous collisions, the speed of any one molecule constantly changes in direction and, generally, in amount.

A gas being compressed, these collisions become more frequent. In addition, the speed a given molecule travels with is greatly increased when a gas is heated.

The law explaining gas pressure on the walls of a container due to the collision of separate molecules was first established and stated by Daniel Bernouilli as early as 1738. Even today, the "Bernoulli effect" is considered to be one of the basic laws of thermodynamics.

The principal physical property distinguishing a gas from a liquid and a solid consists in its ability to expand and occupy all the space available to it. Gasses, therefore, have neither definite volume, nor definite shape; on the contrary, they take both the volume and shape of the container into which they are placed. They readily diffuse. The ease with which the molecules of a gas diffuse shows not only that they are in rapid motion but also that the distance between them is large compared with the space occupied by the molecules themselves, in other words, compared with their own size.

Solid bodies and their behavior are the next subject we shall deal with. It is not difficult to distinguish the property of a solid from that of a gas. It may be stated as follows: in the solid phase or condition, the molecules attract each other strongly and, hence, they are unable to move about freely and rapidly as in the case of a gas.

Of course, they are also in motion but they are limited both in the manner and range of movement. In fact, they are limited to vibrational and sometimes rotational motions. This explains the definite size and shape of solid bodies, which neither flow as do liquids, nor occupy all available space as gasses do. We may consider them as vibrating about their mean positions with a motion like that of a weight vibrating at the end of a spring. It is these vibrations, which produce the sensation of temperature. In a hot body, the energy of the vibrations is large and the speed of the molecules, in passing through their mean positions, is found to be rather high.

On the other hand, in a cold body the energy of the vibrations is less, the speed of molecular motion being greatly reduced.

What feature distinguishes a liquid from the two other states of matter? We find that a liquid is not as compressible as a gas. The reason for a certain degree of compressibility of liquids is easily understood. The molecules of a liquid are much closer together than those of a gas. They are free to move but owing to the closeness of different molecules to each other, they are unable to travel far without colliding with other molecules. Under such conditions, on the one hand, the molecules of a liquid are more free to move than the molecules of a solid but on the other hand, they are less free to travel than those of a gas.

In short, the molecule of a liquid is in a state of constant motion without any definite direction. It is quite free to travel from place to place within the liquid itself; but it cannot easily leave its surface, i.e. evaporate, because of a rather strong force of attraction observed between the molecules of any liquid. This force serves to fix the volume of a given liquid although its shape is changeable.

In other words, liquids have a definite volume at a given temperature but they do not occupy all the available space and always take the shape of the container. They are found, in general, to diffuse much more slowly than gasses do.

The fourth state of matter is considered below.

One of the oldest fields of science is the one of electrical discharges in glasses. Considering special properties of matter in discharge tubes William Crookes put forward the idea that such gasses should be considered a fourth state of matter namely the plasma state. The plasma is first of all an ionized gas in which the charges of both signs are approximately equal. The plasma is caused by heating the matter to very high temperatures. Under such conditions, the so-called ionized gas is produced with a great mass of free electrons forced away from the atoms. The production of the plasma can take place in a number of ways. Among them we find: spark discharge, arc discharge, chemical reactions of high energy and nuclear reactions. One should also mention here the bombardment of electromagnetic fields or particles of any other origin provided sufficient energy is available to provide the required work of the neutral atoms and ions.

An electrical conductivity which can be compared to that of some metals and strong electrolytes exists in the plasma.

23. PIONEERS OF ELECTRICITY: THE MOST IMPORTANT SCIENTISTS IN HISTORY

Ampere, Andre Marie (1775–1836) Born: Lyon, France.

Best known for his pioneering work in the field of Electrodynamics. During his

emotionally troubled life, he held several professorships: at Bourg, Lyon, and at the Ecole Polytechnic in Paris. While Ampere worked in several sciences, the work of the Danish physicist Hans Christian Oerstadonthe electric deflection of a compass needle, as demonstrated to him by Dominique Arago, caused Ampere's great interest in electromagnetism. His seminal work, *Notes on the Theory of Electrodynamic Phenomena Deduced Solely from Experiment,* established the mathematical formulations for electromagnetics including what is now known as Ampere's Law. It can be said that Ampere founded the field of electromagnetics. He is honored for this by the naming of the unit of electric current as the ampere.

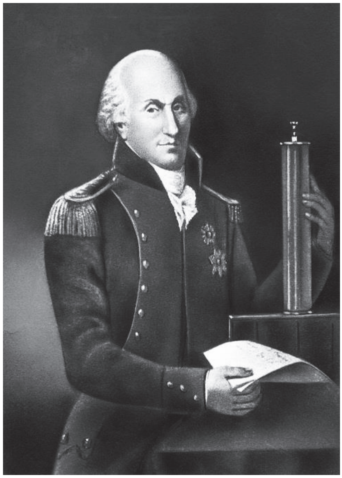
Ayrton, William Edward (1847–1908) Born: London, England.

Best known as the inventor of a number of electrical measurement devices and as an engineering educator. Ayrton's early work was with the Indian Telegraph Service, after which he studied with William Thomson (Lord Kelvin) in Glasgow. After several more telegraph assignments Ayrton traveled to Tokyo, where he established the first electrical engineering teaching laboratory at the Imperial Engineering College. Among his many inventions he is credited with the ammeter and an improved voltmeter. His wife Bertha was also an active researcher and became the first woman to be admitted to the Institute of Electrical Engineers.

Bardeen, John (1908–1991) Born: Madison, Wisconsin, U.S.A.

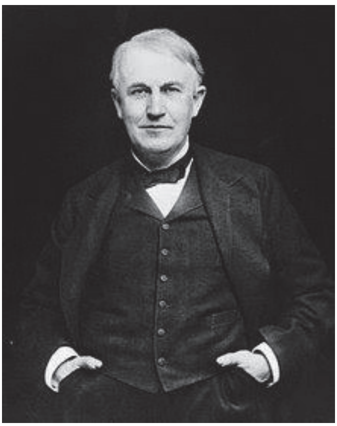
Bardeen is best known as one of the few persons to receive two Nobel Prizes. The first prize he received was in 1956 for his development at Bell Labs, along with Walter Brattain and William Schockley, of the first transistor. When the three applied for a patent for the device in 1948 they called it a germanium transfer resistance unit; hence the name transistor. This device was a significant step in the development of integrated circuits. Bardeen's second Nobel, which he shared with Leon Cooper and John R. Schrieffer, was for his work at the University of Illinois in describing the theory of superconductivity.

Coulomb, Charles (1763–1806) Born: Angouleme, France.



Best known for his study of electric charge and magnetism resulting in Coulomb's Law, as well as his studies in friction. Coulomb also invented the torsion balance in 1777. He used this device in many experiments. Coulomb began his career in the military, but resigned when the French Revolution began. His experience as a military engineer involved him in a wide variety of different projects. It also gave him time to continue his own experimental work. Coulomb's law states that the force between two charges is proportional to the product of the charges and inversely proportional to the square of the distance between the two charges. Coulomb is honored by having his name used as the unit of electric charge, the coulomb.

Edison, Thomas Alva (1847–1931) Born: Milan, Ohio.



Best known as the holder of 1069 patents secured during his lifetime. Among these were patents for the phonograph and the incandescent filament lamp. Edison was largely self-taught. His early interest in communication devices stemmed from his employment as a telegraph operator. He used the profits from the sale of his first invention, a "stock ticker," to set up a lab in Newark, New Jersey. Always a shrewd commercial developer, he followed the invention of the light bulb with work on developing efficient generators to power these bulbs. Edison is considered the archetypal American inventive genius.

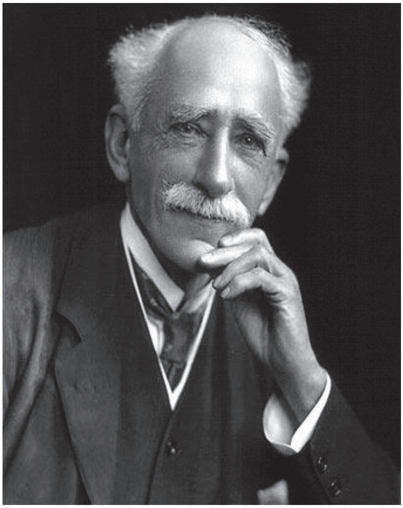
Faraday, Michael (1791–1867) Born: Newington, Surrey, England.

