UNIT IX

SOURCES OF LIGHT

Activity I.

Learn the words and phrases

emission of light – *випромінювання світла*	the derived unit of illumination – *виведена одиниця освітлення*
flame – *полум'я*	wavelength – *довжина хвилі*
fraction – *частинка*	incident light – *падаюче світло*
incandescence – *напруження*	to emit – *випромінювати*
luminous intensity – *інтенсивність світіння*	to illuminate – *освічувати, освітлювати, опромінювати*
measurable – *вимірний*	to maintain – *підтримувати*
point source – *точкове джерело світла*	to reflect – *відображати*
sources of light – *джерела світла*	to compare – *порівнювати*
substance – *речовина*	to course – *спричиняти*

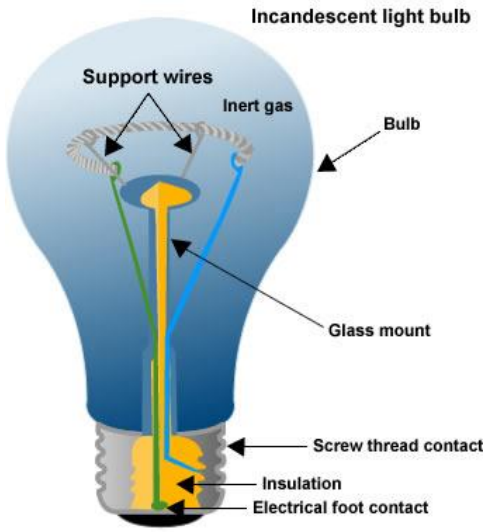
Activity II.

Study the words and phrases. Translate the sentences paying attention the words and phrases in bold.

Light *(n)* 1) світло 2) освітлення 3) джерело світла 4) полум'я, іскра 5) аспект, вигляд, інтерпретація *6) pl* дані, нові відомості	***Light*** *(v)* 1) світити 2) запалювати 3) освітлювати ***Light*** *(adj)* 1) світлий 2) легкий, мало вагомий 3) світловий 4) освітлювальний

ЗАПАМ'ЯТАЙ!

light up – *запалюватися, загорятися*
traffic lights – *світлофор*
turn on the light – *включати світло*
turn off the light – *виключати світло*
light-hearted – *безтурботний*
lightning rod – *блискавковідвід*
lightning strike – *удар блискавки*
flash of lightning – *спалах блискавки*
light-minded – *легковажний*
LED – *світловий діод*



Activity II.

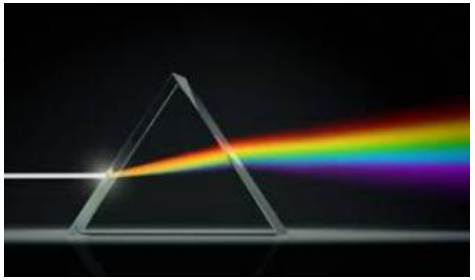
Study the words and phrases. Translate the sentences paying attention the words and phrases in bold.

1. All the rooms in this apartment are **light** and airy. 2. The main source of **light** on Earth is the Sun. 3. They arranged to meet at the **traffic lights**. 4. The hall was **lighted** by a number of small lamps. 5. We found not all **light bulbs** good to use. 6. It was a great carnival and they **were lighting up** a lot of fireworks. 7. He was so **light-minded** in that situation that no one could treat him like a professional. 8. **Lightning rod** should be installed on every house, especially a high building. 9. Companies are developing ways to use organic **light-emitting diodes (LED)** as a source for lighting up rooms. 10. Maybe, without the gadgets that make our lives work at **lightning** speed, people had more time on their hands for long movies.

Activity III.

Read and translate the text:

Light shows two types of nature. It shows particle nature, and it also shows the wave nature. According to the theory of electromagnetic radiation, each wave consists of two types of fields, i.e., electric field and the magnetic field. According to the particle theory of light, light is composed of particles and these particles are termed as photons. Light consists of group of particles and each particle is termed as a photon and each photon has some energy associated with it which depends on the frequency of light. According to wave theory of light it is basically a wave, composed of perpendicular magnetic and electric fields. Each wave has its associated wavelength, frequency, and energy.



There are different kinds of light sources, some of them are caused by high temperatures, others by some other factors. Every source of light known to have a luminous intensity, which is measurable. In general, the higher is the temperature of the source, the greater the luminous intensity of the light it emits. At room temperature we see a piece of metal like platinum by the light it reflects. If we heat it until it reaches a sufficiently high temperature, we can see then this piece of platinum even in a darkened room by the light it emits. Incandescence is the emission of light caused by high temperatures. To produce light by incandescence, we maintain the object we are using as a source at a high temperature relative to, say, room temperature (about 68°F). Under these conditions a substance becomes white or bright-red hot and emits light. Certain substances emit light without becoming incandescent; we consider them to be luminescent.

Activity III.

Read and translate the text:

Luminescent is the emission of light from a body from any cause other than high temperature. We consider fluorescence and phosphorescence to be cases of luminescent. A candle flame is an example of incandescence. The light emitted by a firefly is an example of luminescent. Certain substances emit visible light when ultraviolet light shines on them. We know them to be fluorescent materials. Experiment shows that ultraviolet radiation of this sort does not increase the temperature of fluorescent substances appreciably above room temperature. Light from fluorescent sources is not incandescent.

Almost immediately after, an ordinary light bulb has been lit. It is uncomfortably hot to the touch. As far as an ordinary light bulb is concerned, it is an incandescent source. A lighted fluorescent lamp is unlikely to be too hot to the touch. It is known to be a luminescent light source. Ultraviolet light shining on zinc sulfide causes it to emit a green light. We know it to be a fluorescent source. As we have already stated, every object which emits light has a measurable luminous intensity. The sun certainly has greater luminous intensity than an ordinary electric bulb. To measure luminous intensity, we have to define a unit. The unit is the standard candle (or more briefly the candela). A source which has a luminous intensity of 25 candles is 25 times more intense than the candela. We define a standard candle as 1/60 of the luminous intensity of the light emitted by 1 cm^2 of an incandescent platinum metal surface maintained at a fixed temperature 1763°C. One cm^2 of such a surface has a luminous intensity of 60 (standard) candles. Although we define the standard candle in terms of the luminous intensity of a certain area of incandescent platinum metal surface, we use it to measure the luminous intensity of any luminous object. This means that the luminous intensity of a fluorescent lamp is also measured in a standard candle.

