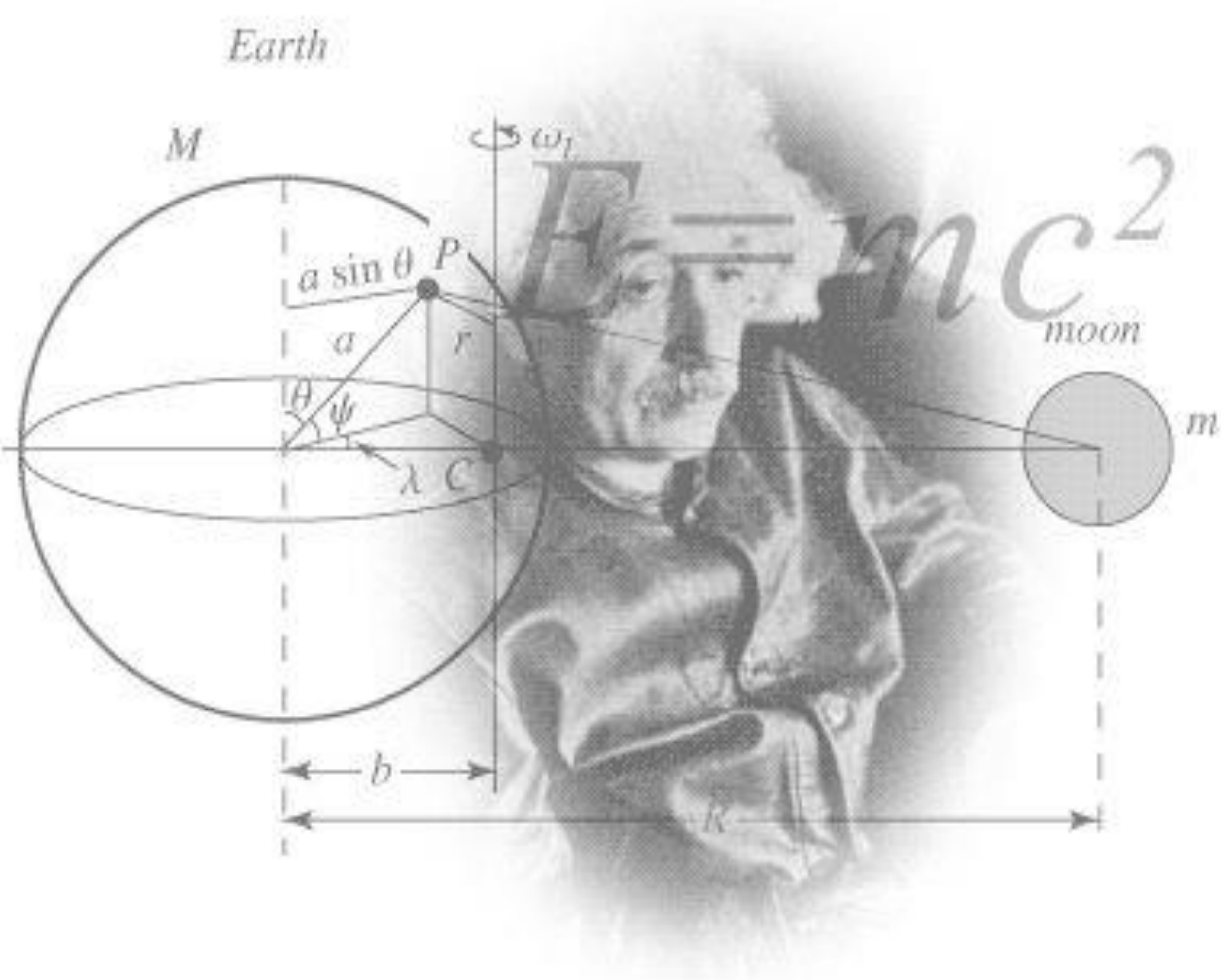
Волинський національний університет імені Лесі Українки
Факультет іноземної філології
Кафедра іноземних мов природничо-математичних спеціальностей

# ENGLISH FOR
# THE STUDENTS OF PHYSICS

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Навчальний посібник «English for the Students of Physics» укладений відповідно до вимог силабусу освітнього компонента «Іноземна мова за професійним спрямуванням» для студентів навчально-наукового фізико-технологічного інституту першого (бакалаврського) рівня вищої освіти. Посібник складається з восьми змістових модулів, добірки текстів для самостійної роботи, граматичної секції, плану і зразку реферування статті та тематичного глосарію. Змістовий модуль поділений на три частини, до кожної з яких входить текст або інше завдання фахового орієнтування та комплекс вправ лексико-граматичного і комунікативного характеру на вправляння і закріплення фахової лексики, розвиток діалогічного і монологічного мовлення.

Рекомендовано студентам різних форм навчання спеціальностей «Фізика та астрономія», «Прикладна фізика та наноматеріали», «Середня освіта (Фізика)» й суміжних, а також спеціалістам у галузі фізики, які прагнуть поліпшити знання англійської мови за фахом.

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CONTENT

# PREFACE

The present study guide is intended as a practical aid for the physics students with a very diverse level of English and designed to meet the needs of the course «Profession-Oriented English Language Study» at the Educational and Scientific Physical and Technological Institute.

The purpose of this book is to systematize and enrich the vocabulary of the students on the themes of physics and to encourage them to learn new terminology.

The study guide contains eight modules with profession-oriented texts for reading and discussion and a lot of lexico-grammatical and communicative exercises that can help the students to learn special vocabulary and develop their reading, speaking and writing skills. The learner will find a large number of physical terms and notions in each module of the study guide and their definitions in the glossary.

The material of the study guide can be used not only by the students of the Educational and Scientific Physical and Technological Institute but it can also serve as a source of educational and practical information for the students of the related specialities and physical experts who are interested in improving their knowledge of Profession-Oriented English.

# MODULE 1. PHYSICS AS A BRANCH OF SCIENCE

## Part I. PHYSICS IN GENERAL

**Task 1. Before reading the text, discuss the following questions:**

1. Why did you choose to study at the Educational and Scientific Physical and Technological Institute of Lesya Ukrainka Volyn National University?
2. How much do you know about physics? Can you define it?
3. What is interesting about physics for you?
4. What was your first encounter with physics?
5. Do you remember your first physical experiment?

**Task 2. Find the meaning and pronunciation of the key words in a dictionary and learn them:**

| | | |
|---|---|---|
| space | optics | electrodynamics |
| matter | modern physics | atomic and nuclear physics |
| energy | acoustics | physics of elementary particles |
| motion | electrostatics | mechanics |
| physics | quantum physics | high-energy physics |
| classical physics | thermodynamics | theory of relativity |

Physics (Greek: physics, meaning "nature") is a natural science that involves the study of matter and its motion through the major science dealing with the fundamental constituents of the universe, the forces they exert on one another, and the results produced by these forces. Sometimes in modern physics a more sophisticated approach is taken that incorporates elements of the three areas listed above; it relates to the laws of symmetry and conservation, such as those pertaining to energy, momentum, charge, and parity. More broadly, it is the general analysis of nature, conducted in order to understand how the world and universe behave. More shortly, physics is a branch of science traditionally defined as a study of matter, energy and the relation between them.

Physics is one of the oldest academic disciplines, perhaps the oldest through its inclusion of astronomy. Over the last two millennia, physics had been considered synonymous with philosophy, chemistry and certain branches of mathematics and biology, but during the Scientific Revolution in the 16th century, it emerged to become a unique modern science in its own right. However, in some subject areas such as in mathematical physics and quantum chemistry, the boundaries of physics remain difficult to distinguish.

Physics today may be divided into classical physics and modern physics. Classical physics includes the traditional branches and topics that were recognized and fairly well developed before the beginning of the 20th century – mechanics, sound, light, heat, electricity and magnetism. Mechanics is concerned with bodies acted on by forces and bodies in motion and may be divided into statistics (study of the forces on a body at rest), kinematics (study of motion without regard to its causes), and dynamics (study of motion and the forces that affect it); mechanics may also be divided into solid mechanics and fluid mechanics. Acoustics, the study of sound, is often considered a branch of mechanics because sound results from the motion of air particles or other medium through which sound waves can travel. Optics, the study of light, is concerned not only with visible light but also with infrared and ultraviolet radiation. Heat is a form of energy, the internal energy contained in the particles of which a substance is composed; thermodynamics deals with the relationships between heat and other forms of energy. Electricity and magnetism have been studied as a single branch of physics since the intimate connection between them was discovered in the early 19th century.

Most of classical physics is concerned with matter and energy on the normal scale of observation; much of modern physics deals with the behaviour of matter and energy under extreme conditions or on the very large or very small scale. For example, atomic and nuclear physics studies matter on the smallest scale at which chemical elements can be identified. The physics of elementary particles is concerned with the most basic units of matter; this branch of physics is also known as high-energy physics because of the extremely high energies necessary to produce many types of particles in large particle accelerators. On this scale common sense notions of space, time, matter and energy are no longer valid.

The two chief theories of modern physics present a different picture of the concepts of space, time, and matter from that presented by classical physics. The quantum theory is concerned with the discrete, rather than continuous, nature of many phenomena at the atomic and subatomic level, and with the complementary aspects of particles and waves in the description of such phenomena. The theory of relativity deals with the description of phenomena that take place in motion with respect to an observer; the special theory of relativity is concerned with relative uniform motion in a straight line and the general theory of relativity with accelerated motion and its connection with gravitation.

**Task 3. Answer the questions on the text:**

1. How many meanings of the word physics are mentioned in the text?
2. Which definition of physics is the clearest for you?
3. Which branches of science are closely related to physics?
4. Why, according to the text, is physics a science?
5. What are the two divisions of physics?
6. What branches does classical physics include?
7. What does mechanics deal with?
8. What does acoustics deal with?
9. What is optics concerned with?
10. What does thermodynamics deal with?
11. What is the subject of modern physics?
12. How does classical physics differ from modern physics?
13. What does atomic and nuclear physics study?
14. What is the physics of elementary particles concerned with?
15. What do you know about the quantum theory and theory of relativity?

**Task 4. Find synonyms in the text for the following words:**

basic – .....................　　to be concerned with – .....................
important – .....................　　to give rise to – .....................
affect – .....................

**Task 5. Make sentences of your own using the words from Task 2:**

1. ……………………………………………………………………………….
2. ……………………………………………………………………………….
3. ……………………………………………………………………………….
4. ……………………………………………………………………………….
5. ……………………………………………………………………………….

## Part II. SCOPE AND AIMS OF PHYSICS

Physics covers a wide range of phenomena, from the smallest sub-atomic particles (such as quarks, neutrinos and electrons), to the largest galaxies. The most basic objects from which all other things are composed are included in these phenomena, and therefore physics is sometimes called the "fundamental science".

Physics is closely related to the other natural sciences and, in a sense, encompasses them. Chemistry, for example, deals with the interaction of atoms to form molecules; much of modern geology is largely a study of the physics of the earth and is known as geophysics; and astronomy deals with the physics of the stars and outer space. Even living systems are made up of fundamental particles and, as studied in biophysics and biochemistry, they follow the same types of laws as the simpler particles traditionally studied by a physicist.

The emphasis on the interaction between particles in modern physics must often be supplemented by a macroscopic approach that deals with larger elements or systems of particles. This macroscopic approach is indispensable to the application of physics to much of modern technology. Thermodynamics, for example, a branch of physics developed during the $19^{th}$ century, deals with the elucidation and measurement of properties of a system as a whole and remains useful in other fields of physics; it also forms the basis of much of chemical and mechanical engineering. Such properties as the temperature, pressure, and volume of a gas have no meaning for an individual atom or molecule; these thermodynamic concepts can only be applied directly to a very large system of such particles. A bridge exists, however, between the microscopic and macroscopic approach; another branch of physics, known as statistical mechanics, indicates how pressure and temperature can be related to the motion of atoms and molecules on a statistical basis.

Physics aims to describe the various phenomena that occur in nature in terms of simpler phenomena. Thus, physics aims to both connect the things we see around us to root causes, and then to try to connect these causes together in the hope of finding an ultimate reason for why nature is as it is. For example, the ancient Chinese observed that certain rocks were attracted to one another by some invisible force.

This effect was later called magnetism, and was first rigorously studied in the 17th century.

A little earlier than the Chinese, the ancient Greeks knew of other objects such as amber, that when rubbed with fur would cause a similar invisible attraction between the two. This was also first studied rigorously in the 17th century, and came to be called electricity. Thus, physics had come to understand two observations of nature in terms of some root cause (electricity and magnetism). However, further work in the 19th century revealed that these two forces were just two different aspects of one force – electromagnetism. This process of "unifying" forces continues today.

Physics emerged as a separate science only in the early 19th century; until that time a physicist was often also a mathematician, philosopher, chemist, biologist, engineer, or even primarily a political leader or artist. Today the field has grown to such an extent that with few exceptions modern physicists have to limit their attention to one or two branches of the science. Once the fundamental aspects of a new field are discovered and understood, they become the domain of engineers and other applied scientists. The 19th century discoveries in electricity and magnetism are now the province of electrical and communication engineers; the properties of matter discovered at the beginning of the 20th century have been applied in electronics; and the discoveries of nuclear physics, most of them not yet 40 years old, have passed into the hands of nuclear engineers for applications to peaceful or military uses.

Physics uses the scientific method to test the validity of a physical theory, a methodical approach to compare the implications of the theory in question with the associated conclusions drawn from experiments and observations conducted to test it. They are to be collected and matched with the predictions and hypotheses made by a theory, thus aiding in the determination of the validity/invalidity of the theory.

Theories which are very well supported by data and have never failed any competent empirical test are often called scientific laws, or natural laws. Of course, all theories, including those called scientific laws, can always be replaced by more accurate, generalized statements if a disagreement of theory with observed data is ever found.

The culture of physics has a higher degree of separation between theory and experiment than many other sciences. Since the 20th century most individual physicists have specialized in either theoretical or experimental physics. In contrast, almost all the successful theorists in biology and chemistry (e.g. American quantum chemist and biochemist Linus Pauling) have also been experimentalists, although this is changing as of late.

Theorists seek to develop mathematical models that both agree with existing experiments and successfully predict future results, while experimentalists devise and perform experiments to test theoretical predictions and explore new phenomena. Although theory and experiment are developed separately, they are strongly dependent upon each other. Progress in physics frequently comes about when experimentalists make a discovery that existing theories cannot explain, or when new theories generate experimentally testable predictions, which inspire new experiments.

**Task 6. Answer the following questions by referring to the reading passage:**

1. What does physics study in general?
2. What is an approach in modern physics related to?
3. Are there any relations between physics and other sciences?
4. What does statistical physics show?
5. When was physics seen as a separate science?
6. What is the aim of physics?
7. Why does physics use the scientific method?
8. Why is there a separation between the theoretical and experimental physics?

**Task 7. a) Give definitions of each of the following jobs connected with physics. Start each explanation with the following words:**
**"A (name of job) is a person who…"**

A scientist …………………………………………………………….
An optician ……………………………………………………………
An electrician …………………………………………………………
A physicist …………………………………………………………….
An engineer ……………………………………………………………
A mathematician ………………………………………………………

**b) Have some fun with physics. What is the difference between a physicist, an engineer and a mathematician? Read the sentences and say if you agree with these statements:**

If an engineer walks into a room and sees a fire in the middle and a bucket of water in the corner, he takes the bucket of water and pours it on the fire and puts it out.

If a physicist walks into a room and sees a fire in the middle and a bucket of water in the corner, he takes the bucket of water and pours it eloquently around the fire and lets the fire put itself out.

If a mathematician walks into a room and sees a fire in the middle and a bucket of water in the corner, he convinces himself there is a solution and leaves.

**Task 8. a) Complete each of the following statements with words/phrases from the text:**

1. Physics covers a wide range of …………… .
2. The most basic …………  are included in these phenomena.
3. Physics is sometimes called the …………………. …………………..
4. Physics is closely related to the other natural …………….. .
5. Chemistry deals with the …………….. of atoms to form molecules.
6. Even living systems are made up of …………….. particles.
7. The interaction between particles in modern physics is known as the …….. approach.
8. This macroscopic approach is …………….. to the application of physics.
9. The thermodynamic concepts can only be applied ……. to a large system of particles.
10. A bridge exists, …………….., between the microscopic and macroscopic approach.

**b) Decide whether each of the following statements is true (T), false (F) or with no information in the text to clarify (N):**

1. Modern physics also deals with the fundamental constituents of the universe.
2. There are relations between physics and other natural sciences.
3. The microscopic approach is more important than the macroscopic one.
4. The macroscopic is unnecessary to the application of physics to modern technology.
5. Thermodynamics deals with the measurement of properties of a system.
6. Statistical mechanics shows the way in which pressure and temperature are related to each other.
7. Before the 19th century, people had had no ideas of what physics was like.
8. Many people studied physics because it was interesting.
9. Today, physics has become the most important science.
10. Nuclear physics was originally for peaceful purposes.

**Task 9. Underline the <u>defining</u> (*the relative clause is necessary to identify the member of a group the sentence talks about*) or <u>non-defining</u> (*the relative clause gives additional information about the noun it refers to*) <u>relative clause</u> in the following sentences:**

1. In the next millennium physicists may achieve a single overarching theory that explains how the four fundamental forces in the universe can be unified.

2. Mankind will always be indebted to Einstein for removal of the obstacles to our outlook which were involved in the primitive notions of absolute space and time.

3. Physicists have also identified the four fundamental forces that govern the interactions between elementary particles.

4. Sir Isaac Newton (1642–1727), who is considered one of the most important scientists of all time, is an English physicist, mathematician and natural philosopher.

5. No other half-century in history has witnessed so revolutionary transformation in man's view of the physical universe as the one through which we have just passed.

6. Over the last 1000 years the science of physics has enabled us to probe and understand the world of the very small fundamental particles that make up matter and the forces that govern their interactions.

7. Physicists believe the universe began about 12 billion years ago in a cosmic explosion, which is known as the big bang, when a magnificent dowry of energy appeared and converted to particles of matter.

8. Newton stated his ideas in works, two of which, Mathematical Principles of Natural Philosophy (1687) and Optics (1704), are considered among the greatest scientific works.

9. The English Scholastic philosopher and scientist Roger Bacon was one of the few philosophers who advocated the experimental method as the true foundation of scientific knowledge and who also did some work in astronomy, chemistry, optics and machine design.

10. We are missing lots of details about this original hot, tiny universe, in which space was expanding and rushing outward and particles were clustering and eventually binding.

**Task 10. Answer the questions in the fun quiz on general physical knowledge:**

1. As early as 3500 B.C., a gnomen (a stick in the ground) was used to measure

a) temperature; b) time; c) water levels; d) wind velocity; e) gravity.

2. The distance an object travels in a given time frame is referred to as its:

a) velocity; b) inertia; c) kinetic energy; d) speed; e) acceleration.

3. What causes tides?

a) The tilt of the earth on its axis; b) Mostly the gravitational pull of the moon; c) Mostly the gravitational pull of the sun.

4. To hit a target on land, at what point would you drop a bomb from an airplane?

a) Before the target; b) Directly over the target; c) After passing the target.

5. If one cannonball is dropped from a given height and another is fired horizontally from the same height, which one will hit the ground first?

a) The one that is dropped; b) The one that is fired; c) They will both hit the ground at the same time.

6. What is the sound barrier?

a) The speed that an object must travel to surpass the speed of sound;
b) A unit for measuring the intensity of sound;
c) The point at which a sound exceeds the human pain threshold;
d) The distance between two people that cannot hear one another talking.

## Part III. BRIEF HISTORY OF PHYSICS

**Task 11. Find the meaning and pronunciation of the key words in a dictionary and learn them:**

geometrical approach heliocentric system gas law geocentric system

laws of motion spectrum corpuscular theory conductor theory of light

mechanistic philosophy law of conservation of energy to convert energy

**Task 12. Read the text (consisting of 9 paragraphs) quickly and put the following headings in the correct order (a-d on the left) to summarize its content. Then define the paragraphs (1-9 on the right) which refer to these headings:**

….. ADVANCES IN ELECTRICITY, MAGNETISM AND THERMODYNAMICS .., ...
….. GREEK CONTRIBUTIONS …....., ………
…...DEVELOPMENT OF MECHANICS AND THERMODYNAMICS ………
…..THE SCIENTIFIC REVOLUTION …...…, …...…, …...…, …...….

1) The earliest history of physics is interrelated with that of the other sciences. A number of contributions were made during the period of Greek civilization (6$^{th}$ and 5$^{th}$ century BC). Democritus (460–370 BC) proposed an atomic theory of matter and extended it to other phenomena as well, but the dominant theories of matter held that it was formed of a few basic elements, usually earth, air, fire, and water.

2) The most important philosophy of the Greek period was produced by two men at Athens, Plato (427–347 BC) and his student Aristotle (384–322 BC); Aristotle had a critical influence on the development of science in general and physics in particular. The Greek approach to physics was largely geometrical and reached its peak with Archimedes (287–212 BC) who studied a wide range of problems and anticipated the methods of the calculus. Another important scientist was the astronomer Aristarchus from Egypt (310–220 BC), who proposed a heliocentric system of the universe. However, the astronomical system that eventually prevailed was the geocentric system developed by Ptolemy (AD 85–AD 165).

3) The first areas of physics to receive close attention were mechanics and the study of planetary motions. Modern mechanics dates from the work of Galileo and Simon Stevin in the late 16$^{th}$ and early 17$^{th}$ century. The great breakthrough in astronomy was made by Nicolaus Copernicus, who proposed (1543) the heliocentric model of the solar system that was later modified by Johannes Kepler into the

description of planetary motions that is still accepted today. Galileo gave his support to this new system and applied his discoveries in mechanics to its explanation.

4) The full explanation of both celestial and terrestrial motions was not given until 1687, when Isaac Newton published his Mathematical Principles of Natural Philosophy. This work, the most important document of the Scientific Revolution of the $16^{th}$ and $17^{th}$ century, contained Newton's famous three laws of motion and showed how the principle of universal gravitation could be used to explain the behaviour of falling bodies on the earth, as well as of the planets and other celestial bodies. To arrive at his results, Newton invented an entirely new branch of mathematics, namely, the calculus (also invented independently by Leibniz), which was to become an essential tool of the later development in most branches of physics.

5) Other branches of physics also received attention during this period. W. Gilbert, a court physician to Queen Elizabeth I, published (1600) an important work on magnetism, describing how the earth itself behaves like a giant magnet. R. Boyle (1627–91) studied gases enclosed in a chamber and formulated the gas law which was later named after him.

6) Newton himself discovered the separation of white light into a spectrum of colours and published an important work on optics, in which he proposed the theory that light is composed of tiny particles, or corpuscles. This corpuscular theory was related to the mechanistic philosophy presented early in the $17^{th}$ century by René Descartes, according to which the universe functioned like a mechanical system describable in terms of mathematics.

7) During the $18^{th}$ century the mechanics founded by Newton was further developed by other scientists. In 1798 Benjamin Thompson found a direct relationship between heat and mechanical energy. In the $19^{th}$ century this connection was established quantitatively by J. R. Mayer and J. P. Joule. Their experimental work provided a basis for the formulation of the first two laws of thermodynamics in the 1850s by William Thomson (later Lord Kelvin) and R. J. E. Clausius. The first law is the law of conservation of energy and the second law describes the tendency of energy to be converted from more useful to less useful forms.

8) The study of electricity and magnetism also came into its own during the 18th and 19th centuries. A. Volta had invented the electric battery, so that electric current could also be studied. In 1820 H. Oersted found that a current-carrying conductor gives rise to a magnetic force surrounding it, and in 1831 M. Faraday (and independently Joseph Henry) discovered the reverse effect, the production of an electric potential or current through magnetism.

9) M. Faraday invented the concept of the field of force to explain these phenomena and Maxwell developed these ideas mathematically in his theory of electromagnetic radiation and showed that electric and magnetic fields are propagated outward from their source at a speed equal to that of light and that light is one of several kinds of electromagnetic radiation, differing only in frequency and wavelength from the others. Experimental confirmation of Maxwell's theory was provided by H. Hertz, who generated and detected electric waves in 1886 and verified their properties, at the same time foreshadowing their application in radio, television, and other devices. The wave theory of light had been revived in 1801 by Thomas Young and received strong experimental support from the work of A. Fresnel and others; the theory was widely accepted by the time of Maxwell's work on the electromagnetic field, and afterward the study of light and that of electricity and magnetism were closely related.

**Task 13. Make up the sentences about the following scientists' contribution to science:**

1. Democritus ……………………………………………………………..
2. Ptolemy …………………..………………………………………………
3. Aristotle ………………………………………………………………..
4. Aristarchus ..……………………………………………………………...
5. Archimedes ……………………….………………………………………
6. Galileo …………………………..………………………….……………..
7. Nicholas Copernicus ……………………..….……………………………
8. Johannes Kepler ………………………………………………………..
9. Isaac Newton ……………………………………………...……………
10. Robert Boyle ……………………………………………..…………………
11. Alessandro Volta ……………………………………..………………..
12. Michael Faraday …………………………………………...…………..
13. Maxwell …………………………………………………………………….
14. Heinrich Hertz ……………………………………………………………

**Task 14. Explain in English the meaning of the words:**

describable: …………………………………………………………………. ,

court physician: ……………………………………………………………. ,

revive: ………………………………………………………………………… ,

phenomenon: ……………………………………………………………….. .

**Task 15. Read the student's survey about physics. Then write 5 questions about physics and its role in the development of other sciences, industries and modern technologies in the table and interview other students. Write down their answers:**

**STUDENT PHYSICS SURVEY**

I don't know how people understand physics. I think it's a fascinating subject and really wish I understood more. Physics seems to explain everything about our world and our universe. It's as though physics is the key to unlocking all of our world's mysteries. I really enjoyed studying physics at the beginning. It was interesting then. But then it got difficult and I couldn't understand the formulae. I have a lot of respect for physicists. They seem to be able to understand lots of really difficult things. Without them, we would still be living very basic lives. Physicists have sent people to the Moon. Their research has led to all of our modern technology. I always read fewer and fewer students are choosing to study physics. This is a shame.

**STUDENT PHYSICS SURVEY**

| | STUDENT 1 | STUDENT 2 | STUDENT 3 |
|---|---|---|---|
| Q.1. | | | |
| Q.2. | | | |
| Q.3. | | | |
| Q.4. | | | |
| Q.5. | | | |

MODULE 2**. MECHANICS**

## Part I. THE SCIENCE OF MECHANICS

**Task 1. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:**

Mechanics is a branch of physics that **concerns** the motions of objects and their **response** to forces. Modern descriptions of such behavior begin with a careful definition of such quantities as **displacement** (distance moved), time, **velocity**, **acceleration**, mass, and force. Until about 400 years ago, however, motion was explained from a very different point of view. For example, following the ideas of Greek philosopher and scientist Aristotle, scientists reasoned that a cannonball falls down because its natural position is in the earth. The sun, the moon, and the stars travel in circles around the earth because it is the nature of heavenly objects to travel in perfect circles.

The Italian physicist and astronomer Galileo brought together the ideas of other great thinkers of his time and began to analyze motion in terms of distance traveled from some starting position and the time that it took. He showed that the speed of falling objects increases steadily during the time of their fall. This acceleration is the same for heavy objects as for light ones, provided air **friction** (air resistance) is **discounted**. The English mathematician and physicist Sir Isaac Newton **improved** this analysis by defining force and mass and relating these to acceleration. For objects traveling at speeds close to the speed of light, Newton's laws were **superseded** by Albert Einstein's theory of relativity. For atomic and subatomic particles, Newton's laws were superseded by quantum theory. For everyday phenomena, however, Newton's three laws of motion remain the **cornerstone** of dynamics, which is the study of what is motion.

**Task 2. Answer the following questions on the text:**

1. What branch of physics concerns the motions of objects and their response to forces?
2. What are the quantities that require careful definition?
3. How did ancient people explain motion?
4. What was the impact of Galileo on the field of physics?

5. Does the speed of the falling object increase steadily during the time of its fall?
6. Is it possible to discount air resistance while calculating acceleration?
7. How did Isaac Newton improve the analysis of acceleration?
8. Whose theory superseded Newton's laws?
9. What is the cornerstone for the study of motion?

**Task 3. Decide whether the following statements are true or false according to the text. Prove your answers using the information from the text.**

1. Mechanics concerns acceleration of objects and their response to mass.
2. Greek philosopher reasoned that a cannonball falls down because its mass is lighter than the earth's.
3. The sun, the moon and the stars travel in circles around the earth because of their nature.
4. Galileo showed that the acceleration of falling objects decreases steadily during the time of their fall.
5. Newton improved the analysis by defining acceleration, mass and relating these to force.

**Task 4. Find an odd word:**

1. *number (n),* zero, amount, quantity, volume, sum;
2. *reduce (v),* condense, contract, increase, decrease, diminish;
3. *conclude(v),* deduce, close, start, complete, determine;
4. *progress (v),* advance, improve, proceed, regress;
5. *increase (v),* extend, grow, decrease, multiply;
6. *opposition (n),* contradiction, contrast, denial, resistance, attraction.

**Task 5. Match the word on the left with the correct definition on the right:**

| | |
|---|---|
| 1. concern | a) take place of sth that is less efficient, less modern; |
| 2. displacement | b) measure of rate of change in position of sth with respect to time, involving speed and direction; |
| 3. acceleration | c) smb or sth that is fundamentaly important to sth; |
| 4. cannonball | d) rate of increase in the velocity of sth; |
| 5. friction | e) resistance encountered by an object moving relative to another object with which it is in contact; |
| 6. supersede | f) be about a particular topic; |
| 7. discount | g) amount of an object movement measured in a particular direction; |
| 8. velocity | h) decide that sth can be disregarded as unimportant; |
| 9. cornestone | i) make sth happen or exist; |
| 10. cause | j) heavy metal or stone ball. |

## Part II. KINETICS

**Task 6. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:**

Kinetics is the description of motion without regard to what **causes** the motion. Velocity is **defined** as the distance traveled divided by the time interval. Velocity may be **measured** in such units as kilometers per hour, miles per hour, or meters per second. Acceleration is defined as the time rate of change of velocity: the change of velocity divided by the time interval during the change. Acceleration may be measured in such units as meters per second or feet per second. Regarding the size or weight of the moving object, no mathematical problems are presented, if the object is very small compared with the distances **involved**. If the object is large, it contains one point, called the center of mass, the motion of which can be described as characteristic of the whole object. If the object is **rotating**, it is frequently convenient to describe its rotation about an **axis** that goes through the center of mass.

To fully describe the motion of an object, the direction of the displacement must be given. Velocity, for example, has both **magnitude** (a scalar quantity measured, for example, in meters per second) and direction (measured, for example, in degrees of arc from a reference point). The magnitude of velocity is called speed.

Several special types of motion are easily described. First, velocity may be constant. In the simplest case, the velocity might be zero; position would not change during the time interval. With constant velocity, the average velocity is equal to the velocity at any particular time. In the second special type of motion, acceleration is constant. Because the velocity is changing, instantaneous velocity, or the velocity at a given instant must be defined. Falling objects accelerate in response to the force exerted on them by Earth's gravity. Different objects accelerate at the same rate, regardless of their mass.

Circular motion is another simple type of motion. If an object has constant speed but an acceleration always at right **angles** to its velocity, it will travel in a circle. The required acceleration is directed toward the center of the circle and is called **centripetal acceleration.**

Another simple type of motion that is frequently observed occurs when a bad is **thrown** at an angle into the air. Because of gravitation, the ball **undergoes** a constant downward acceleration that first slows its original upward speed and then increases its downward speed as it falls back to earth. Meanwhile the horizontal component of the original velocity remains constant (ignoring air resistance), making the ball travel at a constant speed in the horizontal direction until it hits the earth. The vertical and horizontal components of the motion are independent and they can be analyzed separately. The resulting path of the ball is in the shape of a parabola.

**Task 7. Answer the following questions on the text:**

1. What is kinetics?
2. How is the time rate of change of position defined in kinetics?
3. What is acceleration and how is it measured?
4. In what way is it convenient to describe the rotating object?
5. What must be given to fully describe the motion of an object?
6. What is speed?
7. What special type of motion is easily described?

**Task 8. a) Find an odd word:**

1. *movement (n),* move, motion, mobility, stillness;
2. *motivate (v),* cause, impulse, stimulate, tranquilize, impel;
3. *part (n),* bit, section, component, aggregate, fragment, member;
4. *divide (v),* detach, unite, separate, split, dissolve, disconnect;
5. *round (adj),* circular, orbicular, rectangular, spherical, convex.

**b) Match the word on the left with the correct definition on the right:**

| | |
|---|---|
| 1. define | a) turn like a wheel around an axis or a fixed point; |
| 2. measure | b) space between two diverging lines; |
| 3. involve | c) experience or endure smth; |
| 4. rotate | d) acting, moving, or pulling toward a center or axis; |
| 5. angle | e) imaging straight line around an object, such as the earth, etc; |
| 6. instant | f) result of the multiplication of two or more quantities; |
| 7. undergo | g) present or current; |
| 8. centripetal | h) particular system used to determine the dimensions, area; |
| 9. axis | i) contain or include as a necessary element of sth; |
| 10. product | j) state or describe sth clealy. |

**Task 9. Fill in the table with the missing parts of speech (if they exist) and translate them into Ukrainian:**

| Noun | Adjective | Verb |
|---|---|---|
| supersedence | | |
| discount | | |
| | | velocitize |
| | concerned | |
| | | study |
| | | branch |
| | natural | |
| | | separate |
| | analyzed | |
| direction | | |
| | | travel |
| | horizontal | |
| circle | | |
| | | back |

**Task 10. Translate the following sentences into English:**

1. Механіка є галуззю фізики, що вивчає рух об’єктів.
2. У механіці використовують такі поняття, як сила, прискорення, час, маса та швидкість.
3. Стародавні вчені вважали, що Сонце і Місяць обертаються навколо Землі.
4. Галілей почав вираховувати швидкість, беручи до уваги відстань, пройдену від певного початкового положення і час витрачений на це.
5. Галілей довів, що швидкість об’єкта, що падає постійно, зростає протягом падіння.
6. Ньютон вдосконалив аналіз, визначивши силу і масу щодо прискорення.
7. Закони Ньютона стосовно об’єктів, що рухаються зі швидкістю близькою до швидкості світла, були вдосконалені у теорії відносності Альберта Ейнштейна.
8. Три закони Ньютона залишаються основними для розуміння динаміки.
9. Кінетика вивчає рух, не беручи до уваги те, що спричиняє рух.
10. Швидкість – це пройдена відстань, поділена на проміжок часу.
11. Прискорення визначається як коефіцієнт зміни періоду часу швидкості.
12. У центрі великого об’єкта знаходиться точка, що називається центром ваги, рух якої можна визначити як рух цілого об’єкта.
13. Якщо об’єкт обертається, то можна визначати його обертовий момент за допомогою осей, що проходять через центр маси.
14. Якщо швидкість дорівнює нулю, розташування об’єкта не зміниться протягом часового проміжку.
15. Збільшення швидкості називається прискоренням.
16. Важливим висновком, що випливає з цього рівняння, є залежність відстані, помноженої на час у квадраті.
17. Якщо об’єкт має постійну швидкість, але прискорення надається постійно з правого боку, то він буде рухатися по колу.

## Part III. FORCE AND MASS

**Task 11. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:**

To understand why and how objects accelerate, force and mass must be defined. At the **intuitive** level, a force is just a **push** or a **pull**. It can be measured in terms of either of two effects. A force can either distort something, such as a **spring**, or accelerate an object. The first **effect** can be used in the calibration of a spring scale, which can in turn be used to measure the amplitude of a force: the greater the force, $F$, the greater the stretch, $x$. For many springs, over a limited range, the stretch is proportional to the force:

$$F = kx$$

where $k$ is a constant that depends on the nature of the spring material and its dimensions.

**Components of Velocity.** Neglecting air resistance, a ball thrown into the air at an angle will travel in a parabolic path. The velocity of the ball (V) has independent vertical (V) and horizontal (H) components. The horizontal component stays the same the entire time the ball is in the air, while the vertical component, the only component **affected** by gravity, changes continuously while the ball is **aloft**.

Force, in physics is **determined** as any action or influence that accelerates an object. Force is a vector, which means that it has both direction and magnitude. When several forces act on an object, the forces can be combined to give a net force. The **net force** acting on an object, the object's mass, and the acceleration of the object are all related to each other by Newton's second law of motion, named after English physicist and mathematician Newton.

Mass in physics is stated as an amount of matter that a body contains, and a measure of the inertial property of that body, that is, of its resistance to change of motion. Mass is different from weight, which is a measure of the attraction of the earth for a given mass. Inertial mass and gravitational mass are identical. Weight, although proportional to mass, varies with the position of a given mass relative to the earth. Thus, **equal** masses at the same location in a gravitational field will have equal weights. A mass in **interstellar** space may have zero weight. A fundamental principle of classical physics is the law of conservation of mass, which states that matter cannot be created or **destroyed**. This law **holds true** in chemical reactions but is modified in cases where atoms **disintegrate** and matter is converted to energy or energy is converted to matter.

**Task 12. Answer the following questions:**

1. Why must force and mass be defined?
2. What is force at the intuitive level?
3. In what way can the force be measured?
4. What can the effect of distortion be used for?
5. What is proportional to the force for springs over a limited range?
6. How will the ball, thrown into the air at an angle, travel?
7. What do independent vertical and horizontal components state?
8. How is force determined in physics?
9. How are net force, the object's mass and the acceleration related to each other?
10. Is mass different from weight?

**Task 13. Decide whether the following statements are true or false according to the texts from Part I and III. Prove your answers using the given information:**

1. Energy is the description of motion with regard to what causes motion.
2. Velocity may be measured in such units as kilograms.
3. Velocity has both mass and energy.
4. Because the velocity is stable, instantaneous velocity must be defined.
5. Because of magnitude, the ball undergoes a constant downward acceleration.
6. To understand why and how objects move, energy and velocity must be defined.
7. For many springs, over a limited range, the stretch isn't proportional to the acceleration.
8. Matter in physics is stated as an amount of mass that a body contains.
9. Taking into consideration air resistance, a ball thrown into the air at an angle will travel in a narrow path.
10. A mass in interstellar space may have high weight.

**Task 14**. **a) Choose the right variant from the listed below:**

1. When several forces act on an object, the forces can be combined to give a ____

   a) potential energy; b) net force; c) vector; d) equation.

2. A mass in interstellar space may have_________

   a) high velocity; b) net force; c) small weight; d) zero weight.

3. Mass is different from weight, which is a measure of the _______of the earth for a given mass.

   a) diameter; b) addition; c) attraction; d) subtraction.

4. A force can ____ something, such as a spring.

   a) tease; b) create; c) distort; d) ruin.

5. Force is a ______, which means that it has both direction and magnitude.

   a) detector; b) vector; c) quantity; d) conductor.

**b) Match the word on the left with the correct definition on the right:**

| | |
|---|---|
| 1. pull | a) act upon or have an effect on sb or sth; |
| 2. define | b) break into components or fragments; |
| 3. push | c) state or describe sth clearly; |
| 4. distort | d) extend sth; |
| 5. intuitive | e) apply force to a physical object; |
| 6. net | f) resilient metal coil; |
| 7. affect | g) bend, or change from a normal or natural shape; |
| 8. stretch | h) known directly and instinctively, without being discovered or consciously perceived; |
| 9. disintegrate | i) remaining from the amount after all deductions; |
| 10. spring | j) press against sb or sth in order to move that person or object; |

**Task 15. Using active vocabulary of the module speak on the following topics:**

a) Aristotle, Galileo, Newton and Einstein with regard to kinetics;

b) Cornerstone of dynamics;

c) Causes and special types of motion.

## MODULE 3. **MOLECULAR PHYSICS**

### Part I. SOLIDS

**Task 1. Find the meaning and pronunciation of the following words in a dictionary and learn them:**

| | | | |
|---|---|---|---|
| interaction effects | ionic bonds | magnetic properties | magnetic dipoles |
| to handle | inert substances | residual magnetism | semiconductor |
| interrelated effects | donor | energy quantization | energy bands |

In solids, the atoms are closely packed, leading to strong interactive forces and numerous **interrelated effects** that are not observed in gases, where the molecules largely act independently. **Interaction effects** lead to the mechanical, thermal, electrical, magnetic, and optical properties of solids, which is an area that remains difficult **to handle** theoretically, although much progress has been made.

A principal characteristic of most solids is their crystalline structure, with the atoms arranged in regular and geometrically repeating arrays. The specific arrangement of the atoms may arise from a variety of forces; thus, some solids, such as sodium chloride, or common salt, are held together by **ionic bonds** originating in the electric attraction between the ions of which the materials are composed. In others, such as diamond, atoms share electrons, giving rise to covalent bonding. **Inert substances,** such as neon, exhibit neither of these bonds. Their existence is a result of the so called van der Waals forces, named after the Dutch physicist Johannes Diderik van der Waals. These forces exist between neutral molecules or atoms as a result of electric polarization. Metals, on the other hand, are bonded by a so called electron gas, or electrons that are freed from the outer atomic shell and shared by all atoms, and that define most properties of the metal.

The sharp, discrete energy levels permitted to the electrons in individual atoms become broadened into energy bands when the atoms become closely packed in a solid. The width and separation of these bands define many properties, and thus the separation by a so-called forbidden band, where no electrons may exist, restricts their motion and results in a good electric and thermal insulator. Overlapping **energy**

**bands** and their associated ease of electron motion results in their being good conductors of electricity and heat. If the forbidden band is narrow, a few fast electrons may be able to jump across, yielding a **semiconductor.** In this case the energy-band spacing may be greatly affected by minute amounts of impurities, such as arsenic in silicon. The lowering of a high-energy band by the impurity results in a so-called **donor** of electrons, or p-type semiconductor. The raising of a low-energy band by an impurity like gallium results in an acceptor, where the vacancies or “holes" in the electron structure act like movable positive charges and are characteristic of p-type semiconductors. A number of modem electronic devices, notably the transistor, developed by the American physicists John Bardeen, Walter Houser Brattain, and William Bradford Shockley, are based on these semiconductor properties.