Best known as the greatest experimental physicist of the 19th century. It was Faraday who invented the electric motor, generator, and transformer, and first described electromagnetic induction and the laws of electrolysis. Faraday had no formal schooling, although he attended many lectures. The most inspirational of these lectures were by the famed chemist Sir Humphry Davy. Faraday became Davy's assistant and thus began an extraordinary career as an experimentalist. Faraday's contributions are recognized by the use of his name as the unit of electrical capacitance, the farad in the SI system, and the Faraday constant in electrolysis.

Ferranti, Sebastian Zianide (1864–1930) Born: Liverpool, Lancashire, England.

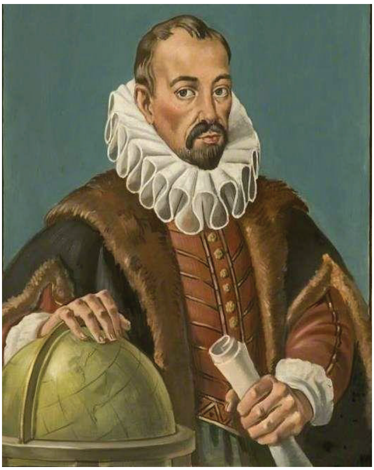
Best known for developing systems of high voltage AC power systems. The generating and transmission systems he designed still form the basis for most modern power systems. As a principal in the London Electric Supply Corporation, Ltd., Ferranti demonstrated that high-voltage AC current could be distributed and then stepped down for use in a more efficient and economical system than the smaller DC current systems then operating. Ferranti invented a number of other devices and systems as a consultant and in his own company. He was named president of the Institute of Electrical Engineers in 1911.

Fleming, John Ambrose (1849–1945) Born: Lancaster, Lancashire, England.



Best known as the inventor of the thermionic diode valve, also known as the Fleming valve. This valve was later adapted by Lee DeForest into a form of vacuum tube he called the Audi on Triode. Fleming was an avid experimentalist as well as a solid theoretician. He began his studies under James Clerk Maxwell and ended up consulting for Edison, Swan, and Ferranti, as well as Marconi. Thus Fleming can be considered one of the earliest pioneers in the field of radio and television electronics.

Gilbert, William (1544–1603) Born: Colchester, Essex, England.

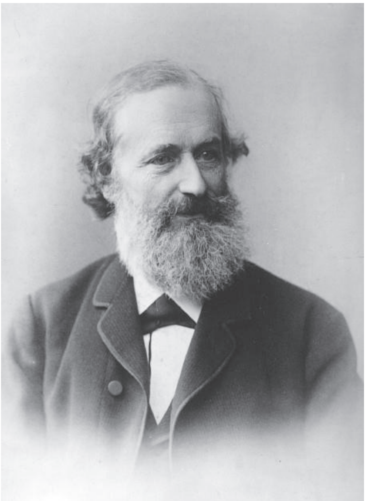


Best remembered as an early investigator into electric charge and magnetism. He is also considered by many to be the inventor of the modern scientific method. This is due to his rigorous experimental methodology, and the detailed records he kept on his investigations. Isaac Newton and Francis Bacon both acknowledged his contributions in this regard. Gilbert was, by training, a physician and held the post of royal physician in the courts of Elizabeth I and James I.

Hertz, Heinrich Rudolf (1857–1894) Born: Hamburg, Germany.

Best known as the person who discovered radio waves. Hertz had several professorships including posts at Berlin, Kiel, Karlsruhe, and Bonn. Hertz's work was both theoretical and experimental. He succeeded in proving important elements of Maxwell's equations, and was able to demonstrate that radio waves could be generated. He died early from a degenerative bone disease. We honor his name by referring to the hertz as a unit of frequency.

Kirchhoff, Gustav Robert (1824–1887) Born: Konigsberg, Germany.

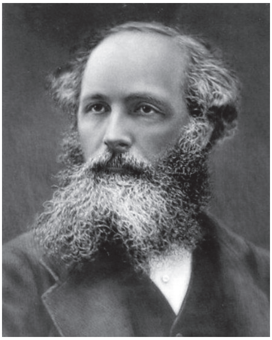


Best known for discovering the laws that govern electric flown networks, known no was Kirchhoff's laws. Kirchhoff is also famous as the inventor of spectroscopy, and his theoretical work led to the quantum theory of matter. Kirchhoff first held a teaching post in Berlin, followed by appointments in Breslau and Heidelberg. In the latter two universities, Kirchhoff had very fruitful collaborations with Robert Bunsen. Kirchhoff's studies in electricity provided a foundation for Maxwell and Lorenz's description of electromagnetic theory.

Lorenz, Ludwig Valentin (1829–1891) Born: Elsinore, Denmark.

Lorenz was not well known. He did, however, do significant work on electromagnetic theory, on the continuous loading method for cables, and for the acceptance of the ohm as the resistance standard.

Maxwell, James Clerk (1831–1879) Born: Edinburgh, Scotland.

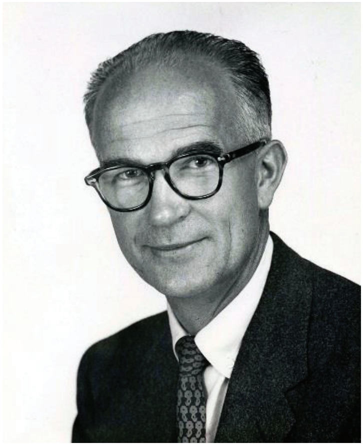


Maxwell is best known as the greatest theoretical physicist of the 19th century. It was Maxwell who discovered, among other things, that light consisted of waves. He developed the fundamental equations describing electromagnetic fields in his work, *A Dynamical Theory of the Electromagnetic Field,* published in 1864. Maxwell also gave us the mathematical foundation for the kinetic theory of gases. Maxwell's life was cut short by cancer, and thus he was unable to see his greatest theoretical propositions proven by experiment.

Ohm, Georg Simon (1789–1854) Born: Erlangen, Germany.

Best known for his discovery of what we now call Ohm's Law. Ohm held a variety of teaching posts at secondary schools as well as universities. In 1827 he published his greatest work, *Die Galvanische Kette.* Along with Andre Ampere, Ohm was the first to publish rigorously mathematical and theoretical work on electricity. Ohm's famous law states that current in a resistor is proportional to the applied voltage and inversely proportional to the resistance. Ohm's work was initially scorned because it lacked the experimental evidence. Worldwide acclaim changed Ohm's fortunes several years later. He is honored by having his name used as the unit of resistance, the ohm, and the unit of conductivity, the mho.

Shockley, William (1910–1989) Born: London, England.

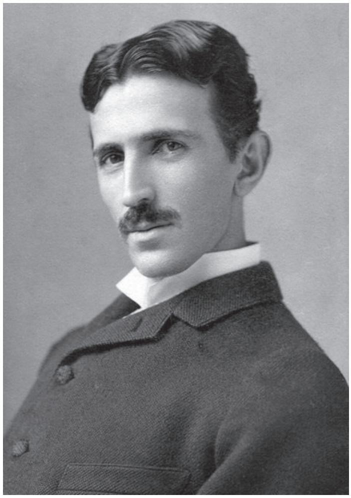


Shockley is best known as one of the developers of the transistor. In 1956 Shockley, John Bardeen, and Walter Brattain received the Nobel Prize for their work. Schockley led the group at Bell Labs responsible for the semiconductor research that led to the development of the "point contact transistor." In later life, Shockley became known for his public pronouncements on various political and genetic issues.

Siemens, Ernst Werner von (1816–1892) Born: Lenthe, Hanover, Germany.

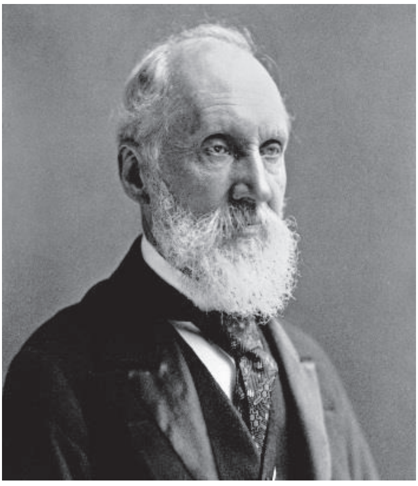
Best known for the German and British companies that bear his name. Siemens was a strong believer in basic research, as well as an avid inventor. His early inventions included an improved gutta-percha wrapped telegraph cable that allowed his companies to secure a number of lucrative cable contracts. His discovery of the dynamo principle, and his use of this in heavy current applications, allowed his companies to become pioneers in devices to generate electricity and rail applications. Siemens' belief in basic research made him a champion of standards and research institutions that he helped to establish.