Activity III.

Read and translate the text:

A source of light which is small compared to the area it illuminates is called a point source. An electric bulb illuminating a large auditorium is a point source. A small candle flame has less luminous intensity than the bulb of a large streetlamp. A surface placed at equal distances from each of these sources is certain to receive more illumination from the streetlamp. The illumination of a surface is called illuminance, and it is the amount of light falling on unit area of the surface per second. The derived unit of illumination in SI system of units is the lux (lumen per square meter). Illuminance is directly proportional to the luminous intensity of the source. However, it depends not only on the luminous intensity of the source but also on the distance of the illuminated area from the source of light. Illuminance is inversely proportional to the square of the distance from the source.

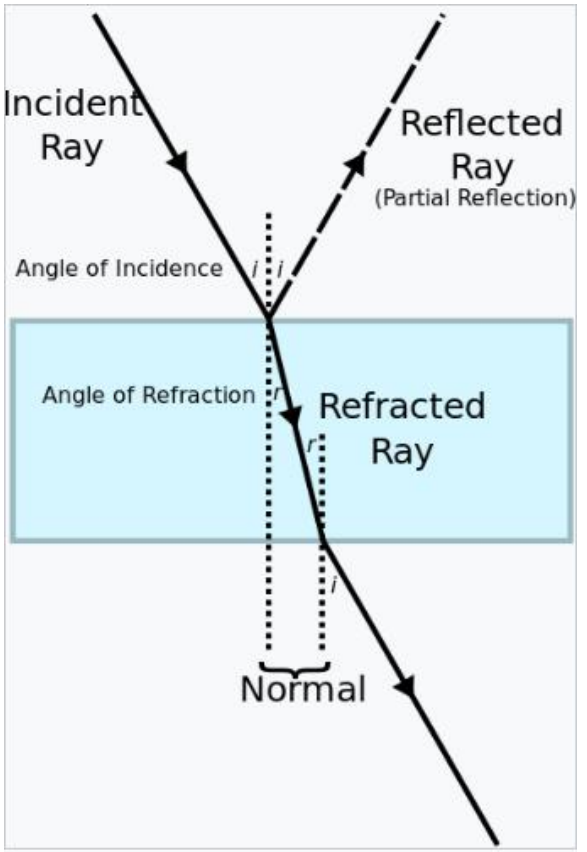
Properties of Light

1. Speed of Light : Light travels in the form of straight line. Light travels with constant speed in the vacuum and this constant speed is equal to the $c = 2.9979245 \times 10^8$ m s^{-1}. This is approximately taken as 3×10^8 m s^{-1}.

2. Reflection: The basic is meaning of a reflection is something returned in response". When the light reflected from the medium or the surface, the angle of reflection depends only on the angle of incidence to the surface. According to the law of reflection, the angle of reflected wave reflected from the surface is always equal to the angle of incidence.

Activity III.

Read and translate the text:



3. Superposition: If in the space multiple light waves are present then at a particular point in the space the resultant electric field would be the vector sum of the all the electric fields present at that point. This is the law of superposition. As light consists of electric and magnetic field, the law of superposition is followed by both electric and magnetic fields, and we get the resultant magnetic and electric fields at that point.

4. Refraction: When light passes through a substance or medium, light gets bend on the basis of the wavelength or frequency. This phenomenon is termed as the Refraction. It follows Snell's Law of Refraction.

5. Light Transmittance: When light falls on a substance, some of the light energy gets refracted, and some gets absorbed by the substance. Light transmittance is defined as the fraction of incident light on the substance which passes through the substance at a particular frequency or wavelength. Light transmittance is defined as the ratio of the intensity of the Incident light on the substance to the intensity of light which passes through the substance or comes out from the substance.

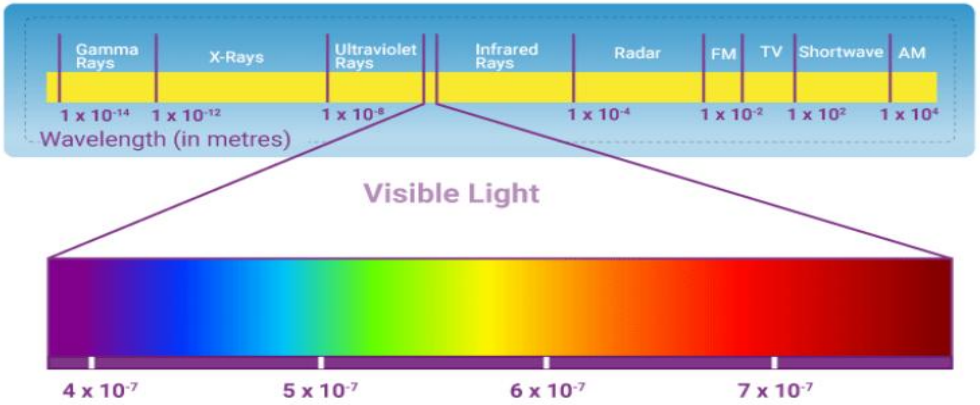
Activity III.

Read and translate the text:

6. Wavelength: Wavelength of Light is defined as the distance between the two consecutive crests or between two consecutive troughs. Wavelength of the light ranges from 380nm to 750nm. In the electromagnetic spectrum, Infrared rays has higher wavelength than the visible rays and the ultraviolet rays has smaller wavelength as compared to the light.

7. Frequency: Frequency of light is defined as the number of crests which passes through a particular point in a second. It is represented in hertz. Frequency of waves is inversely proportional to their wavelength, which means that higher the wavelength, lower is the frequency and vice versa. The frequency range of the light is between 400 to 790 THz.

8. Colors in light: Light consist of different types of colors. These colors are differentiated on the basis of their wavelengths in the visible spectrum . For example, when visible white light is made to pass through the prism, the different colors present in the visible white light bend at different angles depending on their wavelengths and as a result different colors of light are observed. The colors present in the light are Red, orange, yellow, green, and cyan, blue, violet.



Activity IV.