**Magnetic properties** in a solid arise from the electrons' acting like tiny **magnetic dipoles.** Electron spin plays a big role in magnetism, leading to spin waves that have been observed in some solids. Almost all solid properties depend on temperature. Thus, ferromagnetic materials, including iron and nickel, lose their normal strong **residual magnetism** at a characteristic high temperature, called the Curie temperature. Electrical resistance usually decreases with decreasing temperature, and for certain materials, called superconductors, it becomes extremely low, near absolute zero. These and many other phenomena observed in solids depend on **energy quantization** and can best be described in terms of effective “particles” such as phonons, polarons, and magnons.

**Task 2. Answer the following questions on the text:**

1. How do solids differ from liquids and gases?
2. What causes the specific arrangement of atoms?
3. What is a forbidden band?
4. What did John Bardeen develop?
5. What is a superconductor?

**Task 3. Finish the sentences using the information from the text:**

1. In solids, the atoms are ......................................................................... .

2. A principal characteristic of most solids is ..................................................... .

3. The specific arrangement of the atoms may arise from ……………………… .

4. If the forbidden band is narrow ………………………………………………… .

5. In diamond, atoms share ......................................................................... .

6. Ferromagnetic materials lose …………………………………………………… .

**Task 4. For questions 1-10 read the following text below and decide which answer (A, B, C or D) best fits each gap:**

Dielectric, or insulator, substance that is a poor conductor of electricity and that will sustain the force of an electric field passing **(1) _____** it. This property is not exhibited by conducting substances. Two oppositely charged bodies placed on either side of a piece of glass (a dielectric) will **(2)** _____each other, but if a sheet of copper is interposed between the two bodies, the charge will be conducted by the copper.

In most instances the properties of a **(3)** _____ are caused by the polarization of the substance. When the dielectric is placed in an electric field, the electrons and protons of its constituent atoms reorient **(4)** _____, and in some cases molecules become similarly polarized. As a result of this polarization, the dielectric is under stress, and it stores energy that becomes available when the electric field is removed. The polarization of a dielectric resembles the polarization that takes **(5)** _____ when a piece of iron is magnetized. As in the case of a magnet, a certain amount of polarization remains **(6)** _____the polarizing force is removed. A dielectric composed of a wax disk that has hardened while under electric stress will retain its polarization for years. Such dielectrics are known as electrets.

The effectiveness of dielectrics is measured by their relative ability compared to a vacuum, to store energy, and is expressed in terms of a dielectric constant, with the value for a vacuum **(7)** _____as unity. The values of this constant for usable dielectrics vary from slightly more than 1 for air up to 100 or more for **(8)** _____ceramics containing titanium oxide. Glass, mica, porcelain, and mineral oils, often used as dielectrics, have constants ranging from about 2 to 9. The ability of a dielectric to withstand electric fields **(9)** _____ losing insulating properties is known as its dielectric strength. A good dielectric must return a large percentage of the energy stores in it when the field is reversed. Dielectrics, particularly those with high dielectric constants, are used extensively in all **(10)** _____of electrical engineering, where they are employed to increase the efficiency of capacitors.

| | | | |
|---|---|---|---|
| 1. **A** towards | **B** onto | **C** through | **D** into |
| 2. **A** combine | **B** repel | **C** absorb | **D** attract |
| 3. **A** solid | **B** conductor | **C** dielectric | **D** liquid |
| 4. **A** themselves | **B** each other | **C** one another | **D** their |
| 5. **A** in | **B** place | **C** part | **D** on |
| 6. **A** for | **B** when | **C** while | **D** as |
| 7. **A** taken | **B** given | **C** known | **D** such |
| 8. **A** particular | **B** famous | **C** certain | **D** known |
| 9. **A** with | **B** for | **C** via | **D** without |
| 10. **A** sphere | **B** branches | **C** parts | **D** fields |

**Task 5. Translate into English using the active vocabulary of the module:**

Тверді тіла складаються із частинок, які взаємодіють між собою. Це зумовлює певний порядок у системі і особливі властивості цих частинок. Колективні властивості електронів визначають електропровідність твердих тіл, а властивість тіла поглинати тепло залежить від характеру колективних коливань атомів при тепловому русі. За електронними властивостями тверді тіла поділяють на метали, діелектрики і напівпровідники. Рух мікрочастинок відбувається за законами квантової механіки. В електронах у атомі енергія приймає визначені, квантовані значення. У твердих тілах ці рівні енергії об’єднуються у зони, розділені забороненими областями енергії. За принципом Паулі електрони займають рівні із різними енергіями. Діелектрики займають не усі рівні енергії. Електрони у діелектрику не можуть прискорюватись в електричному полі, її провідність при нульовій температурі дорівнює нулю. У металах верхній заповнений рівень енергії знаходиться усередині зони, енергія електронів може змінюватися безперервно,електричне поле створює струм. У напівпровідниках рух електронів у вільній зоні прискорюється електричним полем. Зазвичай напівпровідники мають невелику провідність, яка залежить від температури.

## Part II. LIQUIDS

**Task 6. Find the meaning and pronunciation of the following words in a dictionary and learn them:**

| | | |
|---|---|---|
| expand | arrangement | three-dimensional pattern |
| long-range order | short-range order | attractive forces |
| a drop | intermolecular forces | viscosity |

### Part I

Liquid is one of the three physical states in which matter can exist. The molecules of liquids are arranged less tightly than those of solids but more closely than those of gases. Liquids and gases take the shape of their container, unlike solids, which keep their own shape. Liquids and solids maintain a definite volume while gases will **expand** to fill a container. A liter of liquid will not expand to fill a two-liter container, but a liter of gas will.

Liquids, like all substances, are made up of atoms or bonded groups of atoms called molecules. The physical state of any substance – whether the substance is a liquid, solid, or gas – depends on the **arrangement** of the molecules in the substance. The molecules in a liquid are arranged tighter and more orderly than in a gas, but less orderly than in a solid. In crystalline solids, such as table salt or sugar, the molecules or other particles are stacked in a precise order, forming a **three-dimensional pattern** that repeats throughout the crystal. Scientists say these substances have long-range order. This means the atoms or molecules in the solid are ordered throughout the solid. In gases, the atoms or molecules have no order at all but move freely, allowing gases to expand and fill a container.

Liquids have no **long-range order,** but their molecules have some order with respect to the nearest neighbouring molecules. Every molecule in a liquid has the same number of nearest neighbours, and each of these neighbouring molecules are roughly the same distance from one other. But the position of molecules that are further away from a particular molecule in a liquid becomes more and more random with increasing distance. Liquids, therefore, have **short-range order,** or an orderly pattern only at very small distances (a few molecule lengths) from a given molecule.

Certain liquids, called liquid crystals, can have some long-range order, though not as much as a solid. These liquids contain long, rodlike molecules that, in certain temperature ranges, line up parallel to each other to create a long-range order. Unlike molecules in a solid, however, molecules in a liquid crystal retain the ability to slide past one another. The optical properties of some liquid crystals change with the arrangement of their molecules. For example, digital watches and calculators use liquid crystals that appear opaque when they are aligned in one direction and transparent when they are aligned in another direction.

Order in the molecules of any substance depends on the forces of attraction and repulsion between the molecules. These forces, called **intermolecular forces,** arise from electrical charges on molecules that attract or repel the charges on other molecules. Intermolecular forces account for many of the physical properties of a liquid, such as its boiling point, freezing point, and surface tension. They are also the reason a liquid can form from a gas or freeze into a solid.

## Part II

A liquid forms from a gas when **a drop** in temperature or an increase in pressure causes the atoms or molecules of the gas to move closer together and acquire a short-range order. As the temperature of a gas drops, its molecules lose energy. The loss of energy causes the molecules to move more slowly, allowing them to come into closer contact with one another. An increase in the pressure of a gas brings molecules closer together by forcing them into a smaller space. Pressure can be increased by moving a given volume of gas from a large container into a smaller container, or by adding more gas to the original container. When the gas molecules move near enough to one another, intermolecular forces of **attraction** take over. These forces bring the molecules even closer together and into a short-range order, and a liquid forms. Likewise, when molecules in a liquid lose energy and move closer to one another, these same forces cause the liquid to turn into a solid.

The *boiling* point of a liquid is the temperature at which molecules escape from the liquid and enter the gaseous state. Heat causes a liquid to boil by adding energy to the liquid’s molecules. As the molecules gain energy, they move about more quickly and range farther from each other. When the molecules are far enough apart, intermolecular forces are too weak to pull them back together, so the molecules form a vapor. Boiling starts when bubbles of vapor form within the liquid. These bubbles rise to the top of the liquid and release the gaseous molecules to the atmosphere above the liquid's surface. It takes 540 calories of heat energy to evaporate 1 gram of water at 100° C at sea level.

The *freezing* point of a substance is the temperature at which the liquid form of the substance becomes a solid. The molecules of a liquid arrange into a more ordered structure as the liquid freezes. The freezing point of a substance is essentially the same as its melting point – that is, the point at which a solid becomes a liquid.

The **viscosity** of a liquid is a measure of how much the liquid resists flow. Flow allows a liquid to take the shape of the container that holds it. A liquid's viscosity depends on the structure of the liquid's molecules and on the **attractive forces** between them. Highly viscous liquids often contain molecules that have complicated structures. These molecules can become entangled with one another, impairing their ability to flow past one another. The viscosity of water is lower than that of heavy oils, for example, because oils contain large, convoluted molecules that catch on one another. The polarity of the molecules in water, however, causes them to attract one another, making water more viscous than a non-polar liquid such as propane. Viscosity decreases as temperature increases because additional heat energy enables molecules to overcome attractions to one another and move more freely.

**Task 7. Answer the following questions on the text:**

1. What are intermolecular forces?
2. When does a liquid become a solid?
3. Why is the viscosity of oil larger than the viscosity of water?
4. What are the optical properties of liquid crystals?
5. What role do liquids play?

**Task 8. Rearrange the two columns so that the sentences make sense:**

| | |
|---|---|
| 1. Heat causes a liquid to boil | a) the arrangement of the molecules in the substance. |
| 2. The loss of energy causes | b) by adding energy to the liquid's molecules. |
| 3. The physical state of any substance depends on | c) lower than that of heavy oils. |
| 4. The viscosity of water is | d) the molecules to move more slowly. |
| 5. Every molecule in a liquid has | e) the same number of nearest neighbours. |

**Task 9**. **Fill in the gaps in the text with the words from the box below:**

| | | | | |
|---|---|---|---|---|
| catalyst | tasteless | laboratory | freeze | point |
| ionizing | metric | temperature | maximum | |

Pure water is an odorless **(1)** ____ liquid. It has a bluish tint, which may be detected, however, only in layers of considerable depth. Under standard atmospheric pressure (760 mm of mercury); the freezing **(2)** ____ of water is 0°C and its boiling point is 100°C. Water attains its **(3)** ____ density at a temperature of 4°C and expands upon freezing. Like most other liquids, water can exist in a supercooled state; that is, it may remain a liquid although its **(4)** ____ is below its freezing point. Water can easily be cooled to about -25°C without freezing, either under **(5)** ____ conditions or in the atmosphere itself. Supercooled water will **(6)** ____ if it is disturbed, if the temperature is towered further, or if a crystal or other particle is added to it. Its physical properties are used as standards to define the calorie and specific and latent heat and in the **(7)** ____ system for the definition of the unit of mass, the gram.

Water is one of the best-known **(8)** _______agents. Because most substances are somewhat soluble in water, it is frequently called the universal solvent. Water combines with certain salts to form hydrates. It acts as a **(9)** ______in many important chemical reactions.

**Task 10. Translate into English and compare your translation with the text:**

1. Для рідин характерний рух молекул і незначний вільний простір між ними.
2. Під впливом тиску рідина набуває форму ємності, яка при даному об'ємі має найменшу поверхню.
3. У рідких кристалах діють сили притягання і відштовхування.
4. У молекулах рідких кристалів атоми розташовані уздовж вибраної лінії або лежать у визначеній площині.
5. Деякі речовини у рідкокристалічному стані здатні змішуватись одна з одною і утворювати рідкі кристали із різними структурами і властивостями.
6. Рідини зазвичай розширюються при нагріванні.
7. Температури кипіння і охолодження – характерні ознаки рідин.

## Part III. GASES

**Task 11. Find the meaning and pronunciation of the highlighted words in a dictionary and мake up questions about the text:**

Gas is a fluid that expands to fill any container, however large, without any change of phase. With their discovery of the gas laws that bear their names, Robert Boyle and Jacques Alexandre Charles made important contributions to chemistry. In 1661 English scientist Robert Boyle found that the volume of a gas varies inversely with its pressure, if the temperature is held constant. About a hundred years later, a French physicist, Jacques Alexandre Charles, observed that the volume of a gas varies in proportion to its temperature, if the pressure is held constant.

The atomic theory of matter defines states, or phases, in terms of order. Molecules have a certain freedom of motion in space. These microscopic degrees of freedom are associated with the concept of macroscopic order. Molecules in gases move at random, bounded only by the walls of their container.

Boyle's law, developed by English scientist Robert Boyle, states that the pressure of a gas times its volume is equal to a constant number, for a gas at a **constant temperature**. This relationship means that pressure increases as volume decreases, and vice versa. In this graph, the product of pressure and volume anywhere along one of the lines of constant temperate should be equal.

**Empirical laws** have been developed that correlate macroscopic variables. For common gases, the macroscopic variables include pressure (P), volume (V), and temperature (T). Boyle's law states that in a gas held at a constant temperature the volume is inversely proportional to the pressure. Charles's law, or Gay-Lussac's law, states that if a gas is held at a constant pressure the volume is directly proportional to the absolute temperature. Combining these laws gives the ideal gas law: $PV/T = R$ (per mole), also known as the equation of state of an **ideal gas**. The constant R on the right-hand side of the equation is a universal constant, the discovery of which is a cornerstone of modern science.

With the advent of the atomic theory of matter, the above mentioned empirical laws acquired a microscopic basis. The volume of a gas reflects simply the position distribution of its constituent molecules. More exactly, the macroscopic variable V represents the avail-able amount of space in which a molecule can move. The pressure of a gas, which can be measured with gauges placed on the container walls, registers the average change of momentum experienced by molecules as they collide with, and subsequently rebound from, the walls. The temperature of a gas is **proportional** to the average kinetic energy of the molecules, or to the square of the average velocity of the molecules. The reduction of these macroscopic measures to such mechanical variables as position, velocity, momentum, and kinetic energy of the molecules, which can be correlated through Newton's laws of mechanics, should yield all the empirical gas laws. This turns out to be generally true.

The physics that relates the properties of gases to classical mechanics is called the **kinetic theory of gases**. Besides providing a basis for the ideal gas equation of state, the kinetic theory can also be used to predict many other properties of gases, including the statistical distribution of molecular velocities and transport properties such as thermal conductivity, the coefficient of diffusion, and viscosity.

At low temperatures (reduced molecular motion) and at high pressures or reduced volumes (reduced intermolecular spacing), the molecules in a gas come under the influence of one another's attractive force. Under certain critical conditions, the entire system enters a high-density bound state and acquires a bounding surface. This signifies the onset of the liquid state. The process is known as a **phase transition**. Improved understanding of the properties of gases over the past century has led to large-scale exploitation of the principles of physics, chemistry, and engineering for industrial and consumer applications.

**Task 12. Answer the clues. The number of letters is given:**

1. Substance in a physical state in which it does not resist change of shape and will expand indefinitely to fill any container (3); **G**- -
2. Existing or occurring in the physical world; not imaginary, fictitious, or theoretical; actual (4); - -**A**-
3. A particular stage in a periodic process or phenomenon (5); - - -**S**-
4. Relating to a highly desirable and possible state of affairs (5); - -**E**- -

5. A measure of the resistance to flow of a fluid, equal to its absolute viscosity divided by its density (9);   - - - -**O**- - - -

6. The random thermal motion of atoms, molecules, clusters of atoms, etc., in gases, liquids, and some solids (9);   - - - -**U**- - - -

7. Fixed and invariable; unchanging (8);   - - -**S**- - - -

**Task 13. Insert the extracted parts of sentences (A-I) into their correct places:**

**Van der Waals equation**

The Dutch physicist Johannes Waals won the 1910 Nobel Prize in physics. **(1) ____**, he developed a theory known as the van der Waals equation.

The ideal gas equation of state is only approximately correct. Real gases do not behave **(2) ___**. In some cases the deviation can be extremely large. For example, ideal gases could never become liquids or solids**, (3)** ___. Thus, modifications of the ideal gas law, PV = RT, **(4)** ___. Particularly useful and well known is the van der Waals equation of state: (P + a/V2) *(V - b) = RT, where a and b are adjustable parameters determined from experimental measurements **(5)** ___. They are material parameters rather than universal constants, **(6)** ___.

The van der Waals equation also has a microscopic interpretation. Molecules interact with one another. The interaction is strongly repulsive in close proximity, becomes mildly attractive atintermediate range, **(7)** ____. The ideal gas law must be corrected when attractive and repulsive forces are considered. For example, the mutual repulsion between molecules has the effect of excluding certain territory **(8)** ____. Thus, a fraction of space becomes unavailable to each molecule **(9)** ____. In the equation of state, a volume of exclusion (b) should be subtracted from the volume of the container (V); thus, (V - b).

**A)** interested in thermodynamics;
**B**) as it executes random motion;
**C)** were proposed;
**D)** around each molecule from intrusion by its neighbours;
**E)** in the sense that their values vary from gas to gas;
**F)** no matter how much they have cooled or compressed;
**G)** and vanishes at long distance;
**H)** carried out on actual gases;
**I)** exactly as predicted.

**Task 14. Fill in the gaps in the text with the correct prepositions or conjunctions if necessary:**

In the early 19th century the Italian chemist Amedeo Avogadro made an important advance **(1)** ___ the understanding of how atoms and molecules in a gas behave. He began his work from a theory developed by Dalton who proposed that a gaseous compound, formed **(2) ___** combining equal numbers of atoms of two elements, should have the same number of molecules as the atoms in one of the original elements. For example, ten atoms of the element hydrogen (H) combine with ten atoms of chlorine (Cl) to form ten gaseous hydrogen chloride (HCI) molecules.

In 1811 Avogadro developed a law of physics that seemed to contradict **(3)** ____ Dalton's theory. Avogadro's law states that equal volumes of different gases contain the same number of particles (atoms or molecules) if both gases are **(4)** ____ the same temperature and pressure. In Dalton's experiment, the volume of the original vessels containing the hydrogen or chlorine gases was the same as the volume of the vessel containing the hydrogen chloride gas. The pressures of the original hydrogen and chlorine gases were equal, but the pressure of the hydrochloric gas was twice **(5)** ____ great as either of the original gases. According to Avogadro's law, this doubled pressure would mean that there were twice as many hydrogen chloride gas particles than there had been chlorine particles prior to their combination.

To reconcile the results of Dalton's experiment **(6)** ____ his new rule, Avogadro was forced to conclude that the original vessels of hydrogen or chlorine contained only half as many particles as Dalton had thought. Dalton, however, knew the total weight of each gas **(7)** ____ the vessels, as well as the weight of an individual atom of each gas, so he knew the total number of atoms of each gas that was present in the vessels. Avogadro reconciled the fact that there were twice as many atoms as there were particles in the vessels **(8)** ____ proposing that gases such as hydrogen and chlorine are really made up of molecules of hydrogen and chlorine, with two atoms in each molecule. Today scientists write the chemical symbols for hydrogen and chlorine as $H_2$ and $Cl_2$, respectively, indicating **(9)** ____ that there are two atoms in each molecule. One molecule of hydrogen and one molecule of chlorine combine to form two molecules of hydrogen chlorine ($H_2 + Cl_2 \longrightarrow 2HCI$). The sample of hydrogen chloride contains twice the number of particles as either the hydrogen or chlorine because two molecules of hydrogen chloride form when a molecule of hydrogen combines **(10)** ____ a molecule of chlorine.

**Task 15. Be ready to speak on the topics:**

a) Solids and their properties;
b) Liquids and their properties;
c) Gases and their properties.

MODULE 4. **THERMAL PHYSICS**

## Part I. NATURE OF HEAT

**Task 1. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:**

All matter is made up of molecules and atoms. These atoms are always in different types of motion (translation, rotational, vibrational). Heat has much to do with **molecular motion;** and from the fact that it is able to melt ice, vaporize water and cause bodies to expand, we may well suspect that it is at least closely related to some form of energy. The motion of atoms and molecules creates heat or thermal **energy**. All matter has this thermal energy. It is thermal energy moving from a warmer object to a cooler object. The more motion the atoms or molecules have, the more heat or thermal energy they will have. There are many simple experiments which may be **performed** to support this inference:

1. Try rubbing the face of a button or a coin rapidly against a piece of cloth or wood for a minute or more. It becomes hot.

2. Rapidly bend a rather stiff piece of iron wire back and forth about ten times and then feel the place where the bending was produced. It becomes very warm.

3. Give the end of a nail or a piece of lead a dozen blows with a hammer and then try to detect the heat produced.

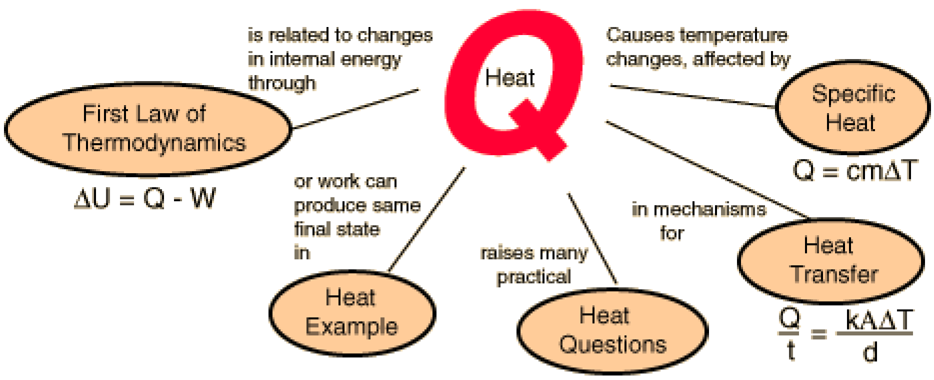
These are only a few of the many ways in which heat may be **generated** at the expense of the work done by the person who performs the experiment. That is, energy is given up by the person and heat appears. A moving train or automobile loses its **kinetic energy** when the brakes are applied; but an examination of the brakes and wheels will show that energy has been **converted** into heat.

On the other hand, heat is constantly used in engines for hauling trains, running machinery, and performing work in many other ways. Therefore, the conclusion is that *the heat energy is a form of energy*. Heat is a form of energy that results from the disordered motion of molecules. As the motion becomes more rapid and disordered, the amount of heat is increased.

Heat may be defined as energy in **transit** from a high temperature object to a lower temperature object. Heat is energy transferred from one system to another solely by reason of a temperature difference between the systems. Heat exists only as it crosses the boundary of a system and the direction of heat transfer is from higher temperature to lower temperature.

So now we can meaningfully restate the definition of temperature. **Temperature** is an average value of energy for all the atoms and molecules in a given system. Temperature is independent on how much matter there is in the system. It is simply an average of the energy in the system. Temperature is a measure of the ability of a substance, or more generally of any physical system, **to transfer** heat energy to another physical system. The higher the temperature of an object is, the greater the tendency of that object to transfer heat is. The lower the temperature of an object is, the greater the tendency of that object to be on the receiving end of the heat transfer is.

Thus, heat is thermal energy that is transferred between two substances because of a temperature difference. Heat is thermal energy in transit. Thermal energy flows from substances with higher temperatures to substances with lower temperatures until thermal equilibrium is reached. Heat is a measurable quantity and can be calculated using mathematics.




Piture 1. Mechanical Equivalent of Heat

**Task 2. Answer the questions on the text:**

1. What motion is heat related to?
2. What is heat or thermal energy?
3. What is the simplest example of heat energy?

4. What ways can heat be generated?
5. Where is heat constantly used?
6. How can heat be defined?
7. Which definition of temperature is the clearest for you?

**Task 3. Complete each of the following statements with words/phrases from the text:**

1. Heat has much to do with ……………… ……………………………..……... .
2. The motion of atoms and molecules creates ……………. …………..……. .
3. The more motion the atoms or molecules have, the more ……..………. .
4. The heat energy is …………………………………………….……..…... .
5. Heat is a form of energy that results ……………………….………….. .
6. Heat may be defined as ……………………………………………………. .
7. Temperature is independent on …………………………………………. .
8. The higher the temperature of an object is, ……………………………….. .
9. The lower the temperature of an object is, …………………………….... .
10. Thermal energy flows from substances with higher temperatures to …..…. .

**Task 4. State the forms and functions of the Infinitives and translate the sentences:**

1. Heat, light and electricity are considered to be different forms of motion.

2. To understand the importance of this invention you should know thermodynamics.

3. The sun is known to send out a great amount of radiant energy steadily.

4. To keep a constant temperature during the experiment is of prime importance.

5. Gold and platinum do not gain weight when heated in air because they are too inactive to unite with oxygen.

6. A steam turbine is known to operate by means of heat which it derives from steam and which it converts into mechanical work.

7. Plastics are known to be classified into groups according to their behaviour when they are heated.

8. A combination of mechanisms designed to transform energy into the form required and thus to do useful work is called a machine.

9. Heat is known as measure of the ability of a substance, or more generally of any physical system, to transfer heat energy to another physical system.

10. Out-of-date equipment is to be replaced.

**Task 5. Translate the dialogue using the given words and expressions and act it out:**

| | | | | |
|---|---|---|---|---|
| solar energy, | to supply with, | kilowatt hours, | radiant energy, | useful, |
| effective use of solar radiation, | to produce high temperatures, | solar batteries, | | |
| a source of energy, | to be converted into, | conversion of sunlight into | | |

**A:** Сонце дає нам світло, тепло і енергію. Скільки енергії посилає сонце на землю?

**B:** Щороку сонце дає землі 6 х $10^{17}$ кіловат-годин енергії, хоча не дає високих температур.

**A:** Це дуже багато. Чи використовують люди всю сонячну енергію?

**B:** Так, це справді дуже багато енергії, але люди використовують незначну кількість її.

**A:** Чому це так? Люди не знають, як використовувати сонячну енергію?

**B:** Вчені знають багато способів її використання, але цього недостатньо. Однією з головних проблем людства є відкриття шляхів більш ефективного використання сонячної енергії.

**A:** Як люди використовують сонячну енергію? Які є джерела її використання?

**B:** Сонце – це джерело всіх основних форм енергії. Одна форма енергії, як відомо, перетворюється в іншу. Знаючи цей закон, люди перетворюють сонячну енергію на корисну енергію, яка їм потрібна.

**A:** Я знаю, що сонячну енергію перетворюють в електричну, але це лише перші кроки у цьому напрямку. Як використовують сонячну енергію для досліджень космічного простору?

**B:** Сонячні батареї використовують на космічних ракетах.

## Part II. TRANSFER OF HEAT

**Task 6. Find the definitions of the following terms in a dictionary and compare them with those from the text:**

Convection – ……………………………………………………………..……..

Conduction – ……………………………………….……………………...

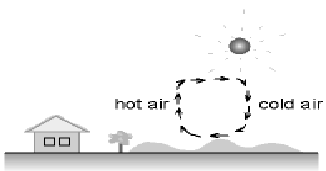
Radiation – ……………………………………………………………………

Transfer – ……………………………………………………………………..

Heat can travel from one place to another in three ways: conduction, convection and radiation. Both conduction and convection require matter to transfer heat. If there is a temperature difference between two systems heat will always find a way to transfer from the higher to lower system.

The simplest way in which heat may be transferred from one place to another is by the motion of the heated substances. Such a transfer is known as **convection.** Thermal energy is transferred from hot places to cold places by convection. Convection occurs when warmer areas of a liquid or gas rise to cooler areas in the liquid or gas. Cooler liquid or gas then takes the place of the warmer areas which have risen higher. The density at the bottom is less than near the top. This results in a continuous circulation pattern. The currents of water thus set up in the liquid are known as convection currents. Water boiling in a pan is a good example of these convection currents.

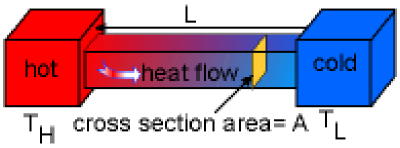
Heat transfer between a solid surface and an adjacent gas or liquid. It is the combination of conduction and flow motion. Heat transferred from a solid surface to a liquid adjacent is conduction. And then heat is brought away by the flow motion. Another good example of convection is in the atmosphere. The earth's surface is warmed by the sun, the warm air rises and cool air moves in. The atmospheric air motion is a case of convection. In winter, heat conducted from deep ground to the surface by conduction. The motion of air brings the heat from the ground surface to the high air.




Picture 1. Convection

**Conduction** is the transfer of heat between substances that are in direct contact with each other. The better the conductor, the more rapidly heat will be transferred. Conduction occurs when a substance is heated, particles will gain more energy, and vibrate more. These molecules then bump into nearby particles and transfer some of their energy to them. This then continues and passes the energy from the hot end down to the colder end of the substance.

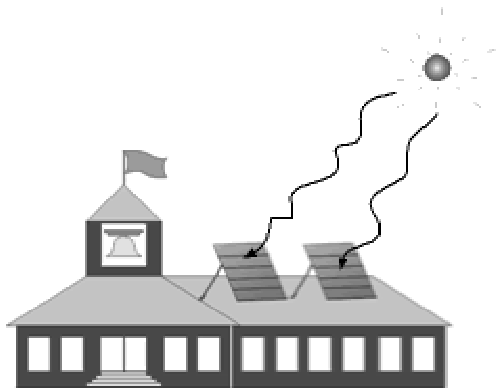
Metal is a good conduction of heat. When a metal rod is held in the fire, the heat travels along the rod and after a time the rod becomes too hot to hold. In this process the vibration of the molecules are handed on from molecule to molecule. The layer of molecules in contact with the fire is heated first and thus made to vibrate more rapidly. This layer hands the motion on to the adjacent layer, because each layer is bound to the adjacent layer by certain cohesive forces. It is thus impossible for the molecules in one layer to vibrate without setting the molecules in the neighboring layers in vibration. As this process goes on, the entire medium is heated after a time. When heat, as in this case, is transferred from one part of the body to another without any progressive motion of the parts of the substance, the heat is said to be transferred by conduction. The conductivity differs widely according to the nature of the substances. Steam pipes are covered to reduce heat losses.




Picture 2. Conduction: heat transferred between two bodies in direct contact

**Radiation** is a method of heat transfer that does not rely upon any contact between the heat source and the heated object as is the case with conduction and convection. Examples of radiation is the heat from the sun, or heat released from the filament of a light bulb. Heat can be transmitted through empty space by thermal radiation often called infrared radiation. This is a type electromagnetic radiation. No mass is exchanged and no medium is required in the process of radiation. Radiation is the energy emitted by matter in the form of electromagnetic waves as a result of the changes in the electronic configurations of the atoms or molecules.

A person sitting in front of a stove receives heat from the stove, or the electric heater although the air in the room is cold. In a similiar manner, sunlight falling on a body will warm it above the temperature of the surrounding air. This method of transfer of heat is distinguished from convection and conduction by the fact that the medium through which the transfer occurs is not heated. Thus, the earth receives great quantities of heat from the sun, although the space that separates the sun from the earth is very cold. The fact that the earth receives such quantities of heat from the sun shows that this heat can pass through the empty space between the sun and the atmosphere that surrounds the earth. When this energy reaches the earth, it causes the molecules of the body on which it falls to vibrate more rapidly, and the body is heated. This movement of heat from one place to another is known as **transfer of heat by radiation.**



Picture 3. Radiation: Solar energy applications mainly use radiation energy from the Sun

The three modes of heat transfer always exist simultaneously. For example, the heat transfer associated with double pane windows are:

- Conduction: Hotter (cooler) air outside each pane causes conduction through solid glass.
- Convection: Air between the panes carries heat from hotter pane to cooler pane.
- Radiation: Sunlight radiation passes through glass to be absorbed on other side.

**Task 7. Read the text and change the word in bold with the one given in brackets:**

## Heat Transfer Convection

Heat energy can be transferred from one point to another by different methods and at different rates. Heat energy **resides** (refuses, stays, replies) in kinetic energy of molecules and in the case of fluids, **portions** (forces, change, parts) of the fluid may move from point to point carrying the fast moving molecules with their energy to points where the energy per molecule is less so that the energy is transferred by the molecules moving to the new point. This is known as convection. It can be **readily** (slowly, easily, really) shown with water in a glass tube. Some ink added at the top **allows** (permits, avoids, ensures) us to follow the motion of convection. In order to get circulation we note that the heating produces a density change and **hence** (even, although, therefore) a pressure gradient and the density gradient cannot be parallel so that acceleration in different directions are different.

**Task 8. Translate the text "Heat transfer convection" and give the opposite of:**

rapidly – ___________, rest – _______________, heat – _________________,
light – _____________, liquid – _____________, external – ______________,
low – ______________, tide – _______________, density – ______________ .

**Task 9. Write a verb in front of a noun:**

___________________ a problem
___________________ an experiment
___________________ research
___________________ a phenomenon
___________________ heat

**Task 10. Make a summary of the most important facts concerning transfer of heat. When writing a summary, use the plan below:**

1. **Introduction**. Interesting opening comments to attract the audience's attention.
2. **Basic information on the topic.** Short paragraphs giving facts.
3. **Closing comments**. Encourage interest in the topic giving opinions and conclusions.

## Part III. LAWS OF THERMODYNAMICS

**Task 11. Before reading the text, discuss the following questions:**

1. How much do you know about transformation of heat into work?
2. Can you define thermodynamics?
3. How many laws concerning thermodynamics do you know?
4. What can you say about The First Law of Thermodynamics?
5. What does the Second Law of Thermodynamics state?

The heat engines that play such a large part in modern life depend on the transformation of heat into work. The heated steam in the cylinder of a steam engine does work in pushing the piston back. This work is available for driving the machinery connected to the engine. A gasoline engine can drive an automobile or a tractor only when it is supplied constantly with heat from the exploding gasoline in the cylinders. In these cases, heat is transformed into work.

**Thermodynamics** is the study of the connection between thermal energy and work and the conversion of one into the other. This study is important because many machines and modern devices change heat into work (such as an automobile engine) or turn work into heat (or cooling, as in a refrigerator). There are two laws of thermodynamics that explain the connection between work and heat. But first, it must be shown how mechanical energy can be equivalent to heat energy.

There are two major laws concerning thermodynamics.

**The First Law of Thermodynamics** is *the Law of Conservation of Energy*. It states that energy cannot be created or destroyed. Instead, it is converted from one form to another, such as from mechanical work to heat, from heat to light, from chemical to heat or such. This Law requires that we balance the energy budget when we describe a change in state. A change in energy content is accompanied by the performance of work, and/or the transfer of heat between the thermodynamic system under consideration and its surroundings. One example of that is how the kinetic energy of a moving car is converted into heat energy at the brakes and tire surfaces. Another example is when chemical energy is released in burning and is converted into light and heat energy.

This Law states that when any mechanical change occurs in an isolated system, the energy of the system remains constant. Heat may be transformed into work or work into heat, but the total energy of the system remains unchanged. In other words, the first law of thermodynamics states that *in the transformation of work into other forms of energy or in the transformation of one form of energy into other forms of energy, no energy is ever created nor destroyed.* The energy before and after the transformation is always the same. This law in its general form can not be proved by experiment but conclusions based on it have always been confirmed by experiment.

**The Second Law of Thermodynamics** states the conditions under which heat may be transferred from one body to another. It is in effect a statement of the fact that heat naturally flows from a place of higher to one of lower temperature but never in the reverse direction. An analogue may make the meaning clearer. Water may flow from a higher to a lower level with the performance of work. Heat may flow from a higher to a lower temperature with the performance of work. To cause water to flow from a lower to a higher level requires that external work be done on it. To cause heat to flow from a lower to a higher temperature also requires the performance of external work. The natural tendency of heat to flow from a higher to a lower temperature makes it possible for a heat engine to transform heat into work. On the contrary, a mechanical refrigerating machine must transfer heat from a colder to a hotter body. Work must be done on such a machine to make this transfer. The following is one form of statement of the law:

*It is impossible for any kind of a machine working in a cycle to transfer heat from a lower to a higher temperature unless external work is done on it.* A similar statement of the water analogy would be: it is impossible for a pump working in a cycle to transfer water from a lower to a higher level unless external work is done on it. The law cannot be proved by direct experiment. It is a generalization based on the fact that in all human experience no contradictions of the law have been found. It merely states that heat of itself can flow only from a lower to a higher temperatures and no exceptions to this rule are known.

**Task 12. Read the text consisting of 4 paragraphs quickly and put the headings (a-d) in the correct order (1-4 on the right) to summarize its content:**

a) HEAT FLOWS FROM HIGH TO LOW ……

b) ENTROPY …...

c) SOME HEAT IS WASTED IN CONVERSION …..

d) HEAT SINK …...

So, the second law of thermodynamics has several variations:

**1) …..** One version of the Second Law of Thermodynamics states that some heat is wasted when converting heat into mechanical energy. In other words, in a car engine, not all of the heat created from the exploding gasoline is used in turning the engine or moving the car. Some of the heat simply heats the engine. The percentage of heat turned to work is called the *thermal efficiency* of the engine.

**2) …..** The Second Law of Thermodynamics also states that heat normally flows from high temperature to low temperature. For example, when you heat the end of a metal rod, the heat will gradually travel to the cool end and heat it up.

**3) …..** Another example of this part of the Second Law of Thermodynamics concerns what is called a heat sink, which is an object that absorbs heat from another. Usually, a large mass that absorbs heat from an object of smaller mass. The effect is seen in water beds. The reason water-beds use heaters to warm the water is because otherwise the heat from your body (at 98.6° F) will flow to the cooler water (at room temperature of 72° F). Since there is so much water in a water bed, it would take much energy from your body to heat the water to body temperature. Thus, you can feel chilled from the loss of body heat.

**4) …..** Another variation on the Second Law of Thermodynamics states that the energy available for work in the universe is continually decreasing. This is also stated as, “The *entropy* of the universe is continually increasing”. Entropy is the measure of the disorder of a system. In other words, in any closed system, objects are getting more and more mixed. Mixtures do not “unmix” by themselves.

**Task 13. Underline the verb in each sentence and determine its grammar form. Put questions to the highlighted words in the sentence:**

**1.** The important properties of aluminium are its low specific **gravity**, high electrical and thermal **conductivities** and corrosion **resistance.**

**2.** There is also nuclear installation where thermal energy generated in the reactor **is transformed directly into electric energy**.

**3.** **Welding** is the process of joining together pieces of metal or metallic parts by heating the places of contact to a state of fusion or plasticity.

**4.** The energy transforms the electric energy to other forms of energy: **radiant, thermal, mechanical and so on**.

**5.** **Lomonosov** developed the theory of heat stating that it was due to the motion of a body's particles.

**Task 14. a) Translate the derivative words and define the ways of word formation:**

period – periodic,
system – systematic,
peculiar – peculiarity,
similar – similarity,
chemical – chemistry – chemist,
to depend – dependent – dependence,
to define – definite – definition,
to arrange – arrangement,
to exist – existence,
to predict – prediction,
to discover – discovery,
to know – knowledge,
to contain – container,
important – importance.

**b) Find in a dictionary words of different parts of speech with the same root:**

| ***Verb*** | ***Adjectives*** | ***Noun*** |
|---|---|---|
| to electrify – | electr _ _, electr _ _ _ _, | electr_ _ _ _ _, electr_ _ _ _ _, |
| to produce – | produc _ _ _ _, | produc _ , produc _ _ _ _, |
| to generate – | | generat _ _, generat_ _ _ , |
| to connect – | connect_ _ _, | connect_ _ _; |
| to develop – | develop _ _, _ _develop _ _, | develop _ _ _ _, |
| to create – | creat _ _ _, | creat _ _, creat_ _ _, |
| to measure – | measur_ _ _ _, | measur_ _ _ _ _, |
| to define – | defin_ _ _, | defin_ _ _ _ _, |
| to differ – | differ_ _ _, | differ_ _ _ _. |

**Task 15. Be ready to speak on the topic "Thermodynamics".**

## MODULE 5. **ELECTRICITY AND MAGNETISM**

### Part I. ELECTRICITY

**Task 1. Find the meaning and pronunciation of the key words in a dictionary and learn them:**

| | | |
|---|---|---|
| electric charge | electric current | outlet |
| electrical activity | to redistribute | fuel cells |
| electron | solid conductor | to emit |
| proton | alternating current | photoelectricity |
| electrically neutral | direct current | thermoelectricity |
| static electricity | electrolytic cells | piezoelectricity |

Electricity is one of the basic forms of energy associated with electric charge, a property of certain elementary particles such as electrons and protons, two of the basic particles that make up the atoms of all ordinary matter. Electric charges can be stationary, as in static electricity, or moving, as in an electric current. Electrical activity takes place constantly everywhere in the universe. Electrical forces hold molecules together. The nervous systems of animals work by means of weak electric signals transmitted between neurons (nerve cells). Electricity is generated, transmitted and converted into heat, light and other forms of energy through natural processes, as well as by devices built by people.

Electricity is an extremely versatile form of energy. It can be generated in many ways and from many different sources. It can be sent almost instantaneously over long distances. It can also be converted efficiently into other forms of energy, and it can be stored. Because of this versatility, electricity plays a part in nearly every aspect of modern technology. It provides light, heat, and mechanical power. It makes telephones, computers and countless other necessities and luxuries possible.

Electricity consists of charges carried by electrons, protons, and other particles. Electric charge comes in two forms: positive and negative. Electrons and protons both carry exactly the same amount of electric charge, but the positive charge of the proton is exactly opposite the negative charge of the electron. If an object has more protons than electrons, it is positively charged; if it has more electrons than protons, it is negatively charged. If an object contains as many protons as electrons, the charges will cancel each other and the object is said to be uncharged, or electrically neutral.