Tesla, Nikola (1856–1943) Born: Smiljan, Croatia



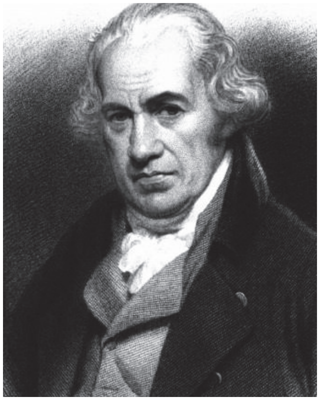
Best known as the electrical pioneer who championed the use of alternating current. When Tesla first came to the United States he worked for Edison. He soon split with Edison, because Tesla approached invention from a theoretical standpoint, whereas Edison was a "trial and error" type experimentalist. Together with his financial backer, George Westinghouse, they battled with Edison, who championed the use of direct current for electrifying the world. Tesla is also known for his many inventions including the Tesla coil and the AC induction motor. It was Westinghouse who made a fortune from Tesla's inventions. Tesla was known for his eccentricities and died a recluse in New York City.

Thomson, William (Lord Kelvin) (1824–1907) Born: Belfast, Ireland.



Best known as a physicist who championed the absolute temperature system that now bears his name (Kelvin). Thomson did significant work to expand Faraday's ideas. It was Thomson's work that Maxwell would extend into his seminal publications on electromagnetics. Thomson received a knighthood for his theoretical suggestions for the use of low-voltage signals in the trans-Atlantic telegraph cable. Thomson was proved correct when on a third attempt, a cable was laid and worked. An earlier high-voltage cable had failed.

Watt, James (1736–1819) Born: Greenock, Scotland.



Best known for his work in the development of efficient steam power. Watt began his career as an instrument maker. When asked to fix a troublesome Newcomer engine, he began to make improvements. Watt eventually partnered with industrialist Matthew Boulton to form a steam engine company. Watt is credited with having devised the horsepower system. The unit of power, the watt, is named in his honor.

Westinghouse, George (1846–1914) Born: Central Bridge, New York

Best known as a financier and industrialist during America's age of great commercial expansion. What is less known today is that Westinghouse's fortune was based on his early inventions in the railroad industry. His braking system was eventually adopted in most rail cars. Westinghouse went on to secure over 400 patents in the rail and the gas distribution industries. Before hiring Tesla and buying his patents, Westinghouse had been a champion of alternating current for power distribution. His company provided illumination for the great Chicago Exposition of 1893. Before his death, Westinghouse was to lose control of the companies that bear his name. Undaunted, he returned to the laboratory for a number of additional years of invention.

APPENDIX 3. EXPLANATORY DICTIONARY OF ELECTRICAL ENGINEERING

A

AC = alternating current

ACcircuit electrical network in which the voltage polarity and directions of current flow change continuously, and often periodically. Thus, such networks contain alternating currents as opposed to direct currents, thereby giving rise to the term.

AC coupling a method of connecting two circuits that allows displacement current to flow while preventing conductive currents. Reactive impedance devices (e.g., capacitors and inductive transformers) are used to provide continuity of alternating current flow between two circuits while simultaneously blocking the flow of direct current.

AC motor an electromechanical system that either converts alternating current electrical power into mechanical power.

AC/AC converter a power electronics device in which an AC input voltage of some magnitude, frequency, and number of phases is changed to an AC output with changes to any of the previously mentioned parameters. AC/AC converters usually rectify the input source to a DC voltage and then invert the DC voltage to the desired AC voltage.

AC/DC converter = **rectifier** - a circuit that changes an AC voltage to DC. Switching elements or diodes are used to create the DC voltage. Diode rectifiers and thyristor rectifiers are the two most commonly used rectifiers.

AC-DC integrated system a power system containing both AC and DC transmission lines.

accelerating power the excess electric power at a synchronous machine unit which cannot be transmitted to the load because of a short circuit near its terminals. This energy gives rise to increasing rotor angle.

accelerator (1) a positive electrode in a vacuum tube to accelerate emitted electrons from its cathode by coulomb force in a desired direction.

(2) a machine used to impart large kinetic energies to charged particles such as electrons, protons, and atomic nuclei. The accelerated particles are used to probe nuclear or sub nuclear phenomena in industrial and medical applications.

accumulation an increase in the majority carrier concentration of a region of semiconductor due to an externally applied electric field.

accumulator (1) a register in the CPU (processor) that stores one of the operands prior to the execution of an operation, and into which the result of the operation is stored. An accumulator serves as an implicit source and destination of many of

the processor instructions.

(2) the storage ring in which successive pulses of particles are collected in order to create a particle beam of reasonable intensity for colliding beams.

ACSR aluminum cable, steel-reinforced. A kind of overhead electric power conductor made up of a central stranded steel cable overlaid with strands of aluminum.

active load a transistor connected so as to replace a function that would conventionally be performed by a passive component such as a resistor, capacitor, or inductor.

active load-pull measurement a measurement method where transfer characteristics of a device can be measured by electrically changing the load impedance seen from the device. In an active load-pull measurement, the load impedance is defined by using an output signal from the device and an injected signal from the output of the device.

active network an electrical network that contains some solid state devices such as bipolar junction transistors (BJTs) or metal-oxide-silicon field effect transistors (FETs) operating in their active region of the voltage vs. current characteristic. To ensure that these devices are operating in the active region, they must be supplied with proper DC biasing.

active power line conditioner a device which senses disturbances on a power line and injects compensating voltages or currents to restore the line's proper waveform.

air line a coaxial transmission line in which the volume between the inner and outer conductors are air-filled.

anode the positive electrode of a device. *Contrast with* cathode.

armature the magnetic circuit of a rotating electrical machine, including the main current carrying winding, in which an alternating voltage is induced by the magnetic field.

armature circuit components of the machine that carry armature current. For example, in a DC machine the armature circuit could consist of the armature windings, brushes, series field winding, compensating windings, interpoles, starting resistor(s), main-line contacts, and overload sensor.

armature voltage control a method of controlling the speed of a DC motor by varying the voltage applied to the armature while keeping the voltage applied to the field circuit constant.

atom a particle of matter indivisible by chemical means, which is chemically neutral. It is the fundamental building block of the chemical elements.

atomic beam a source of atoms traveling primarily in one direction. In practice, atomic beams are usually realized by the expansion of an atomic vapor into a vacuum through a small aperture. The resulting expanding cloud of atoms is usually made nearly unidirectional by a collimator that blocks or otherwise removes all atoms not propagating within a narrow range of angles.

automatic transfer switch a self-acting switch which transfers one or more load conductor connections from one power source to another.

automatic voltage regulator (AVR) an automatic feedback control system that is responsible for maintaining a scheduled voltage either at the terminals of a synchronous generator or at the high-side bus of the generator step-up transformer. The control is brought about by changing the level of excitation.

autotransformer a power transformer that has a single continuous winding per phase, part of this winding being common to both the primary and the secondary sides. As a result, these voltages are not isolated but the transformer is reduced in weight and size. Autotransformers are most suited for relatively small changes in voltage. Three phase autotransformers are by necessity connected in a wye configuration.

autotransformer starter a single three-phase autotransformer or three single phase transformer used to start induction motors at a reduced voltage.

B

backbone wiring that runs within and between floors of a building and connects local-area network segments together.

backfeed in power distribution work, power which flows from the secondary lines into the primary lines through the distribution transformer, *e.g.,* from an emergency generator connected to customer load.

balanced line symmetric multiconductor transmission line in which the voltage on each conductor along the transmission line has the same magnitude, but the phases are such that the voltage would sum to zero. In a two conductor transmission line, the voltages would be equal and 180 degrees out of phase. This is the equivalent of a virtual ground plane or zero E-field plane at the

geometric center plane of the transmission linecross section, or balanced with respect to virtual ground. Balanced wiring configurations are often used to prevent noise problems such as ground loops. *Contrast with* unbalanced line.

bare-hand refers to a method of servicing energized overhead conductors in which the line worker's body is maintained at the same potential as the conductor on which he is working, thus enabling the conductor to be contacted without danger of shock.

battery one or more cells connected so as to produce energy.

beam (1) transverse spatial localization of the power in a wave field.