Answer the following questions:

1. What is light?
2. What do we call a luminous / an illuminated object?
3. What is the main source of light?
4. Is the Moon a source of light?
5. What kinds of light sources do you know?
6. What is incandescence caused by?
7. What materials do we call fluorescent substances?
8. What kind of light source is a firefly?
9. How was the standard candela defined?
10. What is a point source?

Activity V.

Define whether the sentences are true or false:

1. Light from fluorescent sources is not incandescence.
2. We consider fluorescence and phosphorescence to be different
3. cases of luminescence.
4. Ultraviolet radiation of this sort increases the temperature of fluorescence
5. substances appreciably above room temperature.
6. A lighted fluorescent lamp is unlikely to be too hot to the touch.
7. To measure luminous intensity we have to define a unit.
8. Not every object which emits light has a measurable luminous intensity.
9. One cm^2 of an incandescent platinum metal surface has a luminous intensity
10. of 80 standard candles.
11. The illumination of a surface is the amount of light falling on unit area of the
12. surface per second.
13. Illuminance is directly proportional to the square of the distance from the source.
14. A small candle flame has less luminous intensity than the bulb of a large street lamp.

Activity VI.

Insert the words into the following sentences: *thin-walled, discontinuous, continuous, intensity, low, infrared, thermal, artificial, small, natural.*

Nearly all the … light we receive comes from the sun; moonlight is sunlight reflected from the surface of the moon. 2. Distant stars provide an extremely … amount of light. 3. There are several ways of producing … light. 4. Example of … source are incandescent lamp, burning candle, etc. 5. When object is heated until it glows or becomes incandescent, it emits all visible wavelengths along with large quantity of … radiation.
6. Hence, as producers of visible radiation (i.e. luminous energy), they have a … efficiency. 7. The color and … of light depends upon the nature of gas or vapor only. 8. It may be noted that in case of light emitted by a thermal source, the spectrum is … . 9. However, when light is obtained from a gaseous discharge, the spectrum is … i.e. it consists of one or more colored lines. 10. A fluorescent tube consist of a … glass tube with fluorescent substance coated on the inside of the tube.

Activity VII. Pay attention to the following facts:

1. Light energy is the only energy visible to the human eye. Light rays have different colors due to differing wavelengths.
2. Unlike sound waves or water waves, light does not need any matter or material to carry its energy along. Thus, light can travel through a vacuum.
3. If you travelled at the speed of light, you could travel around the Earth 7.5 times every second!
4. Sunlight can reach a depth of about 80m in the ocean!
5. When you turn on a light bulb only 10 % of the electricity used is turned into light, the other 90 % is wasted as heat.
6. We see rainbows because the water droplets in the air cause the light to be split up into the colours it's made from - just like a prism.
7. Animals that only come out at night when it is dark are called nocturnal animals. They include badgers and owls.
8. The northern lights are a display of coloured lights in the sky over the north pole. They are caused by energy from the Sun interacting with gases surrounding the Earth.
9. Eyeglasses can correct vision because light changes speed when it passes from air to a glass or plastic lens; this causes the rays to bend.
10. Every second around 100 lightning bolts strike the Earth. In fact, lightning kills 1000 people every year in the world.

Activity VIII.

Choose and circle the right word in the brackets:

1. We use the standard candle to measure the luminous intensity of (*only some / any*) luminous objects. 2. A source of light which is (*large / small*) compared to the area it illuminates is called a point source. 3. Illuminance of a surface is (*directly / inversely*) proportional to the luminous intensity of the source and (*directly / inversely*) proportional to the square of the distance from the source. 4. The candle is a unit used to measure (*luminous intensity / illuminance*). 5. The lux is a unit used to measure (*luminous intensity / illuminance*) in SI units. 6. All luminous objects emit (*the same amount / different amounts*) of light. 7. A source which has a luminous intensity of 25 candles is 25 times (*more / less*) intense than the standard candle. 8. We define the standard candle in terms of the light emitted by 1 cm^2 of a (an) (*luminescent / incandescent / fluorescent*) platinum metal surface maintained at a (*random / fixed*) temperature.

Activity IX. Match the definitions with the words:

1.	rays	a.	an example of luminescence
2.	luminescence	b.	the emission of light from a body from any cause other than high temperature
3.	incandescence	c.	the standard candle which source has a luminous intensity of 25 candles
4.	candle flame	d.	a source of light which is small compared to the area it illuminates
5.	Firefly	e.	the directed straight lines in geometry
6.	fluorescence materials	f.	the emission of light caused by high temperatures
7.	unit	g.	certain substances which emit visible light when ultraviolet light shines on them
8.	fluorescent source	h.	an example of incandescence
9.	a point source	i.	ultraviolet light shining on zinc sulfide, which causes it to emit a green light

Activity X.

Find Ukrainian equivalents:

energy source_____
emission energy_____
radiation intensity_____
space radiation intensity_____
substance surface_____
surface pressure_____
research value_____
energy source research_____
energy source research value_____
surface radiation intensity research_____

Activity XI.

Find English equivalents:

в 25 разів інтенсивніше_____
кількість світла_____
точкове джерело світла_____
інтенсивність світіння_____
джерело світла_____
на основі інтенсивності світіння_____
обернено пропорційна_____
виведена одиниця_____
прямо пропорційна_____

Activity XII.

Translate into English:

Властивості світла

Перші уявлення давніх учених про те, що таке світло, були досить наївні. Існувало кілька точок зору. Одні вважали, що з очей виходять особливі тонкі щупальця і і зорові враження виникають при обмацуванні ними предметів. Ця точка зору мала велике число послідовників, серед яких був Евклід, Птоломей і багато інших вчених. Інші, навпаки, вважали, що проміння випускається тілом і, досягаючи людського ока, несе на собі відбиток предмета. Такої точки зору дотримувалися Лукрецій та Демокрит. У цей же час Евклідом був сформульований закон прямолінійного поширення світла.

І до початку XVII ст. ці точки зору можна були вже забутими, тоді виникли і почали розвиватися дві зовсім різні теорії про те, що таке світло і яка його природа. Одна з цих теорій пов'язана з ім’ям Ньютона, а інша - з ім'ям Гюйгенса. Ньютон дотримувався корпускулярної теорії світла, згідно якої світло – це потік частинок, що йдуть від джерела в усі боки. Згідно ж уявленням Гюйгенса, світло – це потік хвиль, що розповсюджуються в ефірі, що заповнює весь простір і проникає всередину всіх тіл. Обидві теорії тривалий час існували паралельно. Жодна з них не могла здобути вирішальної перемоги і ці два несумісних один з одним уявлення про природу світла в 30-х роках XX століття вдалося несуперечливим чином об'єднати в новій видатної фізичної теорії – квантовій електродинаміці.