Electricity occurs in two forms: static electricity and electric current. Static electricity consists of electric charges that stay in one place. An electric current is a flow of electric charges between objects or locations.

Static electricity can be produced by rubbing together two objects made of different materials. Electrons move from the surface of one object to the surface of the other if the second material holds onto its electrons more strongly than the first does. The object that gains electrons becomes negatively charged, since it now has more electrons than protons. The object that gives up electrons becomes positively charged. For example, if a nylon comb is run through clean, dry hair, some of the electrons on the hair are transferred to the comb. The comb becomes negatively charged and the hair becomes positively charged. The following materials are named in decreasing order of their ability to hold electrons: rubber, silk, glass, flannel, and fur (or hair). If any two of these materials are rubbed together, the material earlier in the list becomes negative, and the material later in the list becomes positive. The materials should be clean and dry.

An electric current is a movement of charge. When two objects with different charges touch and redistribute their charges, an electric current flows from one object to the other until the charge is distributed according to the capacitances of the objects. If two objects are connected by a material that lets charge flow easily, such as a copper wire, then an electric current flows from one object to the other through the wire. Electric current can be demonstrated by connecting a small light bulb to an electric battery by two copper wires. When the connections are properly made, current flows through the wires and the bulb, causing the bulb to glow. When an electric current flows in a solid conductor, the flow is in one direction only, because the current is carried entirely by electrons. In liquids and gases, however, a two-directional flow is made possible by the process of ionization. Current that flows in one direction only, such as the current in a battery-powered flashlight, is called direct current. Current that flows back and forth, reversing direction again and again, is called alternating current. Direct current, which is used in most battery-powered devices, is easier to understand than alternating current.

There are several different devices that can supply the voltage necessary to generate an electric current. The two most common sources are generators and electrolytic cells.

Generators use mechanical energy, such as water pouring through a dam or the motion of a turbine driven by steam, to produce electricity. The electric outlets on the walls of homes and other buildings, from which electricity to operate lights and appliances is drawn, are connected to giant generators located in electric power stations. Each outlet contains two terminals. The voltage between the terminals drives an electric current through the appliance that is plugged into the outlet.

There are many sources of electric current other than generators and electrolytic cells. Fuel cells, for example, produce electricity through chemical reactions. Unlike electrolytic cells, however, fuel cells do not store chemicals and therefore must be constantly refilled. Certain sources of electric current operate on the principle that some metals hold on to their electrons more strongly than other metals do. Platinum, for example, holds its electrons less strongly than aluminum does. If a strip of platinum and a strip of aluminum are pressed together under the proper conditions, some electrons will flow from the platinum to the aluminum. As the aluminum gains electrons and becomes negative, the platinum loses electrons and becomes positive. The strength with which a metal holds its electrons varies with temperature. If two strips of different metals are joined and the joint heated, electrons will pass from one strip to the other. Electricity produced directly by heating is called thermoelectricity. Some substances emit electrons when they are struck by light. Electricity produced in this way is called photoelectricity. When pressure is applied to certain crystals, a potential difference develops across them. Electricity thus produced is called piezoelectricity. Some microphones work on this principle.

**Task 2. Answer the following questions on the text:**

1. What is electricity and what are its properties?
2. What two types of electric charges do you know?
3. What are the two forms of electricity?

4. When are objects positively or negatively charged?

5. How can static electricity be produced?

6. What are the peculiarities of electric current depending on the type of a conductor?

7. What two types of electric current do you know?

8. What is a generator?

10. What is the difference between fuel and electric cells?

11. What is piezoelectricity?

**Task 3. Find a definition to each given term in the text and write them down:**

1. Electric charge ……………………………………………………………… .
2. An electrically neutral object ……………………………………………… .
3. Static electricity ……………………………………………………………… .
4. An electric current ………………………………………………………… .
5. Direct current ………………………………………… ……………… .
6. Alternating current ………………………………………………………… .
7. Thermoelectricity …………………………………………………………… .
8. Photoelectricity ……………………………………………………………… .

**Task 4. Give as many synonyms as you can for the following words:**

1. Property – ……………………………………………………………… .
2. To take place – ……………………………………………………… .
3. Versatile – ………………………………………………………………… .
4. To generate – ……………………………………………………………… .
5. Condition – ……………………………………………………………… .

**Task 5. Make your own sentences using words from exercise 4:**

1. ………………………………………………………………………… .
2. ………………………………………………………………………… .
3. ………………………………………………………………………… .
4. ………………………………………………………………………… .
5. ………………………………………………………………………… .

## Part II. INDUCTION AND RESISTANCE

**Task 6. Find the meaning and pronunciation of the key words in a dictionary and learn them:**

| | | | |
|---|---|---|---|
| induction | expanding | voltage | to lead to |
| collapsing | pole | to experience | to induce |
| conductor | circuit | coil | inductor |
| loop | choke | inertia | spin |
| resistance | magnetic field | inductance | |

**Induction** is the creation of an electric current in a conductor moving across a magnetic field (hence the full name, electromagnetic induction). The effect was discovered by the British physicist Michael Faraday and led directly to the development of the rotary electric generator, which converts mechanical motion into electric energy. When a conductor, such as a wire, moves through the gap between the poles of a magnet, the negatively charged electrons in the wire will experience a force along the length of the wire and will accumulate at one end of it, leaving positively charged atomic nuclei, partially stripped of electrons, at the other end. This creates a potential difference, or voltage, between the ends of the wire. If the ends of the wire are connected by a conductor, a current will flow around the circuit. This is the principle behind the rotary electric power generator, in which a loop of wire is spun through a magnetic field so as to produce a voltage and generate a current in a closed circuit. Induction occurs only if the wire moves at right angles to the direction of the magnetic field. This motion is necessary for induction to occur, but it is a relative motion between the wire and the magnetic field.

Thus, an expanding or collapsing magnetic field can induce a current in a stationary wire. Such a moving magnetic field can be created by a surge of current through a wire or electromagnet. As the current in the electromagnet rises and falls, its magnetic field grows and collapses (the lines of force move outward, then inward). The moving field can induce a current in a nearby stationary wire. Such induction without mechanical motion is the basis of the electric transformer. A transformer usually consists of two adjacent coils of wire wound around a single core of magnetic material. It is used to couple two or more a-c circuits by employing the induction between the coils. When the current in a conductor varies, the resulting changing magnetic field cuts across the conductor itself and induces a voltage in it. This self-induced voltage is opposite to the applied voltage and tends to limit or reverse the original current. Electric self-induction is thus analogous to mechanical inertia. An inductance coil, or choke, tends to smooth out a varying current, as a flywheel smoothes out the rotation of an engine. The amount of self-induction of a coil, its inductance, is measured by the electrical unit called the henry, named after the American physicist Joseph Henry, who discovered the effect. The inductance is independent of current or voltage; it is determined only by the geometry of the coil and the magnetic properties of its core.

**Resistance** is the property of any object or substance to resist or oppose the flow of an electrical current. The quantity of resistance in an electric circuit determines the amount of current flowing in the circuit for any given voltage applied to the circuit, according to Ohm's law. The unit of resistance is the ohm, the amount of resistance that limits the passage of current to one ampere when a voltage of one volt is applied to it. The standard abbreviation for electric resistance is *R* and the symbol for ohms in electric circuits is the Greek letter omega, *Ω.* For certain electrical calculations it is convenient to employ the reciprocal of resistance, 1/R, which is termed *conductance, G.* The unit of conductance is the mho, or ohm spelled backward, and the symbol is an inverted omega. The resistance of an object is determined by the nature of the substance of which it is composed, known as the resistivity, the dimensions of the object, and the temperature. Resistivity is expressed in terms of the ohms resistance per cubic centimeter of the substance at 20° C.

**Task 7. Answer the following questions on the text:**

1. What is induction and when does it occur?
2. What does the rotary electric generator do?
3. What happens when a conductor moves through the gap between the magnet's poles?
4. What is the basis of the electric transformer?
5. What is the unit of inductance?

6. What is inductance determined by?
7. What is resistance?
8. What does the quantity of resistance in an electric circuit determine?
9. What is the ohm?
10. What is the resistance of an object determined by?

**Task 8. Decide whether the following statements are true (T) or false (F). Prove your answers using the information from the text:**

1. Induction was discovered by Niels Bohr. ………..
2. Wire is a conductor. ………..
3. The self-induced voltage is equal to the applied voltage. ………..
4. The amount of self-induction of a coil is measured by watt. ………..
5. The unit of resistance is ampere. ………..
6. The symbol of conductance is R. ………..

**Task 9. Put the words in the correct order and make up sentences:**

1. a potential / is / between / Voltage / of / the ends / difference / the wire.
2. is / of / independent / The / voltage / inductance.
3. the / Conductance / reciprocal / is / resistance / of.
4. is / by / Inductance / the electrical / measured / the henry / called / unit.
5. invented / generator /Michael Faraday / the / electric / rotary.

**Task 10. Fill in the blanks with a suitable preposition:**

Matter is made up (1) ...... three types of particles: electrons (which have negative charge), protons (positive) and neutrons (neutral). An uncharged object has equal numbers (2) ...... protons and electrons, whose charges therefore cancel out. When one material is rubbed (3) ...... another, there is a force of friction (4) ...... them, and electrons may be rubbed off one material (5) ...... the other. The material that has gained electrons is now negatively charged, and the other material is positively charged. If a positively charged object is brought close (6) ....... an uncharged one, the electrons (7) ...... the second object may be attracted; we observed this (8) ...... a force of attraction between two objects. (This is electrostatic induction). Note that it is usually electrons that are involved (9) ...... moving within a material, or (10) ...... one material to another. This is because electrons, which are (11) ...... the outside of atoms, are less strongly held within a material than protons; they may be free to move about within a material (like the conduction electrons in a metal), or they may be relatively weakly bound within atoms.

## Part III. ELECTRICTY AND MAGNETISM

**Task 11. Find the meaning and pronunciation of the key words and learn them:**

| | |
|---|---|
| to repel | polarity |
| electromagnetism | induced current |
| to constitute | left-hand rule |
| current-carrying | magnetic field |
| solenoid | right-hand rule |

Many similarities exist between electric and magnetic phenomena. A magnet has two opposite poles, referred to as north and south. Opposite magnetic poles attract each other, and similar magnetic poles repel each other, exactly as happens with electric charges.

The force with which magnetic poles attract or repel each other depends on the strength of the poles and the distance between them. The similarities between electric and magnetic phenomena indicate that electricity and magnetism are related. Electricity produces magnetic effects and magnetism produces electric effects. The relationship between electricity and magnetism is called electromagnetism.

It has been noted that an electric field exists around any electric charge. If electric charges are moving, they constitute an electric current. The magnetic effect of electricity is demonstrated by the fact that a magnetic field exists around any electric current. The field can be detected when a magnet is brought close to the current-carrying conductor.

The magnetic field around an electric current can be thought of as lines of magnetic force that form closed circular loops around the wire that carries the current. The direction of the magnetic field can be determined by a convenient rule called the right-hand rule. To apply this rule, the thumb of the right hand is pointed in the direction in which the current is flowing and the fingers are curled around the wire. The direction of the fingers then indicates the direction of the lines of magnetic force. (The right-hand rule assumes that current flows from positive to negative.)

As already stated, a magnetic field exists around a wire carrying an electric current, and a magnetic field exists between the two poles of a magnet. If the wire is placed between the poles, the magnetic fields interact to produce a force that tends to push the wire out of the field. This phenomenon, known as the motor effect, is used in electric motors.

If a wire is bent into many continuous loops to form a long spiral coil, then the magnetic lines of force tend to go through the center of the coil from one end to the other rather than around the individual loops of wire. Such a coil, called a solenoid, behaves in the same way as a magnet and is the basis for all electromagnets. The end from which the lines exit is the North Pole and the end into which the lines reenter is the South Pole. The polarity of the coil can be determined by applying the left-hand coil rule. If the left hand grasps the coil in such a way that the fingers curl around in the direction of the electric current, then the thumb points in the direction of the north pole.

If a wire is moved through a magnetic field in such a way that it cuts the magnetic lines of force, a voltage is created across the wire. An electric current will flow through the wire if the two ends of the wire are connected by a conductor to form a circuit. This current is called an induced current, and the induction of a current in this manner is called electromagnetic induction.

It does not matter whether the wire moves or the magnetic field moves, provided that the wire cuts through lines of force. If a magnet is moved near a stationary wire, the lines of magnetic force are cut by the wire and an electric current is induced in the wire.

Like any electric current, an induced current generates a magnetic field around it. Lenz's law expresses an important fact concerning this magnetic field: The motion of an induced current is always in such a direction that its magnetic field opposes the magnetic field that is causing the current.

**Task 12. Answer the following questions on the text:**

1. What is an electric field?
2. What is a magnetic field?
3. What is an electromagnetic field?

4. How can the direction of the magnetic field be determined?

5. What is the motor effect?

6. How can the polarity of the coil be determined?

7. When is a voltage created across the wire?

8. What is induced current?

9. What happens if a magnet is moved near a stationary wire?

10. What fact does Lenz's law express?

**Task 13. Choose a number, which corresponds to a lexical or grammatical error in one of the underlined fragments of the sentence and correct the mistake:**

1. Many (1) similarities exists (2) between (3) electric and magnetic (4) fields (5).
2. A (1) magnet has (2) a north (3) and south (4) pole (5).
3. Opposite (1) magnetic poles (2) attracts (3) each (4) other (5).
4. A (1) magnetic (2) field exists around (3) any (4) electricity (5) current.
5. The phenomena (1) of the motor (2) effect (3) is used (4) in electric motors (5).
6. The (1) amplifier can to be (2) used with any (3) high resistance (4) galvanometer (5).
7. Rubbed (1) with wood (2) amber becomes (3) charged (4) with kinetic (5) electricity.
8. While working (1) with electricity (2) you should (3) to be (4) extremely (5) careful.
9. If (1) you will rub (2) amber with silk (3) cloth, it will become (4) charged (5).

**Task 14. Fill in the gaps to complete the passage. Each word from the box is used once:**

| | | | | | |
|---|---|---|---|---|---|
| distinct | light | attract | photons | experiments | same |
| particles | forces | quantum | actually | absorbed | experiences |

For centuries, electricity and magnetism seemed (1) …………..forces. In the 1800s, however (2) …………… showed many connections between these two (3) ………….. In 1864 British physicist James Clerk Maxwell drew together the (4) …………of many physicists to show that electricity and magnetism are (5) ……………different aspects of the (6) ……………electromagnetic force. This force causes (7) ……………with similar electric charges to repel one another and particles with opposite charges to (8) ……………one another. Maxwell also showed that (9) …………is a traveling form of electromagnetic energy. The founders of (10) ……………..mechanics took Maxwell's work one step further. In 1925 German-British physicist Max Born, and German physicists Ernst Pascual Jordan and Werner Heisenberg showed that packets of light energy, later called (11) ……………., are emitted and (12) ……………when charged particles attract or repel each other through the electromagnetic force.

**Task 15. Give English equivalents to the words in the box and translate the sentences:**

| | | | | |
|---|---|---|---|---|
| електричний струм, | магнітне поле, | лінії магнітних сил, | полюс, | напруга, |
| становити, | провідник зі струмом, | полярність, | котушка, | індукований струм |

1. Електрика є однією з форм енергії, яка пов'язана з поняттям електричного заряду.
2. Електрика поділяється на статичну електрику та електричний струм.
3. Електричний струм – це рух заряду.
4. Струм, що тече вперед і назад, змінюючи постійно напрямок, називається змінним.
5. Сила, з якою метал утримує свої електрони, залежить від температури.
6. Трансформатор складається із суміжних котушок дроту, намотаного на єдиний сердечник з магнітного матеріалу.
7. При певних електричних обчисленнях зручно використовувати величину, обернену до опору, яку називають провідністю.
8. Ротаційний електричний генератор перетворює механічний рух в електроенергію.
9. Індуктивність незалежна від струму і напруги.
10. Подібність між електричними і магнітними явищами вказує на те, що електрика і магнетизм пов'язані між собою.
11. Якщо дріт розташований між полюсами, то магнітні поля взаємодіють і генерують силу, яка намагається виштовхнути дріт з поля.
12. Магніти мають тенденцію вирівнюватися вздовж ліній магнітного потоку.
13. Відносно джерела енергії провід і приймач утворюють зовнішнє коло.
14. І зовнішнє коло, і джерело струму мають опір, величина якого залежить від матеріалу, форми та розмірів провідників, з яких складається електричне коло.

## MODULE 6. INVENTION OF ELECTRICITY

### Part I. BRIEF HISTORY OF ELECTRICITY INVENTION

**Task 1. Read the text about invention of electricity and the light bulb. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:**

| | | |
|---|---|---|
| breakthrough | viable | arc |
| groundbreaking | ingenuity | ore |
| incandescent | filament | reversibility |

While most people generally attribute Benjamin Franklin as electricity discoverer, it isn't entirely accurate. He did, however, lay the ground work for future scientists to make world changing **breakthroughs**, so there is some degree of accuracy in calling him the father of electricity. He brought into regular use the terms "electrical battery", "conductor" and "nonconductor". His division of different states of electricity into "positive" or "plus" and "negative" or "minus" still holds good.

The list of scientists who did **groundbreaking** work with electricity reads like a who's who list of famous inventors – Thomas Edison, Allessandro Volta (volt), Andre-Marie Ampere (amp), Georg Simon Ohm (ohms), Nikola Tesla, Samuel Morse and Alexander Graham Bell among others. Each of them contributed to our modern electrical technology.

In addressing the question of who invented the **incandescent** lamp, historians Robert Friedel and Paul Israel list 22 inventors of incandescent lamps prior to Joseph Wilson Swan and Thomas Edison. They conclude that Edison's version was able to outstrip the others because of a combination of three factors: an effective incandescent material, a higher vacuum than others were able to achieve (by use of the Sprengel pump) and a high resistance that made power distribution from a centralized source economically **viable**.

Historian, Thomas Hughes, has attributed Edison's success to his development of an entire, integrated system of electric lighting. The lamp was a small component in his system of electric lighting, and no more critical to its effective functioning than the Edison Jumbo generator, the Edison main and the parallel-distribution system.

Other inventors with generators and incandescent lamps, and with comparable **ingenuity** and excellence, have long been forgotten because their creators did not preside over their introduction in a system of lighting.

Most people believe that the light bulb was invented by Thomas Edison. In fact, it was invented in 1809 by Humphry Davy, an English chemist. Unfortunately, it was not very useful, and wasn't like our modern version of a light bulb.

What Edison did? He invented a carbon **filament** that burned for up to 40 hours – a good bit longer than the one invented a year earlier that burned for around 13.5 (and the one before that was even less!). It is said that Edison tried and failed over 2000 times before finally perfecting the filament.

Scientist V. Petrov is called a pioneer of the world electrical engineering. He published a great number of articles on electricity. The electric **arc** discovered by Petrov became the first source of electric lighting. Petrov also discovered the possibility of getting metals out of **ores** by means of electricity.

Another physicist E. Lenz discovered the law of heat generation by the electric current and the law defining the direction of the induced electric current. He established the **reversibility** of electric machines.

**Task 2. After reading the text about invention of electricity, complete the sentences given below with the missing words:**

1. One of the top inventions that changed the world is …………….. ……….. .
2. The father of electricity is … …………. ……………….. .
3. Thomas Edison, Allessandro Volta, Andre-Marie Ampere and others contributed to our modern …………….. ………………… .
4. Most people believe that the light bulb was invented by ……….. ………... .
5. In fact, the light bulb was invented by ……….. ………, an English physicist.
6. Edison invented a …… ……… ……………. that burned for up to 40 hours.
7. It is said that Edison tried and failed over 2000 times before finally perfecting the …………………..…. .

**Exercise 3. Read the article. Underline the phrasal verbs and circle the direct object:**

**Eureka**

Did you know that two university dropouts thought up the idea of the first personal computer? What's more, they put it together in a garage. Inventions don't have to come out of fancy laboratories. Average people in classrooms, kitchens and home workshops often dream up new and useful ideas.

The ability to think of something new seems like magic to many people but in fact anyone can develop the qualities of an inventor. First, inventors follow their curiosity. The Swiss inventor George de Mestral wanted to find out the reason it was so hard to remove burrs from his dog's coat. His answer led to the idea for Velcro@, now used to fasten everything from trainers to space suits. Second, inventors use imagination to put things together in new ways. Walter Morrison watched two men throwing a pan to each other and thought up the Frisbee@, one of the most popular toys in the world. Perhaps most important, successful inventors don't give up. They continuously look up information about their ideas and try new designs out until they succeed.

**Exercise 4. Read the history's of a great inventor. Complete the information with the correct form of the appropriate phrasal verb from the box:**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| fill up | keep away | bring about | try out | set up | carry out | pay back | pick up |

As a child, Thomas Alva Edison (1847–1931) tried out almost everything he heard about – he even tried to hatch goose eggs by sitting on them! Before he was twelve, he ............. his first laboratory using money he had earnt himself. He had hundreds of bottles and he .............. them .............. with chemicals for his experiments. He labelled the bottles 'poison' to .............. his family .............. . When he was fifteen, Edison .............. a new skill. He had saved a child's life and the grateful father, a telegraph operator, .............. Edison .............. by teaching him telegraphy. After that, Edison was able to work at night and .............. his experiments during the day. In 1869 Edison made a piece of equipment for a company that supplied prices to sold brokers. This .............. his first useful invention – the stock ticker – for which he received $40000. He was then able to spend all his time working on his new inventions. During his lifetime, Edison was issued with 1093 patents!

**Task 5. a) Imagine that you are going to talk to some of the most famous inventors of electricity. What questions would you ask them? Tell them about how our society benefitted from their discoveries. Give reasons.**

**b) Write a short report about one of the famous inventors who contributed to electrical technology (Thomas Edison, Allessandro Volta, Andre Maria Ampere, Georg Simeon Ohm, Samuele Morse, V. Popov, E. Lenz, etc.). When writing a report, follow the standard format:**

1) title; 2) purpose; 3) short paragraphs giving facts; 4) opinions/comments;
5) conclusion.

## Part II. THE POWER OF WIND FOR ELECTRICITY PRODUCTION

**Task 6. a) Look at the words below describing weather conditions. Which of them are connected to the wind and its different types? Consult a dictionary when it is necessary:**

flooding, tornado, fog, typhoon, breeze, hail, rain, storm, hurricane, drought, sleet, blizzard

**b) You are going to read the definition of the wind. Complete it with the words from the chart below:**

| | | | | |
|---|---|---|---|---|
| surface (2) | land | motion | heating | rates |

Wind is simply air in (1)……. . It is caused by the uneven (2) ……. of the Earth's (3) ……. by the sun. Because the Earth's (4) ……. is made of very different types of (5) ……. and water, it absorbs the Sun's heat at different (6) ……. .

**Task 7. Match these idioms containing the word "wind" with their meanings; then answer the questions:**

| | |
|---|---|
| 1. Wind down | A close to danger |
| 2. Second wind | B to come or bring to a finish |
| 3. Scattered to the 4 winds | C restored energy of strength |
| 4. Near the wind | D likely to occur |
| 5. It's all an ill wind | E someone profits from every loss |
| 6. Wind up | F to learn of; to hear a rumor of |
| 7. Get wind of | G all around the world |
| 8. In the wind | H to relax; to unwind |

1) How do you usually wind down?
2) Have you ever felt that something is in the wind?
3) Have you ever been near the wind?
4) What did you get the wind of recently?
5) Can you name a situation when a second wind helped you to wind something up?

**Task 8. Read and translate the following words and word expressions:**

**electricity** (n.), **electric** (adj.), **electrical** (adj.) to generate electricity; to transport electricity; to produce electricity; enough electricity; electric field; electric guitar; electric light; electrical engineer.

**cluster** (n.) (v.) clusters of stars; superclusters of galaxies; roses clustered round the window; the children clustered round the teacher.

**pump** (v.) they pumped water out of the hold; the tire needs more air pumping into it; I had maths pumped into me at school; the well had been pumped dry; I pumped him for information.

**scatter** (v.) toys were scattered all over the room; he scattered his papers all over the floor; a wind scattered the clouds; the area is scattered with small hamlets.

**energy** (n.) wind energy; to harness the energy of wind; to use the energy of wind; energy crisis; quantum energy; devote all one's energies to a task.

**power** (n.) (v.) electric power; power lines; there was a power cut; the machine is on full power; two to the power of ten; power station; an aircraft powered by four jets.

**machine** (n.) the machine age; machine shop; grinding machine; machine-made goods; machine operator.

**Task 9. You are going to read the text about the past and present of the power of wind. Read the text and answer the following questions:**

1. How was the power of wind used in Egypt, China, and Persia?
2. Who refined the windmill and adapted it for draining lakes and marshes?
3. What did American colonists use windmills for?
4. When did Americans start using windmills to generate electricity in rural areas without electric service?
5. What is a wind farm?
6. Where is the largest wind farm situated? How many wind turbines does it have?
7. What are the two types of wind machines?
8. What is the size of wind machines?
9. What other alternative sources of energy do you know?
10. Which of them are used in your country?

## The Power of Wind

Since early recorded history, people have been harnessing the energy of the wind. Wind energy propelled boats along the Nile River as early as 5000 B.C. By 200 B.C., simple windmills in China were pumping water, while vertical-axis windmills with woven reed sails were grinding grain in Persia and the Middle East.

New ways of using the energy of the wind eventually spread around the world. By the 11th century, people in the Middle East were using windmills extensively for food production; returning merchants and crusaders carried this idea back to Europe. The Dutch refined the windmill and adapted it for draining lakes and marshes in the Rhine River Delta. When settlers took this technology to the New World in the late 19th century, they began using windmills to pump water for farms and ranches, and later, to generate electricity for homes and industry.

American colonists used windmills to grind wheat and corn, to pump water, and to cut wood at sawmills. As late as the 1920s, Americans used small windmills to generate electricity in rural areas without electric service. When power lines began to transport electricity to rural areas in the 1930s, local windmills were used less and less, though they can still be seen on some Western ranches.

**Wind Farm**

Nowadays, wind power plants, or wind farms, as they are sometimes called, are clusters of wind machines used to produce electricity. A wind farm usually has dozens of wind machines scattered over a large area. The world's largest wind farm, the Horse Hollow Wind Energy Center in Texas, has 421 wind turbines that generate enough electricity to power 220,000 homes per year.

There are two types of wind machines (turbines) used today, based on the direction of the rotating shaft (axis): horizontal-axis wind machines and vertical-axis wind machines. The size of wind machines varies widely. Small turbines used to power a single home or business may have a capacity of less than 100 kilowatts. Some large commercial-sized turbines may have a capacity of 5 million watts, or 5 megawatts. Larger turbines are often grouped together into wind farms that provide power to the electrical grid.

**Task 10. Put these sentences into the chronological order:**

…A) Windmills were extensively used for food production in the Middle East.

B) Wind power plants came into being.

C) Wind energy propelled boats along the Nile River.

…D) The settlers in the New World began using windmills to pump water for farms.

….E) Simple windmills in China were pumping water.

….F) American colonists started to generate electricity for homes and industry.

## Part III. NIKOLA TESLA – THE GENIUS WHO LIT THE WORLD

**Task 11. Find the meaning and pronunciation of the highlighted words in a dictionary and learn them:**

| | | |
|---|---|---|
| patent | remote | to rumour |
| device | amplifier | celebrated |
| current | radar | to divert |
| equipment | terrestrial | celebrity |
| wireless | instantaneously | coverage |

Born in Smiljan, Croatia, Tesla was educated at Graz and Prague, worked for the Continental Edison Company in Paris, and emigrated to the United States in 1884. There he worked briefly for Thomas Edison until the poetic Tesla and the pragmatic Edison fell out. Tesla then went on to sell his **patents** for a series of alternating current **devices** to the Westinghouse Electric Company, making Tesla a relatively wealthy man able to set himself up in his own laboratory.

Tesla was a pioneer in many fields. His alternating **current** induction motor is considered one of the ten greatest discoveries of all time. He designed the first hydroelectric power plant in Niagara Falls in 1895, which was the final victory of alternating current. The Tesla coil, which he invented in 1891, is widely used today in radio and television sets and other electronic **equipment**.

Among his discoveries are the fluorescent light, laser beam, **wireless** communications, wireless transmission of electrical energy, **remote** control, robotics, Tesla’s turbines and vertical takeoff aircraft. Tesla is the father of the radio and the modern electrical transmissions systems. He registered over 700 patents worldwide. His vision included exploration of solar energy and the power of the sea. He foresaw interplanetary communications and satellites. He appears to have discovered X-rays a year before W. K. Roentgen did in Germany, he built a vacuum tube **amplifier** several years before Lee de Forest did, he was using fluorescent lights in his laboratory 40 years before the industry “invented” them, and he demonstrated the principles used in microwave ovens and **radar** decades before they became an integral part of our society. Yet we associate his name with none of them.

In Colorado Springs, where he stayed from May 1899 until 1900, Tesla made what he regarded as his most important discovery – **terrestrial** stationary waves. By this discovery he proved that the Earth could be used as a conductor and would be as responsive as a tuning fork to electrical vibrations of a certain frequency. He also lighted 200 lamps without wires from a distance of 25 miles (40 km) and created man-made lightning. At one time he was certain he had received signals from another planet in his Colorado laboratory, a claim that was met with disbelief in some scientific journals.

Tesla's concept of wireless electricity was used to power ocean liners, destroy warships, run industry and transportation and send communications **instantaneously** all over the globe. To stimulate the public's imagination, Tesla suggested that this wireless power could even be used for interplanetary communication. If Tesla were confident to reach Mars, how much less difficult to reach Paris. Many newspapers and periodicals interviewed Tesla and described his new system for supplying wireless power to run all of the earth's industry.

In 1915, a New York Times article announced that Tesla and Edison were to share the Nobel Prize for physics. Oddly, neither man received the prize, the reason being unclear. It was **rumoured** that Tesla refused the prize because he would not share with Edison, and because Marconi had already received his. In spite of that, Nikola Tesla was one of the most **celebrated** personalities in the American press, in this century. According to Life Magazine's special issue of September, 1997, Tesla is among the 100 most famous people of the last 1,000 years. He is one of the great men who **divert** the stream of human history.

Tesla's **celebrity** was in its height at the turn of the century. His discoveries, inventions and vision had widespread acceptance by the public, the scientific community and American press. Tesla's discoveries had extensive **coverage** in the scientific journals, the daily and weekly press as well as in the literary and intellectual publications of the day. He was the Super Star.

**Task 12. Answer the following questions on the text:**

1. Why did Tesla and Edison fall out?
2. Make a list of some of Tesla’s important inventions.
3. Which of Tesla’s inventions are associated with other scientists?
4. What do you think is the reason for this?
5. Why was he considered eccentric?
6. What do you know about Tesla’s private life?

**Task 13. a) Find the words in the text which mean:**

mental rejection of something as untrue ..................................................................
having wide or considerable extent ......................................................................
relating to the earth or its inhabitants ....................................................................
an electric utility generating station .......................................................................
an electronic device for amplifying voltage, current, or power...............................

**b) Fill in the correct word derived from the word in brackets:**

1. Before the .................. (invent) of the telephone, communicating over great distances was slow and difficult.

2. I see this as ................ (recognise) of my role in supporting learning and as ................ (acknowledge) of the teaching role that I have.

3. ..................... (subscribe) to magazines and periodicals rise.

4. This leaves me with a number of difficult .................. (decision) to make.

**Task 14. Translate the following paragraph:**

Tesla’s generosity eventually left him without adequate funds to pursue and realize his inventions. His idealism and humanism left him with little stomach for the world of industrial and financial intrigue. His New York laboratory was destroyed by a mysterious fire. References to his work and accomplishments were systematically purged from the scientific literature and textbooks. Driven into a Hermetic exile in a New York hotel during the period between the two wars, 20 years of his potentially rich and productive contribution were taken from us. The only occasions of public appearance were the yearly press interviews on his birthday when he would describe amazing and far reaching inventions and technological possibilities. These were distorted and sensationalized in the popular press, particularly when he described advanced weapons systems on the eve of World War II. He died in obscurity in 1943. Only the FBI took note: they searched his papers (in vain) for the design of the “death-ray machine”. It is interesting to note that the motivation for our “Star Wars” defense system was based upon fears that the Soviets had begun deployment of weapons based upon Tesla high energy principles. Public reports of mysterious “blindings” of U.S. surveillance satellites, anomalous high altitude flashes and fireballs, elf wave radio interference, and other cases lend credence to this interpretation.

**Task 15. Be ready to speak on the topic “Invention of Electricity”.**

MODULE 7**. LIGHT**

## Part I. REFLECTION AND REFRACTION

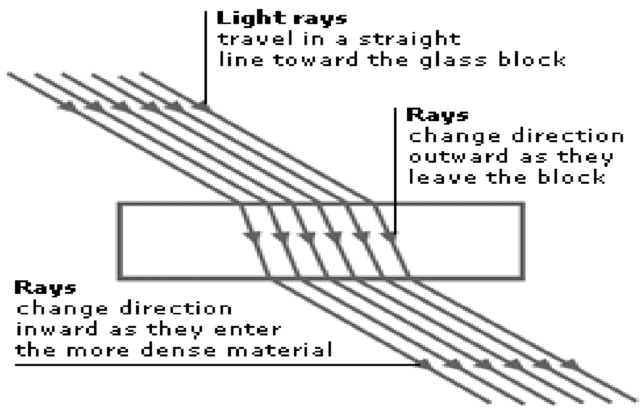
**Task 1. Look at the definitions given below. Try to guess the words they define (reflection, refraction):**

a process in which light, other electromagnetic radiation, sound, particles, etc., are thrown back after impinging on a surface – ………………. .

the change in direction of a propagating wave, such as light or sound, in passing from one medium to another in which it has a different velocity – ………………. .

**Task 2. You are going to read a text about reflection and refraction. Before reading try to answer the questions given below, discuss them with your groupmates. Then read the text and check your answers:**

1. What is refraction? Try to define it.
2. What happens if light rays move into a dense material?
3. When does the speed of the light rays grow as they pass through different materials?
4. How does the light behave when it travels through a glass panel at an angle? Describe its movement.
5. What will happen to a straw if you stand it in a glass of water?
6. What causes hazy appearance of objects on a hot day?
7. Have you ever heard of the mirage? What is it?




Picture 1. Light Rays Movement

### Refraction

Light rays usually travel in straight lines, but when they pass from one material to another they can be forced to bend (change direction and continue on a new straight path). The bending is called refraction. It happens because light travels at different speeds in different materials. If light rays travel through air and enter a more dense material, such as water, they slow down and bend into the more dense material. Light rays moving into a less dense material, such as from water to air, speed up and bend outwards. Light rays bend or refract if they enter a glass block at an angle. When they pass from air into glass, they bend inwards and slow down. They travel in a straight line through the glass at an angle to their original direction. As they pass out from the glass into air, they bend outwards and speed up again.

**Puzzle for the eye.** If you stand a straw in a glass of water, the top and the bottom of the straw no longer seem to fit together. This trick of the light is caused by refraction. Light bends outwards when it travels from water to air, so the eye sees the bottom of the straw (in the water) as deeper than the top of the straw (in the air).

**In heat haze.** On hot days, the surface of the Earth is warmer than the sky above it. This means that air close to the ground is generally much warmer than the air higher up. Hot air rising from the ground can bend and distort the light rays passing through it. This gives a very hazy appearance to objects, as they move on the horizon. Mirage of buildings near Lelystad's radio transmitter tower, as seen over Lake Markermeer, the Netherlands Mirage of energy plant at Lelystad, the Netherlands, seen over Lake Markermeer. The plant is about 30 km distant.

**Mirage.** People who travel through hot deserts often think they can see water or trees on the ground ahead of them, when really there is nothing there. This trick of the light is called a mirage. Layers of warm and cold air bend or refract light rays coming from distant objects – perhaps real trees over the horizon. Our eyes are fooled into thinking the light rays come from objects on the ground instead of from the sky.

## Reflection

Reflections are usually caused by shiny things, such as MIRRORS, that show a reversed image of whatever is placed in front of them. The image seems to be as far behind the mirror as the object is in front of it. Not only mirrors make reflections, however. Most objects reflect some of the light that falls on them. In daytime we see familiar objects like grass, trees, and the sky only because they reflect light from the Sun into our eyes.

Picture 2. Mount Hood reflected in Mirror Lake, Oregon

When light rays bounce off a completely smooth surface, such as a still pool of water, a mirror, or even something like a shop window, we are able to see a very clear reflection on the surface. Every ray of light is reflected perfectly from the surface and bounces back in a regular way. The reflected image is very clear and sharp.

**Irregular reflection.** A rough surface, such as the rippling pond, causes light rays to bounce off it in many different directions. It may still be possible to make out an image on the surface, or, if it is very rough, the image is very broken up. Most objects reflect light in this irregular way. Although we can see them, we cannot see any images reflected in their surfaces.

**Mirrors.** A mirror is a very smooth, highly polished piece of metal or plastic that reflects virtually all the light that falls onto it. The reflection appears to be behind the mirror and may look bigger, smaller, or the same size as the thing it is reflecting, depending on the mirror's shape. We use mirrors when checking our appearance or driving. They also play an important part in telescopes, microscopes, cameras, and other optical (light-based) instruments.

A convex mirror curves or bends outwards and makes an object look smaller and further away than it actually is. It makes light rays seem to come from a point behind the mirror, further from our eyes. Things look smaller, but convex mirrors are helpful because they can show a wider picture or field of view.

**Concave mirror.** A concave mirror curves or bends inwards and makes an object look bigger and nearer than it actually is. It works by making light rays seem to come from a point in front of the mirror, which is closer to our eyes. Concave mirrors are important in such things as bicycle reflectors and reflecting telescopes.

This man is shaving with the help of a concave mirror. Its curved surface makes the man's face seem closer to him than it really is. The reflected image he sees is magnified and he can easily see what he is doing. The mirror's drawback is that less of the man's face fits into the mirror than in a flat mirror of the same size.

**Car wing mirror**. Drivers use mirrors to see traffic coming up behind them. It is important for drivers to see as much of the road behind as they can, so wing mirrors and rear-view mirrors are convex. A drawback is that they make vehicles on the road behind look smaller and further away than they would in a flat mirror of the same size. Drivers must remember that the vehicles are nearer than they appear.

**Task 3. Mark the statements True or False and correct them:**

1. Mirrors used by drivers are concave. ………
2. Mirrors show a reversed image of whatever is placed behind them. ………
3. In a concave mirror everything seems bigger than it really is. ………
4. Reflection is caused by warm and cold air which bend light rays coming from distant objects. ………
5. Hazy appearance of objects on hot days is caused by warm air rising from the ground that distorts the light rays passing through it. ………
6. When we look in the mirror the object seems to be in front of it and may look bigger, smaller, or the same size as the thing it is reflecting, depending on the mirror's shape. ………
7. To reflect means to bend. ………
8. When light rays move water to air they bend outwards. ………
9. The advantage of a concave mirror is that less of the object fits into the mirror than in a flat mirror of the same size. ………
10. The majority of the objects reflect the light that falls on them. ………

**Task 4. Look at the definitions given below (a – f). Match them with the words from the box:**

| | | | | | |
|---|---|---|---|---|---|
| light | lightning | lights | traffic lights | light-headed | light hearted |

a) electromagnetic radiation that is capable of causing a visual sensation and has wavelengths from about 380 to about 780 nanometres – …………………….. .

b) one of a set of coloured lights placed at crossroads, junctions, etc., to control the flow of traffic. A red light indicates that traffic must stop and a green light that it may go: usually an amber warning light is added between the red and the green – …………………….. .

c) a person's ideas, knowledge, or understanding – …………………….. .

d) cheerful or carefree in mood or disposition – …………………….. .

e) frivolous in disposition or behavior – …………………….. .

f) a flash of light in the sky, occurring during a thunderstorm and caused by a discharge of electricity, either between clouds or between a cloud and the earth – ………………….. .

**Task 5. a) Summarize what you know about light with the following questions:**

1. What is light? Try to give a simple and clear definition.
2. How does it travel through space?
3. Does light penetrate all surfaces?
4. What is light, a wave or a particle?
5. What do you know about the speed of light?
6. Do all objects transmit light equally? Are there any which don't transmit it at all?
7. How do we call objects that emit light?
8. Are there any objects that don't emit light but are still bright to our eyes?
9. Does the Sun produce energy? How?
10. Is the Moon a luminous source?
11. What is lunar eclipse?

12. What is bioluminescence? What does it serve for? Do you know any bioluminescent creatures?

13. How is shadow produced from the point of view of a physicist?

14. Is the shade equally dark? Are there any lighter regions?

15. What is umbra/penumbra?

**b) Now read the text. How many right answers did you have?**

**Light.** Light makes the world seem bright and colourful to our eyes. Light is a type of electromagnetic radiation that carries energy from a source (something that makes light) at the very high speed of 300,000 kps (186,000 miles per second, or 670 million mph). Light rays travel from their source in straight lines. Although they can pass through some objects, they bounce off others or pass around them to make SHADOWS. When light shines on a soap bubble, some of the rays reflect back from its outer surface. Others travel through the thin soap film and bounce back from its inner surface. The two sorts of reflected rays are slightly out of step because they travel different distances. They interfere with one another and produce colourful swirling patterns on the bubble's surface.

**Waves and particles.** Sometimes light seems to behave as though it carries energy in waves. Other times it seems to carry energy in particles or packets, called photons, fired off in quick succession from the source. Scientists argued for many years over whether light was really a wave or a particle. Now they agree that light can behave as either a wave or a particle, depending on the situation.

**Lighthouse.** The powerful beam from a lighthouse illustrates that light travels in straight lines. Under normal circumstances, light never bends or goes round corners but travels in a perfectly straight path, making what is known as a light ray. Nothing can travel faster than light. The beam from a lighthouse travels its full length in a tiny fraction of a second.