(2) a slender unidirectional stream of particles or radiation.

beam intensity the average number of particles in a beam passing a given point during a certain time interval. For example the number of protons (electrons) per pulse or protons per second.

bearing currents current flow in the bearings of electrical machines, because of electromagnetic unbalance in the machine or from using high *dv*/*dt* inverters. The latter is able to charge up the stray capacitance present between the stator and rotor and between the rotor and shaft and thus allows motor bearing currents to flow, with resulting bearing damage.

beat frequencies the two frequencies, sum and difference frequencies, generated during the heterodyning process or during the amplitude modulating process. For example, if a 500 kHz carrier signal is amplitude-modulated witha1kHz frequency, the beat frequencies are 499 kHz and 501 kHz.

bias voltage or current the DC power applied to a transistor allowing it to operate as an active amplifying or signal generating device. Typical voltage levels in GA As FETs used in receivers are 1 to 7 volts between the drain and source terminals, and 0 to −5 volts on, or between, the gate and source terminals. For microwave systems, DC voltages and currents, provided by batteries or AC/DC converters required to "bias" transistors to a region of operation where they will either amplify, mix or frequency translate, or generate (oscillators) microwave energy. Since energy can be neither created nor destroyed, microwave energy amplification or creation is accomplished at the expense of DC energy.

boiler a steam generator that converts the chemical energy stored in the fuel (coal, gas, etc.) to thermal energy by burning. The heat evaporates the feedwater and generates high-pressure steam.

boiling water reactor a nuclear reactor from which heat is transferred in the form of highpressure steam.

branch circuit the three components of an electrical circuit are source, load, and interconnecting circuit conductors. A branch circuit is an electrical circuit designed to deliver power to the lowest-order load(s) served on a facility. It includes the overcurrent device, circuit conductors, and the load itself.

branch current the current in a branch of a circuit.

branch relation the relationship between voltage and current for electrical components. Common branch relations are Ohm's Law and the lumped equations for capacitors and inductors. More complex branch relationships would be transistor models.

C

cable an assembly of insulated conductors, either buried or carried on poles (aerial cable).

cable limiter a cable connector that contains a fuse. Cable limiters are used to protect individual conductors that are connected in parallel on one phase of a circuit.

calorimeter a device used to determine particle energies by measuring the ionization of a particle shower in a heavy metal, usually iron and lead.

capacitance the measure of the electrical size of a capacitor, in units of farads. Thus a capacitor with a large capacitance stores more electron (coulombs of charge) at a given voltage than one with a smaller capacitance.

In a multiconductor system separated by nonconductive mediums, capacitance (C) is the proportionality constant between the charge (q) on each conductor and the voltage (V) between each conductor. The total equilibrium system charge is zero. Capacitance is dependent on conductor geometry, conductor spatial relationships, and the material properties surrounding the conductors. Capacitors are constructed as two metal surfaces separated by a nonconducting electrolytic material. When a voltage is applied to the capacitor the electrical charge accumulates in the metals on either side of the nonconducting material, negative charge on one side and positive on the other. If this material is a fluid then the capacitor is electrolytic; otherwise, it is nonelectrolytic.

carbon brush a block of carbon used to make an electrical contact to a rotating coil via the commutator of a DC machine or the slip rings of a synchronous machine.

charge a basic physical quantity that is a source of electromagnetic fields.

charge carrier a unit of electrical charge that when moving, produces current flow. In a semiconductor two types of charge carriers exist: electrons and holes. Electrons carry unit negative charge and have an effective mass that is determined by the shape of the conduction band in energy-momentum space. The effective mass of an electron in a semiconductor is generally

significantly less than an electron in free space. Holes have unit positive charge. Holes have an effective mass that is determined by the shape of the valence band in energy-momentum space. The effective mass of a hole is generally significantly larger than that for an electron. For this reason, electrons generally move much faster than holes when an electric field is applied to the semiconductor.

charging current that portion of an electric power line's current which goes to charge the capacitance of the line. The charging current is not available for power transmission.

complex power a complex number that represents electric power flow for an AC circuit. When expressed in rectangular form its real part is average power P in watts and its imaginary part is reactive power Q in reactive volt-amperes.

converter a generic term used in the area of power electronics to describe a rectifier, inverter, or other power electronic device that transforms electrical power from one frequency and voltage to another.

corona a visible glow discharge which emanates from high-voltage conductors in regions of extremely high electric field intensity.

corona effect flow of electrical energy from a high-voltage conductor to the surrounding ionized air. This effect only becomes significant for potentials higher than 1000 V. This effect is characterized by a faint glow, a crackling noise and conversion of atmospheric oxygen to ozone.

corona loss the electric power lost in high voltage lines due to the radiation of energy by corona discharge.

current the flow of charge, measured in amperes (1 ampere = 1 coulomb/s).

current fed inverter an inverter in which the current is switched instead of the voltage to create AC current from a DC source. A large inductor is used to maintain a nearly constant current on the DC side which is then directed to the load in an alternating fashion by the use of switching elements.

current regulator a device used to control the magnitude and phase of the current in DC, AC or other electrical variable speed drives. May use different control strategies like hysteresis current control or ramp comparison current control.

current unit a protective relay that monitors the magnitude of a power transmission line's current flow.

current-source inverter (CSI) an inverter with a DC current input. Current-source inverters are most commonly used in very high power AC motor drives.

cylindrical-rotor machine a synchronous machine with a cylindrical rotor containing a distributed field winding and an essentially uniform air-gap. This design is limited to two and four pole machines (3600and1800rpmat 60Hz) and is usually used in large generators.

D

DC circuit electrical networks in which the voltage polarity and directions of current flow remain fixed. Thus such networks contain direct currents as opposed to alternating currents, thereby giving rise to the term.

DC current constant current with no variation over time. This can be considered in general terms as an alternating current (AC) with a frequency of variation of zero, or a zero frequency signal. For microwave systems, DC currents are provided by batteries or AC/DC converters required to "bias" transistors to a region of operation where they will either amplify, mix or frequency translate, or generate (oscillators) microwave energy.

DC generator commutator exciter a source of energy for the field winding of a synchronous machine derived from a direct current generator. The direct current generator may be driven by an external motor, a prime mover, or by the shaft of the synchronous machine.

DC machine an electromechanical (rotating) machine in which the field winding is on the stator and carries DC current, and the armature winding is on the rotor. The current and voltage in the armature winding is actually AC, but it is rectified by the commutator and brushes.

DC motor a motor that operates from a DC power supply. Most DC motors have a field winding on the stator of the machine that creates a DC magnetic field in the air gap. The armature winding is located on the rotor of the machine and the DC supply is inverted by the commutator and brushes to provide an alternating current in the armature windings.

DC voltage constant voltage with no variation over time. This can be considered in general terms as an alternating current (AC) with a frequency of variation of zero, or a zero frequency signal. For microwave systems, DC voltages are provided by batteries or AC/DC converters required to "bias" transistors to a region of operation where they will either amplify, mix or frequency translate, or generate (oscillators) microwave energy.

dielectric (1) a medium that exhibits negligible or no electrical conductivity and thus acts as a good electrical insulator.

(2) a medium characterized by zero conductivity, unity relative permeability, and a relative permittivity greater than one. Also known as an insulator.

Dielectrics are usually used to separate two conducting bodies such as to form a capacitor.

dielectric constant (1) a quantity that describes how a material stores and dissipates electrical energy.

(2) ratio of the electrical capacity of a condenser, which has a given material as the dielectric, to the capacity of an identical condenser, but with air as the dielectric.

(3) permittivity of a medium normalized to the permittivity of free space; a measure of the response of a dielectric to an applied electric field.

(4) an electric property of an insulator or semiconducting material, which describes how differently electric fields will behave inside of the material as compared to air.

direct current machine a DC machine is an electromechanical dynamo that either converts direct current electrical power into mechanical power (DC motor), or converts mechanical power into direct current electrical power (DC generator). Some DC machines are designed to perform either of these functions, depending on the energy source to the dynamo.

directional power relay a protective relay that operates for power flow in a given direction. Applications are in cases where normal power flow is in one direction, including anti-motoring protection on a turbine-generator and fault back feed protection on parallel step-down transformers.

dump an area of steel and dense concrete into which unwanted particle beam can be steered so that its energy can be dissipated in a safe and controlled manner. The dump resistor is switched into the magnet/capacitor circuit in order to dissipate the stored energy in the magnets/capacitors.

dynamo a term used to describe any of a variety of rotating machines that convert mechanical to electrical energy, or less commonly, electrical to mechanical energy. Dynamos typically consist of a stationary structure, called the stator, supporting a rotating element called the rotor. Energy conversion occurs via Faraday induction. A field winding (or in some smaller machines, permanent magnets) is mounted on one of the mechanical structures and produces a magnetic flux. An armature winding is mounted on the other structure, and rotation of the rotor produces relative motion between the field flux and the coils of an the armature coil. This Faraday induced voltage is the source of electrical energy at the dynamo output.

E

electric charge a basic physical quantity that is a source of electromagnetic fields. The units of electric charge are coulombs.

electric vehicle (1) a vehicle powered by an electrical energy storage device such as batteries.