WORD STUDY

1W. Supply appropriate preposition.

1. I am not familiar __ that author's works.
2. He doesn't approve __ smoking.
3. I subscribe __ several magazines.
4. Water consists __ oxygen and hydrogen.
5. I became uncomfortable because she was staring __ me.
6. She hid the candy __ the children.
7. He never argues __ his wife.
8. I arrived __ this country two weeks ago.
9. We arrived __ the airport ten minutes late.
10. Has Mary recovered __ her illness?
11. I pray__peace.
12. I am envious __ people who can speak three or four languages fluently.
13. Why are you angry __ me? Did I do something wrong?
14. They are very patient __ their children.
15. The students responded __ the questions.

2W. Complete the sentences, using gerund.

1. He never thought of ____.
2. This student is very clever at _____.
3. I don’t insist on ____.
4. We were tired of _____.
5. Did you succeed in ____?
6. Who is responsible for ____?
7. They were grateful for ____.
8. He had some difficulty in ____.

WORD STUDY

3W. Complete the second sentence so that it has a similar meaning to the first sentence, using the word given. Do not change the word given.

1. *You haven't seen my pen anywhere, have you?*

happen You don't …. my pen anywhere, have you?

2. *Everything I told you was true.*

all I told you a lot … which were true.

3. According to reports, the President is in poor health.

reported The President … in poor health.

4. Julia's inheritance meant that she could give up work.

enabled Julia's inheritance … give up work.

5. We received a warning to stay at home.

should We were … stay at home.

6. You could easily become ill unless you give up smoking.

risk If you don't stop … ill.

7. The decorators didn't leave too much mess when they did the job.

without The decorators managed … too much mess.

8. It's pointless to worry about someone else's problems.

no There … about someone else's problems.

9. According to Valerie, she is a relation of mine.

be Valerie claims .. ..to me.

4W. Learn the following speech patterns.

1. He doesn't do it the **way** I do.	1. Mr. Hopkins **substituted for** a teacher who was in hospital.
2. It's disgraceful the **way** he behaves.	2. A construction which may **substitute for** a word is a phrase.
3. The work must be done one **way** or another.	3. In this cake mixture, you can **substitute** oil **for** butter.
4. It's not his **way** to be so rude.	4. Her big break came when she **substituted for** the ailing star.

1. A cone is **much like** a pyramid but has a circle for a base.
2. A CD-RW disk is **much like** a CD-R but it can be written to multiple times.
3. A modern PC is **nothing like** a bulky computer used in the 1960s-1970s.
4. It's **nothing like** what it used to be.

WORD STUDY

5W. Choose the right word:

1. She didn’t succeed in ….. her sister talk.
a) made; b) to be made; c) making; d) being made.
2. Beryl insisted on ….. in London.
a) to marry; b) being married; c) married; d) having been married.
3. She sat ….. straight before her.
a) gazed; b) to gaze; c) gazing; d) to be gazing.
4. I think I hear Hector ….. back.
a) to have come; b) to come; c) having come; d) coming.
5. She seemed ….. or …..
a) written***drawn; b) to write***to draw;
c) to be writing***to be drawing; d) to be written***to be drawn.
6. Why didn’t you make me ….. about it and ….. it off my heart ?
a) talking; b) to talk; c) talk; d) having talked.
a) got; b)get; c) to get; d) to be getting.
7. ….. my sister about it hurts me.
a) not to tell; b) not to be told; c) not telling; d) not to have been told.
8. Coming up I found my landlord ….. quietly upstairs.
a) going; b) gone; c) to go; d) to have gone.
9. You are mistaking in ….. me a beggar.
a) being supposed; b) supposing; c) to suppose; d) to be supposed.
10. Sam looked from side to side as though ….. to escape.
a) to try; b) trying; c) having tried; d) to have tried.

ADDITIONAL READING PASSAGE

Text 1

Lightning is an atmospheric discharge of electricity accompanied by thunder, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms. Cloud-to-ground lightning bolts are a common phenomenon – about 100 strike Earth's surface every single second – yet their power is extraordinary. Each bolt can contain up to one billion volts of electricity.

This enormous electrical discharge is caused by an imbalance between positive and negative charges. During a storm, colliding particles of rain, ice, or snow increase this imbalance and often negatively charge the lower reaches of storm clouds. Objects on the ground, like steeples, trees, and the Earth itself, become positively charged – creating an imbalance that nature seeks to remedy by passing current between the two charges.

Lightning is one of the most beautiful displays in nature. Beyond its powerful beauty, lightning presents science with one of its greatest local mysteries. Lightning is extremely hot – a flash can heat the air around it to temperatures five times hotter than the sun's surface. This heat causes surrounding air to rapidly expand and vibrate, which creates the pealing thunder we hear a short time after seeing a lightning flash.

Lightning is not only spectacular, it's dangerous. About 2,000 people are killed worldwide by lightning each year. Hundreds more survive strikes but suffer from a variety of lasting symptoms, including memory loss, dizziness, weakness, numbness, and other life-altering ailments. There are various types of lightning besides the standard cloud to ground strikes, all of which work on the principles as described in 'why lightning occurs', however as research continues new types of lightning are still being discovered.

ADDITIONAL READING PASSAGE

Text 1

Cloud-to-Ground lightning is the discharge from the negative lower part of the cloud to the positively charged earth. This is the most common form (it constitutes 25% of all lightning). However, it causes the most damage and so effects our lives the most.

Intercloud is the least common strike between the positive and negative charges within separate clouds where the strike travels in the air between them.

Intercloud lightning is the most common form of lightning. It appears as a flash within the cloud occurring between the positive and negative charges that are within the same thunder cloud. Although this is the most common due to it causing very little danger or damage not a lot of research has been carried out on it in comparison to cloud to ground.

Ball Lightning appears in the form of a glowing sphere which drifts horizontally in the air usually only lasting a few seconds. It is still not fully understood why this occurs.