## Part II. TRANSMISSION OF LIGHT

**Task 6. Before reading the text, read about the verb transmit: its meaning, derived forms, synonyms and examples of its usage in the language and physics:**

**transmit** *verb* (used with object), **transmitted, transmitting**

**Derived forms:**

**transmittable, transmittible,** *adjective*

**nontransmittible,** *adjective*

**pretransmit,** *verb* (used with object), **pretransmitted, pretransmitting**

**untransmitted,** *adjective*

**transmittal, transmission, transmittance,** *noun*

**1.** to send or forward, as to a recipient or destination; dispatch; convey.

**2**. to communicate, as information or news.

e. g. *Wilcox of six criminal counts of unlawfully using telecommunications devices to **transmit.***

**3.** to pass or spread (disease, infection, etc.) to another.

e. g. *People with severely compromised immune systems can **transmit** the virus for weeks or months.*

**4.** to pass on (a genetic characteristic) from parent to off spring.

e. g. *The mother **transmitted** her red hair to her daughter*.

**5.** Physics.

**a)** to cause (light, heat, sound, etc.) to pass through a medium;

**b)** to convey or pass along (an impulse, force, motion, etc.);

**c)** to permit (light, heat, etc.) to pass through.

e. g. *Glass **transmits** light. Radio waves **are transmitted** through the atmosphere.*

**6.** Radio and Television.

**a)** to emit (electromagnetic waves);

**b)** to send a signal by wire, radio, or television waves;

**c)** to pass on a right or obligation to heirs or descendants.

e. g. *Conventional radio of this sort cannot, unfortunately, **transmit** video or webpages.*

**Word Origin:** from Latin *transmittere* to send across, from trans+*mittere* to send.

**Synonyms: 1.** transfer, remit. **2.** bear.

Light transmission is the process in which light travels through a medium without being absorbed or scattered.

Reflection and transmission of light waves occur because the frequencies of the light waves do not match the natural frequencies of vibration of the objects. When light waves of these frequencies strike an object, the electrons in the atoms of the object begin vibrating. But instead of vibrating in resonance at a large amplitude, the electrons vibrate for brief periods of time with small amplitudes of vibration; then the energy is reemitted as a light wave. If the object is transparent, then the vibrations of the electrons are passed on to neighboring atoms through the bulk of the material and reemitted on the opposite side of the object. Such frequencies of light waves are said to be transmitted. If the object is opaque, then the vibrations of the electrons are not passed from atom to atom through the bulk of the material. Rather the electrons of atoms on the material's surface vibrate for short periods of time and then reemit the energy as a reflected light wave. Such frequencies of light are said to be reflected.

Some objects transmit light better than others. Transparent objects, such as glass, let virtually all light rays pass straight through them. When you look at a glass of orange juice, you can see the juice inside very clearly. You can also see other things through the glass. Translucent objects, such as plastic, allow only part of the light through. A plastic bottle lets some light rays pass through it. It is possible to see the orange juice inside the bottle, but you cannot see anything behind the bottle. Transparent materials are materials that allow one or more of the frequencies of visible light to be transmitted through them; whatever color(s) is/are not transmitted by such objects, are typically absorbed by them. The appearance of a transparent object is dependent upon what color(s) of light is/are incident upon the object and what color(s) of light is/are transmitted through the object.

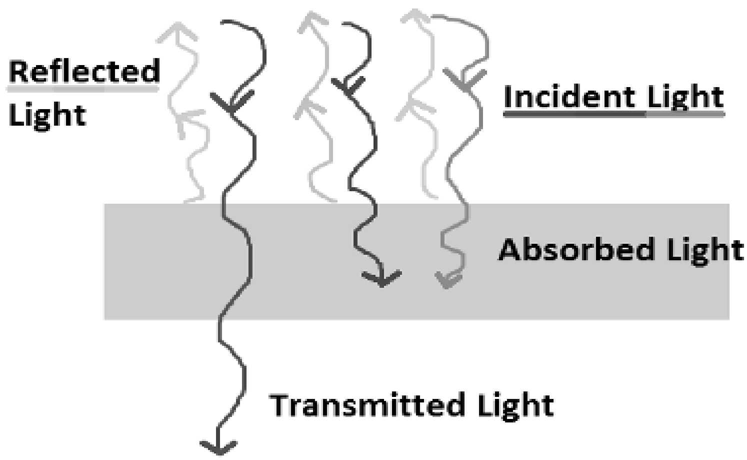
The colors perceived of objects are the results of interactions between the various frequencies of visible light waves and the atoms of the materials that objects are made of. Many objects contain atoms capable of either selectively absorbing, reflecting or transmitting one or more frequencies of light. The frequencies of light that become transmitted or reflected to our eyes will contribute to the color that we perceive.

Opaque objects, such as metal, reflect all the light falling on them and allow none to pass through. When you look at a can of orange juice, all you can see is the can. It is impossible to tell, just from looking, whether or not the can has any orange juice in it.

Visible light is the reason we are able to see anything at all. Light moves as a wave, bouncing off objects so we can see them. Without it, we would be in complete darkness. But in physics, light can refer to any kind of electromagnetic wave: radio waves, microwaves, infrared, visible light, ultraviolet, x-rays or gamma rays.

When you shine light on an object, a number of things can happen. One thing it can do bounce off the surface, and this is called reflection. When light reflects off a shiny surface like a mirror, this is called specular reflection, but when it just illuminates a dull object this is called diffuse reflection.

Another thing it can do is move (or ‘transmit’) through the material, and depending on exactly how it does this, we might call it transmission, refraction, or absorption.




Picture 3. Transmission of Light

So, **transmission of light** is when light waves move all the way through a material without being absorbed.

When light moves through a transparent (or semi-transparent) material, it can be transmitted, absorbed or reflected. The **transmittance** of a material is the proportion of the incident (approaching) light that moves all the way through to the other side.

For example, let's say you're shining a flashlight on a semi-transparent glass block. You start off with 100% of your incident light. The first thing that happens is that 30% of that light is reflected off the outer surface of the glass. That leaves you with 70% to continue through the glass block. Another 50% of the light is absorbed by the molecules inside the glass block itself. That leaves you with 20% that immerges from the opposite side. So you could say that the glass block has a transmittance of 20%.

The transmittance of a material depends on its thickness, but it also depends on the type of 'light' (or electromagnetic waves) you are using. A material might have a different transmittance for visible light than it does for infrared, or X-rays. This is why hospital X-rays go through your skin until they reach the bones, even though visible light does not.

**Task 7. Answer the questions on the text:**

1. What is transmission of light?
2. When does transmission of light occur?
3. What frequencies of light waves are said to be transmitted?
4. What frequencies of light waves are said to be reflected?
5. What objects are transparent?
6. What objects are translucent?
7. What objects can be called opaque?
8. What kind of waves in physics can light refer to?
9. What is the transmittance of a material?
10. What does the transmittance of a material depend on?

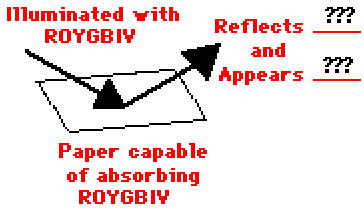
**Task 8. Check your understanding of the process of transmission by matching the question (1-5) and the answer (a-e):**

**1.** Natural philosophers have long pondered the underlying reasons for color in nature. One common historical belief was that colored objects in nature produce small particles (perhaps light particles) that subsequently reach our eyes. Different objects produce different colored particles, thus contributing to their different appearance. Is this belief accurate or not? _____________ Justify your answer.

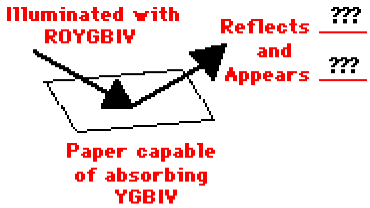
**2.** What color does a red shirt appear when the room lights are turned off and the room is entirely dark? What about a blue shirt? _____________ a green shirt?

**3.** The diagrams depict a sheet of paper being illuminated with white light (ROYGBIV). The papers are impregnated with a chemical capable of absorbing one or more of the colors of white light. In each case, determine which color(s) of light are reflected by the paper and what color the paper will appear to an observer. _____

Practice A

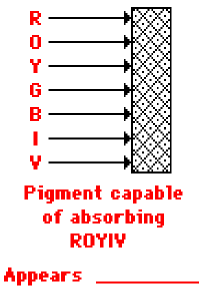



Practice B

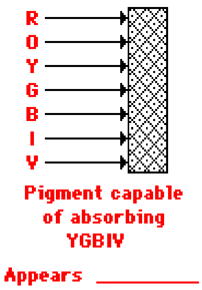



**4.** The appearance of a transparent object is dependent upon which color(s) of light is/are incident upon the object and which color(s) of light is/are transmitted through the object. Express your understanding of this principle by determining which color(s) of light will be transmitted and the color that the paper will appear to an observer. _____

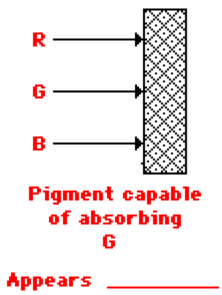
Practice A



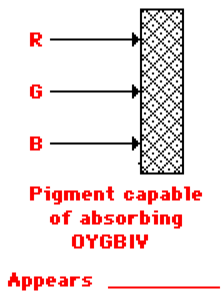

Practice B




Practice C

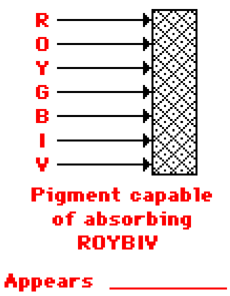



Practice D

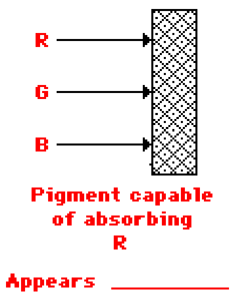



**5.** Express your understanding of this principle by filling in the blanks in the following diagrams. _____

Example A




Example B




**…… a)** ANSWER:

When the room lights are turned off (there is no light), any object present in the room appears black. The color appearance of an object depends upon the light which that objects reflects to the observer's eye. Without any incident light, there can be no reflected light. Such an object appears black – the absence of light.

**…… b)** ANSWER:

Practice A: Green and blue light will be transmitted and so the object would appear greenish-blue to an observer.

Practice B: Red and orange light will be transmitted and so the object would appear reddish-orange to an observer.

Practice C: Red and blue light will be transmitted and so the object would appear reddish-blue to an observer.

Practice D: Only red light will be transmitted and so the object would appear red to an observer.

**…… c)** ANSWER:

Example A: Green will be transmitted and so the object appears green to an observer.

Example B: Both green and blue will be transmitted and so the object appears greenish-blue to an observer.

**…… d)** ANSWER:

This view presumes that the appearance of an object is independent of the colors of light which illuminate the object. We observe that the same object appears different colors when viewed under different light. So the secret to an object's appearance is not strictly due to its ability to produce a color. In fact the object's only role in determining its appearance is in its ability to absorb certain wavelengths of light which shine upon it.

**…… e)** ANSWER:

Practice A: No light will be reflected; it is all absorbed. Thus, the paper would appear black to an observer.

Practice B: Red and orange will be reflected and so the paper appears reddish-orange to an observer.

**Task 9. Try to recall the information from the text and complete the gaps with the correct words.**

Some objects …………. light better than others . …………. objects, such as glass, let virtually all light …………. pass straight through them. When you look at a …………. of orange juice, you can see the juice ………….very clearly. You can also see …………. …………. through the glass. …………. objects, such as plastic, …………. only part of the light through. A plastic bottle lets some light rays………. ………. it. It is possible to see the orange juice …………. the bottle, but you ………. see anything behind the bottle. …………. objects, such as metal, …………. all the light falling on them and allow none to ………….  ………. . When you look at a can of orange juice, all you can see is the can. It is …………. to tell, just from looking, ………. ………. ………. the can has any orange juice in it.

**Task 10. Make up a dialogue about light and dramatize it with a partner.**

## Part III. LIGHT SOURCES

**Task 11. Read the text consisting of 7 paragraphs about light sources and match the headings (a-g) with the paragraphs (1-7):**

**a)** MOONLIGHT
**b)** LIGHT SOURCES
**c)** SHADOWS
**d)** SUNLIGHT
**e)** UMBRA AND PENUMBRA
**f)** BIOLUMINESCENCE
**g)** YOUR CHANGING SHADOW

**…….** 1) Things that give off light are called light sources. When we see something, light rays have travelled from a source of light into our eyes. Some objects appear bright to us because they give off energy as light rays; these objects are said to be **luminous** or light-emitting. Other objects do not make light themselves, but **appear** bright because they reflect the light from a light source.

**…….** 2) The Sun shines because it produces energy deep in its core. The energy is made when atoms join together in nuclear fusion reactions. The Sun fires off the energy into space in all directions in the form of electromagnetic radiation. Some of the radiation travels to Earth as the light and heat we know as sunlight. The Sun is a luminous light source because it makes energy inside itself.

……. 3) The Moon shines much less brightly than the Sun. Unlike the Sun, the Moon does not generate its own energy, so it produces no light of its own. We can see the Moon only because its grey-white surface reflects sunlight towards Earth. If the Earth passes between the Sun and the Moon, the Moon seems to disappear from the sky. This is called a **lunar eclipse.**

**…….** 4) Some sea organisms can make their own light. This **ability** is called bioluminescence, which means making light biologically. Transparent polychaete worms such as this one make yellow light inside their bodies. In their dark seawater habitat they can **glow or flash** to scare off predators. Other bioluminescent sea creatures include shrimps, squid, and starfish.

**…….** 5) Shadows are made by blocking light. Light rays travel from a source in straight lines. If an opaque object gets in the way, it stops some of the light rays travelling through it, and an area of darkness appears behind the object. The dark area is called a **shadow.** The size and shape of a shadow depend on the position and size of the light source compared to the object.

**…….** 6) When you stand with the Sun behind you, the light rays that hit your body are blocked and create a shadow on the ground in front of you. When the Sun is high in the sky at midday, your shadow is quite short. Later on, when the Sun is lower, your shadow is much longer.

**…….** 7) Shadows are not totally black. If you look closely at a shadow, you will see a dark area in the centre and a lighter area around it. The central dark area, called the umbra, **occurs** where rays of light from the source are totally blocked. The outer area, called the penumbra, is lighter because some rays do get through.

**Task 12. Find the highlighted words from the text that will match the definitions:**

a) a dark image on a surface by the interception of light rays by an opaque body;

b) possession of the qualities required to do something; necessary skill, competence, etc. ………..….;

c) permitting the uninterrupted passage of light; clear ………….;

d) to happen; take place; come about …………….;

e) not transmitting light; not transparent or translucent, not reflecting light; lacking luster or shine; dull ………..….;

f) to emit or reflect or cause to emit or reflect light suddenly or intermittently the central, innermost, or most essential part of something ……….…….;

g) to seem or look …………… .

**Task 13. Here you have a gapped text. Try to recall the information from the text and complete the gaps with the correct words:**

Things that give off light are called ………. …….. When we see something, …….. …….. have travelled from a …….. …….. …….... into our eyes. Some objects appear …….. to us because they give off energy as light ………...; these objects are said to be luminous or …….. – …….. . Other objects do not make …….. themselves, but appear bright because they …….. the light from a …….. …….…. .

Shadows are made by …….. …….. Light rays travel from a source in…….. …….. . If an …….. object gets in the way, it stops some of the light …….. travelling through it, and an area of …….. appears behind the object. The …….. …….. is called a shadow. The …….. …….. …….. of a shadow depend on the position and size of the light source compared to the …….. .

**Task 14. Read the sentences and put questions to the subject and to the object in each sentence:**

1. Everybody knows that light moves at the rate of 300, 000 km per second.
2. Today the laser beam is used in metal welding and cutting, in surgery, electronics and so on.
3. The velocity of light is too great to be measured in simple units.
4. The electrician may have turned off the light, we could not continue out experiments in the darkness.
5. A luminous body is seen because of the light it sends to the eye.
6. Plants get energy from sunlight.

**Task 15. Summarize the basic facts about light in the form of the report.**

## MODULE 8. **OPTICS.**

### Part I. THE SCIENCE OF OPTICS.

**Task 1. Find the meaning and pronunciation of the key words in a dictionary and learn them:**

| | | |
|---|---|---|
| propagation | to incorporate | refraction |
| to undergo | modification | apparent |
| incidence | beam | wavelet theory |
| reflection | irrefrangibility | pinhole camera |
| to set the tone | to quantify | patch |
| to trace | to derive | explicitly |

Optics is a branch of physical science dealing with the propagation and behavior of light, the changes that it undergoes and produces, and other phenomena closely associated with it. In a general sense, light is that part of the electromagnetic spectrum that extends from X-rays to microwaves and includes the radiant energy that produces the sensation of vision. The study of optics is divided into geometrical optics and physical optics.

To the ancients, the processes of image formation were full of mystery. Indeed, for a long time there was a great discussion as to whether, in vision, something moved from the object to the eye or whether something reached out from the eye to the object. By the beginning of the 17$^{th}$ century, however, it was known that rays of light travel in straight lines. The science of optics in this century expressed the fundamental outlook of the scientific revolution by combining an experimental approach with a quantitative analysis of phenomena. Optics had its origins in Greece, especially in the works of Euclid, who stated many of the results in geometric optics that the Greeks had discovered, including the law of reflection: the angle of incidence is equal to the angle of reflection.

In the 13$^{th}$ century, such men as Roger Bacon, Robert Grosseteste, and John Pecham, relying on the work of the Arab Alhazen (died 1039), considered numerous optical problems, including the optics of the rainbow. It was Kepler, taking his lead from the writings of these 13th-century opticians, who set the tone for the science in the 17th century. Kepler introduced the point by point analysis of optical problems, tracing rays from each point on the object to a point on the image. Just as the mechanical philosophy was breaking the world into atomic parts, so Kepler approached optics by breaking organic reality into what he considered to be ultimately real units. He developed a geometric theory of lenses, providing the first mathematical account of Galileo's telescope. Descartes sought to incorporate the phenomena of light into mechanical philosophy by demonstrating that they can be explained entirely in terms of matter and motion.

Many of the most important contributions to optics in the 17$^{th}$ century were done by the work of Newton, especially the theory of colors. Traditional theory considered colors to be the result of the modification of white light. Descartes, for example, thought that colors were the result of the spin of the particles that constitute light. Newton upset the traditional theory of colors by demonstrating in an impressive set of experiments that white light is a mixture out of which separate beams of colored light can be separated. He associated different degrees of irrefrangibility with rays of different colors, and in this manner he was able to explain the way prisms produce spectra of colors from white light.

Newton's second important contribution to optics dealt with the interference phenomena that came to be called "Newton's rings." Although the colors of thin films (e.g., oil on water) had been previously observed, no one had attempted to quantify the phenomena in any way. Newton observed quantitative relations between the thickness of the film and the diameters of the rings of color, a regularity he attempted to explain by his theory of fits of easy transmission and fits of easy reflection.

Huygens was the second great optical thinker of the 17$^{th}$ century. Although he was critical of many of the details of Descartes's system, he wrote in the Cartesian tradition, seeking purely mechanical explanations of phenomena. Huygens regarded light as something of a pulse phenomenon, but he explicitly denied the periodicity of light pulses. He developed the concept of wave front, by means of which he was able to derive the laws of reflection and refraction from his pulse theory and to explain the recently discovered phenomenon of double refraction.

Now it is obvious that an optical image may be regarded as the apparent reproduction of an object by a lens or mirror system, employing light as a carrier. An entire image is generally produced simultaneously, as by the lens in a camera, but images may also be generated sequentially by point-by-point scanning, as in a television system or in the radio transmission of pictures across long distances.

A single point of light, which may be a point in an extended object, emits light in the form of a continually expanding train of waves, spherical in shape and centred about the point of light. It is, however, often much more convenient to regard an object point as emitting fans of rays, the rays being straight lines everywhere perpendicular to the waves.

An excellent example of the working of the wavelet theory is found in the well-known pinhole camera. If the pinhole is large, the diverging geometrical pencil of rays leads to a blurred image, because each point in the object will be projected as a finite circular patch of light on the film.

**Task 2. Answer the following questions on the text:**

1. What does optics deal with?
2. What is light in a general sense?
3. Which parts is the study of optics divided into?
4. What was the knowledge about light at the beginning of $17^{th}$ century?
5. What was Euclid's contribution into the science of optics?
6. Who set the tone for the science of optics in the $17^{th}$ century? What were his achievements?
7. What were the discoveries of Newton in the field of light?
8. Why was Huygens the second great optical thinker of the 17th century?
9. What function does the light perform when an optical image is produced?
10. How can an entire image be produced?
11. In what form does a single point of light emit the light itself?
12. What is an example of the wavelet theory working?
13. Why does the diverging geometrical pencil of rays lead to a blurred image if the pinhole is large?

**Task 3. Match definitions (a-j) with each given term (1-10) and study them:**

**1. Propagation 2. Microwave 3. Geometrical optics 4. Physical optics 5. Ray 6. Image 7. Irrefrangibility 8. Light pulse 9. Refraction 10. Reproduction**

**a)** the branch of optics which studies interference, diffraction, polarization, and other phenomena concerning light;

**b)** an idealized model of light, obtained by choosing a line that is perpendicular to the wave fronts of the actual light, and that points in the direction of energy flow;

**c)** the change in direction of a propagating wave, such as light, in passing from one medium to another in which it has a different velocity;

**d)** the act of spreading of something;

**e)** incapability of being refracted;

**f)** something closely resembling another;

**g)** electromagnetic radiation in the wavelength range from0.3 to 0.001 meters;

**h)** an optical counterpart or appearance of an object, as is produced by reflection from a mirror or refraction by a lens;

**i)** the branch of optics that describes light propagation in terms of rays;

**j)** a single, abrupt emission of light.

**Task 4. Insert missing words. Use information given in the text above:**

1. Optics deals with the ……………….. and ……………….. of light.
2. Light is that part of the electromagnetic spectrum that extends from … to….. .
3. The study of optics is divided into ………….. optics and ……………. optics.
4. It was known that rays of light travel in……………….. ……………….. .
5. Kepler developed a geometric theory of ………., providing the first mathematical account of ……………….. telescope.
6. Newton’s second important ……………….. to optics dealt with the interference phenomena that came to be called “………….. ………………..”.
7. Huygens explicitly denied the periodicity of ……………….. ……………... .
8. An optical image may be regarded as the apparent ……………. of an object by a lens or mirror system, employing light as a carrier.
9. Diverging geometrical ………..... of ………….. leads to a ………….. image.

**Task 5. Translate the following sentences into English:**

1. Оптика вивчає поширення та властивості світла.
2. Світло є частиною електромагнітного спектра.
3. Діапазон світлових хвиль має спектр від рентгенівських променів до ультракоротких хвиль.
4. У стародавні часи люди не могли пояснити як виникає зображення.
5. Досить довго точилась дискусія: те, що ми бачимо, відбивається від нашого ока і досягає об’єкта, чи навпаки об’єкт відбиває зображення.
6. До 17 століття було відомо, що промені світла поширюються у вигляді прямих ліній.
7. Оптичне зображення – це чітке відображення об’єкта системою лінз чи дзеркал за допомогою світла, як провідника.
8. Зображення може бути створене методом послідовного сканування.
9. Якщо отвір є великим, то розсіювальний геометричний пучок променів призводить до нечіткого зображення.

## Part II. NATURE OF LIGHT, POLARIZED LIGHT

**Task 6. Find the meaning and pronunciation of the key words from the text in a dictionary and learn them:**

| | | |
|---|---|---|
| to refute | polarization | incandescence |
| luminous | luminescence | monochromatic |
| corpuscular theory | discrete | to be aligned |
| ether | random manner | coherently |
| intangible | beam | tourmaline |
| to pervade | undiminished | axis |
| transverse | diffraction | interference |

### Nature of Light

The nature of light has puzzled humans since the most ancient times. One belief was that it consisted of something that shot out of the eye and made things visible when it struck them. Aristotle refuted this idea when he asked why, if the eye is the source of light, it is impossible to see in the dark.

About 1670 Sir Isaac Newton suggested that light consists of tiny particles that shoot out from luminous bodies, such as the sun and fires. This corpuscular theory could explain some facts about light but not others. In 1678 Christian Huygens suggested the wave theory. Work in the early 19th century by Augustin Jean Fresnel, Thomas Young, and others showed that almost all facts about light could be explained in terms of waves, and the wave theory of light became accepted.

Scientists could not conceive of waves as moving in nothing, so they decided that light must travel through a substance they called the ether. The ether was an invisible, intangible substance that pervaded all space. Light was regarded as being waves in ether. In the 1870's James Clerk Maxwell showed that the ether was not necessary to explain the wave theory of light. Light and other forms of radiation could be explained as alternating pulses of electricity and magnetism that pushed each other out into space as electromagnetic waves.

Max Planck, a German physicist, in 1900 showed that some facts about radiation cannot be satisfactorily explained in terms of waves but only in terms of packets of energy called quanta, or photons. Thusб the quantum theory came into existence.

Some properties of light can be explained only in terms of photons, though some others can be explained only in terms of waves.

Light is a transverse, electromagnetic wave that can be seen by humans. The wave nature of light was first illustrated through experiments on diffraction and interference. Like all electromagnetic waves, light can travel through a vacuum. The transverse nature of light can be demonstrated through polarization.

**1.** Light is produced by one of two methods:

• Incandescence is the emission of light from “hot” matter ($T \gtrsim 800$ K).

• Luminescence is the emission of light when excited electrons fall to lower energy levels (in matter that may or may not be “hot”).

**2.** The speed of light depends upon the medium through which it travels.

• The speed of light in a vacuum is a universal constant in all reference frames.

• All electromagnetic waves propagate at the speed of light in a vacuum.

• The speed of light in a medium is always slower than the speed of light in a vacuum. (The difference is usually negligible when the medium is air.)

• The speed of anything with mass is always less than the speed of light in a vacuum. (The speed of light in a vacuum is the universal speed limit.)

**3**. The amplitude of a light wave is related to its intensity.

• Intensity is the absolute measure of a light wave’s power density.

• Brightness is the relative intensity as perceived by the average human eye.

**4.** The frequency of a light wave is related to its color.

• Monochromatic light can be described by only one frequency.

• Laser light is very nearly monochromatic.

• There are six simple, named colors in English (and many other languages) each associated with a band of monochromatic light. In order of increasing frequency they are red, orange, yellow, green, blue, and violet.

• Polychromatic light is composed of multiple frequencies.

• Every light source is essentially polychromatic.

• White light is very polychromatic.

• A graph of relative intensity vs. frequency is called a spectrum (plural: spectra). Although frequently associated with light, the term can be applied to many phenomena.

• A continuous spectrum is one in which every frequency is present within some range: blackbody radiators emit a continuous spectrum.

• A discrete spectrum is one in which only a set of well defined and isolated frequencies are present. (A discrete spectrum is a finite collection of monochromatic light waves.) The excited electrons in a gas emit a discrete spectrum.

**5.** The wavelength of a light wave is inversely proportional to its frequency.

• Light is often described by it's wavelength in a vacuum.

• Light ranges in wavelength from 400 nm on the violet end to 700 nm on the red end of the visible spectrum.

• Wavelengths slightly shorter than 400 nm are said to be ultraviolet. (They are "beyond violet" in terms of frequency).

• Wavelengths slightly longer than 700 nm are said to be infrared. (They are "below red" in terms of frequency).

**6.** Phase differences between light waves can produce visible interference effects.

## Polarized Light

Physical optics is a branch of optical science, which concerns the study of the polarization of light, interference and diffraction, and the spectral emission, composition, and absorption of light.

Polarized light consists of individual photons whose electric field vectors are all aligned in the same direction. Ordinary light is unpolarized because the photons are emitted in a random manner, while laser light is polarized because the photons are emitted coherently. Polarized light, light in which individual light waves are aligned parallel to one another. The fact that light can be polarized shows that it is made up of transverse waves, because only transverse waves can be polarized.

Light may be polarized partially or completely. Light is polarized when it is reflected from a transparent material, such as glass. The degree of polarization depends on the material and on the angle at which the light is reflected. In the sky, light is polarized by being scattered by particles suspended in the atmosphere. When light is passed through certain crystals, such as Iceland spar, it is split into two polarized beams. When a beam of light is passed through certain other materials, such as tourmaline or Polaroid plastic, one polarized beam emerges. All materials that polarize light are called polarizers.

The light waves of the beam of light that emerges from a polarizer are aligned parallel to the axis of polarizaton of the polarizer. Polarized light can pass undiminished through a second polarizer, called an analyzer, only if the analyzer's axis of polarization is parallel to that of the first polarizer. If the analyzer is rotated so that its axis of polarization is at right angles to that of the polarizer, the light is completely blocked.

Polarizers have a number of practical uses. The glare outdoors on a sunny day is composed of light partially polarized in a horizontal plane. Sunglasses made of Polaroid plastic have the axis of polarization in a vertical plane. These sunglasses, therefore, block out the polarized glare. Polaroid camera filters block out the polarized portion of the light coming from the sky, thereby darkening the sky in the photograph to increase the contrast between the sky and the clouds. They are also used to reduce glare in water scenes.

**Task 7. Answer the following questions.**

1. What idea about the nature of light did Aristotle refute?
2. What main theory of light was accepted by most physicists?
3. What is the ether?
4. When did quantum theory come to existence?
5. How was the wave nature of light first illustrated?
6. How can light be produced?
7. What do you know about the speed of light?
8. What is the amplitude of light related to?
9. What is the frequency of light related to?
10. What does polarized light consist of?
11. Is ordinary light polarized? Why?
12. What does the degree of polarization depend on?
13. What practical uses do polarizers have?

**Task 8. Find the definitions to the following terms in the text below and study them:**

The ether …………………………………………..…………………………. .

Light ………………………………………………………………………… .

Incandescence ……………………………………………………………………. .

Luminescence ……………………………………………………………………. .

Intensity …………………………………………………………………………. .

Brightness ……………………………………………………………………… .

Polychromatic light ……………………………………………………………. .

Monochromatic light ………………………………………………………… .

Spectrum …………………………………………………………………………. .

Polarized light ……………………………………………………………………. .

Polarizer …………………………………………………………………………. .

Analyzer …………………………………………………………………………. .

**Task 9. Decide whether the following statements are True or False according to the text. Prove your answers using the information from the text:**

1. Light is invisible to the human eyes. …………
2. Light is a wave. …………
3. Newton's corpuscular theory could explain all the facts about light. …………
4. Light is still regarded as being waves in ether. …………
5. Properties of light can be explained only in terms of photons. …………
6. The speed of light in a medium is always faster than the speed of light in a vacuum. …………
7. White light is very nearly monochromatic. …………
8. Polarized light consists of individual photons whose electric field vectors are carried in various directions. …………
9. The degree of polarization depends on the temperature of a material. ………
10. Polarized light can pass freely through an analyzer, only if the analyzer's axis of polarization is parallel to that of the first polarizer. …………

**Task 10. Be ready to speak on the topic "Optics".**

## Part III. INTERFERENCE AND DIFFRACTION

### Task 11. Find the meaning and pronunciation of the key words in a dictionary and learn them:

| | | |
|---|---|---|
| interference | trough | grating |
| to superimpose | diffraction | fringe |
| displacement | obstacle | slit |
| crest | refractive index | to encounter |
| magnitude | impedance | dimension |

### Interference

In physics, interference is a phenomenon in which two waves superimpose to form a resultant wave of greater or lower amplitude. Interference usually refers to the interaction of waves that are correlated or coherent with each other, either because they come from the same source or because they have the same (or nearly the same) frequency. Interference effects can be observed with all types of waves, including light, radio, acoustic, and surface water waves.

*Mechanism of Interference.* The principle of superposition of waves states that when two or more waves are incident on the same point, the total displacement at that point is equal to the vector sum of the displacements of the individual waves. If a crest of a wave meets a crest of another wave of the same frequency at the same point, then the magnitude of the displacement is the sum of the individual magnitudes; this is known as constructive interference. If a crest of one wave meets a trough of another wave, then the magnitude of the displacements is equal to the difference in the individual magnitudes; this is known as destructive interference.

Constructive interference occurs when the phase difference between the waves is a multiple of $2\pi$, whereas destructive interference occurs when the difference is $\pi$, $3\pi$, $5\pi$, etc. If the difference between the phases is intermediate between these two extremes, then the magnitude of the displacement of the summed waves lies between the minimum and maximum values.

Consider, for example, what happens when two identical stones are dropped into a still pool of water at different locations. Each stone generates a circular wave propagating outwards from the point where the stone was dropped. When the two waves overlap, the net displacement at a particular point is the sum of the displacements of the individual waves. At some points, these will be in phase and will produce a maximum displacement. In other places, the waves will be in anti-phase and there will be no net displacement at these points. Thus, parts of the surface will be stationary.

## Diffraction

Diffraction refers to various phenomena that occur when a wave encounters an obstacle. In classical physics, the diffraction phenomenon is described as the apparent bending of waves around small obstacles and the spreading out of waves past small openings. Similar effects occur when light waves travel through a medium with a varying refractive index or a sound wave through one with varying acoustic impedance. Diffraction occurs with all waves, including sound waves, water waves, and electromagnetic waves such as visible light, X-rays, and radio waves. As physical objects have wave-like properties (at the atomic level), diffraction also occurs with matter and can be studied according to the principles of quantum mechanics. Italian scientist Francesco Maria Grimaldi coined the word diffraction and was the first to record accurate observations of the phenomenon in 1665.

The effects of diffraction are often seen in everyday life. The most striking examples of diffraction are those involving light; for example, the closely spaced tracks on a CD or DVD act as a diffraction grating to form the familiar rainbow pattern seen when looking at a disk. This principle can be extended to engineer a grating with a structure such that it will produce any diffraction pattern desired; the hologram on a credit card is an example. Diffraction in the atmosphere by small particles can cause a bright ring to be visible around a bright light source like the sun or the moon. A shadow of a solid object, using light from a compact source, shows small fringes near its edges. All these effects occur because light propagates as a wave.

Richard Feynman said, “No one has ever been able to define the difference between interference and diffraction satisfactorily. It is just a question of usage, and there is no specific, important physical difference between them”.

He suggested that when there are only a few sources, say two, we call it interference (as in Young's slits), but with a large number of sources, the process can be labeled diffraction.

While diffraction occurs whenever propagating waves encounter such changes, its effects are generally most pronounced for waves where the wavelength is roughly similar to the dimensions of the diffracting objects. If the obstructing object provides multiple, closely spaced openings, a complex pattern of varying intensity can result. This is due to the superposition, or interference, of different parts of a wave that traveled to the observer by different paths.

**Task 12. Answer the following questions:**

1. What is interference?
2. What does the principle of superposition state?
3. What is constructive interference?
4. What is destructive interference?
5. When does diffraction occur?
6. What is diffraction?
7. What did Francesco Maria Grimaldi do?
8. What are examples of diffraction in everyday life?
9. What can diffraction by small particles cause in the atmosphere?

**Task 13. Make up sentences of given words:**

1. usually /the interaction / Interference / of waves / refers / to / that / with / are correlated / each / other.

2. equal / width / the fringes / Interference / of / has.

3. encounters / a wave / Diffraction / an obstacle / when / occurs.

4. wave / transverse / is / electromagnetic / a / Light.

5. with / can / travelling / each / waves / Two / other / interfere.

6. diffraction / can / Quantum / study / mechanics.

**Task 14. Choose a number which corresponds to a lexical or grammatical error in one of the underlined fragments of the sentence:**

1. If a <u>ray</u> (1) of white light is passed <u>through</u> (2) a glass prism it <u>would</u> (3) split to a <u>range</u> (4) of <u>different</u> (5) colours.

2. To find the velocity(1) of the wave motional (2) we multiply (3) the frequency (4) by the wavelength (5).

3. Before the experiment (1) all the devices (2) must to be (3) cleaned.

4. Who did (1) discovered (2) the basic laws (3) of motion?

5. Edison make (1) a little laboratory in the cellar (2) of his home (3) for making experiments**.**

6. The relative (1) masses is measured (2) with a mass (3) spectrograph.

7. We realize (1) that this experiment is difficultier (2) than that (3) one.

8. Men who work (1) in physical or chemical laboratory (2) must to wear (3) special uniform.

9. After the accident (1) Edison gradually (2) lose (3) his hearing.

10. A point have (1) no dimensions (2) but it is (3) simply a position in space.

**Task 15. Translate the sentences into English:**

1. Зазвичай інтерференція спостерігається, коли когерентні хвилі взаємодіють між собою.

2. Конструктивна інтерференція відбувається тоді, коли величина переміщення є сумою окремих величин.

3. Деструктивна інтерференція спостерігається, коли величина переміщення дорівнює різниці окремих величин.

4. Дифракцією називають будь-яке явище, яке відбувається, коли світлова хвиля зіштовхується з перешкодою.

5. Дифракція відбувається з усіма типами хвиль: із звуковими хвилями, з хвилями на воді, електромагнітними та радіохвилями.

6. Вплив дифракції найбільше помітний для хвиль, довжина яких є приблизно аналогічною розмірам об’єкту, що дифрагується.

TEXTS FOR INDEPENDENT WORK

## Module 1. **PHYSICS AS A BRANCH OF SCIENCE**

### Text 1. Science and Fields of Science

Science (Latin “scientia” means “to know”), is the term which is used in its broadest meaning to denote systematized knowledge in any field, but is applied usually to the organization of objectively verifiable sense experience. The pursuit of knowledge in this context is known as pure science, to distinguish it from applied science, which is the search for practical uses of scientific knowledge, and from technology, through which applications are realized.

Knowledge of nature originally was largely an undifferentiated observation and interrelation of experiences. The Pythagorean scholars distinguished only four sciences: arithmetic, geometry, music, and astronomy. By the time of Aristotle, however, other fields could also be recognized: mechanics, optics, physics, meteorology, zoology, and botany.

Chemistry remained outside the mainstream of science until the time of Robert Boyle in the 17th century, and geology achieved the status of a science only in the 18th century. By that time the study of heat, magnetism, and electricity had become part of physics. During the 19$^{th}$ century scientists finally recognized that pure mathematics differs from the other sciences in that it is a logic of relations and does not depend for its structure on the laws of nature. Its applicability in the elaboration of scientific theories, however, has resulted in its continued classification among the sciences.

The pure natural sciences are generally divided into two classes: the physical sciences and the biological, or life, sciences. The principal branches among the former are physics, astronomy, chemistry, and geology; the chief biological sciences are botany and zoology. The physical sciences can be subdivided to identify such fields as mechanics, cosmology, physical chemistry, and meteorology; physiology, embryology, anatomy, genetics, and ecology are subdivisions of the biological sciences.

The applied sciences include such fields as aeronautics, electronics, engineering, and metallurgy, which are applied physical sciences, and agronomy and medicine, which are applied biological sciences. In this case also, overlapping branches must be recognized. The cooperation, for example, between astrophysics (a branch of medical research based on principles of physics) and bioengineering resulted in the development of the heart-lung machine used in open-heart surgery and in the design of artificial organs such as heart chambers and valves, kidneys, blood vessels, and inner-ear bones. Advances such as these are generally the result of research by teams of specialists representing different sciences, both pure and applied. This interrelationship between theory and practice is as important to the growth of science today as it was at the time of Galileo.

## Text 2. Scope of Fields in Physics

Acoustics: The science of the production, transmission, and effects of sound.

Atomic Physics: A branch of physics concerned with the structures of the atom, the characteristics of the electrons and other elementary particles of which the atom is composed, the arrangement of the atom's energy states, and the processes involved in the radiation of light and X-rays.

Fluid Mechanics: The science concerned with fluids, either at rest or in motion, and dealing with pressures, velocities, and accelerations in the fluid, including fluid deformation and compression or expansion.

Mechanics: The branch of physics which seeks to formulate general rules for predicting the behavior of a physical system under the influence of any type of interaction with its environment.

Nuclear Physics: The study of the characteristics, behavior, and internal structure of the atomic nucleus.

Optics: The study of phenomena associated with the generation, transmission, and detection of electromagnetic radiation in the spectral range extending from the long-wave edge of the x-ray region to the short-wave edge of the radio region, and the science of light.

Particle physics: The branch of physics concerned with understanding the properties, behavior, and structure of elementary particles, especially through study of collisions or decays involving energies of hundreds of MeV or more.

Physics: The science concerned with those aspects of nature which can be understood in terms of elementary principles and laws.

Quantum Mechanics: The modern theory of matter, of electromagnetic radiation, and of the interaction between matter and radiation; it differs from classical physics, which it generalizes and supersedes, mainly in the realm of atomic and subatomic phenomena.

Plasma Physics: The study of highly ionized gases.

Relativity: The study of physics theory which recognizes the universal character of the propagation speed of light and the consequent dependence of space, time, and other mechanical measurements on the motion of the observer performing the measurements, the two main divisions are special theory and general theory.

Solid-state Physics: The branch of physics centering on the physical properties of solid materials, it is usually concerned with the properties of crystalline material only, but it is sometimes extended to include the properties of glasses or polymers.

Spectroscopy: The branch of physics concerned with the production measurement, and interpretation of electromagnetic spectra arising from either emission or absorption of radiant energy by various substances.

Statistical Mechanics: That branch of physics which endeavors to explain and predict the macroscopic properties and behavior of a system on the basis of the known characteristics and interactions of the microscopic constituents of the system, usually when the number of such constituents is very large.

Thermodynamics: The branch of physics which seeks to derive, from a few basis postulates, relations between properties of substances, especially those which are affected by changes in temperature, and a description of the conversion of energy from one form to another.

## Text 3. Physics in Everyday Life

The most basic of the sciences, physics, is all around us every day. If you have ever wondered what makes lightning, why a boomerang returns, how ice skaters can spin so fast, why waves crash on the beach, how that tiny computer can do complicated problems, or how long it takes light from a star to reach us, you have been thinking about some of the same things physicists study every day.