(2) (EV) a vehicle (typically a car or truck) enabled by high-efficiency electric motors and controllers and powered by alternative energy sources, such as fuel cells. Electric vehicles are zero emission vehicles.

electrical network a collection of interconnected electrical devices.

electrolyte current-conducting solution between two electrodes or plates of a capacitor, at least one of which is covered by a dielectric.

electromagnet a magnet that employs an electric current in a coil to produce a magnetic field.

electromagnetic energy energy contained in electromagnetic fields and associated polarizable and magnetizable media.

energy that which does work or is capable of doing work. In electrical systems, it is generally a reference to electrical energy measured in kilowatt hours.

F

ferroelectric material a polar dielectric in which the crystallographic orientation of the internal dipole moment can be changed by the application of an electric field.

fission the nuclear reaction in which a single heavy nucleus is split into two or more lighter nucleii called “daughter” products and emit highly energetic sub-atomic particles plus energy in the process.

flywheel a heavy wheel placed on the shaft of an electrical machine for storing kinetic energy. A flywheel may be used to help damp speed transients or, to help deliver energy to impact loads such as a punch press.

forward voltage the voltage across the device when the anode is positive with respect to the cathode.

frequency variation a change in the electric supply frequency.

fresh fuel nuclear fuel which has never participated in a nuclear reaction and is thus only slightly radioactive.

fuel cycle (1) the operating time of a nuclear reactor between shutdowns for refueling.

(2) the life cycle of nuclear fuel, e.g., raw materials, to fresh fuel, to irradiated fuel, to spent fuel, to recycling, and finally to residual waste.

fuel pool a large vat of water used to store both fresh and spent nuclear fuel at the reactor site.

G

gate turn off device (1) any power semiconductor switching device which can turned off with a signal to its gate.

(2) a thyristor capable of gate-turn-off operation.

H

high-resistance grounded system an electrical distribution system in which the neutral is intentionally grounded through a high resistance. The high-resistance grounded wye system is an alternative to solidly grounded and ungrounded systems. High-resistance grounding will limit ground fault current to a few amperes, thus removing the potential for arcing damage inherent in solidly grounded systems.

hot wire an energized conductor, particularly as opposed to a neutral or ground wire, both of which are typically maintained at ground potential.

hydroelectric generator large, three-phase synchronous alternator powered by a water-driven turbine.

hydropower conversion of potential energy of water into electricity using generators coupled to impulse or reaction water turbines.

I

impact excitation excitation of an atom or molecule resulting from collision by another particle such as an electron, proton, or neutron.

incandescent lamp a lamp made by heating a metal filament in vacuum; not a burning candle.

incident power power in an electromagnetic wave that is traveling in an incident direction.

inductance a parameter that describes the ability of a device to store magnetic flux. The units are henrys per meter.

induction generator an induction machine operated as a generator. If the machine is connected to an AC system and is driven at greater than synchronous speed, the machine can convert mechanical energy to electrical form. The induction generator requires a source of reactive power.

induction machine classification of any of a variety of electrical machines in which an AC current in the stator coils is used to produce a rotating magnetic flux that, by Faraday action, induces an AC voltage in a set of coils (the induction coils) on the machine's rotor. The rotor coils are shorted to cause a second AC current to flow in the rotor coils, which produces, in turn, a second rotating flux. The interaction of the rotor- and stator-produced fluxes creates torque.

insulation resistance measured value of electrical resistance of the insulation of a product or device.

insulator a device designed to separate and prevent the flow of current between conductors. Properties of the dielectric (insulating) material and geometry of the insulator determine maximum voltage and temperature ratings.

isolated a power electronic circuit that has osmic isolation between the input source and the load circuit.

isolation (1) the separation of a part from other parts of the system so that the effects of undesired changes in the system are not seen by the separated part.

(2) a figure (usually expressed in decibels) to describe how well a transmitting device (source) and receiving device (receiver) are separated electrically; the amount of (usually undesirable) signal appearing at the receiver from the transmitting source from an undesirable signal path such as leakage in a coupler, mutual coupling, or multipath.

isolator (1) a two-port passive device based on the Faraday effect. Signals passing in one direction suffer minimal loss, however, in the reverse direction they are strongly attenuated.

(2) in optics, a device inserted in an optical fiber that prevents optical power from flowing in the reverse direction from the transmitted power. Optical fiber isolators can be made either dependent or independent of the polarization direction of the optical energy in the fiber.

isotope a variant of an element whose nucleus contains a greater or lesser number of neutrons but the same number of protons as the base element.

J

jumping jack a voltmeter.

K

kilovolt-ampere (KVA) a measure of apparent power, often in the rating of a piece of equipment or the measure of an electrical load, which is obtained by multiplying the device voltage in kilovolts by the current in amperes.

kilowatt-hour (KWH) a measure of electrical energy: 1000 watts delivered for one hour.

kinetic energy energy of motion.

kinetic energy conservation principle any change of kinetic energy of an electron is transformed into a change in electric potential energy with which the electron is interacting, and vice versa.

Kirchoff's voltage law (KVL) a fundamental law of electricity that states that the sum of the voltage drops and rises in a closed loop must equal 0.

L

lead a conductive path, usually self-supporting; the portion of an electrical component that connects it to outside circuitry.

lead-acid battery a battery that consists of a metallic lead anode and a lead oxide cathode held in a sulfuric acid and water electro lye. Lead–acid batteries have been used since the mid-1800s and are still used as car batteries.

lead circuit a simple passive electronic circuit designed to add a dominant zero to compensate the performance of a given system. It is generally used to make an oscillatory system more damped. A nondominant pole must be included to make the circuit causal. This pole also limits the high frequency gain of the lead circuit, thereby avoiding excessive amplification and transmission of undesirable noise.

lead frame the metallic portion of the device package that makes electrical connections from the die to other circuitry.

leakage the flux in a magnetic circuit that does not do any useful work.

light emitting diode (LED) a forward-biased p-n junction that emits light through spontaneous emission by a phenomenon termed electroluminescence.

line-to-line voltage a voltage measurement of a three phase line made between any two conductors.

lithium battery a battery that is similar in construction to other batteries except for a lack of any rare earth metals, which are an environmental hazard. The battery discharges by the passage of electrons from the lithiated metal oxide to the carbonaceous anode by current flowing via the external electrical circuit.

load break device any switch, such as a circuit breaker or sectionalize capable of disconnecting a power line under load.

load frequency control the purpose of load frequency control is to maintain the power system frequency at its nominal value while maintaining the correct outputs on individual generators to satisfy the loading on the system. As the load varies, the inputs to the generator prime movers must be controlled to keep the generation in balance with the loads.

load tap changer (LTC) a tapped transformer winding combined with mechanically or electronically switched taps that can be changed under load conditions. The load tap changer is used to automatically regulate the output of a transformer secondary as load and source conditions vary.

load-break device any switch which can be opened while the circuit is loaded

load-commutated inverter (LCI) an inverter in which the commutating voltages are supplied by the load circuit.

Lorentz force the mutually perpendicular force acting on a current-carrying element placed perpendicular to a magnetic field.

loss (1) decrease of intensity of an electromagnetic wave due to any of several physical mechanisms.

(2) a term for electric power which does not register on the consumer's electric meter, e.g., through ohmic losses in transmission lines, iron losses in transformers, or theft.

loss coefficient a factor used in economic dispatch calculations that relates power line losses to the power output of generating plants.

loss factor the product of the dielectric constant and the power factor.

loss of service the complete loss of electric power exclusive of sags, swells, and impulses.

low-level transmitter a transmitter in which the modulation process takes place at a point where the power level is low compared to the output power.

M

motor an electromechanical device that converts electrical energy from a DC or an AC source into mechanical energy, usually in the form of rotary motion.

motor circuit the three components of an electrical circuit are source, load, and interconnecting circuit conductors. A motor circuit is an electrical circuit designed to deliver power to a motor. It includes the overcurrent protective devices, controller, disconnect switch, circuit conductors, and the motor itself, as shown in the figure.

motor current signature analysis the use of the currents of an electric machine to provide diagnostic or other information on the health of the machine, coupling, or load.

motor operated switch a switch operated by a motor that is capable of being controlled from a remote location.

motorstarter anelectriccontroller, either manual or automatic, for accelerating a motor from rest to normal speed and for stopping the motor.

motor-generator set a set consisting of a motor mechanically coupled to and driving one or more generators. The set used to be employed for AC-to-DC or DC-to-AC power conversion or voltage level or frequency conversion. Solid-state conversion units are replacing motor-generator sets in most applications.

multipulse converter a three-phase converter that generates more than six pulses of DC per cycle. Multiple converters are connected so that the harmonics generated by one converter are canceled by harmonics produced by other converters, in order to reduce the line harmonics and improve the system power quality.

multispeed motor a motor that can be operated at any one of two or more definite speeds. For DC and induction motors, the speed settings are practically independent of the load, although the speed may vary with load for certain types of motors. Multispeed induction motors typically have two or more sets of windings on the stator with a different number of poles, one of which is excited at any given time.