Sheet Lightning is a term used to describe clouds illuminated by a lightning discharge where the actual lightning channel is either inside the clouds or below the horizon (not visible to the observer).

Bead Lightning. This lightning appears to disintegrate itself into a string of bright segments that give us a view of beads.

Lightning causes damage to buildings and equipment in three different ways:

- √ There can be damage as a result of a direct lightning strike. Such damage includes damage to roofing materials, structures such as chimneys, heating or air conditioning units located on the roof or exterior of a building, or fires caused by lightning igniting combustible material, such Get off of and away from motorcycles, scooters, golf carts and bicycles. Put down golf clubs.
- √ Stay away from wire fences, clotheslines, metal pipes, rails and other metallic paths which could carry lightning to you from some distance away.
- √ Avoid standing in small isolated sheds or other small structures in open areas.
- √ If a forest, seek shelter in a low area under a thick growth of small trees. In open areas, go to a low place such as a ravine or a valley. Be alert for flash floods.

UNIT X

ELEMENTARY PARTICLES

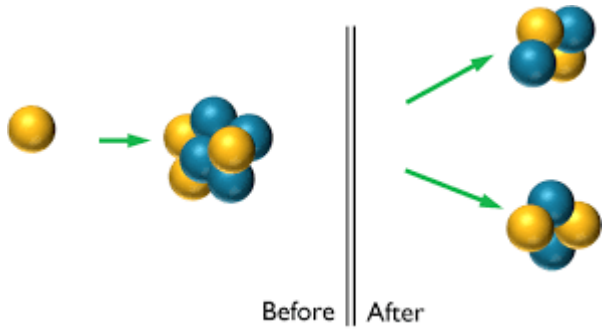
Activity I.

Learn the words and phrases

accumulation – *накопи́чування, ску́пчування*	spinon - *спінóн* || *спінóнний*
confusion – *змішування*	substance – *речовина*
constituent – *складова частина, елемент;*	subatomic - *субатомний*
extension – *узага́льнення, розтяга́ння*	oscillation – *коливання*
excitation –(*процес*) *збу́джування*	to be composed of – *складатися з*
decay – розпад	to propagate – *пошúрювати(ся*)
framework – структу́ра, оболóнка	to split into – *розпадатися на*
spin – власти́вий [вну́трішній] *моме́нт кíлькости ру́ху*	to verify – *пересві́дчуватися*

Activity II.

Study the words and phrases. Translate the sentences paying attention the words and phrases in bold.

Split *(n)* 1) розкол, поділ 2) розрив 3) шпагат (s) 4) різниця	**Split** *(v)* 1) розколювати(ся) 2) розпадатися 3) розщеплювати(ся) 4) розривати 5) розділяти(ся)
ЗАПАМЯТАЙ! to split up – *розійтися* split off into – *розколотися на* split down – *поділити рівно* split on – *доносити на (когось)* split your sides – *ледве себе стримувати* split hairs – *сперечатися, чіплятися до дрібниць*	

1. Rain was getting in through a **split** in the plastic sheeting. 2. There is a widening **split** between senior managers and the rest of the workforce. 3. The tax issue has caused a **split** in the government. 4. There was a 72/25 **split** in the voting. 5. She attends gymnastics club every week, so she can do the **splits**. 6. The prize was **split** between Susan and Kate. 7. X-rays **split** the electrons into a spinon and an orbiton. 8. The wooden floor had cracked and **split** in the heat. 9. The electronics division was **split** off into a freestanding company. 10. Let's **split** the cost right down the middle. 11. They knew Josie wouldn't **split** on them to the teacher. 12. We practically **split our** sides with laughter watching Paul trying to get the dog into the bicycle basket.
13. To live peacefully for a long time we shouldn't **split** hairs.

Activity III.

Read and translate the text:

In physics, particles that cannot be broken down into any other particles are called elementary particles. The term *elementary particles* also is used more loosely to include some subatomic particles that are composed of other particles. Particles that cannot be broken further are sometimes called fundamental particles to avoid confusion. These fundamental particles provide the basic units that make up all matter and energy in the universe.

Scientists and philosophers have sought to identify and study elementary particles since ancient times. Aristotle and other ancient Greek philosophers believed that all things were composed of four elementary materials: fire, water, air, and earth. People in other ancient cultures developed similar notions of basic substances. As early scientists began collecting and analyzing information about the world, they showed that these materials were not fundamental but were made of other substances.

In the 1800s British physicist John Dalton was so sure he had identified the most basic objects that he called them *atoms* (Greek for “indivisible”). By the early 1900s scientists were able to break apart these atoms into particles that they called the electron and the nucleus. Electrons surround the dense nucleus of an atom. In the 1930s, researchers showed that the nucleus consists of smaller particles, called the proton and the neutron. Today, scientists have evidence that the proton and neutron are themselves made up of even smaller particles, called quarks.

Activity III.

Read and translate the text:

Scientists now believe that quarks and three other types of particles—leptons, force carrying bosons, and the Higgs boson-are truly fundamental and cannot be split into anything smaller. In the 1960s American physicists Steven Weinberg and Sheldon Glashow and Pakistani physicist Abdus Salam developed a mathematical description of the nature and behavior of elementary particles. Their theory, known as the standard model of particle physics, has greatly advanced understanding of the fundamental particles and forces in the universe. Yet some questions about particles remain unanswered by the standard model, and physicists continue to work toward a theory that would explain even more about particles.

Elementary-particle physics deals with the fundamental constituents of matter and their interactions. In the past several decades an enormous amount of experimental information has been accumulated, and many patterns and systematic features have been observed. Highly successful mathematical theories of the electromagnetic, weak, and strong interactions have been devised and tested. These theories, which are collectively known as the standard model, are almost certainly the correct description of Nature, to first approximation, down to a distance scale 1/1000th the size of the atomic nucleus. There are also speculative but encouraging developments in the attempt to unify these interactions into a simple underlying framework, and even to incorporate quantum gravity in a parameter-free "***theory of everything***." In this article we shall attempt to highlight the ways in which information has been organized, and to sketch the outlines of the standard model and its possible extensions.

Activity IV.