Physicists like to ask questions. They try to find answers for almost everything from when the universe began to why soda fizzes. If you like to explore and figure out why things are the way they are, you might like physics. Alf Rawls performs the "Ollie", the aerial maneuver on which all new skateboard tricks are based. The "Ollie" depends on a rapid compression and decompression of the skater's legs. If you have had a back-row seat at a rock concert, and could still hear, you experienced physics at work! Physicists studying sound contribute to the design of concert halls and the amplification equipment. Lasers and radioactive elements are tools in the war on cancer and other diseases.

Geophysicists are developing methods to give advance warning of earthquakes. The work of physicists made possible the computer chips that are in your digital watch, CD player, electronic games, and hand-held calculator. The laboratory of the physicist extends from the edge of the universe to inside the nucleus of an atom. A physicist may work in a laboratory designing materials for the computer chips of tomorrow, or smashing atomic particles in a quest to understand a laboratory designing materials for the computer chips of tomorrow, or smashing atomic particles against one another in a quest to understand how our universe began.

Physicists have orbited the Earth as astronauts, and plumbed the oceans' depths. Individuals who have studied physics seek to make instruments that diagnose and cure disease; to develop safer and cleaner fuels for our cars and homes; to harness the power of the sea; to calculate the movement of arctic glaciers; and to create smaller, faster electronic components and integrated circuits.

Research physicists work in industry and government, in laboratories and hospitals, and on university campuses. Some physicists serve in the military, teach in high schools and colleges, design science museum exhibits, write books and news articles about science, give advice to federal, state, local, and foreign governments, run businesses, even become artists. Students not interested in pursuing a science career can still benefit from courses in physics. The study of physics helps you acquire very special problem-solving skills and teaches you to better observe and understand the world.

Module 2. **MECHANICS**

## Text 1. Isaac Newton and His Laws of Motion

Sir Isaac Newton (1642-1727) did change the world. He was not a good farmer and was sent to Cambridge to study to become a preacher. One summer Newton was forced to leave his university when it was closed because of plaque. During this period he made some of his most significant discoveries and two years later he came back with a revolutionary understanding of mathematics, gravitation, and optics. A professor of his, upon understanding what Newton had done, resigned his position at Cambridge so Newton could have it. Newton's calculus provided a new mathematical framework for the rapid solution of whole classes of physical problems. Newton was the first scientist ever knighted.

His Philosopia Naturalis Principia Mathematica, published in 1687, is considered to be the most influential book in the history of science. In this work, Newton described universal gravitation and the three laws of motion, laying the groundwork for classical mechanics, which dominated the scientific view of the physical universe for the next three centuries and is the basis for modern engineering. Newton showed that the motions of objects on Earth and of celestial bodies are governed by the same set of natural laws by demonstrating the consistency between Kepler's laws of planetary motion and his theory of gravitation, thus removing the last doubts about heliocentrisism and advancing the scientific revolution.

In mechanics, Newton formulated the principles of conservation of momentum and angular momentum. In optics, he invented the reflecting telescope and developed a theory of colour based on the observation that a prism decomposes white light into a visible spectrum. He also formulated an empirical law of cooling and studied the speed of sound. In mathematics Newton shares the credit with Gottfried Leibnitz for the development of the differential and integral calculus.

In a 2005 poll of the Royal Society asking who had the greater effect on the history of science, Newton was deemed much more influential than Albert Einstein.

Newton's first law of motion is often stated as: An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force. There are two parts to this statement – one which predicts the behaviour of stationary objects and the other which predicts the behaviour of moving objects. The behaviour of all objects can be described by saying that objects tend to "keep on doing what they're doing". All objects resist changes in their state of motion.

Second Law of motion: Acceleration is produced when a force acts on a mass. The greater the mass (of the object being accelerated), the greater the amount of force needed (to accelerate the object). Everyone unconsciously knows the Second Law. Everyone knows that heavier objects require more force to move the same distance as lighter objects.

Third Law of motion: For every action there is an equal and opposite reaction. This means that for every force there is a reaction force that is equal in size, but opposite in direction. That is to say that whenever an object pushes another object it gets pushed back in the opposite direction equally hard.

Newton's Three Laws of Motion:

1. A body in rest tends to stay at rest, and a body in motion tends to stay in motion, unless the body is compelled to change its state. The evidence supporting the first part of this statement is easily seen. We know that a wheel will not begin rolling by itself. However, we do not see the proof of the second half in our world. That is because there is an ever present inhibiting force known as friction that acts as the external force resisting perpetual motion.

2. The second law is a formula: A=F/m. The acceleration of a body is dependent upon both the mass of the object (not its weight) and the net force

perpetuating the motion (total force in the direction of the motion minus the force resisting motion). In the formula, a resisting force would be written as negative to produce a negative acceleration, which means the object would be slowing down.

3. For every action there is an equal and opposite reaction. This means that if I push you, I myself will be slightly pushed back in the process. This is the principle at work behind how jet planes and rockets propel themselves. They expel gases in the opposite direction, are pushed themselves in the process, and thus move forward.

## Text 2. Forces

From the movements of the planets to the energy produced inside atoms, everything that happens in the Universe is ultimately caused by forces. A force is a push or pull that can make an object move or turn around. The bigger the force, the more movement it can produce. When two or more forces act together on an object, their effects are combined. Sometimes the forces add together to make a larger force, and sometimes they cancel each other out.

Forces are measured in units called newtons (N), named after English scientist Sir Isaac Newton. The size of a force can be measured using a device called a force meter or newtonmeter. As the load pulls on the hook, it stretches a spring to give a reading on the scale. On Earth, the force of gravity on 1 kg (2.2 lb) is 9.8 newtons.

If an object is fixed at one point and can rotate around, it that point is called a pivot. If a force acts on the object, the object turns around the pivot. The turning force is called a torque and the effect it produces is called a moment. The bigger the force, the greater the moment. The moment also increases if the force acts at a greater distance from the pivot. A wheelbarrow is free to pivot around the large wheel at the front. When the worker lifts the handles, the force causes the entire wheelbarrow to swing upwards and turn around the wheel. The long body and handles of a wheelbarrow increase the turning effect and make it easier to tip out a heavy load.

It is easier to unscrew a nut with a spanner than with your fingers, because the spanner's long handle increases the turning effect or moment of the force. The size of a moment is equal to the force used times the distance from the pivot on which it acts.

If you use a spanner twice as long, you double the moment, and the nut is twice as easy to turn.

When forces act in the same direction, they combine to make a bigger force. When they act in opposite directions, they can cancel one another out. If the forces acting on an object balance, the object does not move, but may change shape. If the forces combine to make an overall force in one direction, the object moves in that direction.

A suspension bridge has to support the weight of its own deck, plus the weight of the vehicles that go across it. The deck of the bridge hangs from huge steel cables suspended over giant pillars. The cables and pillars are arranged so that there is no overall force in any direction. A bridge stays up because the forces on it are balanced and cancel one another out.

When you press or push something, the force you apply is called pressure. Pressure is measured as the force you use divided by the area over which you use it. If you use a bigger force, or if you use the same force over a smaller area, you increase the pressure. We experience air pressure all the time because of the weight of air pressing in on our bodies. Water pressure increases as you go deeper in the ocean.

## Text 3. Air and Water Pressure

The gases in Earth’s atmosphere are made up of tiny molecules that are constantly crashing into your body and trying to press it inwards. This pressing force is called air pressure. It is greatest at ground level where there are most air molecules. At greater heights above Earth, there are fewer air molecules and the air pressure is much less. It is possible to compress (squeeze) air, and this is used to inflate vehicle tyres and to power machines such as pneumatic drills.

Heavy construction machines have large tyres for two reasons. The compressed air in the tyre helps to absorb bumps, so the ride is much smoother than it would be with a solid wheel. Large tyres also help to spread the weight of the machine over a much bigger area. This reduces the pressure on the ground and stops the machine sinking into the mud.

Water behaves differently from air when it is under pressure. It cannot be compressed (squeezed). This makes it useful for transmitting force in machines, using a system called hydraulics. Water is also heavier than air, and an increase in water pressure affects humans more than a drop in air pressure. Even with a snorkel or other breathing apparatus, it feels much harder to breathe underwater. The water above you presses down from all sides on your body, so your lungs find it harder to expand to take in air. The deeper you go, the more water there is above you and the greater the pressure on your body.

Liquid pressure is used to carry force through pipes. The small force pushing down does not compress the liquid but moves through the liquid to push another piston a small distance upwards. The wider area of this piston increases the force applied. The higher we go, the less air there is in the atmosphere above us. The deeper in the sea we go, the more water there is pressing down on us.

At the height of 20,000 m (65,600 ft) air pressure is less than one-tenth that at sea level. Aircraft cabins at the height of 11,000 m (36,000 ft) are pressurized to allow us to breathe as easily as at sea level. Oxygen is also supplied in case of emergency, as there is less air at this height. At the height of mountain tops 7,500 m (24,600 ft) climbers often use breathing apparatus to give them more oxygen.

The human body is ideally adapted to deal with the air pressure at sea level of 120 m (400 ft) deep. Divers cannot go any deeper than this without special suits to protect them from the pressure of the water.

Underwater craft such as submarines have strong, double-skinned hulls to withstand water pressure. The world’s deepest-diving crewed submersible can dive to 6,500 m (21, 300 ft). At the depth of 10,000 m (32,800 ft) the pressure of water is 1,000 times greater than it is at sea level.

When an object such as a boat or an airship rests in a fluid (a liquid or gas), it has to displace (push aside) some of the fluid to make room for itself. The object’s weight pulls it downwards. But the pressure of the fluid all around the object tries to push it upwards with a force called upthrust. The object SINKS if the upthrust is less than its weight, but floats if the upthrust is equal to, or more than its weight.

Not everything will float. A block of wood will float on water, but a lump of iron exactly the same size will sink. This is because a piece of wood of a certain size weighs less than the same volume of water, so wood floats on water. However, iron is much heavier than either wood or water. A block of iron weighs more than the same volume of water. This is why iron sinks in water.

Some fish can raise or lower themselves in water using their swim bladder. This is an organ inside their body that they can fill with gas to make their bodies lighter, so they rise towards the surface. When they reduce the amount of gas in the swim bladder, their bodies become heavier and sink.

## Module 3. **MOLECULAR PHYSICS**

### Text 1. Matter and Measurement

Matter, in science, is the general term applied to anything that has the property of occupying space and the attributes of gravity and inertia. In classical physics, matter and energy were considered two separate concepts that lay at the root of all physical phenomena. Modern physicists, however, have shown that it is possible to transform matter into energy and energy into matter and have thus broken down the classical distinction between the two concepts. When dealing with a large number of phenomena, however, such as motion, the behavior of liquids and gases, and heat, scientists find it simpler and more convenient to continue treating matter and energy as separate entities.

Certain elementary particles of matter combine to form atoms; in turn, atoms combine to form molecules. The properties of individual molecules and their distribution and arrangement give to matter in all its forms various qualities such as mass, hardness, viscosity, fluidity, color, taste, electrical resistivity, and heat conductivity, among others. In philosophy, matter has been generally regarded as the raw material of the physical world, although certain philosophers of the school of idealism, such as the Irish philosopher George Berkeley, denied that matter exists independent of the mind.

Matter exists in three states: solid, liquid and gas. A solid, for example a stone, has a definite shape and a definite volume; a liquid, for example oil, has definite volume but no definite shape; a gas, for example hydrogen (H), has neither definite shape nor volume. Water can exist in all three states; below 0º C as a solid (ice); between 0º C and 100º C as a liquid (water); and above 100º C as a gas (vapor). All matter consists of elements such as zinc (Zn) or oxygen (O), or of compounds such as nitric acid ($HNO_3$) or sulphur dioxide ($SO_2$).

When we measure quantities of matter, we may use the fundamental units of time (e.g. the second), mass (e.g. the kilogram) and length (e.g. the meter). Or we may use the units such as area (e.g. $m^2$ ) or volume (e.g. $cm^3$) or density (e.g. $g/cm^3$). These are known as derived units. The area of a rectangle is found by multiplying the length by the width. The volume of a cylinder is equal to Π x radius 2 x height (V = Π r 2 x h). The density of a substance is equal to the mass divided by the volume (d=m/v). We use the terms specific density or relative density to indicate density relative to the density of water. The table of densities below shows that mercury (Hg) has a density of $13.6 g/cm^3$. This means that a cubic centimeter of mercury has 13.6 times the mass of a cubic centimeter of water.

**Text 2. Elementary Particles**

In physics, particles that cannot be broken down into any other particles are called elementary particles. The term elementary particles is also 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.

Scientists now believe that quarks and three other types of particles – leptons, force-carrying bosons and the Higgs-bosons 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. Although the various particles differ widely in mass, charge, lifetime and in other ways, they all share two attributes that qualify them as being “elementary”. First, as far as we know, any two particles of the same species are, except for their position and state of motion, absolutely identical, whether they occupy the same atom or lie at opposite ends of the universe. Second, there is not now any successful theory that explains the elementary particles in terms of more elementary constituents, in the sense that the atomic nucleus is understood to be composed of protons and neutrons and the atom is understood to be composed of a nucleus and electrons. It is true that the elementary particles behave in some respects as if they were composed of still more elementary constituents, named quarks, but in spite of strenuous efforts it has been impossible to break particles into quarks.

The scientists have discovered that the electron has a sibling and cousins that are apparently equally fundamental. The sibling is an electrically neutral particle, called the neutrino, which is much lighter than the electron. The cousins are two electrically charged particles, called the mu and the tau, which also have neutral siblings. The mu and the tau seem to be identical copies of the electron, except that they are respectively 200 and 3,500 times heavier. Their role in the scheme of things and the origin of their different masses remain mysteries – just the sort of mysteries that particle physicists, who study the constituents of matter and the forces that control their behavior, wish to resolve.

The number of protons in the nucleus of an atom determines what kind of chemical element it is. All substances in nature are made up of combinations of the 92 different chemical elements, substances that cannot be broken into simpler substances by chemical processes. The atom is the smallest part of a chemical element that still retains the properties of the element. The number of protons in each atom can range from one in the hydrogen atom to 92 in the uranium atom, the heaviest naturally occurring element. (In the laboratory, scientists have created elements with as many as 114 protons in each nucleus). The atomic number of an element is equal to the number of protons in each atom's nucleus. The number of electrons in an uncharged atom must be equal to the number of protons, and the arrangement of these electrons determines the chemical properties of the atom.

**Text 3. Structure and Characteristics of Proton**

The proton is 1,836 times as heavy as the electron. For an atom of hydrogen, which contains one electron and one proton, the proton provides 99.95 percent of the mass. The neutron weighs a little more than the proton. Elements heavier than hydrogen usually contain about the same number of protons and neutrons in their nuclei, so the atomic mass, or the mass of one atom, is usually about twice the atomic number.

Protons are affected by all four of the fundamental forces that govern all interactions between particles and energy in the universe. The electromagnetic force arises from matter carrying an electrical charge. It causes positively charged protons to attract negatively charged electrons and holds them in orbit around the nucleus of the atom. This force also makes the closely packed protons within the atomic nucleus repel each other with a force that is 100 million times stronger than the electrical attraction that binds the electrons. This repulsion is overcome, however, by the strong nuclear force, which binds the protons and neutrons together into a compact nucleus.

The other two fundamental forces, gravitation and the weak nuclear force, also affect the proton. Gravitation is a force that attracts anything with mass (such as the proton) to every other thing in the universe that has mass. It is weak when the masses are small, but can become very large when the masses are great. The weak nuclear force is a feeble force that occurs between certain types of elementary particles, including the proton, and governs how some elementary particles break up into other particles.

The proton was long thought to be an indivisible particle, like the electron. In the 1950s, however, scientists used beams of electrons to probe the proton and found that it has a definite shape and size. These experiments showed that, rather than being an indivisible point, the proton has an outer diameter of about 10-13 cm, with a cloudlike shell surrounding a dense center.

Beginning in 1947, physicists discovered more and more elementary particles in addition to the proton, neutron, and electron. These particles appeared to be related to protons and neutrons and to each other. Two different elementary particles had one property, such as an electric charge, that was identical, while another two particles were related by having the exact opposite property. These relationships suggested that protons and other elementary particles might be made up of smaller building blocks, which scientists called quarks. In 1967 physicists used high-powered electron beams to probe deep inside the proton and discovered evidence that quarks exist. Three quarks join together to form a proton. The strong nuclear force is actually a force that attracts quarks to each other to make a proton or neutron. The quarks of a neutron or proton will also attract the quarks of another neutron or proton, thus holding a nucleus together.

Protons originally formed about a thousandth of a second after the Big Bang, the explosion that scientists believe occurred at the beginning of the universe (see Big Bang Theory). In that short time, the temperature of the early universe dropped sufficiently for energetic quarks to join together. It is possible that protons may break up again, but this type of event, called proton decay, would be extremely rare. Experiments have shown that the average lifetime of the proton is at least $10^{35}$ years (the number $10^{35}$ means a 1 followed by 35 zeros). This may appear to be an odd answer, since the age of the universe is only about $15x10^{9}$ years. Some protons live for a much shorter time than the average value, however, and scientists are constructing large experiments with thousands of tons of material, hoping to see a proton decay.

## Module 4. **THERMAL PHYSICS**

### Text 1. Heat and Work, Fusion

**Heat and work.** Heat is the energy that a body possesses by virtue of the fact that its molecules are in motion. In solids they do not alter their relative positions greatly, but vibrate back and forth through positions of equilibrium. If two sticks are rubbed together vigorously, they become hot. Drills or augers become too hot to hold in the hand when used to bore hard wood or metal. Heat is generated when a chisel is ground on an emery wheel. A grindstone is kept wet with water to prevent the tools that are being ground from becoming too hot. In all such cases, work is done on the body, and heat is developed in consequence of this work.

**Mechanical equivalent of heat.** Since work is a form of energy, it may be converted into heat. According to the law of conservation of energy, it is not possible to create or to destroy energy. Hence, a definite quantity of work is required to produce a given amount of heat. Experiments have shown that this amount of work is the same under all conditions.

The following experiment shows one method of determining the amount of mechanical work necessary to generate one unit of heat. The apparatus that was used in this experiment consists of a calorimeter in which revolves a series of paddle wheels. The calorimeter is fitted with baffle plates that have spaces cut in them to allow the paddle wheels to pass. By this means, the water in the calorimeter is thoroughly churned. The paddle wheels are driven by two weights which are hung over two pulleys. When the weights are allowed to descend thorough a given distance, the paddle wheels revolve and do work on the water in the calorimeter. This work causes the water in the calorimeter to increase in temperature. By observing the weights and the distance thorough which they descend, the work done on the water can be calculated from the relation:

$$\text{Work} = \text{force} \times \text{distance} = \text{weight in pounds} \times \text{feet}.$$

**Fusion. The melting point.** If a vessel of ice or snow is heated, the temperature at first rises until it is 0° C and then remains stationary until all the ice is melted. After all the ice has been melted¸ the temperature of the water begins to rise. That temperature at which the solid changes into a liquid without a change of temperature is called the melting point. For ice this temperature is 0° C or 32° F. At the melting point, the addition of heat simply serves to hasten the melting process without any change of temperature.

If a pail of water is placed in a freezing mixture of ice and snow, the temperature of the water decreases until ice begins to be formed in the pail. After this temperature has been reached, the temperature of the water in the pail remains the same until all the water has become ice. That temperature at which the liquid changes into the solid state is its freezing point. This temperature is ordinarily the same as the temperature at which the solid melts. For crystalline substances, such as ice or copper, the freezing point or the melting point is sharply defined. For substances that are not crystalline, such as wax or glass, the substances gradually softens in passing from the solid to the liquid state. Such substances do not have a definite melting point. In the cases of certain fact, the melting point is not the same as the freezing point. For example, butter melts between 28 and 32° C and solidifies between 20 and 23° C.

**Heat of fusion.** In order to cause a solid like ice to change into a liquid, it is necessary to supply a given quantity of heat to each gram or each pound of it. The heat of fusion of a substance is defined to be the number of calories necessary to convert 1g at the melting point into liquid at the same temperature.

**Text 2. Basic Units in International System of Measurements.**

Everyone has to measure lengths, reckon time, weigh various bodies. Therefore, everyone knows just what a centimeter, a second, and a gram are. But these measures are especially important for a physicist-they are necessary for making judgments about most physical phenomena. People try to measure distance, intervals of time and mass, which are called the basics concepts of physics, as accurately as possible.

**Length.** The meter and the kilogram had their origin in the metric system. By international agreement, the standard meter had been defined as the distance between two fine lines on a bar of platinum-iridium alloy. The 1960 conference redefined the meter as 1,650,763.73 wavelengths of the reddish-orange light emitted by the isotope krypton-86. The meter was again redefined in 1983 as the length of the path traveled by light in vacuum during a time interval of 1/299,792,458 of a second.

**Mass.** When the metric system was created, the kilogram was defined as the mass of 1 cubic decimeter of pure water at the temperature of its maximum density (4.0° C/39.2° F). A solid cylinder of platinum was carefully made to match this quantity of water under the specified conditions. Later it was discovered that a quantity of water as pure or as stable as required could not be provided. Therefore the primary standard of mass became the platinum cylinder, which was replaced in 1889 by a platinum-iridium cylinder of similar mass. Today this cylinder still serves as the international kilogram, and the kilogram in SI is defined as a quantity of mass of the international prototype of the kilogram.

**Time.** For centuries, time has been universally measured in terms of the rotation of the earth. The second, the basic unit of time, was defined as 1/86,400 of a mean solar day or one complete rotation of the earth on its axis. Scientists discovered, however, that the rotation of the earth was not constant enough to serve as the basis of the time standard. As a result, the second was redefined in 1967 in terms of the resonant frequency of the cesium atom-that is, the frequency at which this atom absorbs energy, or 9,192,631,770 hertz (cycles per second).

**Temperature.** The temperature scale adopted by the 1960 conference was based on a fixed temperature point, the triple point of water, at which the solid, liquid, and gas are in equilibrium. The temperature of 273.16 K was assigned to this point. The freezing point of water was designated as 273.15 K, equaling exactly 0° on the Celsius temperature scale. The Celsius scale, which is identical to the centigrade scale, is named for the 18th-century Swedish astronomer Anders Celsius, who first proposed the use of a scale in which the interval between the freezing and boiling points of water is divided into 100 degrees. By international agreement, the term Celsius has officially replaced centigrade.

## Text 3. Physical and Chemical Changes in Matter.

A physical change is a change in matter that involves no chemical reaction. When a substance undergoes a physical change, the composition of its molecules remains unchanged, and the substance does not lose its chemical identity. Melting, evaporating, and freezing are three types of physical change. For example, water ($H_2O$) is a liquid that freezes to form the solid ice, which may again be melted into water. Because molecules of water and ice are composed of the same chemical elements in the same proportions, the change from water to ice is a physical change.

Physical changes include any alteration in the shape and size of a substance. For example, cutting, grinding, crushing, annealing, dissolving, or emulsifying produce physical changes. Still another physical change is sublimation, the change from a solid to a gas.

When a substance undergoes a chemical change, the composition of its molecules changes. The properties of the original substance are lost, and new substances with new properties are produced. An example of a chemical change is the production of rust (iron oxide) when oxygen in the air reacts with iron. Chemical changes may also result in physical changes. For example, when wood (a solid) is burned, it is combined with oxygen gas to produce gaseous carbon dioxide ($CO_2$), liquid water, and solid carbon.

There are several differences between a physical and chemical change in matter or substances. A physical change in a substance doesn't change what the substance is. In a chemical change where there is a chemical reaction, a new substance is formed and energy is either given off or absorbed.

For example, if a piece of paper is cut up into small pieces it still is paper. This would be a physical change in the shape and size of the paper. If the same piece of paper is burned, it is broken up into different substances that are not paper.

Physical changes can be reversed, chemical changes cannot be reversed with the substance changed back without extraordinary means, if at all. For example, a cup of water can be frozen when cooled and then can be returned to a liquid form when heated.

If one decided to mix sugar into water to make sugar water, this would be a physical change as the water could be left out to evaporate and the sugar crystals would remain. However, if one made a recipe for a cake with flour, water, sugar and other ingredients and baked them together, it would take extraordinary means to separate the various ingredients out to their original form.

When heat is given off in a chemical change or reaction, it is called an exothermic reaction. When heat is absorbed in a chemical change or reaction, it is called an endothermic reaction. The speed at which chemical reactions take place depend on the temperature pressure and how concentrated the substances involved in the chemical reaction are. Sometimes substances called catalysts are used to speed up or help along a chemical reaction.

Chemical reactions occur continuously in the atmosphere, in factories, in vehicles, in the environment, and in our bodies. In a chemical reaction, one or more kinds of matter is changed into a new kind-or several new kinds-of matter. A few common chemical reactions are shown here. Life as we know it could not exist without these processes: plants could not photosynthesize, cars could not move, pudding could not thicken, muscles could not burn energy, glue could not stick, and fire could not burn.

**Chemical change** is any change that results in the formation of new chemical substances. At the molecular level, chemical change involves making or breaking of bonds between atoms. These changes are chemical:

- iron rusting (iron oxide forms);
- gasoline burning (water vapor and carbon dioxide form);
- eggs cooking (fluid protein molecules uncoil and crosslink to form a network);
- bread rising (yeast converts carbohydrates into carbon dioxide gas);
- milk souring (sour-tasting lactic acid is produced);
- suntanning (vitamin D and melanin is produced).

**Physical change** rearranges molecules but doesn't affect their internal structures. Some examples of physical change are:

- whipping egg whites (air is forced into the fluid, but no new substance is produced);
- magnetizing a compass needle (there is realignment of groups ("domains") of iron atoms, but no real change within the iron atoms themselves);
- boiling water (water molecules are forced away from each other when the liquid changes to vapor, but the molecules are still $H_2O$);
- dissolving sugar in water (sugar molecules are dispersed within the water, but the individual sugar molecules are unchanged);
- dicing potatoes (cutting usually separates molecules without changing them).

## Module 5. **ELECTRICITY AND MAGNETISM**

### Text 1. History of Electromagnetism - Innovations Using Magnetic Fields

Until 1820, the only magnetism known was that of iron magnets and of "lodestones", natural magnets of iron-rich ore. It was believed that the inside of the Earth was magnetized in the same fashion, and scientists were greatly puzzled when they found that the direction of the compass needle at any place slowly shifted, decade by decade, suggesting a slow variation of the Earth's magnetic field.

**Edmond Halley's Theories.** How can an iron magnet produce such changes? Edmond Halley (of comet fame) ingeniously proposed that the Earth contained a number of spherical shells, one inside the other, each magnetized differently, each slowly rotating in relation to the others.

**Hans Christian Oersted - Electromagnetism Experiments.** Hans Christian Oersted was a professor of science at Copenhagen University. In 1820 he arranged in his home a science demonstration to friends and students. He planned to demonstrate the heating of a wire by an electric current, and also to carry out demonstrations of magnetism, for which he provided a compass needle mounted on a wooden stand.

While performing his electric demonstration, Hans Christian Oersted noted to his surprise that every time the electric current was switched on, the compass needle moved. He kept quiet and finished the demonstrations, but in the months that followed worked hard trying to make sense out of the new phenomenon.

However, Hans Christian Oersted could not explain why. The needle was neither attracted to the wire nor repelled from it. Instead, it tended to stand at right angles. In the end he published his findings without any explanation.

**Andre Marie Ampere and Electromagnetism.** Andre Marie Ampere in France felt that if a current in a wire exerted a magnetic force on a compass needle, two such wires also should interact magnetically. In a series of ingenious experiments Andre Marie Ampere showed that this interaction was simple and fundamental - parallel (straight) currents attract, anti-parallel currents repel. The force between two long straight parallel currents was inversely proportional to the distance between them and proportional to the intensity of the current flowing in each.

There, thus, existed two kinds of forces associated with electricity – electric and magnetic. In 1864, James Clerk Maxwell demonstrated a subtle connection between the two types of force, unexpectedly involving the velocity of light. From this connection sprang the idea that light was an electric phenomenon, the discovery of radio waves, the theory of relativity and a great deal of present-day physics.

## Text 2. Linear Voltage Regulators

Linear voltage regulators are commonly found in low voltage DC systems. Often in modern electronics several voltage levels will be used due to the desire to optimize power consumption and the availability of components designed for certain operating voltage ranges. Linear voltage regulators are one of the simplest ways to create a stable voltage source in a circuit.

**Voltage Regulator Overview.** When a steady, reliable voltage is needed, voltage regulators are the go to component. Voltage regulators take an input voltage and create a regulated output voltage regardless of the input voltage at either a fixed voltage level or and adjustable voltage level (by selecting the right external components). This automatic regulation of the output voltage level is handled by various feedback techniques, some as simple as a zener diode while others include complex feedback topologies that can improve performance, reliability, efficiency, and add other features like boosting output voltage above the input voltage to the voltage regulator.

**Linear Regulators.** One of the most basic ways to regulate voltage and provide a stable voltage for electronics is to use a standard 3-pin linear voltage regulator such as the LM7805 which provides a 5 volt 1 amp output with an input voltage at up to 36 volts (depending on the model). Linear regulators work by adjusting the effective series resistance of the regulator based on a feedback voltage, essentially acting like a voltage divider circuit. This lets the regulator output an effective constant voltage regardless of what current load is placed on it, up to its current capacity. One of the big downsides to linear voltage regulators is the large minimum voltage drop across the voltage regulator which is 2.0 volts on the standard LM7805 linear voltage regulator. This means that to get the stable 5 volts output, at least a 7 volt input is required. This voltage drop plays a large role in the power dissipated by the linear regulator which would have to dissipate at least 2 watts if it was delivering a 1 amp load (2 volt voltage drop times 1 amp). The power dissipation gets worse the larger the difference between the input and output voltage, so for example while a 7 volt source regulated to 5 volts delivering 1 amp would dissipate 2 watts through the linear regulator, a 10 volt source regulated to 5 volts delivering the same current would dissipate 5 watts making the regulator only 50% efficient.

**Low Drop out Linear Voltage Regulators (LDO Regulators).** A Low Drop-Out (LDO) linear regulator is a variation of the standard linear regulator with a much lower minimum voltage drop across the regulator. The biggest advantage to a LDO regulator is that with the lower voltage drop across the device which lets the LDO regulator provide an output voltage much closer to its input voltage. With the voltage drop in standard linear regulators is 2.0 volts, they are rarely usable in the lower voltage systems where the maximum voltage may be 3.3 volts and 3, 2.6, 2.5, 2.2, or 1.8 volts are needed. Even in the cases where a standard linear regulator can be used, the large relative voltage drop wastes a lot of power, too much for the long battery life required in modern electronics. Enter the LDO regulator with a voltage drops lower than 0.025 volts.

**Zener Diodes.** A linear regulator is a pretty basic component with few extra components and little design complexity, but a zener diode can provide adequate voltage regulation in some cases with just a single component. Since a zener diode shunts all extra voltage above its breakdown voltage threshold to ground, it can be used as a very simple voltage regulator with the output voltage pulled across the leads of the zener diode. Unfortunately, zeners are often very limited in their ability to handle power which limits where they can be used as voltage regulators to very low power applications only.

## Text 3. Generation and Transmission of Electricity

In the 6$^{th}$ century BC, the Greek philosopher Thales of Miletus experimented with amber rods and these experiments were the first studies into the production of electrical energy. While this method, now known as the triboelectric effect, can lift light objects and generate sparks, it is extremely inefficient. It was not until the invention of the voltaic pile in the eighteenth century that a viable source of electricity became available. The voltaic pile, and its modern descendant, the electrical battery, store energy chemically and make it available on demand in the form of electrical energy. The battery is a versatile and very common power source which is ideally suited to many applications, but its energy storage is finite, and once discharged it must be disposed of or recharged. For large electrical demands electrical energy must be generated and transmitted continuously over conductive transmission lines.

Electrical power is usually generated by electro-mechanical generators driven by steam produced from fossil fuel combustion, or the heat released from nuclear reactions; or from other sources such as kinetic energy extracted from wind or flowing water. The modern steam turbine invented by Sir Charles Parsons in 1884 today generates about 80 percent of the electric power in the world using a variety of heat sources. Such generators bear no resemblance to Faraday's homopolar disc generator of 1831, but they still rely on his electromagnetic principle that a conductor linking a changing magnetic field induces a potential difference across its ends. The invention in the late nineteenth century of the transformer meant that electrical power could be transmitted more efficiently at a higher voltage but lower current. Efficient electrical transmission meant in turn that electricity could be generated at centralized power stations, where it benefited from economies of scale, and then be despatched relatively long distances to where it was needed.

Since electrical energy cannot easily be stored in quantities large enough to meet demands on a national scale, at all times exactly as much must be produced as is required. This requires electricity utilities to make careful predictions of their electrical loads, and maintain constant co-ordination with their power stations. A certain amount of generation must always be held in reserve to cushion an electrical grid against inevitable disturbances and losses.

Demand for electricity grows with great rapidity as a nation modernises and its economy develops. The United States showed a 12% increase in demand during each year of the first three decades of the twentieth century, a rate of growth that is now being experienced by emerging economies such as those of India or China. Historically, the growth rate for electricity demand has outstripped that for other forms of energy.

Environmental concerns with electricity generation have led to an increased focus on generation from renewable sources, in particular from wind and hydropower. While debate can be expected to continue over the environmental impact of different means of electricity production, its final form is relatively clean.

## Module 6. **INVENTION OF ELECTRICITY**

### Text 1. Early Pre-Commercial and Commercial Research of the Lightbulb

In 1802, Humphry Davy had what was then the most powerful electrical battery in the world at the Royal Institution of Great Britain. In that year, Davy created the first incandescent light by passing the current through a thin strip of platinum, chosen because the metal had an extremely high melting point. It was not bright enough nor did it last long enough to be practical, but it was the precedent behind the efforts of scores of experimenters over the next 75 years.

Over the first three-quarters of the $19^{th}$ century many experimenters worked with various combinations of platinum or iridium wires, carbon rods, and evacuated or semi-evacuated enclosures. Many of these devices were demonstrated and some were patented.

In 1835, James Bowman Lindsay demonstrated a constant electric light at a public meeting in Dundee, Scotland. He stated that he could “read a book at a distance of one and a half feet”. However, having perfected the device to his own satisfaction, he turned to the problem of wireless telegraphy and did not develop the electric light any further. His claims are not well documented, although he is credited in Challoner et al. with being the inventor of the “Incandescent Light Bulb”.

In 1840, British scientist Warren de la Rue enclosed a coiled platinum filament in a vacuum tube and passed an electric current through it. The design was based on the concept that the high melting point of platinum would allow it to operate at high temperatures and that the evacuated chamber would contain fewer gas molecules to react with the platinum, improving its longevity. Although a workable design, the cost of the platinum made it impractical for commercial use.

In 1841, Frederick de Moleyns of England was granted the first patent for an incandescent lamp, with a design using platinum wires contained within a vacuum bulb. In 1845, American John W. Starr acquired a patent for his incandescent light bulb involving the use of carbon filaments. He died shortly after obtaining the patent, and his invention was never produced commercially. Little else is known about him.

In 1851, Jean Eugène Robert-Houdin publicly demonstrated incandescent light bulbs on his estate in Blois, France. His light bulbs are on display in the museum of the Château de Blois.

Heinrich Göbel in 1893 claimed he had designed the first incandescent light bulb in 1854, with a thin carbonized bamboo filament of high resistance, platinum lead-in wires in an all-glass envelope, and a high vacuum. Judges of four courts raised doubts about the alleged Goebel anticipation, but there was never a decision in a final hearing due to the expiry date of Edison's patent. A research work published 2007 concluded that the story of the Goebel lamps in the 1850s is a legend. On 24 July 1874, a Canadian patent was filed by Henry Woodward and Mathew Evans for a lamp consisting of carbon rods mounted in a nitrogen-filled glass cylinder. They were unsuccessful at commercializing their lamp, and sold rights to their patent (U.S. Patent 0,181,613) to Thomas Edison in 1879.

## Text 2. Commercialization of Electricity Invention

Joseph Swan (1828–1914) was a British physicist and chemist. In 1850, he began working with carbonized paper filaments in an evacuated glass bulb. By 1860 he was able to demonstrate a working device but the lack of a good vacuum and an adequate supply of electricity resulted in a short lifetime for the bulb and an inefficient source of light. By the mid-1870s better pumps became available, and Swan returned to his experiments.

With the help of Charles Stearn, an expert on vacuum pumps, in 1878 Swan developed a method of processing that avoided the early bulb blackening. This received a British Patent in 1880. On 18 December 1878 a lamp using a slender carbon rod was shown at a meeting of the Newcastle Chemical Society, and Swan gave a working demonstration at their meeting on 17 January 1879. It was also shown to 700 who attended a meeting of the Literary and Philosophical Society of Newcastle upon Tyne on 3 February 1879. These lamps used a carbon rod from an arc lamp rather than a slender filament. Thus, they had low resistance and required very large conductors to supply the necessary current, so they were not commercially practical, although they did furnish a demonstration of the possibilities of incandescent lighting with relatively high vacuum, a carbon conductor and platinum lead-in wires.

Besides requiring too much current for a central station electric system to be practical, they had a very short lifetime. Swan turned his attention to producing a better carbon filament and the means of attaching its ends. He devised a method of treating cotton to produce ‘parchmentised thread’ and obtained British Patent 4933 in 1880. From this year he began installing light bulbs in homes and landmarks in England. His house was the first in the world to be lit by a lightbulb and so the first house in the world to be lit by hydroelectric power. In 1878 the home of Lord Armstrong at Cragside was also among the first houses to be lit by electricity. In the early 1880s he had started his company. In 1881, the Savoy Theatre in the City of Westminster, London was lit by Swan incandescent lightbulbs, which was the first theatre, and the first public building in the world, to be lit entirely by electricity.

Thomas Edison began serious research into developing a practical incandescent lamp in 1878. Edison filed his first patent application for “Improvement in Electric Lights” on October 14, 1878. After many experiments, first with carbon in the early 1880s and then with platinum and other metals, in the end Edison returned to a carbon filament. The first successful test was on 22 October 1879, and lasted 13.5 hours. Edison continued to improve this design and by 4 November 1879, filed for a US patent or an electric lamp using “a carbon filament or strip coiled and connected … to platina contact wires.” Although the patent described several ways of creating the carbon filament including using “cotton and linen thread, wood splints, papers coiled in various ways,” Edison and his team later discovered that a carbonized bamboo filament could last over 1200 hours. In 1880, the Oregon Railroad and

Navigation Companysteamer, Columbia, became the first application for Edison's incandescent electric lamps (it was also the first ship to execute use of adynamo). Columbia sank in a collision with a schooner off California in 1907.

Hiram S. Maxim started a lightbulb company in 1878 to exploit his patents and those of William Sawyer. His United States Electric Lighting Company was the second company, after Edison, to sell practical incandescent electric lamps. They made their first commercial installation of incandescent lamps at the Mercantile Safe Deposit Company in New York City in the fall of 1880, about six months after the Edison incandescent lamps had been installed on the steamer Columbia. In October 1880, Maxim patented a method of coating carbon filaments with hydrocarbons to extend their life.

Lewis Latimer, his employee at the time by Edison, developed an improved method of heat-treating carbon filaments which reduced breakage and allowed them to be molded into novel shapes, such as the characteristic "M" shape of Maxim filaments. On January 17, 1882, Latimer received a patent for the "Process of Manufacturing Carbons," an improved method for the production of light bulb filaments which was purchased by the United States Electric Light Company. Latimer patented other improvements such as a better way of attaching filaments to their wire supports.

In Britain, the Edison and Swan companies merged into the Edison and Swan United Electric Company (later known as Ediswan, which was ultimately incorporated into Thorn Lighting Ltd). Edison was initially against this combination, but after Swan sued him and won, Edison was eventually forced to cooperate, and the merger was made. Eventually, Edison acquired all of Swan's interest in the company. Swan sold his United States patent rights to the Brush Electric Company in June 1882.

The United States Patent Office gave a ruling 8 October 1883, that Edison's patents were based on the prior art of William Sawyer and were invalid. Litigation continued for a number of years. Eventually on 6 October 1889, a judge ruled that

Edison's electric light improvement claim for "a filament of carbon of high resistance" was valid.

In 1897, German physicist and chemist Walther Nernst developed the Nernst lamp, a form of incandescent lamp that used a ceramic globar and did not require enclosure in a vacuum or inert gas. Twice as efficient as carbon filament lamps, Nernst lamps were briefly popular until overtaken by lamps using metal filaments.

## Text 3. Electric Current

In some materials, electrons are stuck tightly in place, while in other materials, electrons can move all around the material. Protons never move around a solid object because they are so heavy, at least compared to the electrons. A material that lets electrons move around is called a conductor. A material that keeps each electron tightly in place is called an insulator. Examples of conductors are copper, aluminum, silver, and gold. Examples of insulators are rubber, plastic, and wood. Copper is used very often as a conductor because it is a very good conductor and there is so much of it in the world. But sometimes, other materials are used.

Inside a conductor, electrons bounce around, but they do not keep going in one direction for long. If an electric field is set up inside the conductor, the electrons will all start to move in the direction opposite to the direction the field is pointing (because electrons are negatively charged). A battery can make an electric field inside a conductor. If both ends of a piece of wire are connected to the two ends of a battery (called the *electrodes*), the loop that was made is called an electrical circuit. Electrons will flow around the circuit as long as the battery is making an electric field inside the wire. This flow of electrons around the circuit is called electric current.

A conducting wire used to carry electric current is often wrapped in an insulator such as rubber. This is because wires that carry current are very dangerous. If a person or an animal touched a bare wire carrying current, they could get hurt or even die depending on how strong the current was. You should be careful around electrical sockets and bare wires that might be carrying current.

It is possible to connect an electrical device to a circuit so that electrical current will flow through a device. This current will make the device do something that we want it to do. Electrical devices can be very simple. For example, in a light bulb, current flows through a special wire called a filament, which makes it glow. Electrical devices can also be very complicated. Electricity can be used to drive an electric motor inside a tool like a drill or a pencil sharpener. Electricity is also used to power modern electronic devices, including telephones, computers, and televisions.