N

nominal voltage a number given to a system to name its classification of voltage, such as rated values.

nonlinear load an electrical load operating in the steady state that has a current that is not continuous or in which the impedance changes during each cycle of the supply voltage.

nuclear fuel fissile material, including natural uranium, enriched uranium, and some plutonium prepared for use in a nuclear reactor.

nuclear power plant a thermal electric power plant in which the heat for steam turbines is produced by nuclear fission.

nuclear reaction a reaction which causes changes in the nucleus of an atom, thus changing elements to another element or isotope, usually with the release of energy.

nuclear reactor (1) an apparatus designed to facilitate, contain, and control a nuclear chain reaction.

(2) any heat-producing array of fissile radioactive materials constructed so as to produce a controlled chain-reaction.

O

overvoltage a voltage having a value larger than the nominal voltage for a duration greater than 1 minute.

overvoltage relay a protective relay that operates on overvoltage.

P

P commonly used symbol for power in watts or milliwatts.

permanent magnet (PM) a magnet that produces an external magnetic field by virtue of the alignment of domains inside the material and retains its magnetism after being subjected to demagnetizing fields.

permanent magnet AC motor a generic term used to describe both permanent magnet synchronous motors and brushless DC motors.

permanent magnet DC machine a DC machine in which the field excitation in the stator is provided by permanent magnets instead of electromagnets.

permanent magnet machine a machine that uses permanent magnets to establish the field. In DC machines, the permanent magnets are placed on the stator, while on AC synchronous machines they are placed on the rotor.

pigtail short electrical conductor used to connect the brushes of an electrical motor or generator to the external electrical connections of the machine.

pipe cable a paper-insulated high-voltage electric power transmission cable laid within a rigid steel pipe containing pressurized insulating oil.

power (1) a measurable quantity that is the time rate of increase or decrease in energy. Units are in watts.

(2) ratio of energy transferred from one form to another (i.e., heat, radio waves, light, etc.) to the time required for the transfer, expressed in watts.

power supply an electronic module that converts power from some power source to a form which is needed by the equipment to which power is being supplied.

power transformer a transformer that is used to transmit power from one voltage level to another. Power transformers can be of either single phase or three-phase design, and include either two or three windings.

primary voltage in power distribution the voltage at the primary winding of the distribution transformer.

prime mover the system that provides the mechanical power input for a mechanical to electrical energy conversion system (generator), e.g., the diesel engine of an engine–generator set.

R

rated voltage the voltage at which a power line or electrical equipment is designed to operate.

real power consider an AC source connected at a pair of terminals to an otherwise isolated network. The real power, equal to the average power, is the power dissipated by the source in the network.

resistivity (1) the product of the resistance of a given material sample times the ratio of its cross-sectional area to its length.

(2) an electrical material property described by a tensor constant indicating the impedance of free electron flow in the material. Resistivity relates the electric field strength to the conduction current, and can be expressed as the inverse of the conductivity.

resistance ratio of the potential of an electrical current applied to a given conductor to the current intensity value.

S

secondary voltage in power distribution work the voltage at the secondary of the distribution transformer.

semiconductor device a transistor, resistor, capacitor, or integrated circuit made from a semiconductor material.

semiconductor a material in which electrons in the outermost shell are able to migrate from atom to atom when a modest amount of energy is applied. Such a material is partially conducting (can support electrical current flow), but also has properties of an insulator. The amount of current conduction that can be supported can be varied by "doping" the material with appropriate materials, which results in the increased presence of free electrons for current flow. Common examples are silicon and Ga As. Also called semi-insulator.

shell-type transformer a power transformer in which the magnetic circuit surrounds and normally encloses a greater portion of the electrical winding.

slot a space between the teeth used to place windings in electrical machines.

solar–thermal–electric conversion collection of solar energy in thermal form using flat-plate or concentrating collectors and its conversion to electrical form.

T

three phase fault a fault on a three phase power line in which all three conductors have become connected to each other and possibly the ground as well.

touch voltage used in power system safety studies, the voltage between any two conductive surfaces which can be touched simultaneously by a person.

transformed circuit an original circuit with the currents, voltages, sources, and passive elements replaced by transformed equivalents.

transformer a device that has two or more coils wound on an iron core. Transformers provide an efficient means of changing voltage and current levels, and make the bulk power transmission system practical. The transformer primary is the winding that accepts power, and the transformer secondary is the winding that delivers power. The primary to secondary voltages are related by the turns ratio of the coils. The corresponding currents are related inversely by the same ratio.

V

volt (v) the SI unit for electrical potential differents and electromotive force.

voltage the potential to do work, voltage is the ratio of the energy available to the charge, expressed in volts.

voltage regulation the change in delivered voltage from a generator or transformer from no-load to full-load. Voltage regulation is usually expressed as a percentage of the no-load voltage. For a DC generator, the voltage will always drop as the load increases and the voltage regulation will be a positive quantity. For AC generators and transformers, voltage regulation is the difference in the magnitude of the no-load and full-load voltages (ignoring phase angles). For capacitive (leading power factor) loads, the full-load voltage may have a higher magnitude than the no-load voltage, resulting in negative voltage regulation. Such a condition may lead to instability and is undesirable.

voltmeter an instrument for measuring a potential difference between different points of an electrical circuit. Units are volts.

W

watt unit of power in the SI system of units.

wattmeter an instrument for measuring electric power in watts. A wattmeter requires connections to measure both the current through and the voltage across the load being measured.

wind–electric conversion the process by which wind (mechanical) energy is converted to electrical energy, usually by the use of wind turbine.

wind power generator a system that utilizes the energy in the wind to generate electricity. The energy in the wind drives a wind turbine which acts as the prime mover for the generator. A wind turbine operates at a variable speed, and an appropriate electric machine and controller converts the mechanical energy into electrical energy and pumps it into a utility grid.

Z

zone of protection the area of a power system for which a particular set of protective relays has primary protection responsibility. In typical cases, operation of any of these relays will open circuit breakers, which will isolate this zone. Each major power system component (line, transformer, bus and generator) has a separate zone of protection.

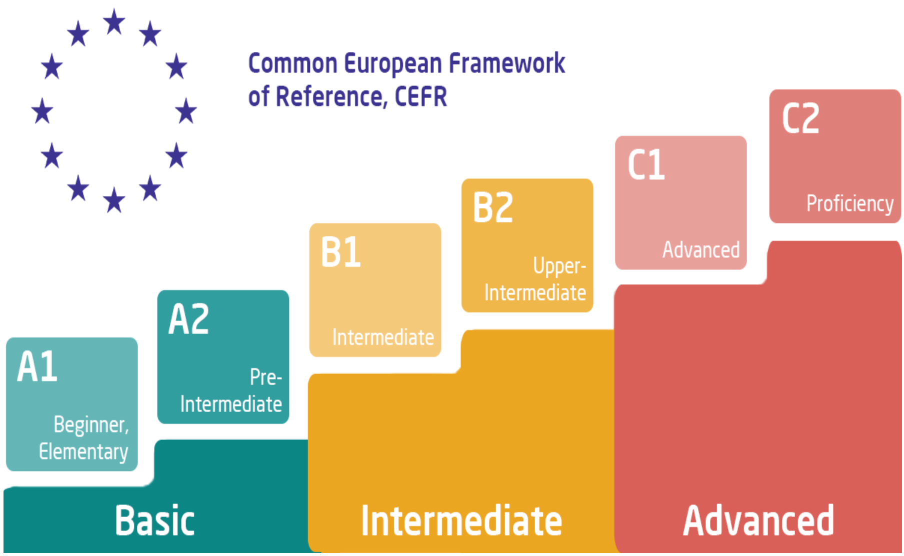
APPENDIX 4. COMMON EUROPEAN FRAMEWORK OF REFERENCE (CEFR)

Common European Framework of Reference (CEFR) — найпопулярніша система оцінки знання англійської мови. Найчастіше саме з її допомогою роботодавці позначають необхідний рівень володіння мовою кандидатом.

Складається з 6 рівнів:

1. Beginner, Elementary (A1).
2. Pre-Intermediate (A2).
3. Intermediate (B1).
4. Upper-Intermediate (B2).
5. Advanced (C1).
6. Proficiency (C2).