Answer the following questions:

1. What are elementary particles?
2. Have elementary particles been studied recently? How long?
3. What did Greek philosophers believe?
4. What was noticeable in 1800s?
5. Do scientists now fully understand particles? What will they have to do?
6. Which elementary particles form the nucleus of an atom?
7. What does the word *atom* mean from Greek?
8. What scientists have made contributions to the study of matter?
9. How is common theory of elementary particles called?
10. What particles are composed of quarks?
11. What things were the basis of matter according to Aristotle?

Activity V.

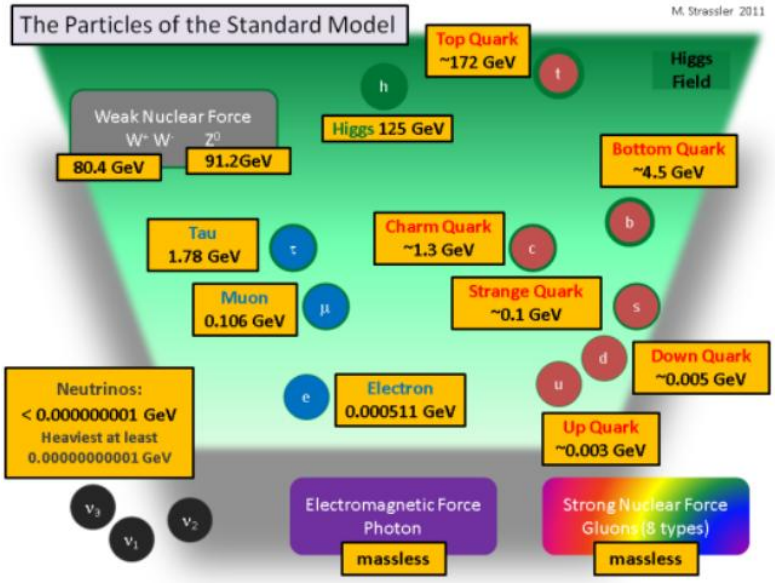
Define whether the sentences are true or false:

1. Elementary particles are the smallest ones.
2. Elementary and fundamental particles are the same.
3. All matter and energy are made up basing on fundamental particles.
4. Elementary particles have been studied for a very long time.
5. According to Aristotle and other Greek philosophers, everything consisted of fire, water, air, and earth.
6. People in other ancient cultures had different opinions about fundamental particles.
7. Early scientists showed that the materials were not fundamental after they had collected and analyzed information about the world.
8. In Greek, ‘atom’ means ‘visible’.
9. Quarks may soon be broken down into smaller particles.
10. The ‘standard model’ theory contributed greatly to the understanding of the universe.

Activity VI.

Insert the words into the following sentences: *identify, broken down, fundamental, universe, confusion, remain, subatomic, surround, notions, identified*

1. Elementary particles are particles that cannot be … into any other particles. 2. The term elementary particles also is used more loosely to include some … particles. 3. Particles that cannot be broken further are sometimes called fundamental particles to avoid … . 4. These fundamental particles provide the basic units that make up all matter and energy in the … . 5. Scientists and philosophers have sought to … and study elementary particles since ancient times. 6. People in other ancient cultures developed similar … of basic substances. 7. In the 1800s British physicist John Dalton was so sure he had … the most basic objects. 8. Electrons … the dense nucleus of an atom. 9. Quarks and three other types of particles-leptons, force-carrying bosons, and the Higgs boson-are truly … . 10. Yet some questions about particles … unanswered by the standard model.



Activity VII.

Match the definitions with the words:

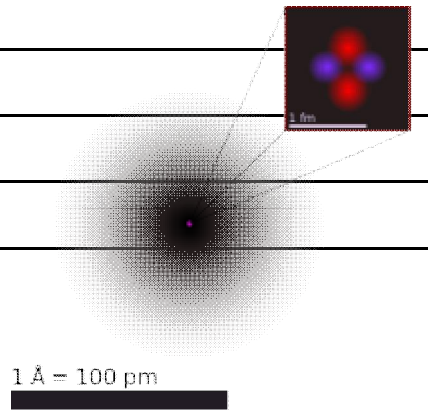
1.	substance	a.	An extremely small piece of matter that is smaller than an atom or found in or found inside the atom, such as a proton, neutron, or electron
2.	extension	b.	material with particular physical characteristics
3.	quark	c.	a machine that makes extremely small pieces of matter travels at very high speeds, so that scientists can study the way they behave
4.	pattern	e.	one of the most basic forms of matter that make up the heavier elementary particles
5.	subatomic particles	f.	the act of adding to something to make it bigger or longer
6.	accumulation	g.	an amount of something that has been collected
7.	antiparticle	h.	a particular way in which something is done, is organized, or happen
8.	particle accelerator	i.	which make up antimatter, containing the same amount of matter r but having the opposite electrical charge that a regular particle has

Activity VIII.

Form compound adjectives from participles, basing on the following explanations. *Example:*

Explanation	Word combination
the objects that oscillate freely	fully-oscillating objects