Electricity is mostly generated in places called power stations. Most power stations use heat to boil water into steam which turns a steam engine. The steam engine's turbine turns a machine called a 'generator'. Generators have wires inside which spin inside a magnetic field. Electromagnetic induction causes electricity to flow through the wires. There are many sources of heat which can be used to generate electricity. Heat sources can be classified into two types: renewable energy resources in which the supply of heat energy never runs out and non-renewable energy resources in which the supply will be eventually used up.

Sometimes a natural flow, such as wind power or water power, can be used directly to turn a generator so no heat is needed.

- Electric current is when electric charge flows. When 1 coulomb of electricity moves past somewhere in 1 second, the current is 1 ampere.
- Electric voltage is the "push" behind the current. It is the amount of work per electric charge that an electric source can do. When 1 coulomb of electricity has 1 joule of energy, it will have 1 volt of electric potential.
- Electrical resistance is the ability of a substance to resist the flowing of the current, i.e. to reduce the amount of current that flows through the substance. If an electric voltage of 1 volt maintains a current of 1 ampere through a wire, the resistance of the wire is 1 ohm. When the flow of current is opposed energy gets used or gets converted to other forms.
- Electric energy is the ability to do work by means of electric devices. Electric energy is a "conserved" property, meaning that it behaves like a substance and can

be moved from place to place. Electric energy is measured in joules or kilowatt-hours (kW h).

· Electric power is the rate at which electric energy is being used, stored, or transferred. Flows of electrical energy along power lines are measured in watts. If the electric energy is being converted to another form of energy, it is measured in watts. If it is stored (as in electric or magnetic fields), it is measured in volt-amperes reactive. If some of it is converted and some of it is stored, it is measured in volt-amperes.

## Module 7. **LIGHT**

### Text 1. Some Facts about Light

Light usually refers to visible light, which is visible to the human eye and is responsible for the sense of sight. Visible light is usually defined as having a wavelength in the range of 400 nanometres (nm), or $400\times10^{-9}$ m, to 700 nanometres – between the infrared, with longer wavelengths and the ultraviolet, with shorter wavelengths.

The main source of light on Earth is the Sun. Sunlight provides the energy that green plants use to create sugars mostly in the form of starches, which release energy into the living things that digest them. This process of photosynthesis provides virtually all the energy used by living things. Historically, another important source of light for humans has been fire, from ancient campfires to modern kerosene lamps. With the development of electric lights and of power systems, electric lighting has all but replaced firelight. Some species of animals generate their own light, called bioluminescence. For example, fireflies use light to locate mates, and vampire squids use it to hide themselves from prey.

Primary properties of visible light are intensity, propagation, direction, frequency or wavelength spectrum, and polarization, while its speed in a vacuum, 299,792,458 meters per second, is one of the fundamental constants of nature. Visible light is experimentally found to always move at this speed in vacuum.

In physics, the term light sometimes refers to electromagnetic radiation of any wavelength, whether visible or not. In this sense, gamma rays, X-rays, microwaves and radio waves are also light. Like all types of light, visible light is emitted and absorbed in tiny "packets" called photons, and exhibits properties of both waves and particles. This property is referred to as the wave–particle duality.

Scientists have found some experimental evidence for dark matter. Astronomers at Bell Labs in the United States found evidence for dark matter in an image taken by the Hubble Space Telescope (HST) in 1997. Light from a cluster of galaxies in the image was bent by another cluster of galaxies in the foreground of the picture. By making computer models of the cluster in the foreground and matching them to the way it bent the light of the background cluster in the image, the scientists were able to estimate the mass of the foreground cluster. The model that fit best showed that the cluster's mass was about 250 times as great as the mass of just the visible part of the cluster.

## Text 2. Applications of Light and Electricity

Electricity is a very convenient way to transfer energy, and it has been adapted to a huge, and growing, number of uses. The invention of a practical incandescent light bulb in the 1870s led to lighting becoming one of the first publicly available applications of electrical power. Although electrification brought with it its own dangers, replacing the naked flames of gas lighting greatly reduced fire hazards within homes and factories. Public utilities were set up in many cities targeting the burgeoning market for electrical lighting.

The Joule heating effect employed in the light bulb also sees more direct use in electric heating. While this is versatile and controllable, it can be seen as wasteful, since most electrical generation has already required the production of heat at a power station. A number of countries, such as Denmark, have issued legislation restricting or banning the use of electric heating in new buildings. Electricity is however a highly practical energy source for refrigeration, with air conditioning representing a growing sector for electricity demand, the effects of which electricity utilities are increasingly obliged to accommodate.

Electricity is used within telecommunications, and indeed the electrical telegraph, demonstrated commercially in 1837 by Cooke and Wheatstone, was one of its earliest applications. With the construction of first intercontinental, and then transatlantic, telegraph systems in the 1860s, electricity had enabled communications in minutes across the globe. Optical fibre and satellite communication have taken a share of the market for communications systems, but electricity can be expected to remain an essential part of the process.

The effects of electromagnetism are most visibly employed in the electric motor, which provides a clean and efficient means of motive power. A stationary motor such as a winch is easily provided with a supply of power, but a motor that moves with its application, such as an electric vehicle, is obliged to either carry along a power source such as a battery, or to collect current from a sliding contact such as a pantograph.

Electronic devices make use of the transistor, perhaps one of the most important inventions of the twentieth century, and a fundamental building block of all modern circuitry. A modern integrated circuit may contain several billion miniaturised transistors in a region only a few centimetres square. Electricity is also used to fuel public transportation, including electric buses and trains.

## Text 3. Albert Einstein

Albert Einstein (1879-1955) is one of the world ever greatest scientists who has contributed much to our beautiful life. He was born on March 14, 1879 in Ulm, Wurttemberg, Germany. Einstein contributed more than any other scientist since Sir Isaac Newton to our understanding of physical reality.

Einstein was slow to learn to talk, not beginning to speak until sometime after his second birthday. His slow verbal development combined with a native rebelliousness toward authority, led one schoolmaster to say that young Albert would never amount to much.

When Einstein was 10, a poor student named Max Talmud began dining with the Einstein family once a week. Max would bring illustrated science for Albert to study, and they would discuss what Albert learned. Max gave him a geometry textbook two years before Albert was to study the subject at school. Max later recalled, “Soon the flight of his mathematical genius was so high that I could no longer follow”.

In 1896, Einstein entered the Swiss Federal Polytechnic School in Zurich to be trained as a physics and mathematics instructor. He graduated in 1901, and unable to find a teaching position, accepted a job as technical assistant in the Swiss Patent Office in Bern. At that time he completed an astonishing range of theoretical physics publications, written in his spare time, without the benefit of scientific literature or close contact with colleagues.

The most well known of these works is Einstein’s 1905 paper proposing “the special theory of relativity”. He based his new theory on the principle that the laws of physics are in the same form in any frame of reference. As a second fundamental hypothesis, Einstein assumed that the speed of light remained constant in all frames of reference.

Later in 1905 Einstein showed how mass and energy were equivalent expressing it in the famous equation: E=mc2 (energy equals mass times the velocity of light squared). This equation became a cornerstone in the development of nuclear energy.

Einstein received the Nobel prize in 1921 but not for relativity, rather for his 1905 work on the photoelectric effect. He worked on at Princeton until the end of his life on an attempt to unify the laws of physics.

With the death of Albert Einstein, a life in the service of science and humanity which was as rich and fruitful as any in the whole history of our culture has come to an end. Mankind will always be indebted to Einstein for the removal of the obstacles to our outlook which were involved in the primitive notions of absolute space and time. He gave us a world picture with a unity and harmony surpassing the boldest dreams of the past.

Einstein’s genius, characterized equally by logical clarity and creative imagination, succeeded in remolding and widening the imposing edifice whose foundations had been laid by Newton's great work. Within the frame of the relativity theory, demanding a formulation of the laws of nature independent of the observer and emphasizing the singular role of the speed of light, gravitational effects lost their isolated position and appeared as an integral part of a general kinematics description, capable of verification by refined astronomical observations. Moreover, Einstein's recognition of the equivalence of mass and energy should prove an invaluable guide in the exploration of atomic phenomena.

Indeed, the breadth of Einstein's views and the openness of his mind found most remarkable expression in the fact that, in the very same years when he gave a widened outlook to classical physics, he thoroughly grasped the fact that Planck's discovery of the universal quantum of action revealed an inherent limitation in such an approach. With unfailing intuition Einstein was led to the introduction of the idea of the photon as the carrier of momentum and energy in individual radiative processes. He thereby provided the starting point for the establishment of consistent quantum theoretical methods which have made it possible to account for an immense amount of experimental evidence concerning the properties of matter and even demanded reconsideration of our most elementary concepts.

The same spirit that characterized Einstein's unique scientific achievements also marked his attitude in all human relations. Notwithstanding the increasing reference which people everywhere felt for his attainments and character, he behaved with unchanging natural modesty and expressed himself with a subtle and charming humor. He was always prepared to help people in difficulties of any kind, and to him, who himself had experienced the evils of racial prejudice; the promotion of understanding among nations was a foremost endeavor. His earnest admonitions on the responsibility involved in our rapidly growing mastery of the forces of nature will surely help to meet the challenge to civilization in the proper spirit.

To the whole of mankind Albert Einstein's death is a great loss, and to those of us who had the good fortune to enjoy his warm friendship it is a grief that we shall never more be able to see his gentle smile and listen to him. But the memories he has left behind will remain an ever-living source of fortitude and encouragement.

Module 8. **OPTICS**

## Text 1. Huygens' Principle

This principle of wave analysis, proposed by the physicist Christiaan Huygens (1629-1695), basically states that: *Every point of a wave front may be considered the source of secondary wavelets that spread out in all directions with a speed equal to the speed of propagation of the waves.*

What this means is that when you have a wave, you can view the "edge" of the wave as actually creating a series of circular waves. These waves combine together in most cases to just continue the propagation, but in some cases there are significant observable effects. The wave front can be viewed as the line *tangent* to all of these circular waves.

These results can be obtained separately from Maxwell's equations, though Huygens' principle (which came first) is a useful model and is often convenient for calculations of wave phenomena. It is intriguing that Huygens' work preceded Maxwell's by about two centuries, and yet seemed to anticipate it, without the solid theoretical basis that Maxwell provided. Ampere's law and Faraday's law predict that every point in an electromagnetic wave acts as a source of the continuing wave, which is perfectly in line with Huygens' analysis.

**Huygens' Principle & Diffraction.** As shown in the picture to the right, when light goes through an aperture (an opening within a barrier) every point of the light wave within the aperture can be viewed as creating a circular wave which propagate outward from the aperture.

The aperture, therefore, is treated as creating a new wave source, which propagates in the form of a circular wave front. The center of the wave front has greater intensity, with a fading of intensity as the edges are approached. This explains the diffraction observed, and why the light through an aperture does not create a perfect image of the aperture on a screen. The edges "spread out" based upon this principle.

An example of this principle at work is common to every day life. If someone is in another room and calls toward you, the sound seems to be coming from the doorway (unless you have very thin walls).

**Huygens' Principle & Reflection/Refraction.** The laws of reflection and refraction can both be derived from Huygens' principle. Click on the image to the right to view an image of Huygens' principle as it applies to refraction. See how points along the wave front are treated as sources along the surface of the refractive medium, at which point the overall wave bends based upon the new medium.

The effect of both reflection and refraction is to change the direction of the independent waves that are emitted by the point sources. The effects of performing the rigorous calculations obtains results that are identical to what is obtained from Newton's geometric optics (such as Snell's law of refraction), which was derived under a particle principle of light (Although Newton's method is less elegant in its explanation of diffraction).

## Text 2. What is a Photon?

Under the photon theory of light, a *photon* is a discrete bundle (or *quantum*) of electromagnetic (or light) energy. Photons are always in motion and, in a vacuum, have a constant speed of light to all observers, at the vacuum speed of light (more commonly just called the speed of light) of = $2.998 \times 10^8$ m/s.

**Basic Properties of Photons.** According to the photon theory of light, photons:

· move at a constant velocity, = $2.9979 \times 10^8$ m/s (i.e. "the speed of light"), in free space;

· have zero mass and rest energy.

· carry energy and momentum, which are also related to the frequency *nu* and wavelength *lambda* of the electromagnetic wave by *E* = *h nu* and *p* = *h*/*lambda*.

· can be destroyed/created when radiation is absorbed/emitted.

· can have particle-like interactions (i.e. collisions) with electrons and other particles, such as in the Compton effect.

**History of Photons.** The term photon was coined by Gilbert Lewis in 1926, though the concept of light in the form of discrete particles had been around for centuries and had been formalized in Newton's construction of the science of optics.

In the 1800s, however, the wave properties of light (by which I mean electromagnetic radiation in general) became glaringly obvious and scientists had essentially thrown the particle theory of light out the window. It wasn't until Albert Einstein explained the photoelectric effect and realized that light energy had to be quantized that the particle theory returned.

**Wave-Particle Duality in Brief.** As mentioned above, light has properties of both a wave and a particle. This was an astounding discovery and is certainly outside the realm of how we normally perceive things. Billiard balls act as particles, while oceans act as waves. Photons act as both a wave and a particle all the time (even though it's common, but basically incorrect, to say that it's "sometimes a wave and sometimes a particle" depending upon which features are more obvious at a given time).

Just one of the effects of this *wave-particle duality* (or *particle-wave duality*) is that photons, though treated as particles, can be calculated to have frequency, wavelength, amplitude, and other properties inherent in wave mechanics.

**Fun Photon Facts.** The photon is an elementary particle, despite the fact that it has no mass. It cannot decay on its own, although the energy of the photon can transfer (or be created) upon interaction with other particles. Photons are electrically neutral and are one of the rare particles that are identical to their antiparticle, the antiphoton.

Photons are spin-1 particles (making them bosons), with a spin axis that is parallel to the direction of travel (either forward or backward, depending on whether it's a "left-hand" or "right-hand" photon). This feature is what allows for polarization of light.

## Text 3. X-Rays

As the 19th century drew near its close, physicists felt that they had completed their task. At the end of the 19th century scientists said that it was probable that all the great discoveries in the field of physics had been made. The physicist of the future, they said, would have nothing to do but repeat the experiments of the past.

And then, two years later, in December 1895, Prof. Wilhelm Konrad Roentgen announced his discovery of X-rays. He published photographs of the bones of his hand, and of key and coins photographed through the leather pocketbook which contained them. A new discovery had been made! Roentgen had found some mysterious ray which penetrated opaque objects as easily as sunlight penetrated window glass. There was nothing in the nineteenth century physics to explain this phenomenon. It was soon evident that the work of the physicist, far from being at the end, was only at its beginning.

The discovery of X-rays ended the self-satisfaction of the 19th century physicists and started research workers all over the world on new lines of work.

A year later – in 1896 – in Paris, Antoine Henri Becquerel made his discovery of the mysterious rays given off by uranium salts. Marie Curie asked his permission to go on with the experiments. Her desire was to find if any substances besides the salts of uranium gave off these rays. After many experiments she found that only one, the salt of thorium, did so. But the most amazing discovery she made was the fact that pitchblende, the ore from which uranium is obtained, gave off rays four times as strong as those of pure uranium.

It was apparent to Becquerel and the Curies that this could mean only one thing. The pitchblende must contain some unknown chemical element which was far richer in these mysterious rays than was uranium. Pierre Curie decided to drop his own researches, and he and his wife began the fascinating task of finding this unknown element. The Austrian government presented them with a ton of pitchblende. It was necessary to remove one known substance after another from the pitchblende, carefully conserving the, residue for further analysis.

The first result of the work was the discovery of a substance giving off "Becquerel rays", as the world of science began to call the mysterious rays. Marie Curie named it "polonium" in honour of her native Poland. But polonium was not rich enough in the rays to be the end of the search.

In 1898, the search came to a triumphant conclusion. From the ton of pitchblende, the Curies had obtained a fraction of a grain of a new element which was two and a half million times as rich in "Becquerel rays" as was uranium. They named this new substance "radium". It possessed many interesting properties. It liberated heat, electrified the air in its immediate neighbourhood, caused many substances to become phosphorescent when brought near it, and possessed the power of killing bacteria and other minute organisms. The world of physics was astonished. Three great discoveries in the three years, each one more astonishing than the other – X-rays in 1895, the "Becquerel rays" in 1896 and radium in 1898. Those were exciting days in the field of physics.

# GRAMMAR EXERCISES

## NOUN

**Exercise 1.** ***Put in a / an or the. Sometimes you don't need either word – you leave it blank.***

1. There was _____ waiter standing at _______ entrance of ______ restaurant. I ordered him ___ glass of ___ vodka with some juice in it.

2. There was ____ question I wanted to ask ___ biology teacher about _____ cangroo. She had said ___ cangroo carried her baby in ___ kind of bag in ___ front part of ___ her body. I wanted to know how many baby cangroos it could carry at ____ time.

3. "Is that your wife?" - "No, my wife's _____ woman in ____ red dress."

4. I work with ____ man and two women. ____ man is quite nice, but ___ women are not very friendly.

5. What's in ___ newspaper?

6. Can you show me ____ that book, please?

7. What's ____ name of ___ woman in ___ blue dress?

8.______ water turns into _____ ice at 0 degree C.

9. I like __ steak, but I don't like __ eggs.

10. She lives in ___ nice flat on ___ fifth floor of ___ old house.

11. It's terrible - ____ eggs are $2 ___ dozen.

12. There was ___ boy and ____ girl in the room. ____ boy was Japanese but ____ girl looked foreign. She was wearing ____ fur coat.

13. This morning I bought ____ newspaper and ___ magazine. ____ newspaper is in my bag but I don't know where ____ magazine is.

14. "Have you got ___ car?" - "No, I've never had ____ car in my life."

15. We don't go to _____ cinema very much these days. In fact, in ____ town where we live there isn't _____ cinema.

16. Don't stay in that hotel. _____ beds are very uncomfortable.

17. After I leave _____ school, I want to go to ____ university.

**Exercise 2.** ***Insert the right article (a/an/the) if necessary.***

1. Do you still live in … Bristol?
2. Carol's father works as … electrician. Wednesday.
3. After this tour you have … whole afternoon free to explore the city.
4. The tomatoes are 99 pence … kilo.
5. My grandmother likes ... flowers very much.
6. I always listen to the radio in … morning.
7. What about going to Australia in … February?
8. There is … new English book on the desk.
9. Loch Ness is … most famous lake in Scotland.
10. Peter has … aunt in Berlin.
11. Look! There's … bird flying.
12. … most children like sweets.
13. Great Britain consists of ... three parts.
14. We celebrate New Year on ... 31st of December.
15. Last year I gave my mother ... bracelet for her birthday.
16. Britain is … island.

17. What is … name of this village?
18. Montreal is a large city in … Canada.
19. When I went to Milan, I stayed with … Italian friend of mine.
20. Tom is in … bathroom. He's having a bath.

**Exercise 3.** ***Make following nouns plural.***

1. Postcard. 2. Dish. 3. Watch. 4. Box. 5. Potato. 6. Man. 7. Child. 8. Foot. 9. Sheep.

**Exercise 4.** ***Use following sentences in the plural form.***

1. This is my foot. 2. Is this an ox? – No? it isn't. 3. That lady doesn't play the piano. 4. This wolf is eating a sheep. 5. This hobby is not bad. 6. Is this a mouse? 7. This child is looking at the falling leaf. 8. This man is doctor. 9. This deer lives in the forest. 10. I like this tomato.

**Exercise 5.** ***Define whether these nouns countable or uncountable.***

1. water ___ 2. fruit ___ 3. coconut ___ 4. bread ___ 5. DVD ___ 6. meat ___ 7. ball ___ 8. snack __ 9. glasses ___ 10. pen ___ 11. milk _____ 12. chair __ 13. gasoline __ 14. table __ 15. cream ___ 16. money ___ 17. oil __ 18. insect __ 19. sofa __ 20. yogurt ___ 21. school __ 22. bus ___ 23. food __ 24. chocolate __ 25. ship ____.

**Exercise 6. Fill in the blank spaces with <u>some</u>, <u>any</u>, <u>no</u>.**

1. Can you see __________ cars in front of the restaurant? – No, __________ cars.
2. Have you got __________ cold juice in the fridge? – Yes, I have got __________.
3. We'd like _____ crisps. Are there ________? – I'm sorry. There are ________ crisps today.
4. I'd like __________ chocolate but there isn't __________.
5. We'd like __________ bread but there is __________ butter.
6. We'd like hamburgers. Are there __________?
7. Is there much cheese on the plate? – No, there isn't __________ cheese.
8. Have you got ________ CDs? – No, I haven't ________ but I've got __________ DVDs.
9. Have you got __________ money? – No, I've got __________ money.
10. There are __________ good films on TV tonight. Shall we listen to the radio?
11. Have they got ____ children? – No, they haven't got ___ but they've got _____ nephews.

**Exercise 7. Fill in the blanks with <u>many</u>, <u>much</u>, <u>a lot of</u> or <u>lots of</u>.**

1. We don't have ______________ bread, so we'll have to buy some.
2. There aren't ______________ students in my class.
3. He's very busy; he has ______________ work to do.
4. Lisbon has ______________ interesting places to visit.
5. I can't buy a new car. I don't have ______________ money.
6. Hurry up! We don't have______________ time.
7. Your garden's got ______________ pretty flowers.
8. There weren't ______________ people at the party.
9. "Do you have ______________ friends?" " Not ____________, but they're good friends."
10. I think you eat too ______________ sugar.
11. He gave me ______________ chocolates and nice things.

**Exercise 8. Choose the correct quantifier.**

1. We are going to be late. There is too _________________ (much/many) traffic.
2. He has _________________(a few/ a little) ideas about how to earn money online.
3. I want to save _________________(some/several) money for the future.
4. There are _________________(much/many) students in this school.
5. You should drink _________________(a couple of/ a great deal of) water during the day.
6. He has _________________ (little/few) friends he can count on.

7. They told me there were ________________( a few/ a little) tickets lefts.
8. There were ________________(several/much) people interested in the car.
9. We have ______________ (little / few) bread. It is not enough for dinner
10. We have _____________ (little / few) time left. Let's try to get finished quickly.

**Exercise 9.**

**A) Fill in <u>how much</u>, <u>how many</u>, <u>a few</u>, <u>a little</u>, <u>some</u> or <u>any</u>:**

1. A: …………………………… bananas would you like, sir?
B: Just …………………………. , please.
2. A: Can I have …………………………… milk?
B: Sorry, we haven't got ……………………….. milk.
3. A: ………………………… bread would you like?
B: Just ……………………….. , please.
4. A: ……………………… carrots do we have?
B: We have only …………………………. .
5. A: ……………………….. oranges do we need?
B: We don't need ……………………….. oranges.
6. A: …………………….sugar would you like in your coffee?
B: Just ………………………, please.
7. A: Could I have ……………………. tea, please?
B: Of course. Would you like ………………………. biscuits, too?
8. A: Is there ………………………. wine in the fridge?
B: No, we need to buy ……………………. .
9. A: ……………………. flour does she need?
B: Just ……………………... .
10. A: Have you got ……………………… potatoes?
B: Yes. …………………………. would you like?

**B) Fill in <u>some</u>, <u>any</u>, <u>much</u> or <u>many</u>:**

1. A: I'd like ……………………. eggs, please.
B: Of course. How ……………………. would you like?
A: Six, please. Are there ……………………… tomatoes?
B: Certainly. How …………………… do you need?
A: A kilo, please.
2. A: I'd like …………………… olive oil.
B: How ……………………… do you need?
A: Half a bottle. Is there ……………………. flour?
B: Certainly. How ………………………. do you need?
A: A kilo, please.

**Exercise 10. Fill in <u>little</u>, <u>a little</u>, <u>few</u> and <u>a few.</u>**

1. What you need is _____________ more self-confidence.
2. _____________ is known about how the disease spreads.
3. I'm sorry, but I speak _____________ Spanish. Can't we communicate in English?
4. Very _____________ people went to see the movie.
5. Mary managed to get _____________ piece of cake.
6. She saves _______ money every month because she wants to go on a cruise next summer.
7. There are _____________ posts that are really worth reading. Most of them are rubbish.
8. I have drunk _____________ water today, so I guess that's why I'm so thirsty.
9. There are _____________ good books that I would recommend reading.
10. Have you got any money left in your bank account? Yes, I have ____, but not very much
11. There are _____________ cities in the world that have a multicultural society.
12. There was _____________ time to finish the project, so we had to work on weekends.
13. We stayed in New York for _____________ days before moving on to the Midwest.
14. I'd like to tell you _____________ about my childhood.

## DEGREES OF COMPARISON OF ADJECTIVES

**Exercise 11. Write the appropriate comparative and superlative form of these adjectives:**

1 light ________________ ________________
2 clever ________________ ________________
3 sunny ________________ ________________
4 hard ________________ ________________
5 thin ________________ ________________
6 good ________________ ________________
7 poor ________________ ________________
8 short ________________ ________________
9 late ________________ ________________
10 happy ________________ ________________
11 shady ________________ ________________
12 stupid ________________ ________________
13 rainy ________________ ________________
14 soft ________________ ________________
15 fat ________________ ________________
16 bad ________________ ________________
17 rich ________________ ________________
18 long ________________ ________________
19 early ________________ ________________
20 sad ________________ ________________

**Exercise 12. Underline the best word.**

1. Don't eat the fish. It smells *bad* / *badly.*
2. It's a *two-hours* / *two-hour* train journey from here to Manchester.
3. I stumbled across *an asleep* / *a sleeping* man in the doorway.
4 They ran home through the rain, and when they arrived were *sheer* / *soaking* wet.
5. As far as Maria was concerned, it was a *losing* / *lost* opportunity.
6. Tom opened the door and found a very *large* / *enormous* parcel on the doorstep.
7 I read that article, but I thought it was *mere* / *complete* rubbish!
8. The smell of *baking-fresh* / *freshly baked* bread made me feel hungry.
9. That suitcase looks really *heavy* / *heavily.*
10. What's the matter with you? You look *worrying* / *worried.*

**Exercise 13. Put *very* in front of the adjective where possible, or leave blank (-).**

*e.g. I put my foot in the water, and it was - freezing!*

1. Please don't make that silly noise! It's ____________annoying!
2. When we first saw the wave we were shocked, because it was_________enormous.
3. You really should read this book. It's ______________interesting.
4 Jeff has been missing for two days, and we're __________worried.
5. Unfortunately, the ring I found turned out to be ______worthless.
6. At the end of the race, most of the runners felt _______exhausted.
7. By the end of the second week, many of the villagers were_______ starving.
8. It's _____________unusual for so much rain to fall here in July.
9. I've checked the figures again, and I can assure you that they are___________correct.
10. How do you do. I'm ____________ pleased to meet you.
11. When I realized what she had said, I was ___________ upset.

**Exercise 14. Complete the sentences using the correct forms.**

1. The president hopes that people of all races will live together ____________ *(peaceful)*
2. She told us that the streets in the capital city were___ *(dirty, ugly)*
3. Do you think nuclear energy is ____________? *(safe)*
4. I get all the food _____ from the farmers.*(direct)*

5. The minister was ______ worried that the deal would not pass parliament. *(deep)*
6. Marty drove home from the party as _______ as he could and got there. *(fast, safe)*
7. When the director found out about the scandal he shouted ____ at his employees. *(angry)*
8. The old woman walked across the street very _______. *(careful)*
9. She didn't see me. She______ knocked me down with her brand-new car! *(near)*
10. After a few weeks people forgot about him ______. *(complete)*
11. He ______ works anymore, because he already has enough money. *(hard)*
12. She _____ climbed down from the tree as soon as the bear had disappeared. *(slow)*
13. He is a very ___________ volleyball player. *(good)*
14. Bob excused himself ________ and went home.*(polite)*
15. English is an ___ language to learn,however he couldn't learn grammar rules so ___. *(easy)*
16. The sun shone ___________ in the sky.*(bright)*
17. The new colleague seems to be _________ intelligent. *(high)*
18. The boy felt ______because he knew what he had done. *(guilty)*

**Exercise 15. Fill in *too* or *enough*.**

1. I can't carry this suitcase. It's ___________ heavy.
2. This bag isn't big _____________. I can't put all my possessions in it.
3. Is your meal warm ________? If not, I'll put it in the microwave.
4. Mom was _______ worried to go to sleep, so she stayed up all night.
5. I don't like this fizzy drink. It's much________ sweet.
6. I'll ring you up later. I haven't got _______ time at the moment.
7. She's ______ young to drink alcohol. She's not even 15 yet.
8. We weren't able to buy tickets for both games because we didn't have ______ money.
9. I couldn't see her anywhere because it was getting _________ foggy.
10. You can't play in our first team. You're not good __________

**Exercise 16. Fill in the correct form: Adjective or Adverb?**

1. If anything goes ___________, someone must be blamed. *(wrong)*
2. The parliament was _________elected. *(free)*
3. You shouldn't go up that ladder. It's not _________. *(safe)*
4. Coffee in the morning smells __________. *(fantastic)*
5. The western part of the US was colonized _________by the Spanish. *(main)*
6. The sun was shining ________in the sky. *(bright)*
7. She likes to wear _______clothes when she goes out. *(colorful)*
8. My son was ______disappointed because he didn't get the job. *(bitter)*
9. Don't be so ________when you leave and close the door ______, please. *(noisy, quiet)*
10. The plane was able to land _______ on the main runway. *(safe)*

**Exercise 17. Use *as….as* or *so….as.***

1. These houses are … high…those.
2. Peter is … thin … his brother.
3. This room is not … comfortable … that one on the first floor.
4. I'm not … strong … a horse.
5. Their apartment is twice … big … ours.
6. The blue car is …fast …the red car.
7. Peter is not … tall … Fred.
8. The violin is not … low … the cello.
9. This copy is … bad … the other one.
10. Oliver is … optimistic … Ivan.

**Exercise 18. Choose the correct variant.**

1. She has never seen … a small house.

a) so b) such c) what d) as

2. Some people are working … others.

a) hard as b) hardly c) harder than d) as hardest than

3. Grandmother can't hear them ….
a) very good b) very well c) much good d)much well
4) The film was …. funnier than I expected.
a) so b) by far c) very d) even
5. His car is not ….. as mine.
a) moderner b) more modern c) most modern d) so modern
6. He's a good guitarist, but he plays the piano …
a) very good b) quite well c) much better d) too hardly
7. The teacher complains: 'The others were bad, but these pupils are … of all'
a) worse b) more bad c) the worst d) baddest
8. He knew he had to get there….
a) quickly b) more quick c) quicker d) quicklier
9. I don't watch TV … you.
a) as much as b) so much as c) more as d) much then
10. Her behavior is getting … to understand.
a) stranger and stranger c) most and most strange
b) more and more strange d) the most strange

**Exercise 19. Complete the sentences using the correct forms of the adjectives.**

1. He is probably ______________________ tennis player I have ever seen (**bad**).
2. Jane is the ______________________-working student in our class (**hard**).
3. Sit over there. It's __________________________ chair in this room. (**comfortable**)
4. This pub is so noisy. Can we go to a place that is ______________________ (**quiet**)?
5. I don't have ______________________ idea of what you are taking about. (**slight**)
6. John is a ______________________ person than Humphrey. (**reliable**)
7. The new Mission Impossible movie is good, but the next James Bond film will be ______________________. (**exciting**)
8. How much __________________ is it to the airport? – We'll be there in ten minutes. (**far**)
9. Why can't you stay a bit ______________________? - It's only half past six. (**long**)
10. The more you practice, the ______________________ you will get. (**good**)
11. Piccadilly Circus is one of ______________________ places in London . (**noisy**)
12. The essay you wrote wasn't very creative. I'm sure you can do ________________.(**good**)
13. What's ______________________ news from the conflict zone? (**late**
14. Getting the right people for the job is one of __________________________ problems we have at the company. (**serious**)
15. The headmaster's speech was OK, but what the students said was_______. (**interesting**)
16. Helping her with the dishes was ______________________ I could do for her. (**little**)
17. How did you like the roller-coaster ride? – Well, it was ___________________________ experience I have ever had. (**frightening**)
18. Mum makes ______________________ lasagne you have ever eaten. (**good**)
19. This apartment is ___________________ of all the apartments I have seen. (**convenient**)
10. Annie usually gets up _________________ than her sister. (**early**)

## PERSONAL PRONOUNS

**Exercise 20. Rewrite the sentences and change the underlined nouns into personal or objective pronouns.**

1. Jane told Alice to help Mary and Peter.
2. I met Betty in the library yesterday.
3. My mother came out. My mother was surprised to see Peter and I there.
4. Kate will phone David in the evening.
5. Charles gave I the book as a present.
6. The flowers were in the vase.

7. Robert and Mark met Lucy in the cinema yesterday.
8. Mike must go to see Jane and Marta.
9. Mrs. Swift always gives the students homework.
10. Mary works at National Bank.
11. The cups are in the cupboard.
12. Derek lives in Oakland, California.
13. My brother and I enjoy watching movies on Friday evenings.
14. Tom was speaking to Jim and Mike.
15. Our colleagues usually attend all our meetings.

**Exercise 21. Fill in objective pronouns.**

1. Who is that woman? Why are you looking at _________?
2. Do you know that man? Yes, I work with ________.
3. I am talking to you. Please listen to _____________.
4. These photos are nice. Do you want to look at ____________?
5. I like that camera. I am going to buy ________________.
6. I don't know Peter's girlfriend. Do you know ________________?
7. Where are the tickets? I can't find _____________.
8. We are going to the disco. Can you come with ____________?
9. I don't like dogs. I'm afraid of _______________.
10. Where is she? I want to talk to ___________.
11. Those apples are bad. Don't eat ____________
12. I don't know this girl. Do you know ____________?
13. Alan never drinks milk. He doesn't like __________.
14. Where are the children? Have you seen ______________?
15. I can't find my pencil. Can you give one to ______________?

**Exercise 22. Circle the correct word.**

1. *He/Him* didn't want to tell *we/us* about his problem.
2. *I/Me* was very grateful for what *she/her* had done for *I/me.*
3. *She/Her* saw *they/them* as *they/them* were crossing the street.
4. I can't see my sunglasses. Where are *they/them*? - I've put *they/them* on the shelf.
5. I'd like to speak to *he/him*, but I don't know if *he/him* is in the office.
6. This letter isn't for *I/me*, it's for *she/her*.
7. Are those flowers for *I/me*?
8. He reported *we/us* about the results of the conference.
9. Can you pass *they/them* the salt, please?
10. I couldn't visit *she/her* yesterday but I phoned *she/her*.

**Exercise 23. Complete the sentences with the correct pronouns.**

1. I don't know her phone number. Can you tell _______ to ______, please?
2. Your grandparents are so kind! I always enjoy my visits to ____________
3. Is Helen in the gym? We can't see _________ anywhere.
4. Excuse us, can you help _______? We don't know the way to the station.
5. I didn't answer the teacher's question and he gave ______ a bad mark.
6. She asked Den to phone ________ as she wanted to tell _____ some news.
7. Where is your father? I need ____ help.
8. The secretary told ____ that we had to wait for some minutes.
9. John is a hardworking employee. She often sees ______ in the office.
10. We like this teacher. He explains the rule to ______ very often.

**Exercise 24. Use the correct pronouns to complete the sentences.**

1. Josh lost the purse. _____ doesn't know when it happened.
2. We met girls in the café, but Bob hadn't met ______ before.
3. Kate was there too. I talked to _______ for twenty minutes.
4. Carol bought a new car. _______ is a Mercedes.
5. I need some help. Please, help _____.
6. My friend and I sold all the trees. _______ need some new flowers now.
7. He looked at me. _______ couldn't help him.
8. They invited us. ______ agreed to come.
9. I want to send _____ this present. They will be glad.
10. We locked his documents. _____ was very angry.

**Exercise 25. Use the correct personal pronouns (subject and object).**

1. _________ is dreaming. *(George)*
2. The teacher always gives _________ homework. *(The students)*
3. _________ is green. *(The book)*
4. _________ are on the wall. *(The posters)*
5. I am reading the book to ________. *(My sister)*
6. Open ________, please. *(The window)*
7. _________ are watching TV. *(My mother and I)*
8. _________ are in the garden. *(The flowers)*
9. _________ has got a brother. *(Diana)*
10. Can you help __________, please? *(My sister and I)*

## POSSESSIVE PRONOUNS

**Exercise 26. Circle the correct word.**

1. I'm sure *her/hers* brother is at home. 2. This disc is *my/mine*. It isn't *your/yours*. 3. She put *her/hers* report on the table and started to read *my/mine*. 4. Let's leave *my/mine* car at the car park and take *your/yours*. 5. This is *her/hers* house and *their/theirs* is near the river. 6. Mary gave Peter *her/hers* address and wrote down *him/his*. 7. Grilled chicken is *their/theirs* favourite dish. 8. This phone number is *our/ours*. 9. They bought a new house. Now it's *their/theirs*. 10. I don't need this eraser. I have *my/mine*.

**Exercise 27. Use the correct possessive pronoun.**

1. The bus stop is near _______ house. *(We)*
2. How is ________ new school? *(You)*
3. This is my bag and that is ________. *(He)*
4. Sophia's hair is longer than ________. *(I)*
5. It's _________ turn now. *(I)*
6. The bike on the right is _________. *(You)*
7. Which desk is ________? *(We)*
8. Here are _________ tickets. *(She)*
9. The children brushed _________ teeth. *(They)*
10. Our school is much nicer than _________. *(They)*

**Exercise 28. Complete the sentences with the correct form of possessive pronouns in brackets.**

1). Frank showed me photos of ... family and I showed.... (*mine, his*). 2) I spent ... day doing shopping and Jane spent ... in the swimming-pool (*my, hers*). 3) We described ... adventures to Mr. Harris and he told about.... (*his, our*). 4) They didn't know that was ... car. They were surprised to know that it's.... (*your, yours*). 5) I returned them ... key. ... Granny told the key was.... (*my, their, theirs*). 6) Has she found ... pen? If not, you can use ... then (*mine, your*). 7) We don't need ... help because he didn't accept.... (*his, ours*). 8) Dogs are ... favourite animals and what are...? (*my, yours*) 9) She took ... hands into ... and smiled at me (my, hers). 10) We gave ... passes to the guard. He gave me ... pass back but didn't return Bob.... (*my, his, our*).

**Exercise 29. Circle the correct item.**

1) Could you tell ... the time, please?
a) I b) my c) me
2) This dog is ... .
a) she b) her c) hers
3) We left ... things in the room of the hotel,
a) us b) our c) ours
4) Thomas often phones ....
a) they b) their c) them
5) Ann didn't see ... at school yesterday,
a) you b)your c)yours
6) Pass me ... phone, please.
a) I b) my c) mine
7) John always has the driven license with ....
a) he b) his c) him
8) The ring is really beautiful, but ... price is too high for me.
a) it b) its c) my

**Exercise 30. Translate into English.**

1) Він учора розповів нам про свої плани.
2) Я хочу повернути тобі твою книгу.
3) Ми зустріли їх вчора біля метро.
4) Вона бачила вас у лікарні минулого тижня.
5) Вчитель виправив наші помилки та повернув нам зошити.
6) Де мої черевики? — Вони під стільцем.
7) Ми щойно показали їй наше чудове місто.
8) Я не зрозумів його слів та попросив його повторити запитання.
9) Вона не могла зателефонувати вам, бо загубила ваш номер.
10) Я щойно поклав олівець на стіл, але не можу його зараз знайти.

## DEMONSTRATIVE PRONOUNS

**Exercise 31. Complete the sentences with the demonstrative pronouns.**

1) Can you see _______________ building in the distance?
2) _______________ pen doesn't write. Give me another one, please.
3) I don't recognize _______________ people. They are too far from us.
4) Here you are! Take _______________ flowers. I've bought them for you.
5) _______________ castle far away looks mysterious.
6) I'm really enjoying _______________ (experience that's happening now).
7) _______________ painting (that we saw yesterday) was really beautiful.
8) I really liked _______________ cakes. (I'm talking about the cakes we ate last week.)
9) _______________'s a great idea! (the idea you explained to me.)
10) David, _______________ is Lukas.
11) Who is _______________ woman by the door?
12) _______________ are fabulous trousers! (That you're wearing.)
13) I really like _______________ chocolates (that I'm eating now).
14) _______________ people we met last night were really nice.
15) Could I please try on _______________ t-shirts? (I'm holding the t-shirts).

## REFLEXIVE PRONOUNS

**Exercise 32. Circle the correct item.**

1) She calls *yourself/herself* the smartest girl in the class. 2) We have organized the festival *ourselves/myself.* 3) I *herself/ myself* wanted to check all the details of the plan. 4) My parents grow these wonderful tomatoes *yourselves/themselves.* 5) He couldn't see it, but I saw it *himself/myself.* 6) Our mother needs help, she can't do all the housework *herself/ourselves.* 7) Sam couldn't phone *herself/himself* and asked me to phone you. 8) I'm awfully sorry to tell this, but the computer destroyed the programme *itself/himself.* 9) The children made the New Year toys *yourselves/themselves.* 10) Bob and Ron will make the project *themselves/ourselves.*

**Exercise 33. Complete the sentences with the reflexive pronouns.**

1) Ted solved the problem... . 2) Vicky and Albert are going to paint the car... . 3) I ... have given you the promise. 4) Did Patricia write the letter...? 5) You, children, must tidy this room.... 6) I won't be able to come ..., but my wife will. 7) This programme has to check the mistakes... . 8) Have you, Nancy, cooked this meat... ? 9) Hilda... doesn't understand the meaning of that word. 10) The room ... was very comfortable, and the service was excellent.