Їх об’єднують в систему, де є базовий, середній та просунутий рівні володіння англійською мовою.



/ A1

Beginner, Elementary (A1)

З цього етапу починається вивчення англійської мови. Людина вчить алфавіт, базові слова, цифри, календар. Намагається порахувати до ста, розповісти елементарну інформацію про себе (як звати, де і коли народилася, де живе), вчиться писати й читати прості речення з 5–9 слів.

Ось за якими параметрами можна зрозуміти, що ви вже освоїли цей рівень:

- вмієте розповісти про себе двома-трьома короткими реченнями;
- знаєте, як підтримати просту розмову (про погоду, справи, плани);
- розумієте, як відповідати на елементарні питання;
- сприймаєте на слух короткі речення з простими словами;
- знаєте ази часів Present, Past, Future Simple;
- можете порахувати до ста, озвучити будь-яку дату.

Pre-Intermediate (A2)

Ті, хто володіють мовою на цьому рівні, можуть підтримати просту розмову на базові життєві теми (професія, сім’я, хобі) і в різних ситуаціях (кафе, заправка, магазин, лікарня). Вміють писати короткі записки й твори, але зі словником. Можуть читати адаптовані тексти обсягом до 500 слів, де трапляються незнайомі слова, але це не заважає вловити загальну суть твору.

Як ще зрозуміти, що ви вже на цьому рівні володіння англійською мовою:

- можете переказати просту історію або висловити свою думку з приводу якоїсь інформації;
- починаєте використовувати модальні дієслова;
- знаєте, що таке Present Continuous, Past Continuous, Present Perfect;
- сприймаєте на слух невеликі розповіді з простою лексикою;
- вмієте підтримати розмову на такі теми, як здоров’я, їжа, подорож, вихідні, свята, спорт, одяг, тварини.

Intermediate (B1)

Ті, хто володіють англійською мовою на середньому рівні, зможуть підтримати розмову в будь-яких типових ситуаціях (зокрема, під час подорожі англомовною країною) і без пауз грамотно висловити свою думку. Зокрема, розповісти про мрії, наміри, минулий досвід.

Інші параметри, що вказують на те, що ви знаєте англійську на рівні B1:

- читаєте тексти на загальні теми, інструкції, офіційні документи;
- пишете тексти до 20 речень у форматі розповіді або особистого листа;
- знаєте, що таке пасивна форма дієслова, ступені порівняння прикметників, герундій, Present Perfect, Present Perfect Continuous;
- широко володієте лексикою на базові теми: побут, стосунки між людьми, робота, кіно, шопінг, освіта, транспорт, подорожі.

Upper-Intermediate (B2)

Той рівень мови, який найчастіше запитують роботодавці як мінімально необхідний. Чому? Тому що ті, хто знають англійську на рівні B2, вміють:

- висловлювати свою думку з прикладами, аргументами;
- описувати в подробицях ситуації, емоції й почуття;
- легко спілкуватися на повсякденні теми як з тими, хто починає вивчати мову, так і з носіями;
- читати ділову і художню літературу, пресу, аналітичні звіти;
- практично вільно сприймати на слух англомовні інтерв'ю, радіопередачі, ТВ-шоу, кінофільми;
- писати об'ємні тексти на велику кількість тем, ділові та неформальні листи.

Advanced (C1)

На цьому етапі людина вже вільно володіє мовою, але ще не на рівні носія. Може висловити свою думку на будь-яку тему, використовуючи складні граматичні конструкції. У неї виходить писати як художні тексти з метафорами, так і наукові статті, вести бізнес-листування.

Вона також:

- читає неадаптовані тексти з повним розумінням як суті, так і окремих деталей;
- добре, хоч і не вільно, розуміє співрозмовника, який вживає діалектизми або має сильний акцент;
- використовує в мові й листуванні інверсію, причинну форму дієслова, правильно і вільно вживає усі часові форми, які потрібні для розповіді.

Proficiency (C2)

Цей рівень означає, що ви володієте мовою вільно, як носій. Відмінно розумієте іншу людину, навіть якщо вона говорить дуже швидко (наприклад, як Емінем у своїх піснях). Можете підтримати будь-яку розмову, використовуючи складні граматичні конструкції, ідіоми. У вас виходить висловлювати свою думку навіть із вузькоспеціалізованих питань, як письмово, так і усно. Можете читати в оригіналі будь-які тексти — науково-популярні книги, наукові статті, художню або бізнес-літературу.

Таблиця рівнів знання англійської мови

Традиційно володіння англійською ділять на чотири категорії-навички: читання, письмо, аудіювання та говоріння.

Не завжди ці навички перебувають на одному рівні. Дуже часто вони розвинені нерівномірно, якась із них дається у вивченні простіше, а для розвитку іншої знадобиться докладати більше зусиль.

Саме тому будь-який іспит тестує кожну з цих навичок, щоб дати якомога точну оцінку знанням кандидата. Що саме має вміти людина, яка освоїла кожен із рівнів англійської:

Рівень	Мовлення	Читання	Письмо	Граматика	Лексика	Сприйняття на слух
A 1	Підтримуєте просту розмову про справи. Вмієте привітатися зі співрозмовником та попрощатися з ним.	Читаєте короткі речення (до 9 слів) з простою лексикою.	Вмієте писати ім'я, прізвище дату народження, місто, вік.	Відрізняєте множину і однину. Володієте Present Simple, Past Simple, Future Simple. Вмієте ставити прості запитання.	Словниковий запас — 1000-1500 слів. Знаєте елементарні дієслова, іменники, числівники та займенник. Можете описати сім'ю, друзів, свої вподобання.	Сприймаєте короткі речення (до 9 слів), які вимовляють повільно і з чіткою артикуляцією.
A 2	Розповідаєте про свої справи, роботу, хобі декількома реченнями. Можете висловити думку, використовуючи просту лексику.	Читаєте невеликі тексти (до 300–400 слів) на прості теми. До 25% слів можуть бути незрозумілі, але суть вловлюєте.	Вмієте писати короткі записки чи розповіді, але ще зі словником.	Володієте часовими формами Present Continuous, Past Continuous. Починаєте вивчати модальні дієслова, інфінітиви, умовні речення.	Словниковий запас — 1500–2000 слів. Володієте лексикою на теми: вихідні та канікули, здоров'я, їжа, розваги, спорт, тварини, одяг.	Сприймаєте прості діалоги і розповіді на життєві теми.
B 1	Описуєте свій досвід або ділитеся думкою, підкріплюючи їх прикладами. Можете підтримати спонтанну розмову на будь-яку типову тему	Читаєте тексти різних типів і стилів, попри 10–15% незнайомих слів.	Можете написати особистий чи діловий лист, невелику розповідь (до 20 речень), не користуючись словником.	Знаєте модальні дієслова, умовні речення, герундій, інфінітив. Освоїли Present Perfect, Present Perfect Continuous, ступені порівняння прикметників.	Словниковий запас — 2000–3000 слів. Володієте лексикою на теми: спорт, гроші, кіно, шопінг, дім, стосунки, подорожі.	Розумієте сюжет розповіді, відчуття і вчинки героїв. Специфічну лексику вгадуєте за контекстом.

B 2	Вмієте висловлювати свою думку чітко, наводячи аргументи і приклади	Читаєте як тематичні професійні звіти, так і неадаптовані художні тексти, без словника і з повним розумінням суті.	Пишете тексти з великою кількістю деталей, прикладів на різні теми.	Знаєте особливості всіх типів умовних речень, модальні дієслова, герундій, інфінітив. Володієте усіма часовими формами	Словниковий запас — 3000–4000 слів. Володієте лексикою на теми: здоров'я, одяг, мода, тіло, емоції, враження.	Практично вільно сприймаєте на слух різні типи текстів — від художніх оповідань до інтерв'ю і репортажів.
C 1	Легко ведете бесіду на будь-які теми (крім вузькоспеціалізованих), використовуючи складні мовні конструкції й аргументи.	Читаєте неадаптовані тексти, розумієте їх суть. Вмієте працювати з аналітичними звітами та науковими матеріалами.	Вмієте писати найрізноманітніші тексти, використовуючи художні прийоми. Успішно ведете бізнес-листування	Використовуєте інверсію, причинну форму дієслова, часи, які потрібні для розповіді.	Словниковий запас — 4000–6000 слів. Володієте лексикою за темами: робота, емоції, зовнішнє середовище, політика, транспорт, навчання, культура, мистецтво, спорт.	Сприймаєте як стандартну англійську, так і мовлення з різними акцентами та особливостями.
C 2	Легко говорите на будь-яку тему, навіть вузькоспеціалізовану. Використовуєте ідіоми, художні засоби, можете цитувати інших.	Вільно читаєте будь-які тексти — як художні романи, так так і наукову, науково-популярну літературу.	Пишете в будь-якому стилі будь-які типи текстів — листи, художні розповіді, репортажі, звіти.	Знаєте всі ази граматики.	Ваш словниковий запас становить понад 6000 слів, що дозволяє підтримати будь-яку розмову і написати будь-який текст.	Чудово розумієте як того, хто тільки вивчає мову, так і носія з діалектами, акцентами або дуже швидким темпом.