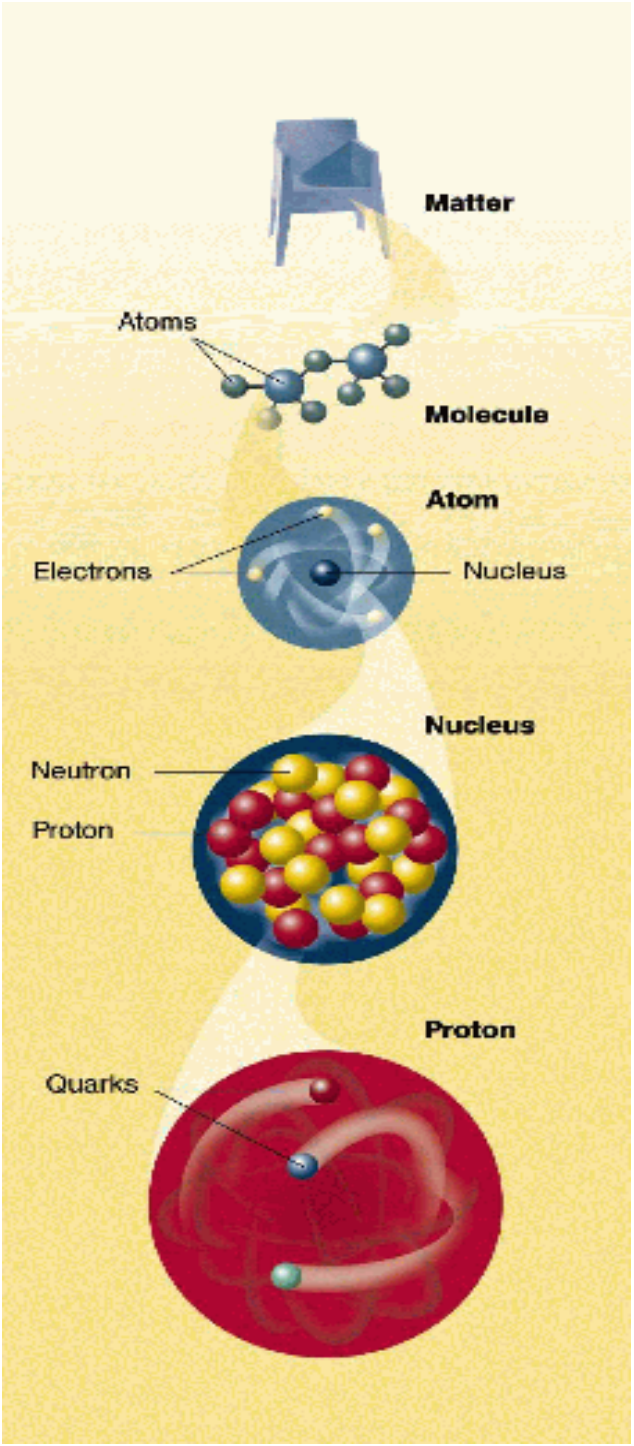
Explanation	Word combination
the device that sounds echo	
the students who work industriously	
the graph that slopes upwards	
the system that transfers energy	
the waves that interfere destructively	
the devices which are used to conduct	
the analyzer which describes in detail	
the device which is used to develop film	
the pole that points to the south	
the matter which is discussed heatedly	
a report that is well presented	
the particles that move fast	



ACTIVITY IX.

PAY ATTENTION TO THE FOLLOWING FACTS:

1. Over 200 elementary particles have so far been seen in particle accelerators, though most are so unstable and short-lived that they can barely be said to exist at all.
2. There are six different types of quarks. These are the up quark, the down quark, the strange quark, the charm quark, the bottom quark, and the top quark.
3. A neutron is made of two down quarks and one up quark . The proton is made up of two up quarks and one down quark.
4. The Higgs Boson is a particle that is believed to give other particles mass.
5. The Higgs Boson is thought to have played an important role in the formation of protons and neutrons, the building blocks of atoms.
6. The Higgs Boson has a short lifetime of about 10^-22 seconds before it decays into other particles.
7. Neutrinos are very mysterious. Neutrino flavor can change. Electron neutrino can change into a muon neutrino, and a muon neutrino can change into a tau neutrino. This is known as neutrino oscillation.
8. Particle accelerators come in a variety of shapes and sizes. But they tend to fall into one of two main categories; linear accelerators and circular ones.
9. The Linear Accelerator building at SLAC national Acceletor Laboratory in San Francisco is one of the longest buildings in the world. The building is around **2 miles (3.2 km)** long, and it houses a very powerful linear particle accelerator.
10. A blistering temperature of **around 5.5 trillion degrees Celsius** was recorded in 2012 at the Brookhaven National Laboratory's Relativistic Heavey Ion Collider. This not only won them a Guinness World Record but also enabled them to produce a small amount of quark-gluon plazma (a state of matter thought to have dominated the early universe).



Activity X.

Find Ukrainian equivalents:

collect information _____

identify elementary particles _____

avoid confusion _____

similar notions _____

dense nucleus _____

be made up of _____

greatly advanced understanding _____

work towards a theory _____

be broken into pieces _____

attractive forces _____

move apart _____

bump into nucleus _____

Activity XI.

Find English equivalents:

нестійкі атоми _____

вирішальне відкриття _____

головна характерна риса _____

загальна теорія атома _____

взаємодія нейтрона з різними ядрами _____

структура ядра _____

поняття матерії _____

чиста речовина _____

рухомі частинки _____

стан матерії _____

Activity XII.

Translate into English:

Фізика високих енергій та елементарних частинок – це одна з дуже важливих наук через наслідки для сучасної науки в цілому і для перспектив прикладної науки.

Впродовж багатьох поколінь фізики вивчали структуру матерії і закони, що керують мікросвітом, у пошуках “структури Всесвіту” і ”атома”, який утворив світ.

З часу прискорювачів заряджених частинок відбувся швидкий прогрес у вивченні мікросвіту. Прискорювачі дозволили нам не лише заглянути всередину атома, але й всередину ядра атома, вивчаючи його структуру і розглядаючи частинки, з яких він складається. Зараз вчені збираються дослідити структуру протонів і нейтронів, з яких побудовані частинки атомного ядра.

Вчені вірять, що вони знайшли деякі з цих об’єктів: субатомні частинки, або фундаментальні частинки, які, не маючи розміру, не можуть мати структуру. Вони зараз пробують пояснити властивості цих частинок, і працюють, щоб показати, як вони можуть бути використані для пояснення структури Всесвіту. Є два типи фундаментальних частинок: частинки матерії, деякі з яких об’єднуються, щоб утворювати світ навколо нас, і силові частинки. Вони класифікуються в стандартну модель фізики частинок, яка вивчає, як взаємодіють основні будівельні блоки матерії, що керуються фундаментальними силами.

WORD STUDY

1W. Fill in the gaps with the appropriate conjunctions: *still, yet, already, anymore, any longer* and *no longer.*

1. He ..... lives in that old house at the end of the village.
2. He ..... lives in that old house at the end of the village. He moved somewhere last week.
3. Have you seen my new car .....?
4. The guests have ..... arrived so we can start eating.
5. We aren't friends ..... We haven't talked for two months now.
6. We are ..... friends. We haven't talked for two months now.
7. I ..... haven't found my glasses.
8. It's 11 o' clock and she hasn't arrived .....
9. It's 10 o' clock and she ..... hasn't arrived. I'm getting worried.
10. Do you ..... know him or shall I introduce you to each other?
11. He's moving abroad and perhaps we won't see each other .....
12. I can't stand my boss .....

2W. Use the infinitive in the required form.