**Exercise 34. Translate into English.**

1. Ті книги ваші чи їхні? — Вони — наші.
2. Де ваша кішка? — Наша — на вікні.
3. Яблука її чи твої? — Вони наші.
4. Цей сік його чи Тома? — Його.
5. Той сад — малий. Наш більший. А ваш? — Наш — такий самий.
6. Ті квіти ваші чи її? — Вони — наші.
7. Це авто Теда чи ваше? — Воно — його.
8. Сумка твоя чи Анни? — Її. — А де твоя?
9. Персики їхні чи твої? — Вони її.
10. Книги студентів чи ваші? — Вони їхні.
11. Цуценя ваше чи сусідів? — Ні, воно їхнє.
12. Де твій кашкет? — Мій — на полиці, а його — на столі.
13. Де ваші зошити? — Наші — у школі, а його — вдома.
14. Бутерброд мій чи її? — Твій — на тарілці, а її — у портфелі.
15. Квіти ваші чи її? — Її. Наші — у вазі.

***NOTE!* We do not use reflexive pronouns with the verbs:** *concentrate, feel, relax* **and** *meet.*

**Exercise 35. Insert reflexive pronouns where it is possible.**

1. Tom cut ________________ while he was shaving this morning.
2. We really enjoyed ____________very much.
3. I repaired my bike ______________
5. He felt _____________tired.
6. Why don't you clean the windows ____________?
7. Jack and I introduced _________ to our new neighbor.
8. They are relaxing ___________ at the SPA center.
9. Let's paint the house _____?
10. The children cleaned their room ____________.
11. John used to concentrate _____ on different affairs.
12. The cat caught the mouse ________.
13. Tell me a little about __________.
14. We met _____ at the train station.
15. She did all the work by ____________.

## INDEFINITE PRONOUNS

**Exercise 36. Choose the appropriate pronoun from the box.**

| *any, anybody, anything, every, everybody, everything* |
|---|

1. She does morning exercises __________ day.
2. You can meet her _________ time between 1 and 2.
3. This is a small town where _______ knows __________ about _____________
4. He will do __________to save her.
5. There are a lot of carpets here. You can choose _________ colour you need.
6. They told us ________they wanted and there isn't __________ else to say.
7. He seemed to know ____________about music.
8. She doesn't know ____________ about this gossip.
9. We know ____________ person in this club.
10. ____________knows him as a very talented writer.

**Exercise 37. Translate the following sentences into English.**

1. Чи бачив хто-небудь дітей?
2. Ми не можемо ніде знайти цю книгу.
3. Там хтось ходить на горі.
4. Є що-небудь поїсти в холодильнику?
5. Щось велике лежало на столі.
6. Я десь поклала олівець і не можу знайти.
7. Хтось ходив по садку і співав пісеньку.
8. Ви бачили що-небудь цікаве на виставці?
9. Покличте кого-небудь, щоб допоміг нам.
10. Чи є у тебе щось цікаве почитати?

**Exercise 38. Fill in the gaps with *none, nobody,* and *nothing.***

1. _______ of us will go there. It's not the place we should go.
2. ________ has happened. Don't worry
3. It was too dark outside and we could see ____________
4. He found two copies but _____________of them was correct.
5. Kate had watched _________of the two films I told her to watch.
6. There was ________in the hall when we entered.
7. He will buy ________today because it is Sunday and the shops are closed.
8. There was __________at the counter.
9. You can see ________out of the window. It is snowing heavily.
10. ________of them is rigid.

**Exercise 39. Supply necessary indefinite pronouns.**

1. There is _______ in the clothes basket. It is empty.
2. I've tried phoning but every time I tried there was __________ in.
3. I have prepared __________ for dinner which you will like very much.
4. Would you like __________ to start with before the main meal?
5. He sat at the table but didn't have __________ to eat.
6. You can do __________. I don't really care.
7. I met __________ you know last night. She told me she had missed you very much.
8. That's a very easy job. __________ can do it.

9. Did you turn the oven off? I think I can smell __________ burning.
10. __________ offered help. They probably didn't have time.
11. __________ arrived in good time and the meeting started promptly at 3:30.
12. When the show finished there was complete silence. __________ clapped.
13. __________ likes being poor.

## THE PRESENT SIMPLE TENSE

**Exercise 40. Write the verbs in the third person singular.**

1. They pass. He _________.
2. I carry. She ___________.
3. We watch. She ________.
4. I dry. He _____________.
5. We call. He ___________.
6. They go. She ___________.
7. We play. It _____________.
8. They reach. He __________.

**Exercise 42. Choose the correct option:**

1. Doctors always (examine /examines) patients.
2. He often (suffer / suffers) from the splitting headache.
3. Architect (design / designs) buildings.
4. This lawyer always (consult / consults) our family.
5. Alice (visits / visit) her family doctor regularly.
6. Students often (decorates /decorate) the hall for parties.
7. They (plays /play) volleyball every Saturday in the university gym.

**Exercise 43 Put verb in brackets in the Present Simple:**

1. Students of the first year _______ (to study) general subjects.
2. Training of a pharmacist ______ (to include) many subjects common to the medical curriculum.
3. Chemistry _____ (to deal) with the properties of a substance.
4. Our university library _____ (to have) many books on medicine.
5. They _______(not/ to attend) classes regularly.
6. Physician ______ (to treat) people for different diseases.
7. Dentists say that sweets ____ ( to spoil) our teeth.
8. Higher medical institutions of our country ______(to train) pharmacists and doctors.
9. Students ______ (to have) practical classes four times a week.
10. She ________(to research) physical and medical properties of the new medicines.

**Exercise 44 Read this part of a book review. Put verbs in brackets in the Present Simple tense and underline them. Circle the adverbs of frequency.**

**COME DOWN!**

*Dr. Roads*

In today's fast-paced world, we never __________(to escape) stress. Stress always __________ (to affect) us psychologically, but according to Dr. Roads, author of the new bestseller, *Calm Down!*, it also _________ (to affect) us physically. For example stress ________ (to cause) high blood pressure. Doctors often ________ (to prescribe) medication for stress-related illnesses. Medicine usually _______ (to lower) a patient's blood pressure. But, Dr. Roads _______ (to claim), "You don't always need pills. Relaxation exercises ______ (to be) sometimes as effective as pills. For example, breathing exercises both _______ (to relax) you and __________ (to lower) your blood pressure. It only ______ (to take) a few minutes!"

**Exercise 45 Put the time expressions in the correct order.**

1. Tracy is a hard-working student. (always)
2. Bob works long in the Chemistry Lab. (usually)
3. Students work in the library. (sometimes)
4. She is late. (never)
5. Students take practical classes. (often)
6. The faculty trains students from different countries of the world. (always)
7. Medical students have practical training at the hospital. (usually)
8. The internship lasts longer than a year. (sometimes)

**Exercise 46. Put the verb ‘to be’ in Present Simple.**

1. Her mother … a doctor.
2. This … my house.
3. … they at school? – No, they … not. They … in the yard.
4. My friend … an engineer. He … at work.
5. These … his newspapers.
6. You … so cute.
7. She …my sister.
8. Where … your brother? – He … at home.
9. Whose book … this? – This book … his.
10. These … my toys. They … new.

**Exercise 47. Put the verbs in brackets in Present Simple. Make each sentence negative and interrogative.**

1. He … in Australia. (to live)
2. Samanta Harry … here. (to work)
3. You never … your work. (to finish)
4. We … a lot of tea. (to drink)
5. Alice … sweets. (to love)
6. She ... (to eat) pizza very often.
7. I ... (to like) traditional music.
8. They ... (to play) football in the park every weekend.
9. Our teacher always ... (to give) us a lot of homework.
10. He … (to wash) his car every Saturday.

**Exercise 48. Put the verb in brackets in the Present Continuous form. Make each sentence negative and interrogative.**

1. Please be quiet. I … (try) to read my book.
2. I … (use) the computer at the moment so you can’t use it.
3. Mary is ill so Sue … (teach) her 1essons today.
4. Excuse me, I … (look) for a hotel. Is there one near here?
5. We …(wait) for our friends.
6. Jack, you are very careless. You … (always/forget) to do your homework!
7. The cost of living … (rise) very fast. Every year things are more expensive.
8. I … (clean) my shoes now.
9. They … (wear) shorts today. It's so hot today.
10. The neighbours are so noisy! They … (argue) 1oudly.

**Exercise 49. Use the following time expressions <u>usually, never, sometimes, always, seldom, often, rarely</u> in the sentences below.**

1. The doctor is angry when patients are late.
2. Nelson is on time for his date.
3. The doctor’s advice is useful.
4. His blood pressure is high.
5. He is in poor health.
6. Her reports are informative.

7. The pharmaceutical students have practical training in the drug's store.
8. Nurses look after the patients.
9. Dr. Graham have his dinner in the hospital canteen.
10. Our district doctor is on a sick-leave.

**Exercise 50. Put the correct form of the verb to be.**

1. It ____ necessary to consult the doctor.
2. We ____ proud of our country.
3. Students _____ at the lab now.
4. The emergency department ____ on the first floor.
5. Larry's parents _______ doctors.
6. They ______ partners.
7. The patient _____ in the examination room.
8. Cytology _____ the study of the cells.
9. The results _______ surprising.
10. Angina pectoris ______ a disease of the heart.

## PRESENT CONTINUOUS

**Exercise 51. Put the verbs in brackets into the Present Simple or the Present Progressive tense.**

1. ***A:*** _________________ (you /to do) anything interesting this weekend?
***B:*** No, I _______________ (to study) for my Anatomy exam.
2. ***A:*** Why _______________(you /to be) in such a rush?
***B:*** Because my train _________________ (to leave) in ten minutes.
3. ***A:*** What ________________ (James / to do)?
***B:*** He ________________ (to work) at the Natural History Museum in the city centre.
4. ***A:*** ___________________ (you / to like) your flat?
***B:*** Not really. Actually, I _____________ (to look) for a new one at the moment.
5. ***A:*** Nina __________ (to look) nervous.
***B:*** She is. She ___________( to see) the dentist this afternoon.
6. ***A:*** _____________ (he /to want) to go to the theatre this evening?
***B:*** He can't. He ___________ (to have) an important business appointment.
7. ***A:*** Why __________________ (Ann /not/ to come) to work these days? Is she ill?
***B***: No, she's on leave. She ________________ (to get) married next week.
8. A: How much _______________________ (the brain / to weigh)?
**B**: About 2% of your

**Exercise 52. Put the verb into the correct form, Present Continuous or Present Simple.**

1. I … (not/belong) to this particu1ar government committee.
2. Hurry! The bus … (come). I … (not/want) to miss it.
3. Gregory is a vegetarian. He … (not/eat) meat.
4. I … (1ook) for the manager. I can't find him anywhere.
5. We are successful because we … (take) the time to ta1k to our customers.
6. John … (deal) with all the enquiries about sales.
7. At the moment we … (make) a training video for Siemens.
8. … (you/know) what Mr Briceson … (do)? He is not in his office.
9. I … (apply) for a job in the sales department, but I don't know if I will be successful. It … (depend) on whether or not they have any vacancies.
10. Unemployment … (fa1l) and is now down to 5.6%.
11. Jane is doing some research in the library. She needs it for a book she … (write).
12. While Anna is away on holidays, Matt … (work) in her office.

13. He … (teach) French and German at University and … (learn) Greek.

14. There … (be) two flights to Honduras this afternoon. The British Airways flight … (1eave) at 13:00 and … (arrive) at 22:00.

15. Inflation … (rise) at a rate of 2% per annum.

**Exercise 53. Put the verb in brackets into the Present Simple or the Present Continuous.**

1. She a1ways … (remember) my birthday.
2. Mr Brown … (work) in a supermarket.
3. I … (work) in this factory until I find a better job.
4. Look! It … (snow).
5. Can you hear those girls? What … (they/ta1k) about?
6. … (you/know) Helen?
7. We … (never/go) to work by tube. It is too busy.
8. When I'm in Paris I … (usually/stay) in the Hotel du Pont, but this time I … (stay) in the more expensive Hotel Notre Dame.
9. Ruth … (be) a vegetarian. She … (not/eat) meat or fish.
10. My father … (be) an engineer, but he … (not/work) right now.
11. … (you/believe) in ghosts?
12. My parents … (live) in Sydney. Where … (your parents/1ive)?
13. We … (own) two cars, an estate car and a sports car.
14. Can you drive? No, but I … (learn) at the moment.
15. Look! That woman … (try) to steal that man's wallet.
16. The River Nile … (f1ow) into the Mediterranean.
17. … (you/like) Bon Jovi?
18. I … (get) thirsty. Let's get something to drink.
19. Those f1owers … (smell) lovely. What are they?
20. Jane … (repair) her bike. She … (know) exactly what to do.

**Exercise 54. Open the brackets putting the verb in the Present Simple or Present Continuous Tense:**

1. Look at Philip. He …(*to cross*) the street.
2. The bus usually …(*to stop*) here.
3. She …(*to watch*) a lot of TV every night.
4. Alex is busy. He … (*to study*) for a test.
5. Today Frank …(*to work*) late.
6. They always …(*to have dinner*) at two o'clock in the afternoon.
7. He never …(*to rest*) at this time.
8. Where … (*to be*) Helen? – She …(*to listen*) to music upstairs.
9. They … (*to be*) at work now.
10. Tom …(*to need*) a new computer.

**Exercise 55. Put all possible questions to the following sentences.**

1. He goes to school every day.
2. My sister works here.
3. She is reading at the moment.
4. We rest every weekend.
5. He is preparing for his exams in the library.
6. I have a very good friend.
7. Her daughter is playing chess at the moment.
8. They usually invite friends every Sunday.
9. You are listening to great music now.
10. We are meeting on Monday evening.

**Exercise 56. Translate into English.**

1. Мій друг живе в Лондоні.
2. Ми любимо класичну музику.

3. Зараз його друзі грають у футбол.
4. Скільки часу займає ця подорож?
5. Мої батьки приїжджають в наступну суботу.
6. Перший екзамен ми здаємо 25 травня.
7. Ми йдемо в театр на наступному тижні.
8. Він досі працює над своєю доповіддю.
9. Я вважаю, що ми повинні бути ввічливими.
10. Зараз все залежить від тебе.
11. Моя мама зараз поливає квіти.
12. Що ви тут робите?
13. Кожен день вона повертається з роботи, готує обід та відпочиває.
14.Давайте підемо в кіно. Я думаю, що фільм цікавий.
15.Діти зараз в дворі? – Так, вони там граються зараз.

**Exercise 57. Complete the following sentences using the Present Simple or Present Progressive:**

1.Mr. Bredford ______________________________________________now.
2. Douglas ____________________________________________ at the moment.
3. Doctors ____________________________________________ every morning.
4. Surgeon ____________________________________________________ now.
5. Look! They _____________________________________________________.
6. Scientists ________________________________________________ this year.
7. Students usually _________________________________________________.
8. Jill ________________________________________________________ today.
9. Our graduates always ______________________________________________.
10. Alexandra ___________________________________________ every week.

## THE PRESENT PERFECT TENSE

**Exercise 58. Fill in blank spaces with correct form of the given verbs (Present Perfect).**
***take / work / find / see / speak / know / begin / do / learn /eat / have / write / give / live / buy / be***

1. I met Barbara when we were in elementary school. We _______________ each other for over twenty years.
2. We __________________ many new words since we started this course.
3. That's a wonderful movie. I ____________________ it three times.
4. Mr. and Mrs. Tonner _____________________ married for 10 years.
5. You are late! The class ________________ already __________________.
6. Robert is my neighbor. He ___________________ next door to me for five years.
7. Mary ____________________ several letters to her parents since she left home.
8. We _____________________ in that restaurant several times.
9. Our teacher _____________________ us a lot of help with the homework assignment.
10. She ______________________ to her landlord many times about the broken window.
11. We have a new camera. We ____________ some beautiful pictures of the grandchildren.
12. They ____________________ all their homework already.
13. Mrs. Baxter _________________________ all her groceries for the week.
14.Tommy ______________________ a bad cold for two weeks.
15. Frank ______________________ for that company for many years.
16. After three months of looking, she __________________ a beautiful apartment to rent.

**Exercise 59. Put the verbs in Present Perfect. Put each sentence in negative and interrogative forms.**

1. They …. a cold. (have)
2. She … up at seven. (get up)
3. We … breakfast at eight. (have)
4. Peter … to school. (go)

5. Anna … home at two. (get)
6. He … an ice cream. (want)
7. I … peppermint. (hate)
8. Kelly … TV. (watch)
9. She … her homework. (do)
10. Our teacher … in Oxford Street. (live)
11. Eric and Tom … blue shirts. (wear)
12. My sister … a song. (sing)
13. My mum … spaghetti. (cook)
14. Mr Black … in his office. (work)
15. The girls often … a book. (read)

**Exercise 60. Complete the sentences using the present perfect and add <u>since</u> or <u>for</u>.**

1. Maria ________________ (learn) English ___________ two years.
2. I ________________ (write) letters ____________ 8:00.
3. Robert and Jane ________________ (travel) around Europe ___________ five weeks.
4. We ________________ (go) to Ireland for our holidays ___________ 1968.
5. It ________________ (rain) ___________ this morning.
6. Anne ________________ (look) for a new job ___________ a long time.
7. Mark ________________ (sell) computers ___________ he started his job with Olivetti.
8. We ________________ (wait) for the bus ___________ twenty-five minutes.
9. She ________________ (play) piano ___________ she was eight.
10. They ________________ (watch) TV ___________ hours.

## THE PAST SIMPLE

**Exercise 61. Open the brackets putting the verb in the Past Simple Tense.**

1. Yesterday she ________________(to try) to find her key.
2. They _________ (to be) to Paris last month.
3. We ______________(not to have) the test two days ago.
4. When ______ you ________(to get up) yesterday?
5. Mary _________ (to write) a letter to her friend on Wednesday.
6. He ____________(not to call) me at 7.
7. They __________(to hear) the news yesterday.
8. We _________(not to drink) tea, we _________(to have) coffee.
9. My friend __________(to leave) the town two months ago.
10. The family _________(to stay) in that hotel last summer.

**Exercise 62. Complete the sentences with the Past Simple of the verbs in parentheses:**

1) They ______________________ (watch) TV last night.
2) Priscila ______________________ (talk) to her friends all day.
3) I _____________________ (have) a terrible headache yesterday.
4) Bob _______________________ (come) home from school late.
5) They ______________________ (arrive) late and ________________ (miss) the bus.
6) She ______________________ (study) hard and ____________ (pass) the exam.
7) He ______________________ (call) the office to tell them he was sick.
8) I _____________________ (speak) to the director as he was leaving the room.
9) Dr. Johnson ________________________ (get up) early this morning.
10) Mary _______________________ (do) her homework and ____________ (go) to school.
11) Chris ______________________ (find) a ten-dollar bill.
12) The dog ________________________ (follow) us down the road.
13) Those students ______________________ (work) hard last semester.
14) Kelly ____________________ (stop) at the corner and ____________________ (call) us.
15) I ____________________ (try) to talk to Helen last night.

**Exercise 63. Complete the following text with verbs from the box in their past form:**

| |
|---|
| ***say – drink – go – send – speak – get – forget – eat – hear - buy – can - tell – know – put – be(x5) – drive*** |

Last weekend my boyfriend and I ____________ to a very nice party. We ____________ a mysterious invitation to a party in our mailbox but we____________ (not) who ____________ it; anyway, we decided to go. John, my boyfriend, ____________ a very big present and____________ it in our car; then we ____________ for two hours before coming to a very big house. It ____________ a very elegant five-story house but all the lights ____________ off and there was no noise either. We____________ very confused and a little scared. I ____________ John to go back home, but he insisted on staying. When we knocked on the door, I realized it____________ open. I ____________ a little noise and when we walked in the house most of my friends and family __________: "HAPPY BIRTHDAY SUSAN!" It was a surprise party for me! We____________ delicious food and ____________ lots of wine and beer. I ____________ with all my beloved ones all night long and _____________ (not) believe how lucky I ________ - they __________________ (not) my birthday, they just celebrated it some days later to surprise me!

**Exercise 64. Complete the interview.**

A: When .................... you eighteen years old?
B: I .................. eighteen years old in 2016.
A: And when ......................... you born?
B: I ...................... born on 30 June.
A: .................. your birthday party on the same day?
B: No, it ...................... . It .................... a week later.
A: Why ..................... your birthday party on the same day?
B: I have a twin brother and he .................... at home. He ............... in France.
A: ............... you and your brother born at the same time?
B: No, we ....................... . I ...................... born one hour after him.
A: .................. your parents happy to have twins?
B: Yes, they ......................... . But our grandma ........................ She ................. shocked.

**Exercise 65. Complete the sentences with verbs in Present Perfect or Past Simple.**

1. - …………………(you/see) any good films lately? Yes, actually, I ………… (see) a great movie last Saturday afternoon.
2. - How long …………. (Sonia/work) as a lawyer? She ………… (begin) two months ago.
3. - ……………...(you/enjoy) your stay in Spain so far? Very much, but I ……….. (not like) the food at all. It ……………… (cook) with a lot of oil.
4. - My sister's computer ……….. (stop) working this morning.
5. - Emily …………… (leave) her job at the hospital because she …............ (want) to travel round the world.
6. - Lucas …………. (be) born in France but his parents ……..…. (take) him to Germany when he was 5 years old.
7. - Why ………………… (Patrick/decide) to sell his car? He …………… (spend) a lot of money on it and so he wants to get rid of it.
8. - What ……………….. (the kids/eat) for lunch today? They …………. (have) lunch at school, so I don't know.
9. - Martha ……….. (arrive) home very tired yesterday. She ….. (go) to bed straight away.
10. - The firemen ……………… (manage) to put out the fire pretty fast.
11. - Last year his father …………….. (threaten) Paul to punish him if he failed any exams.
12. -The thief …………………….. (admit) having stolen the money from the safe.
13. -My brother ……………. (live) in Canada for ten years. He is visiting me for Christmas.
14. Helen ………….. (buy) a new printer but it ……………… (not be) very expensive.
15. -I …………. (leave) my calculator on the desk but someone …………. (take) it.
16. -The Spice Girls ……………. (bring) out their first record in 1996.
17. -Lucy's baby ………………. (get) ill and she …………. (phone) the doctor last night.

18. -Steve …………...... (not go) hunting since last winter.
19. -I …………….. (meet) a famous writer last week in a London library.
20. -Brian and his friend Laura ……………….. (walk) around the streets of the city.

## THE PAST CONTINUOUS

**Exercise 66. Make the Past Continuous (choose positive, negative or question):**

1. (they / take the exam?) ______________________________________________
2. (when / he / work there?) ____________________________________________
3. (you / make dinner?) _________________________________________________
4. (they / drink coffee when you arrived?) __________________________________
5. (when / we / sleep?) __________________________________________________
6. (they / study last night) _______________________________________________
7. (we / talk when the accident happened) __________________________________
8. (he / not / exercise enough) ____________________________________________
9. (I / talk too much?) _________________________________________________
10. (it / not / snow) ____________________________________________________

**Exercise 67. Complete the sentences with the Past Continuous form.**

1. I ______________________ (run) when you saw me because I was late.
2. They ______________________ (wait) for a bus when the car crashed.
3. Gabi and Laura ______________________ (dance) at 8pm.
4. Tomek ______________________ (not / eat) a sandwich when Ben fell into the river.
5. What __________________ Carol and Jack _________________ (do) when Pedro phoned?
6. ______________________ Sally ______________________ (take) a photo when I phoned?
7. Pedro and Tomek ______________________ (not / laugh) when Ben fell in the river.
8. We _____ ________ (to go) to the mall last night at 8 o’clock.
9. She _____ ________ (to talk) to the police officer last week when I met her.
10. I _____ ________ (to buy) a new bicycle when you called me.

**Exercise 68. Fill in the correct form of the past tense.**

1. My friend Harry ____ off the ladder while he ___ the ceiling of his room. (fall, paint)
2. We ___ the house in 2003. At that time it ___ £ 150,000. (buy, cost)
3. Dad ____ interested in buying a new car. (not be)
4. My sister ___ for me at the airport terminal when I ____. (wait, arrive)
5. A few nights ago, I ____ a book when suddenly I ____ a noise outside. A few teenagers ____ loud music. (read, hear, play)
6. The fire ___ when the first firefighters __ at the scene. (still burn, arrive)
7. My brother _ for a job when he __ across an interesting ad in the newspaper. (look, come)
8. I ___ someone call my name. I ___ around and __ my dad standing at the back of the queue. I __ so surprised. (hear, turn, saw, be)
9. My sister ___ a bright summer dress when I ___ her at the performance. (wear, see)
10. I ___ preparing dinner at 4.pm and I __ still at it when my wife _ home. (start, be, come)
11. Our housekeeper ___ the vase. As she ___ up the pieces, she ___ her middle finger. (break, pick, cut)
12. We suddenly ___ that we ___ in the wrong direction. (realize, drive)
13. She ____ a great skier when she was young. (be)
14. I ___ an old friend in town while I ___ the shopping. (meet, do)
15. While the children ___ with others my husband and I ___ to have a cup of coffee. (play, decide)

16. Magellan ___ around the world for the first time 500 years ago. (sail)

17. I ___ my dog for a walk in the park when suddenly another dog ___ him. (take, attack)

18. When I ___ back from town everyone was at home. Mum ____ homework. Dad __the car and my sister Julia ___ on her school project. (come, correct, wash, work)

19. We ___ (choose) the flowers when we __ (see) Nick. He ___ (speak) to somebody near the metro.

20. While Maria ___ (dust) the furniture her brother ___ (vacuum) the carpets.

**Exercise 69. Put the verbs in brackets into the correct form.**

1. … you … (to wash) the clothes at 4 o'clock yesterday? – No, I… . I … (to tidy) my room at that time.

2. … Lucy … (to do) the shopping when you met her? – Yes, she …

3. … they … (to translate) the text in the afternoon? – No, they … They … (to prepare) for the Math test.

4. … Alison and Rita …(to sit) in a café at three o'clock? – Yes, they … They … (to eat) ice cream.

5. … Steve … (to play) computer games all the evening? – No, he … He … (to do) his homework.

6. … Barbara … (to sunbathe) in the morning yesterday? – Yes, she …

7. … the children … (to help) their grandparents yesterday? – Yes, they … They … (to gather) fruit in the garden.

8. … you …(to sleep) at four o'clock yesterday? – Yes, I …

9. … Phil … (to speak) to the receptionist when you came into the hall of the hotel? – No, he … He … (to have) breakfast in the café.

10. … you (to pack) your luggage when the taxi arrived? – No, I …

**Exercise 70. Put the verbs in the brackets into the Past Simple or Continuous.**

1. George ___ off the ladder while he ____ the ceiling. (fall, paint)
2. Last night I ___ in bed when I suddenly __ a scream. (read, hear)
3. __ TV when I __ you? (you watch, phone)
4. Ann ___ for me when I __ . (wait, arrive)
5. Maisie ___ up the kitchen when John ___ her to marry him. (clean, ask)
6. The house ___ £ 150,000 in 2003. (cost)
7. The fire _____ at six in the morning. (still burn)
8. My brother ____ a new job a week ago (get).
9. Columbus ____ America over 500 years ago (discover)
10. She ____ not interested in the book because she ______________ it (be ,not understand)
11. ____ at school yesterday? (you be)
12. We ___ in a house near the sea last summer (live)
13. She ___ the piano very well when she ____ young (can play, be)
14. She ____ the office very early last night (leave).
15. I ____ a friend while I __ the shopping (meet, do)

## THE PAST PERFECT

**Exercise 71. Fill in the blanks with the Past Simple or Past Perfect of the verbs in brackets:**

1. Dave finally ____(reject) the promotion that his manager _____ (offer) him due to his hard work.

2. I ______ (never/ travel) abroad until I _____ (move) to Germany.

3. As soon as Patrick _____ (get) the telegram, he _____ (know) what _____ (happen).

4. Once the party ______ (finish) everybody ______ (leave) except for Sue that ____ (help) us to tidy the house.

5. Carl ______ (not/ tell) me about our economic problems until everything ______ (be settled).

6. Alice finally ______ (buy) her wedding dress after she ______ (try on) at least twenty of them. What a bore!

7. Carol _______ (resit) her exam in September since she ______ (fail) it in June.

8. Lewis _____ (not/ change) as much as his wife! I ______ (not/ see) them for five years.

9. When Tina's mother _____ (die), she ____ (inherit) a fortune and a fabulous mansion in Los Angeles.

10. Kim _____ (not/ get) the job because she ____ (not/ prepare) herself for the interview.

11. When I _____ (wake up) this morning, everything ____ (be) white. Definitely, it ___ (snow) during the night.

12. Pam ____ (never/ forget) that they _____ (not/ invite) her to their wedding reception.

13. Our daughter _____ (send) an e-mail as soon as she ____ (arrive) in London. She _____ (promise) to phone us, but she _______ (not).

14. Dick ____ (recognise) that he _____ (not/ work) as hard as his teacher _______ (expect).

15. Brian ____ (understand) that he _____ (make) some mistakes in her test paper.

**Exercise 72. Put the verbs in the brackets into the Past Simple, Past Continuous or Past Perfect tense.**

1. When the manager ____ (to come up) to the boss, he ____ (to speak) to somebody on the phone.

2. Jane ___ (to pay) for the dress she ___ (to choose) some minutes before.

3. Jim ___ (to read) the article and ____ *(to return)* me the magazine.

4. It _____ *(still to rain)* when we ___ *(to get)* home yesterday.

5. Dave ____ *(to cheek)* the mail before he ___ *(to turn off)* his computer.

6. While the professor ___ *(to give)* a lecture he ___ *(to realize)* that his wife ___ *(not to remind)* him about one important appointment.

7. While Mrs Simpson ___ *(to cook)* dinner she ___ *(to understand)* that she ___ *(not to buy)* potatoes.

8. When Laura ___ *(to come)* to the hospital, all the doctors ___ *(to discuss)* the medicine for cancer which the scientists ___ *(to invent)* some days before.

9. Sam ___ *(to get)* to the airport after the plane ... *(to fly up)*.

10. When little Betty ___ *(to play)* with her toys yesterday evening she ___ *(to find)* the key her mother ___ *(to lose)* a week before.

**Exercise 73. Fill in the blanks with the Past Simple or Past Perfect of the verbs in brackets:**

1. …………. he …………….. (know) her for a long time before they ………………… (get) married?

2. He ………………………………. (drive) down the hotel where the ………………. (spend) their honeymoon years ago.

3. When we ………………………… (get) to the station the train ……………………... (already / leave).

4. He ………………………… (sit) at a table by the window where he ……………….. (have) a meal with Jane.

5. Why …. he …… (not / ask) her to wait and think again before she ….. (leave) Paris.
6. He was wondering why he ……………………………… (let) her leave so easily.
7. He knew he …………………………… (earn) that money with a great difficulty.
8. After they ……… (go), he ……….. (sit) down and ……………… (light) a cigarette.
9. He ………….. (have to) go to work by bus because his car ………… (break) down.
10. He …………………………… (angry) before he …………………… (hear) my offer.

**Exercise 74. Combine the following sentences by using AFTER / BEFORE:**

1. My mother took her umbrella. She went out.
………………………………………………………………………………………….
2. Frank called me. I went to school.
………………………………………………………………………………………….
3. I washed the dishes. I watched TV.
…………………………………………………………………………………………
4. She washed her hands. She had lunch.
…………………………………………………………………………………………
5. The boys bought a ball. They played football.
…………………………………………………………………………………………
6. My mother made a cake. The guests came.
…………………………………………………………………………………………
7. He put sugar in his tea. He drank it.
…………………………………………………………………………………………
8. I got up. I had breakfast.
…………………………………………………………………………………………
9. The children ran away. They broke the window.
………………………………………………………………………………………..
10. I fastened my seat belt. The plane took off.
………………………………………………………………………………………..

**Exercise 75. Translate into English.**

1) Учора до шостої хлопці зіграли дві партії в шахи. 2) Вона не переглянула всі документи до кінця робочого дня вчора. 3) Скільки повідомлень ви отримали до минулого понеділка? — Я отримав сім повідомлень. 4) Перед тим як вона вийшла з дому, вона написала записку братові. 5) Коли ми приїхали до дідуся та бабусі, вони збирали яблука в саду. 6) Після того як закінчились уроки, вони пішли до парку. 7) Коли Бен ішов додому, він пригадав, що не купив молока для кота. 8) Коли ми слухали його розповідь, я пригадав, що вже чув щось подібне. 9) Олена побачила свою подругу після того, як автобус зупинився. 10) Том сказав, що він уже відремонтував свою машину.

## THE PRESENT PERFECT CONTINUOUS
## THE PAST PERFECT CONTINUOUS

**Exercise 76. Respond to the following situations using Present Perfect Continuous.**

1. Why are you so tired? Because I ...................................... the wheels on my car. (replace)
2. Your French is perfect. Really? I .......................................... French for ten years. (learn)
3. Look at Jane. She's so nervous. No wonder. She .................................................... for her boyfriend for ages. (wait)
4. Bill is sunburnt. Yes, he really is. He .................................. since the morning. (sunbathe)
5. Your parents look relaxed. They ................................................... all the weekend. (relax)
6. All the footballers are so wet. They .............................................................. in the rain since the match started. (play)
7. Have you talked to Richard yet? Not yet. But I ........................................................ to phone him since you told me. (try)
8. Is Grace your neighbour? Yes, she is. She .................... next door for six years now. (live)
9. Why are Patt and Matt so dirty? They ............................................ their bedroom. (paint)

10. Shall I wake Doris up? Yes, please. She ........................................... all day long. (sleep)

**Exercise 77. Make Present Perfect Continuous questions.**

1. How long ..................................................................... for me? (you | wait)
2. What ........................................................... since he returned? (John | do)
3. Why ........................................................................... meat lately? (you | not eat)
4. There's so much snow on the road. .................................................... all night? (it | snow)
5. Why ........................................................... for such a long time? (Sam and Mary | argue)
6.................................................................... my shampoo? There's not much left. (you | use)
7. How long ......................................................................... glasses? (Jill | not wear)
8. .............................................................. since you decided to take the exam? (you | revise)
9. Where ................................................................................ lately? (your dad | work)
10. Your hands are covered with chocolate. ........................................... a cake? (you | make)

**Exercise 78. Complete the sentences with the correct form of the verbs in brackets (Present Perfect or Present Perfect Continuous).**

1. At last! I ____________ (solve) the problem.
2. What _______________ recently? (you / do) Anything interesting?
3. My brother _____________ (buy) a new motorbike. It looks great.
4. ______________ (you / swim)? Your hair looks wet.
5. Oh, There you are! I _____________ (look) for you everywhere.
6. Sorry we are late. How long ________________ (you / wait)?
7. I _____________ (know) Peter for a long time.
8. My friends ______________ (run) for two hours already.
9. I _____________ (never / understand) Maths and Physics.
10. The children are tired because they ____________ (play) all day.
11. Susan ______________ (never / believe) in ghosts and fairies.
12. I ________________ (write) emails all day.
13. John ______________ (never / see) this film before.
14. What on earth ____________ (you / do)? You're covered in mud.
15. ________________ (you / ever / see) Altamira Cave? I hear it's incredibly beautiful.
16. How long _________________ (he / learn) English?
17. I _____________ (just / speak) to my cousins. They told me the news.
18. I'm sorry. Monica is not here.. She ______________ (go) out.
19. We're really tired because we ____________ (train) for the marathon since eight o'clock.
20. ________________ (you / finish) doing your homework yet?
21. The students _________ (revise) for their Spanish exam for two hours.
22. Peter, why are you sweating? Because I __________ (hoover) the carpets.
23. Is the lawn finished? Yes, Gonzalo _____________ (cut) the grass.
24. It's still raining. It _____________ (rain) for hours.
25. How much money ______________ (you / spend) this week.

**Exercise 79. Fill in the spaces with the correct form of the verb in Present Perfect or Present Perfect Continuous.**

1) We (already, bake) ________ _________ _________ the cake. Now, we just have to decorate it with icing. Would you like to help?

2) Have you ever been to Italy? I (see) ________ ________ pictures of the town of Assisi. Some day, I would like to travel there to see its beautiful churches.

3) The voters (elect) ________ _________ a new governor. She (make) ________ ________ __________ her acceptance speech for the past thirty minutes. I hope she will finish soon!

4) The package I sent to Pablo (not, arrive) ________ ________ __________ yet. He (call) ________ ________ __________ the Post Office every day. I don't know what happened to it.

5) The fishermen (not, catch) _______ _______ _________ many fish today. A strong wind (blow) _______ _______ _________ all day, and they are having trouble with their nets.

6) (Edward, receive) _______ ________ ________ the money yet? I sent it to him last week.

7) Mahmoud and Rickie are dirty. They (play) _______ _______ _________ outside all day. It is time for them to come in and take a bath.

8) (You, hear) _______ _______ ________ the news? There was a terrible earthquake in Haiti! The residents need a lot of help.

9) Igor (want) _______ ________ to visit Paris for years. He (save) _______ _______ _________ his money for a plane ticket. He (almost, save) _______ _______ ________ enough.

10) The roses (not, bloom) _______ _______ _______ _________ much lately. We (not, water) _______ _______ _______ _________ them enough. The soil is getting dry.

**Exercise 80. Fill in the following sentences by using Past Perfect Continuous Tense.**

1. We ………………………………..… (play) football for half an hour when it started to rain.
2. I ……………………….………. (study) English for a short time when the electricity went off.
3. She …………………………………………… (do) her homework before you came in.
4. His knees and hands were very dirty. He ………………………….. (crawl) in the garden.
5. I …………………………………………… (drive) the car for five years when I sold it.
6. We were very tired. We ………………………………… (travel) for about sixteen hours.
7. They were out of breath. They …………………………..……… (run) for a long time.
8. He ………………..…………… (live) in London for ten years when he had an accident.
9. He was tired because he ……………..……………………….. (write) letters all morning.
10. He ……………………...……….. (repair) the radio for an hour when you arrived.

**Exercise 81. Make The Past Perfect Continuous or The Past Simple.**

1. I __________ (wait) for hours, so I was really glad when the bus finally _______ (arrive).
2. Why ____________ (be) the baby's face so dirty? He _______________ (eat) chocolate.
3. I ___________ (see) John yesterday, but he __________ (run) so he was too tired to chat.
4. It _______________ (rain) and the pavement _____________ (be) covered with puddles.
5. When I __________________ (arrive), it was clear that she ______________________ (work). There were papers all over the floor and books everywhere.
6. They __________ (study) all day so, when we ___________ (meet), they were exhausted.
7. The boss _________ (talk) to clients on Skype for hours, so she ________ (want) a break.
8. I __________ (drink) coffee all morning. By lunchtime, I _________ (feel) really strange.
9. Lucy ________ (hope) for a new car, so she was delighted when she ________ (get) one.
10. I __________________ (dream) about a holiday in Greece! I couldn't believe it when my husband _________________________ (book) one as a surprise!

**Exercise 82. Make the Past Perfect Continuous Tense in the following sentences.**

1. They _________(scream) the place down for a few hours before their parents came back.
2. They ____________________(use) drugs for a few hours before their parents came back.
3. They ____________________ (play) music at full volume for a few hours before their parents came back.
4. They ________________ (curse) vulgarly for a few hours before their parents came back.
5. They ______________ (devastate) their neighbour's lawn for a few hours before their parents came back.
6. I got a high grade on my essay because I ___________(study) very hard.
7. Jack fall asleep at the computer because he _____________(play) all night long.
8. We were very tired because we ___________________(dance) the whole evening.
9. He had dirt on his hands because he _____________(repair) his bike.
10. The flight was cancelled because it ____________(snow) all night.
11. My clothes were covered in paint because I ______________(paint) my room.

## THE FUTURE SIMPLE
## THE FUTURE CONTINUOUS

**Exercise 83. Put the verbs in brackets into the Future Simple or the Future Continuous.**

1. I want to tour the area today. ________ (you/use) the car?
2. Please don't forget your tie because you ____ (meet) the administrators during your visit.
3. The taxi driver ________(take) you to the Savoy Hotel.
4. A shuttle ________(wait) for you outside the airport building at 8:30 p.m.
5. There's a big sale at Selfridges tomorrow. I'm sure people ________(queue) up the street from early morning.
6. Put on something nice for the party. The photographers ________(take) pictures.
7. You can't stay here if you've decided not to go. We ________(look) for you.
8. It's an acceptable suggestion. I ________(think) it over.
9. The price of petrol has gone up again. People ________(ride) their bicycles soon.
10. I'm sure this statue ________(stand) here in the year 2010.
11. ________ you ________ (join) us at 3.00 p.m.? we ________ (discuss) the new plan
12. Come to the stadium at 4:00 p.m. The world-famous football player ________(sign) the T-shirts.
13. This time tomorrow I ________(fly) across the Pacific.
14. I don't want to call Janet just now. I'm sure she ________(bathe) the baby and she ________ (be able/not) answer the phone.
15. If you need me, you ________(find) me at school. I ________(teach) in pavilion A until the lunch time.
16. The festival begins next Saturday. People ________ (dance) and ________(sing) in the streets all week.
17. I'm sure you ________(pass) your driving test, but I ________(keep) my fingers crossed for you all the same.
18. We ________(not/learn) English this month. Our teacher has left.
19. Our neighbours are having a party tonight. They _______(make) a lot of noise all night as usual.
20. You can use John's computer. He ________(not/work) here anymore.

**Exercise 84. Put the verbs in brackets into Present Simple or Future Simple Tense.**

1. Today after I (get).... out of class, I (go) ............ to a movie with some friends.
2. When you (arrive) ............. in Stockholm, call my friend Gustav. He (show)......... you around the city and help you get situated.
3. A: Do you know what you want to do after you (graduate) .............?
B: After I (receive) .................. my Master's from Georgetown University, I (go) ................ to graduate school at UCSD in San Diego. I (plan).......... to complete a Ph.D. in cognitive science.
4. If it (snow) ............... this weekend, we (go) .................. skiing near Lake Tahoe.
5. Your father (plan) .............. to pick you up after school today at 3:00 o'clock. He (meet).................you across the street near the ice cream shop. If something happens and he cannot be there, I (pick)............. you up instead.
6. If the people of the world (stop, not) .............. cutting down huge stretches of rain forest, we (experience)...............huge changes in the environment during the twenty-first century.
7. If Vera (keep) ............. drinking, she (lose, eventually) .................... her job.
8. I promise you that I (tell, not) ..................... your secret to anybody. Even if somebody (ask)............. me about what happened that day, I (reveal, not) ........ the truth to a single person.
9. She (make) .................. some major changes in her life. She (quit).......................... her job and go back to school. After she (finish) .................. studying, she (get)............ a better paying job and buy a house. She is going to improve her life!
10. Tom (call) ................... when he (arrive) ............. in Madrid. He (stay)........... with you for two or three days until his new apartment (be) ............. available.