APPENDIX 5. USEFUL RESOURCES FOR LEARNING ENGLISH

РЕСУРСИ ДЛЯ ПІДГОТОВКИ ДО ЄВІ З АНГЛІЙСЬКОЇ МОВИ:

https://lv.testportal.gov.ua/testmktEnglish/

https://ilearn.org.ua/

https://zno.osvita.ua/english/

https://ed-era.com/

https://www.liveworksheets.com/worksheets/en

https://prometheus.org.ua/

ТЕСТОВІ ЗАВДАННЯ ДЛЯ ПІДГОТОВКИ ДО ІСПИТІВ З АНГЛІЙСЬКОЇ МОВИ:

https://www.liveworksheets.com/w/en/english-second-language-esl/2177597

https://www.liveworksheets.com/w/en/english-second-language-esl/270489

https://www.liveworksheets.com/w/en/english-second-language-esl/802890

https://www.liveworksheets.com/w/en/english-second-language-esl/7133066

https://www.liveworksheets.com/w/en/english-second-language-esl/229000

https://www.liveworksheets.com/w/en/english-second-language-esl/169782

https://www.liveworksheets.com/w/en/english-second-language-esl/7132036

https://www.liveworksheets.com/w/en/english-second-language-esl/7133300

https://www.liveworksheets.com/w/en/english-second-language-esl/163924

https://www.liveworksheets.com/w/en/english-second-language-esl/1706213

https://www.liveworksheets.com/w/en/technology/304306

https://www.liveworksheets.com/w/en/english-second-language-esl/709237

https://www.liveworksheets.com/w/en/english-second-language-esl/7132036

https://www.liveworksheets.com/w/en/english-second-language-esl/399421

https://www.liveworksheets.com/w/en/english-second-language-esl/1043143

https://www.liveworksheets.com/w/en/english-second-language-esl/290357

https://www.liveworksheets.com/w/en/english-second-language-esl/1737605

https://www.liveworksheets.com/w/en/english-second-language-esl/91079

ОНЛАЙН-РЕСУРСИ, ВПРАВИ, БЛОГИ:

https://www. bbc.co.uk/learningenglish — BBC Learning English. Великий вибір безкоштовних матеріалів, статей і завдань різних рівнів.

https://www. learnenglish.britishcouncil.org — British Council Learn English. Навчальні матеріали для всіх рівнів.

https://www. cambridgeenglish.org/learning-engl…/activities-for-learners/— сайт Cambridge Assessment English, на якому зібрано багато вправ для різних рівнів.

https://www.learn-english-online.org/ — безкоштовні уроки для тих, хто хоче самостійно вивчати англійську мову.

https://www.oxfordonlineenglish.com/free-english-lessons-mobile — матеріали та завдання різних рівнів у вільному доступі.

https://www. dictionary.com — не лише словник, а й блог зі статтями про походження різних слів і виразів, тести, кросворди, ігри в слова, рубрика «Слово дня».

https://www.dictionary.cambridge.org — онлайн-версія словника Cambridge English Dictionary. Містить довідник з граматики.

https://www.merriam-webster.com — провідний словник американської англійської. На цьому сайті багато ігор, тестів та гарних статей для любителів мови. Наприклад, рубрика «Words we're watching» — про слова, яких поки що немає в офіційних словниках.

https://www. ldoceonline.com — Longman Dictionary of Contemporary English. Там можна знайти не лише пояснення слів, а й правильну транскрипцію та озвучення (в британському й американському варіанті). Сайт містить кластери слів за темами. Обираєте ту, що цікавить вас — і маєте готовий глосарій з прикладами вживання і вимовою.

https://www. oxfordlearnersdictionaries.com — Oxford Learners' Dictionaries. Містить транскрипцію і списки слів за темами. А в розділі Text Checker можна вставити будь-який текст, обрати рівень і система опрацює його.

https://www. vocabulary.com — сайт для вивчення англійських слів. Вводите свій список слів, вставляєте текст чи обираєте одну з тем, і сайт створює для вас тест.

https://www. italki.com — сайт пошуку співрозмовників для навчання в тандемі. Вчіть англійську з британцями й американцями, а за це навчайте їх своєї рідної мови. Ще там можна писати тексти, і носії мови будуть їх редагувати.

YOUTUBE КАНАЛИ, ВІДЕОУРОКИ, ПОДКАСТИ:

https://www.youtube.com/user/JenniferESL — канал, на якому Дженіфер в коротких відео легко і доступно подає лексичний матеріал та розбирає граматичні конструкції.

engvid.com — безкоштовні відеоуроки англійської мови, записані командою вчителів. Цікаві, динамічні, зрозумілі пояснення.

https://www.youtube.com/channel/UCz4tgANd4yy8Oe0iXCdSWfA — Люсі Белли Ерл має дуже красиву британську вимову. А ще вона цікаво розповідає про різні аспекти англійської мови, особливо в контексті своєї культури.

https://www.bbc.co.uk/learningenglish/english/features/6-minute-english — подкасти на різні теми від компанії BBC.

https://www.youtube.com/user/GreenForestSchool — цікаві матеріали від креативних викладачів допоможуть опанувати англійську мову легше і швидше.

https://www.youtube.com/c/mmmEnglish_Emma — Емма, ведуча цього каналу — австралійка. Знімає багато відео не тільки про вивчення англійської, а ще й про те, як говорити нею впевненіше та подолати розмовний блок.

teacherluke.co.uk — Luke's English Podcast. Цікаві довгі подкасти для advanced learners про міжкультурну комунікацію, життя в Британії й Франції і, звичайно ж, англійську мову.

YouTube => Lexical Lab — канал Г'ю Деллара і Ендрю Воклі, відомих методистів і вчителів англійської. У них є серія One-Minute English, де Г'ю розбирає різні автентичні англійські вирази і приклади їх вживання.

КНИГИ ДЛЯ САМОСТІЙНОЇ ОСВІТИ:

Кембриджська серія **In Use.** У ній є посібники з усіх категорій: English Grammar in Use (граматика Мерфі), English Vocabulary in Use, English Collocations in Use, English Idioms in Use, English Phrasal Verbs in Use, English Pronunciation in Use. Підручники, побудовані за принципом: пояснення — вправи. Є різні рівні.

Grammarway by Virginia Evans and Jenny Dooley. Підхід до граматики: ґрунтовний, з термінами і роз’ясненням усіх деталей. Є чотирьох рівнів.

Oxford Word Skills by Ruth Gairns and Stuart Redman. Лексика. Люди, що займалися за цими книжками, хвалять їх за логічне й структуроване подання інформації. Є для трьох рівнів: Beginner, Intermediate і Advanced.

Oxford Word Skills: Idioms and Phrasal Verbs by Ruth Gairns and Stuart Redman. Англійські фразеологізми і фразові дієслова, організовані за темами.

Work on Your Accent by Helen Ashton and Sarah Shepherd. Зрозуміло про англійську вимову, поради і вправи для зменшення акценту, є аудіо.

FOR NOTES

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https://study.com/academy/lesson/types-components-of-electric-circuits.html
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https://learn.sparkfun.com/tutorials/what-is-electricity/all
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https://engineeringonline.ucr.edu/blog/power-systems-engineering-a-career-on-the-grid/
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Рибак Т. М.

ENGLISH FOR ELECTRICAL ENGINEERING

НАВЧАЛЬНИЙ ПОСІБНИК
З ДИСЦИПЛІНИ «ІНОЗЕМНА МОВА (АНГЛІЙСЬКА)
ЗА ПРОФЕСІЙНИМ СПРЯМУВАННЯМ»

Формат 60х84\16. Умовн. друк.арк. 8,83.
Тираж 300 прим. Зам. № 122.

Віддруковано з готових оригінал-макетів автора

Видавець та виготівник ПП "Євро-Волинь"
м. Житомир, вул.Крошенська, буд.45, кв.34

Свідоцтво серія ДК № 7208 від 07.12.2020