1. The man seems (to wait) for you. He seems (to wait) for a long time.
2. Perhaps it will upset him (to tell the news).
3. The key was believed (to lose) until I happened (to find) it.
4. The girl seems (to know) English well. She is said (to spend) a few years in the USA.
5. I believe she deserves (to tell) the truth.
6. They seem (to discuss) something very loudly.
7. The house is known (to build) in the 18th century.

WORD STUDY

3W. Make the right choice:

1. That man does look rather strange, but you shouldn't _____ at him.
A) glare B) blink C) stare D) frown
2. He made a hole in the fence so that he could _____ through without being seen.
A) peer B) blink C) wink D) peep
3. If you go out into bright sunlight after being in the dark, you sometimes _____.
A) peer B) blink C) glare D) peep
4. Boys often stand outside the bicycle shop and _____ at the wonderful machines in the window.
glare B) gaze C) wink D) frown
5. We _____ if we are rather annoyed or if we are concentrating.
A) peer B) gaze C) stare D) frown
6. Did you _____ someone pass the window a moment ago? I thought I just saw someone.
A) wink B) glimpse C) glare D) frown
7. I thought he was serious until I saw him _____ at me to show he was joking.
A) wink B) glimpse C) glance D) frown
8. Grandfather has very bad eyes. He has to _____ at the newspaper to read it.
A) peer B) blink C) wink D) peep
9. I saw him get out of his car and _____ furiously at the driver who had run into the back of him.
A) glare B) gaze C) blink D) wink
10. I saw him _____ quickly at his watch.
A) wink B) gaze C) glance D) stare

WORD STUDY

4W. Study the meaning of the word rather and translate the sentences:

1. I was ***rather*** hoping you'd forgotten about that.
2. They went there ***rather a lot***.
3. It was ***rather a*** surprise to find them in the house before me.
4. Now that she saw Rupert again, he was ***rather less*** interesting and a little older than she had remembered him.
5. They were small animals, ***rather like*** rats.
6. He wanted to be an actor ***rather than*** a comedian.
7. He commanded and I obeyed, ***or rather***, I pretended to.
8. He criticizes his opponents by insinuation ***rather*** than directly.
9. The TV news was depressing, so ***rather than*** start crying I turned it off.
10. He would ***rather*** die than comply. It's ***rather*** a glimmering reflection ***than*** a true light.
11. I ***would rather*** you did not go out today.

5W. Look at the following list and decide whether we are talking about something big (in terms of size, quantity or dimension) or something small.

1. a great deal of time 2. tons of work 3. an enormous book 4. a vast crowd of supporters 5. a huge waste of time 6. a vast room 7. a gigantic wave 8. a tiny car 9. a monumental error 10. a colossal statue	11. plenty of food 12. dozens of times 13. a narrow alleyway 14. a giant building 15. a shallow pool 16. a wide avenue 17. a broad river 18. a long-legged man 19. a multistorey block of flats 20. a profound lake

Particles and Fields

In particle physics, a particle is defined as an energy quantum associated with a “field”. The field is an entity that is defined over all space and time (collectively called space-time) and is able to produce waves, according to classical physics, or quanta, in present day terminology, when excited or when some amount of energy is injected. In a microworld the quanta are observed as particles, but collectively they behave like waves. A quantum is the name given to an object that possesses the dual properties of both a particle and a wave. A typical example of a field is the electromagnetic field. It is created by a charge and extends all over space. It is static when the charge that creates it does not move, but it can be excited by vibrating the source of the field, the electric charge; then the vibrating field propagates. This is a charge radiating an electromagnetic wave. It is well known that historically quantum mechanics has its origin in Planck’s recognition that blackbody radiation is a collection of countable quanta, photons.

In 19th century physics, waves could only be transmitted by some kind of vibrating medium and the electromagnetic waves were considered to propagate in a medium called the “ether”. The existence of the ether was ruled out with the advent of special relativity, and people began to consider that the vacuum, though void of anything in the classical sense, has the built-in property of producing all kinds of fields, whose excitations are observed as quanta or particles. The Standard Model has advanced the idea that the vacuum is not an empty entity but rather filled with various kinds of exotic material, including the Higgs particle, and exhibits dynamical properties like those observed in ordinary matter. The vacuum as we view it nowadays is a kind of resurrected ether with strange attributes that nobody had thought of. In this chapter, we describe an intuitive picture of both particles and fields, define some associated variables and prepare basic tools and terminologies necessary for the treatment of quantum field theory.

ADDITIONAL READING PASSAGE

Text 2

What is the Higgs boson?

The Standard Model of particle physics lays out the basics of how elementary particles and forces interact in the universe. But the theory crucially fails to explain how particles actually get their mass. Particles, or bits of matter, range in size and can be larger or smaller than atoms. Electrons, protons and neutrons, for instance, are the subatomic particles that make up an atom. Scientists believe that the Higgs boson is the particle that gives all matter its mass. Experts know that elementary particles like quarks and electrons are the foundation upon which all matter in the universe is built. They believe the elusive Higgs boson gives the particles mass and fills in one of the key holes in modern physics.

The Higgs boson is part of a theory first proposed by Higgs and others in the 1960s to explain how particles obtain mass.The theory proposes that a so-called Higgs energy field exists everywhere in the universe. As particles zoom around in this field, they interact with and attract Higgs bosons, which cluster around the particles in varying numbers.

Imagine the universe like a party. Relatively unknown guests at the party can pass quickly through the room unnoticed; more popular guests will attract groups of people (the Higgs bosons) who will then slow their movement through the room.

The speed of particles moving through the Higgs field works much in the same way. Certain particles will attract larger clusters of Higgs bosons – and the more Higgs bosons a particle attracts, the greater its mass will be.
Scientists have searched for the Higgs boson by smashing protons together at high energy in the $10 billion Large Hadron Collider (LHC) at CERN in Geneva, Switzerland.

Inside the LHC, which is located 328 feet underground in a 17-mile tunnel and is the most powerful particle accelerator ever built, high speed proton collisions generate a range of even smaller particles that scientists sift through in search of a signal in the data suggesting the existence of the Higgs boson.The discovery of the Higgs particle is an astonishing triumph of mathematics' power to reveal the workings of the universe. It's a story that's been recapitulated in physics numerous times, but each new example thrills just the same.