**Exercise 85. Put the verbs in brackets into the Future Simple or the Future Continuous.**

1. *Sandra*: Where is Tim going to meet us?

*Marcus*: He (wait) ................ for us when our train arrives. I am sure he (stand) ................ on the platform when we pull into the station.

*Sandra*: And then what?

*Marcus*: We (pick) ................. Michele up at work and go out to dinner.

2. *Ted*: When we get to the party, Jerry (watch) ................ TV, Sam (make)………. ... drinks, Beth (dance) ..................by herself, and Thad (complain) ............... about his day at work.

*Robin*: Maybe, this time they won't be doing the same things.

*Ted*: I am absolutely positive they (do) ...... the same things; they always do the same things.

3. *Florence*: Oh, look at that mountain of dirty dishes! Who (wash) .................all of those?

*Jack*: I promise I (do) ............... them when I get home from work.

*Florence*: Thanks.

*Jack*: When you get home this evening, that mountain will be gone and nice stacks of sparkling clean dishes (sit) ................... in the cabinets.

4. *Doug*: If you need to contact me next week, I (stay) ................. at the Hoffman Hotel.

*Nancy*: I (call) ............... you if there are any problems.

*Doug*: This is the first time I have ever been away from the kids.

*Nancy*: Don't worry, they (be) ................. fine.

5. *Samantha*: Just think, next week at this time, I (lie) ................. on a tropical beach in Maui drinking Mai Tai's and eating pineapple.

*Darren*: While you are luxuriating on the beach, I (stress) ................. out over this marketing project. How are you going to enjoy yourself knowing that I am working so hard.

*Samantha*: I 'll manage somehow.

*Darren*: You're terrible. Can't you take me with you?

*Samantha*: No. But I (send) ................ you a postcard of a beautiful, white-sand beach.

*Darren*: Great, that (make) ................. me feel much better.

**Exercise 86. Put the verbs in brackets into the Present Simple, the Future Simple, the Present Continuous or the Future Continuous.**

1. Right now I am watching T.V. Tomorrow at this time, I (watch) ................... T.V. as well.

2. Tomorrow after school, I (go) ................. to the beach.

3. I am going on a dream vacation to Tahiti. While you (do) ........... paperwork and (talk) ..... to annoying customers on the phone, I (lie) ............. on a sunny, tropical beach. Are you jealous?

4. We (hiding) .................. when Tony (arrives) ................. at his surprise party. As soon as he opens the door, we (jump) ............. out and (scream) ................."Surprise!"

5. We work out at the fitness center everyday after work. If you (come) ...............over while we (work) ............out, we will not be able to let you into the house. Just to be safe, we (leave) ......... a key under the welcome mat so you will not have to wait outside.

6. While you (study) ............... at home, Magda (be) ..............in class.

7. When I (get) ........to the party, Sally and Doug (dance) ........., John (make) .............. drinks, Sue and Frank (discuss) .................. something controversial, and Mary (complain) …………. about something unimportant. They are always doing the same things. They are so predictable.

8. When you (got) ................. off the plane, I (wait) ................ for you.

9. I am sick of rain and bad weather! Hopefully, when we (wake) ................ up tomorrow morning, the sun (shine) ................

10. If you (need) ..... to contact me sometime next week, I (stay) ...... at the Sheraton in San Francisco.

## THE FUTURE PERFECT
## THE FUTURE PERFECTCONTINUOUS

**Exercise 87. Put the verbs in brackets into Future Perfect or Future Perfect Continuous.**

1. Margaret: Do you think everything will be finished when I get back from the store?

Jerry: Don't worry. By the time you get back, I (pick) ................. up the living room and (finish) ............washing the dishes. Everything will be perfect when your parents arrive.

Margaret: I hope so. They (arrive) ............. around 6 o'clock.

Jerry: Everything (be) .............. spotless by the time they get here.

2. Nick: I just have two more courses before I graduate from university. By this time next year, I (graduate) ...............and I will already be looking for a job.

Stacey: Does that scare you? Are you worried about the future?

Nick: Not really. I (go) ……….. to a career counselor and get some advice on how to find a good job.

Stacey: That's a good idea.

Nick: I am also going to do an internship so that when I leave school, I (complete, not, only) ............... over 13 business courses, but I (work, also) .............the real world.

3. Stan: Did you hear that Christine (take) .............. a vacation in South America this winter?

Fred: I can't believe how often she goes abroad. Where exactly does she want to go?

Stan: She (visit) ..............Peru, Bolivia and Ecuador.

Fred: At this rate, she (visit) ............... every country in the world by the time she's 50.

4. Judy: How long have you been in Miami?

Elaine: I have only been here for a couple of weeks.

Judy: How long do you plan on staying?

Elaine: I love Miami, so I (stay) ..............here for an extended period of time. When I go back home, I (be) .......... here for more than three months.

Judy: Wow, that's quite a vacation! You (see, definitely) ............. just about everything there is to see in Miami by then.

5. Jane: I can't believe how late we are! By the time we get to the dinner, everyone (finish) ...... eating.

Jack: It's your own fault. You took way too long in the bathroom.

Jane: I couldn't get my hair to look right.

Jack: Who cares? By the time we get there, everyone (left)....... . Nobody (see, ever) …... your hair.

## SEQUENCE OF TENSES

**Exercise 88. Report the following sentences, using the model**.

***Model**: He said, "I have read this book". He said that he had read that book.*

1. The pupils said, "We study English". 2. The girl said, "I learned French at school". 3. The man said, "I am an engineer". 4. She said, "I'll be at home at seven o'clock". 5. Mary said, "I was here with my parents". 6. The boy said, "I have done my homework". 7. His father said, "I do not speak Spanish". 8. The doctor said, "I'll come again in the morning". 9. He said, "I did not see Helen here". 10. They said, "We had lunch at school". 11. She said, "I have three children. 12. Ann said, "I did not buy anything at this shop". 13. The boy said, "I am not hungry at all". 14. The teacher said, "Nick doesn't know this rule at all". 15. She said, "I didn't recognize him". 16. The boy said, "My name is Paul". 17. The girl said, "I'm doing my homework". 18. He said, "I was here in 1995". 19. She said, "I saw him at five o'clock". 20. The teacher said, "London is the capital of Great Britain". 21. He said, "We finished our work". 22. She said, "He is going to Boston tomorrow". 23. I said, "I was ill yesterday". 24. She said, "I met them last year". 25. He said, "This exercise is very easy".

**Exercise 89. Render the following sentences in the Reported Speech.**

1. "My friend lives in Lindon," said Alec. 2. "You have not done your work well," said the teacher to me. 3. The poor man said to the rich man, "My horse is wild. It can kill your horse." 4.

The rich man said to the judge, "This man's horse has killed my horse." 5. "This man spoke to me on the road," said the woman. 6. "I can't explain this rule to you," said my classmate to me. 7. The teacher said to the class, "We shall discuss this subject tomorrow." 8. The woman said to her son, "I am glad I am here." 9. Mike said, "We have bought these books today." 10. She said to me, "Now I can read your translation," 11. Our teacher said, "Thackeray's novels are very interesting." 12. She said, "You will read this book in the 9th form." 13. Nellie said, "I read 'Jane Eyre' last year." 14. Mary said, "I usually spend my holidays in the south." 15. She said, "I spent my holidays in the Crimea last year." 16. Boris said, "I go to the south every year." 17. He said, "I am going to a rest-home tomorrow." 18. Ann said to us, "They haven't yet come." 19. She said to us, "They arrived in Paris yesterday." 20. I said, "I was in London last year. My friends in London sometimes invite me to spend my holidays with them." 21. Nick said, "I have never been to London. I think I shall go there next year." 22. He said, "I shall not stay with my friends too long." 23. He said to me, "They are staying at the 'Europe' hotel. 24. He said, "They are leaving next Monday." 25. The clerk said to them, "You can leave the key with the maid upstairs."

**Exercise 90. Render the following sentences in the *Direct Speech*.**

1. He said that while crossing the English Channel they had stayed on deck all the time. 2. The woman said she had felt sick while crossing the Channel. 3. She said she was feeling bad that day. 4. Tom said he would go to see the doctor the next day. 5. He told me he was ill. 6. He told me he had fallen ill. 7. They told me that Tom had not come to school the day before. 8. I told my sister that she might catch cold. 9. She told me she had caught cold. 10. The old man told the doctor that he had pain in his right side. 11. He said he had just been examined by a good doctor. 12. He said he would not come to school until Monday. 13. The man said he had spent a month at a health-resort. 14. He said that his health had greatly improved since then.

**Exercise 91. Render the following general questions in Reported Speech.**

***Model: He asked, "Is this your book?" He asked if (whether) it was my book.***

1. She asked, "Do you study phonetics?" 2. He asked, "Do you go in for sports?" 3. He asked, "Will they go to the cinema tonight?" 4. She asked, "Are you tired?" 5. The trainer asked, "Did you like to play volley-ball at school?" 6. The teacher asked, "Do your children usually do their homework?" 7. She asked, "Are you hungry?" 8. She asked, "Has he read the novel?" 9. He asked, "Does she play piano?" 10. We asked, "Do you get up early?" 11. They asked, "Will you go skiing today?" 12. She asked, "Was he busy yesterday?" 13. She asked, "Did you play chess two days ago?" 14. We asked, "Has he returned yet?" 15. They asked, "Does she drink tea for breakfast?" 16. He asked, "Do you speak English?" 17. She asked, "Did he like the concert yesterday?" 18. He asked, "Is this Bond Street?" 19. He asked, "Are these your books?" 20. We asked, "Has the rain stopped?" 21. They asked, "Are we late?" 22. She asked, "Have you been reading long?" 23. He asked, "Is she sleeping?" 24. He asked, "Are you angry with me?" 25. She asked, "Will you do me a favour?"

**Exercise 92. Render the following general questions in the Reported Speech.**

1. I said to Boris, "Does your friend live in London?" 2. I said to the man, "Are you living in a hotel?" 3. Nick said to his friend, "Will you stay at the 'Hilton'?" 4. He said to me, "Do you often go to see your friends?" 5. He said to me, "Will you see your friends before you leave Hamburg?" 6. Mike said to Jane, "Will you come to the railway station to see me off?" 7. She said to me, "Have you sent them a telegram?" 8. She said to me, "Did you send them a telegram yesterday?" 9. I said to Mike, "Have you packed your suitcase?" 10. I said to Kate, "Did anybody meet you at the station?" 11. I said to her, "Can you give me their address?" 12. I asked Tom, "Have you had breakfast?" 13. I asked my sister, "Will you stay at home or go for a walk after dinner?" 14. I said to my mother, "Did anybody come to see me?" 15. I asked my sister, "Will Nick call for you on the way to school?" 16. She said to the young man, "Can you call a taxi for me?" 17. Mary said to Peter, "Have you shown your photo to Dick?" 18. Oleg said to me, "Will you come here tomorrow?" 19. He said to us, "Did you go to the museum this morning?" 20. She asked, "Have you finished your work yet?"

## RENDERING THE ARTICLE

**Rendering the article** is the way in which the article is translated and explained.

### Instruction for rendering the article

1. Read the article carefully.
2. Make up the plan of the article using narrative sentences. Leave blanks after each point for working out the plan in detail.
3. Find the meaning of the key words from the article in the bilingual dictionary.
4. Formulate the main idea of the article in a one sentence.
5. Work out the plan in detail.
6. Read the article again and compare it with your plan. Check up if you haven't missed the essential material.
7. Make up a clean copy according to the plan for rendering the article.

### Plan for rendering the article

1. **The title of the article:**

   The article is headlined ......... . / The headline of the article I've read is ......... .

2. **The author of the article, when and where it was published:**
   a) The author of the article is ......... . / The article is written by ......... .
   b) It was published (printed) in the issue ......... .

3. **The main idea of the article:**
   a) The main idea of the article is ......... .
   b) The article is devoted to (dedicated to / deals with) ......... .
   c) The purpose of the article is to give the reader some information about ......... .
   d)
4. **The content of the article:**
   a) The author starts by telling us about ......... .
   b) The author writes (stresses / thinks / points out / describes) ......... .
   c) The author considers (tackles) the problem of ......... .
   d) The author gives a quotation from ......... .
   e) The article draws the reader's attention to ......... .
   f) The article goes on to say that ......... .
   g)
   h) In conclusion, ......... . / The author comes to the conclusion that ......... .
5. **Your opinion of the article:**
   a) I found the article interesting (of no value / dull / too hard to understand / easy to read / important / exciting / actual / useful.
   b) I recommend my fellow-students to read it because it enriches our knowledge in the field of / it tries to solve the problem of / it raises the question of ......... .

## Sample rendering

Провідний український лабораторний портал / 28 вересня 2012 р.

### Вплив магнітного поля на властивості води

У 1936 році бельгійський інженер Т. І. С. Вермейрен виявив, що при нагріванні води, яка перетнула силові лінії магнітного поля, на теплообмінній поверхні не утворюється накип. З тих самих пір магнітною обробкою води почали займатися майже всі. Так був запущений шалений ажіотаж навколо впливу магнітного поля на властивості води.

Ставлення до магнітної обробки води має полюсний характер. Одні відчайдушно вірять у магічні властивості омагніченої води, інші – скептики – готові знайти найменші недоліки й зовсім не сприймають науково обґрунтованих фактів і навіть називають їх шарлатанством. Але як казав Жан Луї Агасис: «Будь-яке велике відкриття в науці проходить три неминучі стадії. Спершу люди заявляють, що воно суперечить Біблії (О.М. – в нашому випадку в ролі Біблії виступає традиційна наука). Потім вони стверджують, що це давним-давно було відомо. Нарешті, вони кажуть, що ніколи не сумнівалися в його правильності».

Як відомо, вода – одна з найзагадковіших речовин, відомих на сьогодні науці. Існує безліч теорій і гіпотез аномальних властивостей води. На сьогодні немає чіткого науково підтвердженого уявлення про структуру та властивості води. А у випадку магнітного впливу на воду взагалі відбуваються процеси, які традиційна наука пояснити не може. Теорії щодо магнітного впливу можна поділити на колоїдні, йонні, водяні та динамічні.

Прихильники колоїдної теорії стверджують, що магнітне поле, діючи на воду, може руйнувати колоїдні частинки, які в ній присутні. Таким чином, центром кристалізації замість поверхонь труб стають ці частинки, що легко видаляються з потоку у вигляді шламу. Накип на поверхні труб не утворюється. Наявність йонів заліза інтенсифікує появу зародків кристалізації.

Прихильники йонної теорії пов'язують дію магнітного поля з гідратацією йонів. Вплив магнітного поля на воду та її домішки пояснюється поляризаційними явищами та деформацією йонів солей. Гідратація йонів при обробці зменшується, вони зближуються й утворюють кристалічну форму солі. Таким чином, замість твердого накипу у воді з'являється мігруючий тонкодисперсний шлам, який легко видаляється з поверхні трубопроводів.

Прихильники гіпотез водяної теорії припускають, що магнітне поле впливає безпосередньо на структуру асоціатів води. Це може привести до деформації водневих зв'язків або перерозподілу молекул води у тимчасових асоціативних утвореннях, що також тягне за собою зміну фізико-хімічних характеристик процесів, які перебігають у ній.

На сьогодні найбільш популярною є динамічна теорія. Потік в'язкої рідини зводиться, з молекулярно-кінетичної точки зору, до трансляційного руху йонів і молекул рідини в напрямку руху прикладеної сили. Вважають рідину механічною системою, яка складається з незалежних частинок (йонів) та молекул води, що знаходяться в тепловому русі. На заряджені домішки, що рухаються в потоці води під дією магнітного поля, діє сила Лоренца, яка намагається змінити траєкторію руху цих частинок – закручує навколо магнітних ліній. Виникає макроскопічний потік води: усю масу нейтральних молекул води «тягне» одночасно множина низькомолекулярних катіонів та аніонів, причому джерелом енергії слугує енергія електричного поля, а магнітне поле виконує керуючі функції. Таким чином, під дією магнітного поля за рахунок ефекту Холла суттєву роль відіграють електричні поля, викликані електричним зарядом поверхні розділу фаз і сумарним об'ємним зарядом йонів.

Підтвердити або спростувати одну з цих теорій сьогодні неможливо. Але говорити, що це чисте шарлатанство – це не розуміти процесів наукового пізнання.

Олена Можаровська

The headline of the article I have read is “The magnetic field effect on water properties”.

The author of the article is Olena Mozharovska. It was published on the website ”Leading Ukrainian laboratory portal” in the section “Physics” on the 28th of September, 2012.

The article deals with water, one of the most mysterious substances known to science. It also states that there is no clear scientific evidence of structure and properties of water.

The author starts by telling that in 1936 a Belgian engineer T.Y.S. Vermeiren found that by heating water that crossed force lines of the magnetic field there was no boiler scale on the heat – exchange surface. It has been a frenetic rush around the magnetic field on the properties of water since that time. Some believe in the magical properties of magnetic water others – skeptics – are ready to find the smallest faults and do not accept scientifically grounded facts and even called them a fraud.

The author gives a quotation from Jean-Louis Ahasys who says that a great science discovery consists of three stages: first, people say it contradicts the Bible (in this case, Bible serves as traditional science), second, they claim it has been known since early time, finally, they say they have never doubted its correctness. The author points out that there are a lot of theories and hypotheses of water anomalous properties. They can be divided into colloidal, ionic, water and dynamic. Colloidal theory supporters argue that the magnetic field acting on the water can destroy the colloidal particles. Ionic theory supporters link up the magnetic action with the ions hydration. Hypotheses water theories supporters suggest that the magnetic field acts directly on the structure of water associates. The author stresses that at present the dynamic theory is the most popular. Supporters of this theory try to give a detailed explanation of the magnetic field effect on water properties.

In conclusion, the author states that it is impossible to reject one of these theories. But to say that it is fraud means not to understand the processes of scientific knowledge.

I found the article interesting and useful. The facts given there may be of value for students and teachers of Physics. So I recommend my fellow students to read it because it enriches our knowledge in the field of physics.

GLOSSARY

## Module I

**element** *n* [C] an important basic part of something complicated, for example a system or plan. ***Collocations:*** *an important / essential element*; ***e. g.:*** *Our new management system includes two essential elements*.

**investigation** *n* [C] the process of trying to find out all the details or facts about something in order to discover who or what caused it or how it happened; ***investigation of / into; under investigation***

**nuclear physics** *n* [U] scientific study of the nucleus central part of atoms and how they react to various forces

**particle physics** *n* [U] area of physics that deals with particles

**phenomenon** *n* [C] ***Pl*** **phenomena** an event or situation that can be seen to happen or exist; ***phenomenon of:*** *a study of the phenomenon of physical attraction*

**physicist** *n* [C] someone who has special knowledge and training in physics

**physical** *adj* related to physics. ***Collocations:*** *physical chemistry*

**physical science** *n* [C] natural sciences, for example chemistry and physics that deal with things that are not alive; ***e. g.:*** *Sciences such as biology that deal with things that are alive are called life.*

**physics** *n* [U] the science concerned with the study of physical objects and substances and of natural forces such as heat, light and other forms of energy and how they affect objects

**property** *n* [C] *often Pl* a quality or feature of something; ***e. g.:*** *The water is said to have healing properties.*

**research** *n* [U] the detailed study of something in order to discover new facts, especially in a university or scientific institution; ***e. g.:*** *She teaches a lot of classes and doesn't have much time for her own research.* ***Collocations:*** *medical / historical / linguistic research;* ***research into:*** *research into the causes of schizophrenia*; ***research on:*** *There is clearly a need for further research on this topic;* ***carry out research:*** *Government scientists have carried out extensive research into the effects of these drugs.*

**research** *v* [transitive] to make a detailed study of something in order to discover new facts*;* ***e. g.:*** *The subject has not been fully researched before.*

**science** *n* [C, U] **1.** the study and knowledge of the physical world and its behaviour that is based on experiments and facts that can be proved, and is organized into a system; ***e. g.:*** *There's a shortage of people competent in maths, science and technology.* **2.** an area of study that uses scientific methods. ***Collocations:*** *medical / veterinary sciences.* **3.** scientific subject such as chemistry, physics or biology. ***Collocations:*** *earth sciences;* ***science of****: the modern science of ecology*

**scientific** *adj* relating to science, or based on its methods. ***Collocations:*** *scientific research / evidence / procedures; a scientific truth / fact / claim; scientific instruments*

**scientist** *n* [C] someone who is trained in science, especially someone whose job is to do scientific research. ***Collocation:*** *research scientists*

**substance** *n* [C] a particular type of liquid, solid, or gas; ***e. g.:*** *The wood is coated with a special substance that protects it from the sun;* ***a hazardous / harmful / radioactive****: Some workers had developed cancer after exposure to radioactive substances*
**theory** *n* [U] the set of general principles that a particular subject is based on. ***Collocations:*** *the theory and practice of education; psychoanalytic / literary theory*

## Module II

**acceleration** *n* [U] rate of increase in the velocity of something
**aloft** *adv* upward, high up, or in a higher position
**angle** *n* [C] figure formed by two lines diverging from a common point or two planes diverging from a common line
**axis** *n* [C] imaginary straight line around which an object, such as the earth turns; ***e.g.*****:** *The Earth rotates barely perceptibly on its axis*.
**cornerstone** *n* [C] somebody or something that is fundamentally important to something
**disintegrate** *v* [intransitive] split the nuclei of atoms, cause the nuclei of atoms to split
**displacement** *n* [C] amount of movement of an object measured in a particular direction
**dynamics** *n* [U] the branch of mechanics dealing with the motions of material bodies under the action of given forces
**force** *n* [U] the influence on a body that causes it to accelerate, as expressed by the formula F = ma; *in physics* a power that makes an object move or that changes the way it moves. ***Collocations:*** *the force of gravity; electromagnetic forces*
**frequency** *n* [U] the number of oscillations or waves of an active repetitive motion in one second other*; in physics n* [C,U] the rate at which a sound wave, light wave, or radio wave vibrates moves up and down. ***Collocation:*** *a frequency of 7.5 MHz*
**friction** *n* [C, U] resistance encountered by an object moving relative to another object with which it is in contact
**gravity** *n* [U] *in physics* the force that makes any two objects that have mass move towards each other. The most common example of this is when an object falls to the ground. ***Collocation:*** *the laws of gravity*
**hold true** *v* [intransitive] remain the same identical
**inertia** *n* [U] *in physics* the force that makes an object stay in the same position until another force makes it move or that makes an object continue moving at the same speed until another force slows it down
**kinetic energy** *n* [U] energy that is associated with the motion of an object as expressed by the formula KE - 1/2mv{2}
**magnitude** *n* [U] greatness of size, volume, or extent
**measure** *v* [transitive] find out the size, length, quantity, rate of something using a suitable instrument or device; ***e.g.:*** *The satellite measures atmospheric gases responsible for ozone destruction.*

**power** *n* [U] *in physics* the rate at which work is performed, as expressed by the formula P = W/t
**product** *n* [C] result of the multiplication of two or more quantities
**push** *v* [transitive] press against somebody/something in order to move that person/ object
**relativity** *n* [U] *in science* the relationship between time, space, and movement as described in Einstein's 'Theory of Relativity'. Einstein's observation that the pull of gravity and forces of acceleration cannot be distinguished from one another. One consequence is that the laws of physics must be studied in isolated frames of reference
**rotate** *v* [transitive] turn like a wheel around an axis or a fixed point*;* ***e.g.:*** T*he Earth rotates 360 degrees every 24 hours.*
**second** *n* [C] unit of measurement of angles equal to one sixtieth of a minute or one 360th of a degree
**spring** *n* [C] metal coil used especially for cushioning and in clockwork
**stretch** [intransitive] lengthen, widen, or extend something
**velocity** *n* [U] speed of motion action or operation rapidity swiftness
**weight** *n* [C,U] the force on a body produced by the downward pull of gravity on it. It may be expressed by the formula W = mg, where m represents the mass of the object and g represents the acceleration of gravity
**work** *n* [U] the force applied to an object times the distance over which it is applied, as expressed by the formula W = Fd. Work may be independent of the energy expanded

## Module III

**change** *v* [intransitive/transitive] to become different, or to make someone or something different; ***e. g.:*** *Some things never change.*
**crystal** *n* [C] a solid that is packed with ions, molecules or atoms in an orderly fashion
**energy** *n* [U] **1.** a form of power such as electricity, heat, or light that is used for making things work; ***e. g.:*** *Insulating your home is a good way to save energy. Environmentally friendly energy sources include water and wind power.* **2**. the power that is present in all physical things and that can be changed into something such as heat, movement or light. **3.** the ability to perform work. Energy may be changed from one form to another, as from heat into light, but it normally cannot be created or destroyed.
**fluid** *n* [C, U] something that can flow; not solid; able to move and change shape without separating when under pressure
**gas** *n* [C, U] a substance such as air that is neither a solid nor a liquid; ***e. g.:*** *carbon dioxide; They detected high levels of radon gas in the building.*
**liquid** *n* [C, U] **1.** a substance that can flow, has no fixed shape, and is not a solid or a gas; ***e. g.:*** *a glass of colourless liquid; The detergent is available as a powder or a liquid.* **2.** *in physics* a substance in a physical state in which it does not resist change of shape but does resist change of size

**matter** *n* [U] **1.** a particular type of substance; ***e. g.:*** *You can improve the soil by adding composted organic matter.* **1a.** physical substance that everything in the world is made of

**oxygen** *n* [U] a colourless odourless highly reactive gaseous element: the most abundant element in the earth's crust (49.2 %). It is essential for aerobic respiration and almost all combustion and is widely used in industry. Symbol: O; atomic no.: 8; atomic wt.: 15.9994; valency: 2; density: 1.429

**potential energy** *n* [U] energy that is stored because of position or configuration, such as the gravitational energy of a weight that is positioned on the roof of a building

**state** *n* [C, U] the condition of something at a particular time; ***the state of:*** *We're collecting data on the state of the environment.*

**state of matter** *n* [C, U] matter having a homogeneous, macroscopic phase

**plasma** *n* [U] state of matter similar to gas in which a certain portion of the particles are ionized

**solid** *n* [C, U] **1.** one of the states of matter, where the molecules are packed close together, there is a resistance of movement / deformation and volume change. **2.** *in physics* a substance in a physical state in which it resists changes in size and shape

**water** *n* [U] a chemical substance, a major part of cells and Earth, and covalently bonded. ***Collocations:*** *a glass of water; sparkling (carbonated) water (=water for drinking that has gas added to it)*

## Module IV

**atom** *n* [C] the smallest unit of any substance. It consists of a nucleus made of protons and neutrons with electrons travelling around it. ***Collocations:*** *hydrogen / carbon / oxygen atoms*

**atomic number** *n* [C] the number of protons in the nucleus of an atom, the number representing an element which corresponds with the number of protons within the nucleus

**atomic weight** *n* [C, U] relative atomic mass

**conduction** *n* [U] the transfer of heat by molecular motion from a source of high temperature to a region of lower temperature, tending toward a result of equalized temperatures

**convection** *n* [U] **1.** the process by which the very small parts in a liquid or gas move and give out heat. **2.** the mechanical transfer of heated molecules of a gas or liquid from a source to another area, as when a room is warmed by the movement of air molecules heated by a radiator

**heat** *n* [U] **1.** the quality of being hot, or the degree to which something is hot; ***e. g.:*** *These paints can withstand heat up to 200 degrees. The fire fighters were driven back by the intense heat and smoke.* ***heat of:*** *He could feel the heat of the sun on his back.* **2.** *in physics* the energy that is produced when the temperature of something changes; ***e. g.:*** *These chemical processes generate a lot of heat.* **3.** a form of energy that results from the disordered motion of molecules; ***e. g.:*** *As the motion becomes more rapid and disordered, the amount of heat is increased.*

**heat-resistant** *adj* not easily damaged by heat
**molecule** *n* [C] a chemically bonded number of atoms that are electrically neutral
**motion** *n* [U] the process or action of moving; ***e. g.:*** *Special instruments record the speed and motion of the atoms.*
**movement** *n* [C, U] the act, process or result of moving
**radiation** *n* [U] **1.** *in chemistry* a form of energy produced during a nuclear reaction that is used for making electrical power but can also kill or harm humans who receive too much of it. ***e. g.:*** *There is a clear link between exposure to radiation and some forms of cancer. Some workers at the power station were exposed to high levels of radiation.* **2.** *in physics* a type of energy that is sent out in the form of electromagnetic waves, for example, heat, light, or radio waves. ***Collocation****: ultraviolet radiation from the sun*
**spectroscopy** *n* [U] study of radiation and matter, such as X-ray absorption and emission spectroscopy
**temperature** *n* [C,U] **1.** a measurement of how hot or how cold a place or object is. Temperature is measured in **degrees Celsius** or **degrees Fahrenheit**, using the symbol; ***e. g.:*** *It's stopped snowing here but the temperature is still minus three;* ***temperature of:*** *The seeds need a minimum temperature of about 15° C to germinate;* ***at a temperature:*** *Make sure that you bake it at the correct temperature;* ***air / water / ground temperature:*** *The water temperature is 79° F;* ***the temperature drops:*** *Temperatures dropped below freezing last night*; ***the temperature rises:*** *The temperature rose steadily throughout the day.* **2.** *in physics* the average kinetic energy of molecules
**thermal** *adj* **1.** relating to or caused by heat. ***Collocations:*** *thermal power, thermal energy.* **2.** thermal clothing is made of special material that keeps you warm. ***Collocations:*** *thermal underwear.* **3.** thermal water is heated by natural processes in the Earth. ***Collocations:*** *thermal springs*
**thermodynamics** *n* [U] the science of the relationship between heat and other forms of energy
**transfer** *n* [C,U] **1.** an act of moving something or someone to another place, organization, team, etc. ***Collocation****: electronic data transfer.* ***e. g.:*** *Low noise transfer of digital data is particularly beneficial in electrically noisy environments and for transmission over long distance.* **2.** *in physics* The conversion of one form of energy into another, or the movement of energy from one place to another.
**transfer** *v* to move someone or something from one place, vehicle, person, or group to another. ***Collocation****: to transfer heat.* ***e. g.:*** *Data is easily transferred electronically.*

## Module V

**capacitance** *n* [C,U] **1**. the ratio of the charge on either conductor of a capacitor to the potential difference between the conductors. **2**. the property of being able to collect a charge of electricity
**carry** *v* [transitive] **1**. to hold or support while moving, bear. **2**. to serve as a means for the conveyance of, transmit. **3**. to hold or be capable of holding

**convert** *v* [transitive] **1**. to alter the physical or chemical nature or properties especially in manufacturing. **2**. a) to change from one form or function to another; b) to alter for more effective utilization; c) to appropriate without right. **3**. to exchange for an equivalent: convert foreign currency into dollars; convert a bond

**electricity** *n* [U] **1.** a form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current. **2.** a form of energy that can produce light, heat, and power for machines, computers, televisions etc; ***e. g.:*** *The machines run on electricity.* ***Collocation:*** *an electricity supply: Switch off the electricity before you attempt any repairs.* ***generate / produce electricity:*** *Household waste could be burned to generate electricity;* ***conduct electricity*** (= let it pass through): *Salt water conducts electricity more easily*

**electric charge** *n* [U] the quantity of unbalanced electricity in a body (either positive or negative) and construed as an excess or deficiency of electrons

**electric current** *n* [U] the movement of electrically charged particles, atoms, or ions, through solids, liquids, gases, or free space

**electron** *n* [C] a stable subatomic particle with a negative electric charge

**generate** *v* [transitive] **1**. a) to bring into existence; b) to originate by a vital, chemical, or physical process. ***Collocation:*** *generate electricity.* **2**. to be the cause of (a situation, action, or state of mind); ***e. g.:*** *These stories generate a good deal of psychological suspense.*

**generator** *n* [C] **1**. any device for converting mechanical energy into electrical energy by electromagnetic induction, esp a large one as in a power station. **2**. a device for producing a voltage electrostatically. **3**. any device that converts one form of energy into another form

**induction** *n* [U] **1**. the generation of electromotive force in a closed circuit by a varying magnetic flux through the circuit. **2**. the charging of an isolated conducting object by momentarily grounding it while a charged body is nearby

**magnetic field** *n* [C] a field of force surrounding a permanent magnet or a moving charged particle, in which another permanent magnet or moving charge experiences a force

**phenomenon** *n* [C] **1**. something that happens or exists in society, science, or nature, especially something that is studied because it is difficult to understand. ***Collocation:*** *the growing phenomenon of telecommuting*; ***e. g.:*** *Homelessness is not a new phenomenon.* **2**. something or someone that is very unusual because of a rare quality or ability that they have

**polarity** *n* [C,U] **1**. intrinsic polar separation, alignment, or orientation, especially of a physical property. ***Collocations:*** *magnetic polarity*, *ionic polarity*. **2**. an indicated polar extreme. ***Collocation:*** *an electric terminal with positive polarity*. **3**. the possession or manifestation of two opposing attributes, tendencies, or principles. ***Collocation:*** *political polarity*

**proton** *n* [C] **1.** one of the three basic particles in the atom, found in the nucleus with the neutron. **2.** a positive unit or subatomic particle that has a positive charge

**redistribute** *v* [transitive] **1**. to distribute again or anew. **2**. to alter the distribution of; apportion differently

**resistance** *n* [U] **1**. any force that tends to retard or oppose motion. ***Collocations:*** *air resistance, wind resistance.* **2**. the tendency of a conductor to oppose the flow of current, causing electrical energy to be changed into heat. **3**. the magnitude of the real part of the acoustic or mechanical impedance

**thermoelectricity** *n* [U] **1**. electricity generated by a thermocouple. **2**. the study of the relationship between heat and electrical energy

**voltage** *n* [C,U] a measure of the difference in electric potential between two points in space, a material, or an electric circuit, expressed in volts

## Module VI

**conductive** *adj* a conductive substance allows heat or electricity to pass through it

**conductor** *n* [C] substance or medium that conducts heat, light, sound, or especially an electric charge; ***e. g.:*** *Metals are good conductors of electricity and heat*.

**current** *n* [C,U] a flow of electricity. ***Collocation:*** *electric current*

**current electricity** *n* [U] electricity that flows from one place to another

**discover** *v* [transitive] **1.** to find out something that you did not know before; ***e. g.:*** *He became very friendly when he discovered that she was my sister*. **2.** to find a place, fact, or substance that no one knew about before; ***e. g.:*** *William Herschel discovered Uranus in 1781. New antimalarial drugs have been discovered.*

**discovery** *n* [C,U] the process of learning something that was not known before, or of finding someone or something that was missing or hidden; ***e. g.:*** *The award recognizes distinction in exploration, discovery, and research. Our country continues to lead the world in scientific discoveries.*

**electrical** *adj* **1.** working by electricity; ***e. g.:*** *They sell all kinds of electrical equipment and appliances.* **2.** relating to electricity; ***e. g.:*** *The fire was caused by an electrical fault.* ***Collocation:*** *electrical engineering*

**electrician** *n* [C] someone whose job is to repair or fit electrical equipment

**electromotive force** *n* [U] the force that causes the movement of electrons through an electrical circuit

**invent** *v* [transitive] to design or create something such as a machine or process that did not exist before; ***e. g.:*** *Alfred Nobel invented dynamite.*

**invention** *n* [C] a machine, tool, or system that someone has made, designed, or thought of for the first time; ***e. g.:*** *Inventions like the electric light bulb changed the way people lived.*

**inventor** *n* [C] someone who has invented something or whose job is to invent things

**mains electricity** *n* [U] the public supply of electricity for people to use in their homes, offices etc

**power** *n* [U] ability or capacity to do something

**static electricity** *n* [U] electricity that does not flow in a current but is found in some objects when they rub together and can give an electric shock

**technology** *n* [C,U] advanced scientific knowledge used for practical purposes, especially in industry; ***computer / software / military technology; the development of new technologies and new branches of science***

## Module VII

**absorb** *v* [transitive] **1.** to take in a gas, liquid, or other substance; ***e. g.:*** The timber expands as it absorbs moisture. ***absorb something into something****: Caffeine is rapidly absorbed into the bloodstream.* **1a.** [often passive] to take in heat, light, or some other form of energy, instead of reflecting it; ***e. g.:*** *The planes are fitted with a device that absorbs enemy radar signals.* **2.** *in physics* to take in (all or part of incident radiated energy) and retain the part that is not reflected or transmitted

**fluorescent light** *n* [C] a very bright light that consists of a long glass tube containing fluorescent gas

**laser** *n* [C] a piece of equipment that produces a powerful narrow line of light. It is used for cutting hard substances, directing the paths of missiles, and in medical operations; ***e. g.:*** *The cancer cells are destroyed by a tiny laser. New laser eye surgery can correct your vision.* ***Collocations: laser beam:*** *Computer technology and laser beams can be used to control the weather;* ***laser display*** **(**=patterns of coloured lights): *The crowd enjoyed the fireworks and the laser display*

**light** *n* [U] **1.** brightness from the sun or from a light, which allows you to see things; ***e. g.:*** *The room gets a lot of light in the afternoons*; ***light shines:*** *Light from the street lamps was shining through a gap in the curtains;* ***a beam / flash / shaft /ray of light:*** *The clouds parted and a single beam of light fell on the church;* ***by the light of something*** (=using the light from something): *The house could be clearly seen by the light of the moon.* **2.** *in physics* electromagnetic radiation with a wavelength visible to the human eye

**lighting** *n* [U] light of a particular type or quality, or the equipment that produces it. ***Collocation:*** *fluorescent lighting*

**penetrate** *v* [intransitive/transitive] to get through something into a place and be heard, seen, or felt by people in it; ***e. g.:*** *Few sounds penetrate the thick wall.*

**ray** *n* [C] an amount of light or heat from the sun; ***e. g.:*** *The last rays of the sun were disappearing behind the mountains. Your skin needs protection from the sun's rays*.

**reflect** *v* [transitive] *in physics* if a surface reflects something, you can see the image of that thing on the surface; ***e. g.:*** *The lake reflected the surrounding mountains.* ***be reflected in:*** *I caught a glimpse of them reflected in the mirror.* **1a**. *[intransitive/transitive]* if light reflects, or if something reflects light, the light shines back off that thing; ***e. g.:*** *Pale colours reflect light.* ***reflect off:*** *The morning light reflected off the snow.*

**reflection** *n* [U] *in physics* the process of reflecting light, sound, or images

**reflective** *adj* able to reflect light

**transmit** *v* [transitive] if a substance transmits light, sound, or energy, the light, sound, or energy can pass through it

**transmission** *n* [U] the process of sending power or energy from one place to another. ***Collocation:*** *electricity transmission lines.*

**velocity** *n* [U] the speed with which an object travels over a specified distance during a measured amount of time. It may be expressed by the formula v = d/t.

**wave** *n* [C] *in physics* the way in which sound, light, a radio signal etc travels. It is represented by a line that curves upwards and then downwards again many times

**wavelength** *n* [U] *in physics* the distance between two waves of sound or light that are next to each other

## Module VIII

**beam** *n* [C] *in physics* a line of light or other form of energy. ***Collocations:*** *the beam of the car headlights; a laser beam*
**bright** *adj* full of strong shining light; ***e. g.:*** *It was a bright sunny day. I could see a bright light in the sky. It's nice and bright in here (=there is a lot of light).* ***Collocations:*** *bright sunshine / sunlight*
**brighten** *v* [transitive] to give something more colour or light; ***e. g.:*** *Light colours brighten a dark room.*
**chromatic** *adj in science* relating to colour
**diffraction** *n* [U] *in physics* the process by which sound, water, and light waves change when they pass over an object or through a narrow space
**diffuse** *v* [intransitive/transitive] if light diffuses, or if something diffuses it, it shines over a large area but not very brightly
**diffusion** *n* [U] *in physics* the movement of light in many directions after it hits a surface that is not smooth or when it passes though a substance that is not completely clear
**dimension** *n* [C] length, height, or width; the size of something
**incandescent** *adj* producing light as a result of being made very hot
**intensity** *n* [C,U] the strength of colour, sound, light, or temperature
**interference** *n* [U] the process of deliberately becoming involved in a situation and trying to influence the way that it develops, although you have no right to do this
**luminescence** *n* [U] *in physics* light that is produced without heat
**luminous** *adj* **1.** very bright; ***e. g.:*** luminous pink flowers; **1a.** shining in the dark. ***Collocation:*** *a luminous watch dial*
**monochrome** *adj* not brightly coloured and usually grey in colour
**optics** *n* [U] the scientific study of sight and light
**optical** *adj* connected with sight or light. ***Collocation:*** *optical equipment*
**optical fibre** *n* [C,U] *in physics* a very thin string made of glass or plastic, used in telephone and computer systems for sending information in the form of light
**polar** *adj* relating to the pole of a battery or magnet
**pole** *n* [C] *in science* one of the two ends of a magnet or battery
**polarity** *n* [U] *in science* the condition of having opposite electrical charges
**polarize** *v* [intransitive/transitive] to form two very different groups, opinions, or situations that are completely opposite to each other, or to cause this to happen

ANSWER KEY

Module 1. Physics. Part II. Task 10: ***(Answers:*** **1. a; 2. d; 3. b; 4. a; 5. c; 6. a).**
Module 4. Thermal Physics. Part III. Task 12: ***(Answers:*** **a) 2; b) 4; c) 1; d) 3).**
Module 7. Light. Part II. Task 8: ***(Answers:*** **a) black 2; b) 4; c) 5; d) not accurate 1; e) 3).**

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# *Notes*

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# English for the Students of Physics

# Англійська мова для студентів-фізиків

Навчальний посібник
*(англійською мовою)*

Друкується в авторській редакції